Non-Residential New Construction (NRNC) Programs Impact Evaluation

California Investor-Owned Utilities' Non-Residential New Construction Program Evaluation for Program Years 2006-2008

Study ID: CPU0030.04 NRNC Appendices Part 1

Final Evaluation Report

Appendices to Volume II (Part 1)

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For the
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Energy Division

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Appendix A. Whole Building M&V Plan

The Whole Building Measurement &Verification Plan is a detailed outline of the steps taken to evaluate the Whole Building HIM measure. This M&V Plan is part of the impact evaluation of the Non-Residential New Construction Contract Group. The primary goal of the impact evaluation is to assess the net program-specific energy and demand impacts for the programs in this group. The objectives of the impact evaluation are to:

- Determine the impacts at this site of the installed energy efficiency measures on annual gross energy and peak demand.
- Establish annual performance profiles for the whole building based on review of records, building plans, energy management control systems (EMCS), and, when available, measurements and interviews.
- Explain discrepancies between the results of this study and the ex-ante savings estimated by utilities, if possible.
- Inform future updates to ex-ante energy savings estimates (including the DEER database) for program planning purposes.

GENERALIZED MEASUREMENT AND VERIFICATION

COMPREHENSIVE WHOLE BUILDING

JULY 29, 2009

SUMMARY INFORMATION

PROJECT

Evaluation Site ID	
IOU	
Recruitment Date	
Customer Name	.
Site Name	
Site Address	
Site Description	

PRINCIPAL SITE CONTACT

Name		**Telephone**	
E-mail		**Title**	

SITE LEAD

Name	

AUTHOR

Name	

1. Goals and Objectives

This Measurement and Verification (M&V) Plan is part of the impact evaluation of the Non-Residential New Construction Contract Group. The primary goal of the impact evaluation is to assess the net program-specific energy and demand impacts for the programs in this group.

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- Determine the impacts at this site of the installed energy efficiency measures on annual gross energy and peak demand.
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- Inform future updates to ex-ante energy savings estimates (including the DEER database) for program planning purposes.

2. SITE REVIEW APPROACH AND PROCEDURE

The first prerequisite for the evaluation of any Savings by Design sample project is to obtain the project documentation from the utility. Utility documentation gives us a detailed account of the project scope and complexity. The project documentation typically includes tracking savings information, measure details, project correspondence, verification documentation, and in some cases architectural, lighting, and mechanical details. The project files are used by the site leads to develop a plan for the site visit as well as metering plans when warranted. The file review is a systematic process to extract key data that informs the subsequent efforts of net to gross measure identification, modeling input definition, and end use metering planning. The data collection manager will be responsible for coordinating the project file data extraction and will assign experienced site leads to the task of file review. The experienced site lead will be able to derive key model inputs as well as understand the end uses that may be subject to metering and model calibration. The file review will help to determine the complexity of the measures and the necessary time required onsite to efficiently complete the audit. This will also facilitate development of a site specific measurement and verification plan prior to site visit.

Whole building approach projects are subject to a detailed file review to identify measures for the decision maker surveys. This is necessary for whole building projects as the program reporting does not include individual measures. Since we assess free ridership at the measure level, the individual program-influenced measures need to be identified so the free ridership of each individual measure can be addressed in the decision maker survey.

Measure Description

Typically, sites are comprised of multiple energy efficiency measures. Sections 2.1-2.3 below provide a description of a typical commercial site and provides additional sections to cover the maximum number of measures.

Measures Baseline

The gross saving base case uses the minimum Title 24 standards, the version that was in effect when the project was permitted. The base case of the sites under 2006-08 Savings by Design evaluation are either 2001 or 2005 Title-24 standards .The base case uses minimal compliance for all building components such as lighting, HVAC equipment, insulation, and envelope construction to arrive at a baseline for comparison. Since there are no energy standards for grocery store refrigeration systems, the Savings by Design program baseline equipment specifications will be used as the reference. For building types where Title 24 does not apply (e.g. hospitals and industrial process equipment), we carefully evaluated the baseline defined by the program, making adjustments when necessary for estimating the program savings.

Sample Type

Using the tracking data provided by each of the 4 IOUs, KEMA selected a sample using Model Based Statistical Sampling. PG&E, SCE, and SDG&E are stratified using tracking kWh. Since SoCalGas claimed no kWh savings for the 2006-08 Savings by Design program we stratified SoCalGas using tracking therms. The sample design is expected to achieve ±10% relative precision at the 90% confidence level at the statewide level.

2.1. Whole Building with Non Central HVAC

Whole building measures commonly found in the Savings by Design program generally fall within three categories: building envelope, lighting, and HVAC.

Building Envelope- Fenestration measures typically include U-value and SHGC reductions. Reductions in U-value and SHGC are commonly achieved through the use of multiple glazing layers, low-e coatings, and thermal break frames. Window overhangs that extend beyond both ends of the window are also commonly used to reduce fenestration solar heat gain.

Envelope measures also include added insulation installed in roofs, exterior walls, and radiant barriers. Roofing measures are generally related to increasing the R-value of the roof surface or reducing radiant heat gain. These goals are commonly achieved through the use of either elastomeric or single ply membrane surface coatings and added insulation between the roof and conditioned space.

Lighting- Lighting measures can be broken into three categories: LPD reduction, daylighting, and lighting controls. LPD reduction is commonly achieved through the use of more efficient lighting technologies in conjunction with lighting controls based on occupancy or lumen maintenance. Skylights are commonly coupled with daylighting controls that deactivate or dim lights as a function of the outdoor light incident on sensors.

HVAC- HVAC savings are generally achieved through the installation of high efficiency split or packaged air conditioners and heat pumps. Cooling efficiency is characterized by SEER and EER ratings, while heating efficiency is generally given in AFUE for gas fired systems and HSPF for heat pumps. To achieve increased efficiency, economizers, variable air volume supply fans, and high efficiency fan motors are typically used.

2.2. Whole Building Commercial Refrigeration Measures

Commercial refrigeration measures are primarily implemented in grocery and large retail stores. Refrigeration energy efficiency measures (EEMs) are typically bundled together into EEM packages under the whole building approach. Commercial refrigeration energy efficiency measures (EEMs) commonly found in the Savings by Design program includes:

- Efficient condenser
- Mechanical sub-cooling
- Display case reach-in doors
- Floating head pressure
- Variable speed drives
- Variable set point controls
- Floating suction pressure
- Variable speed evaporator fans
- Premium efficiency motors

- Display case lighting controls
- Refrigeration heat recovery
- Improved insulation
- Anti sweat heater controls.

Efficient Condenser– This measure specifies a higher efficiency condenser compared to typical standard refrigeration condenser units.

Mechanical sub-cooling - Mechanical sub-cooling is provided for the low temperature condenser racks by the medium temperature condenser racks. Sub-cooling the refrigerant reduces the temperature at the evaporator, resulting in an increase in cooling capacity and overall efficiency.

Display case reach in doors – Energy efficient doors designed with tight fitting door gaskets, door frames, and multi–pane glass door.

Floating head pressure-This control strategy allows the compressor's head pressure to float as a function of the outdoor air temperature. During mild weather conditions, the head pressure is allowed to float down, resulting in savings from reduced compressor load. This strategy may or may not be coupled with variable speed controls and variable condenser set point.

Variable speed drive and variable set point - Variable speed drives and fan control at the condenser fans allow the system to optimally control the saturated condensing temperature based on the ambient wet-bulb and in concert with floating head pressure results in savings from lower fan power consumption. Otherwise, savings is limited because the condenser fans have to be turned on more often.

Floating suction pressure – Compressor suction pressure is allowed to float instead of being fixed. During times of low load, the system can operate at a higher suction pressure. The compressor uses less energy during these times since the pressure differential between suction and discharge is reduced.

Variable speed controls of evaporator fans – Variable speed drives installed on evaporator fans save energy by ramping down fan speed when the conditioned space set point temperature is met.

Premium efficiency motors – The proposed motors are high efficiency motors that exceed the standard efficiency for their respective motor size. These motors may be installed at evaporator fans, condenser fans, or compressor pumps.

Display lighting control – Display lights at the refrigerated display cases are turned off at night when the store is closed instead of being left on for all hours. In addition, occupancy sensors may be installed at walk-in boxes. One or both control combination saves energy when the space is unoccupied.

Refrigeration heat recovery – A heat reclaim coil is affixed to the refrigeration evaporative condenser and is designed to recover heat back to the main HVAC unit.

Improved insulation – The walls and floors of refrigerated zones have high R-value material (freezers, coolers, walk-in boxes) installed to provide improved insulation.

Anti-sweat heater control – Anti-sweat heaters are controlled on store humidity reducing the amount of time they need to be on as opposed to being on at all hours even when the display cases are not "sweating."

2.3. Whole Building Central Plant HVAC Measures

High efficiency chillers – Chiller savings result from having higher rated efficiency when compared to code baseline requirements. The high efficiency of the chillers can be attributed to a number of chiller design improvements that may include premium efficiency pump motor, existence of a variable speed drive at the compressor, enhanced controls, enlarged and improved condenser sections to name a few.

Premium efficiency motors – The proposed motors are high efficiency motors that exceed the EPACT efficiency for their respective motor size. These motors can be installed at air handling units, cooling tower fans, condensing water pumps (CWP), chilled water pumps (CHWP), and/or heating hot water pumps (HHWP).

High efficiency boiler – Boilers installed have a higher thermal efficiency rating than standard boilers.

Variable frequency drives (VFD) – Fan or pump controls can be installed at air handling units, cooling tower fans, CWP, CHWP, and/or HHWP. Energy savings comes from a reduction in fan or pump usage during non peak hours when the VFD is ramped down.

3. Algorithms for Estimating Savings

3.1. Utility Algorithms

The utilities use DOE-2 based energy simulation software such as eQuest or Energy Pro to estimate energy savings for Whole Building measures, while other tools and algorithms are used for Systems and Industrial projects. For commercial sites with extensive refrigeration measures, the utilities use a DOE-2.2R hourly refrigeration simulation tool to model the refrigeration as well as the building's shell, HVAC, and lighting systems for their savings estimate. For all sites, building data is collected from Title 24 compliance documentation, as-built building plans, interviews with the owners, and the equipment manufacturer's specification sheets. The data is input into one of the simulation software mentioned above and a simulation is run to compute the yearly energy consumption. The results are compared with the baseline to give an estimated peak demand and energy savings in kW, kWh, and therms.

3.2. Evaluation Algorithms

The evaluation algorithm will involve the creation of a simplified IPMVP Option D simulation model to estimate the energy and demand savings of the site.

3.2.1. Modeling Approach

The data requirements of the evaluation include kW, kWh and therm savings for program and non-program measures during specific costing periods, including end-use interactions. Based on the California protocols and the prior NRNC evaluations, the gross impact analysis is conducted using the DOE-2.2 building energy simulation program. The DOE-2 program is well suited to analyzing the impacts of most measures included in the Savings by Design new construction program. DOE-2 is a very flexible modeling tool; it allows for the calculation of energy savings and demand reduction for lighting, lighting controls, shell measures, HVAC efficiency improvements and many HVAC control measures, among others. DOE-2.2Ris used for its abilities to model commercial refrigeration.

The keys to efficiently developing accurate and defensible DOE-2 models are:

1. Collection of appropriate building information during the on-site survey. This relies on competent, well-trained surveyors focused on collecting key building data. The team places the responsibility for creating and controlling for quality of the DOE-2 models in the hands of the surveyors responsible for data collection, i.e., the person most familiar with each site.
2. Quality control over the on-site data collection and data entry, including range, internal consistency, and reasonableness checks. These are incorporated into the data-entry software provided to the surveyors.
3. Automated tools to calculate model input parameters from the on-site survey databases and automatically generate as-built and Title-24 DOE-2 input files.

4. A second level of model review and quality control by an experienced DOE-2 engineer. Senior engineering staff review and check the models after surveyor has constructed and checked the models for quality and validity.
5. For a subset of the simulated sites, focused short-term monitoring is conducted for the purpose of calibrating the engineering model. In addition concurrent weather and utility billing data is collected to improve the model match with real world site conditions in the model calibration process.
6. Automated data validation of model outputs and energy savings projections.
7. Tools to automatically perform the required parametric runs and store the results in an electronic database.

.Energy Savings (kWh, therms)

The surveyor divides the building into logical zones for modeling based on the architectural floor plans, mechanical plans, and operational schedules. The HVAC system is developed from a combination of the mechanical plans, manufacturer's specification sheets, the nameplate description as found onsite, and any control system as verified. Information on the building shell, plug loads, and lighting is input into the database. After all operation parameters are entered, the DOE-2 simulation can be run and compared to the baseline. The results are an estimated annual energy savings in kWh, and therms.

Demand savings (kW)

For the central plant and commercial sites, the modeling software calculates the peak kW demand savings automatically based on weather data provided. For commercial with refrigeration sites, the modeling software uses CTZ weather data to calculate the peak kW demand savings. Peak demand is defined as the average grid level impact for the measure from 2 PM to 5 PM during the three consecutive weekday period containing the weekday with the hottest temperature of the year. This calculation method is consistent with the DEER peak demand definition adopted by the CPUC.

4. Data Collection

All relevant building characteristics, operational schedules, and control strategies serving as inputs into the AEC Survey-IT database are collected. The details of these input parameters are described below.

4.1. Required C&I Whole Building Modeling Parameters

For a given whole building site, modeling parameters fall into the following hierarchy. All parameters ending with a "P" are collected if possible. In most cases, these items include things like wall insulation, which cannot be gathered unless as-built plans are made available by the site contact. Survey-IT contains built in Title 24 defaults based on building type to account for those parameters that are not readily collected on site. All parameters that do not include a "(P)" are considered essential to the building model and must be collected.

4.1.1. Whole Building Models with Non Central HVAC

I. Site Overview Information

A. Title 24 building type
B. Overall floor area
C. Number of floors
D. Baseline (2005 Title 24 or 2001-Title 24)
E. Site type: new building, alteration, or addition
F. City

II. Facility Operating Schedules

A. Hourly operating schedules are collected for each distinct usage area of the retail space (shipping/receiving, management offices, sales floor, etc.) for full operating, light operating and closed days
B. Seasonal variations in schedules
C. Observed holidays

III. HVAC and Ventilation Systems

A. Primary Heating and Cooling Systems
   1. System type (packaged/split AC, packaged/split heat pump)
   2. Manufacturer
   3. Model number (Indoor and Outdoor for split systems)
   4. Serial number "P"
   5. Cooling capacity
   6. Cooling efficiency (SEER or EER)
   7. Heating capacity [kBtuh]
   8. Heating efficiency (AFUE, HSPF, or COP)
   9. Evaporative cooling section if applicable (Direct, Direct/Indirect, or Indirect)

10. Supply fan system type (CV or VAV)
11. Fan control (CV, Cycles, VAV, Discharge Dampers, or Inlet Vanes)
12. Supply fan motor HP and efficiency "P"
13. Return fan motor HP and efficiency (if applicable) "P"
14. Condenser type (dry coil or evaporative)
15. % outside air "P"
16. Economizer type (Fixed, Temperature, or enthalpy)

B. HVAC Schedules (for each system)

1. Hourly fan use schedules for full use, light use, and closed day-types
2. Thermostat set points for heating and cooling during occupied and unoccupied periods
3. Hours during which the occupied thermostat set points apply
4. Fan control during unoccupied periods

C. Zone Level HVAC

1. Equipment type (Exhaust fan, computer equipment coolers, baseboard or radiant heaters, etc.)
2. Fan HP (where applicable)
3. Motor efficiency (where applicable)
4. Heat Capacity [kBtuh] (where applicable)

IV. Envelope Characteristics

A. Exterior Walls

1. Frame type (concrete, wood, metal, brick, etc.)
2. R-value or U-value "P"
3. Orientation (N, S, E, W)
4. Height and width

B. Windows

1. Number of panes
2. Glass type (clear, tinted, reflective or fritted)
3. Frame type (standard metal, thermal break metal, or vinyl)
4. SHGC "P"
5. U-Value "P"
6. Height and width of each window
7. Quantity of each type
8. Internal shading
9. Overhangs (offset and projection)

C. Interior Walls (separating distinct zones defined by their HVAC system)

1. Type (Solid wall or air wall)
2. Height and width
3. Adjacent zone

D. Roofs

1. Type (wood joist, metal joist, or concrete deck)

2. Roof R-value or U-Value “P”
3. Surface area
4. Orientation and Tilt
5. Surface (Paint , elastomeric coating, single ply membrane, metal roofing, asphalt shingles, or gravel)
6. Color
7. Reflectivity and emittance “P”
8. Ceiling R-value “P”
9. Plenum height and plenum wall R-value “P”

E. Skylights
1. Number of panes
2. Glass or plastic type (clear, white, tinted, fritted, or translucent)
3. Added features (low-E or gas filled) “P”
4. Frame type (Thermal break metal or thermal break metal with or without curbs)
5. SHGC “P”
6. U-value “P”
7. Length and width
8. Quantity
9. Shape (Domed, pyramid, etc)
10. Curb
11. Internal shading

V. Lighting

A. Interior Lighting (to be cataloged in Title 24 spaces defined by occupancy)
The following parameters will be collected for all interior lights:
1. Fixture type
2. Fixture wattage
3. Lamps per fixture
4. Lamp wattage
5. Mounting type (recessed, direct, indirect, direct-indirect, track, plug in task, or furniture integrated task)
6. Control strategy (none, occupancy sensor, stepped daylighting, continuous daylighting, lumen maintenance, or some combination thereof)

B. Interior Lighting Schedules
1. Hourly operating schedule for full use, light use, and closed days by area

C. Exterior Lighting
The following parameters will be collected for all exterior lights:
1. Fixture type
2. Fixture wattage
3. Control strategy (photocell or timer)
   a) Hours of operation if on timer control

VI. Internal Plug Loads

A. Load characteristics
1. Equipment type (coffee pot, computer, microwave, television, printer)
2. kW, HP or kBtuh "P"
3. Use factor (if possible to estimate)

B. Load schedules
1. Hourly operating schedules for full use, light use, and closed days

VII. Exterior and Miscellaneous Equipment

A. Hot Water Heaters
1. Type (storage, instantaneous, heat pump)
2. Manufacturer
3. Model number
4. Capacity
5. Input [kBtuh gas, kW electric]
6. Thermal efficiency, % "P"
7. Standby loss, %/hr "P"
8. Recirculation pump HP "P"

B. Vertical Transportation
1. Type (Escalator, Elevator)
2. HP
3. Number of floors (elevators)
4. Width, rise and run (escalators)

C. Exterior Equipment
1. Type (Compressor, machine tools, etc.)
2. kW or HP
3. Hourly operating schedules for full, light and closed day types

4.1.2. Whole Building Sites with Refrigeration

VII. Refrigeration System

A. Compressor

1. Type (stand alone, parallel equal multiplex, unequal, stand-alone with VSD)
2. Manufacturer
3. Model number
4. Circuit
5. Mechanical sub-cool

B. Condenser

1. Type (air, evaporative)
2. Manufacturer
3. Model number
4. Rated capacity
5. Outdoor temperature rating
6. Condensing temperature rating
7. Fan/pump control
8. Fan/pump horsepower
9. Fan/pump efficiency
10. Phase, RPM

C. Evaporator fan

1. Motor efficiency
2. Controls
3. Settings

D. Refrigeration loads

1. Display case types (island, single decks, walk-in, etc.)
2. Length, area or volume
3. Quantity
4. Space location
5. Compressor location
6. Case lighting type
7. Night Control
8. Door type for reach-in cases (panes, low infiltration)
9. Heat recovery

E. Refrigeration settings

1. Floating head pressure control
2. Floating suction pressure control
3. Minimum condensing temperature set point "P"
4. Refrigerant type
5. Anti-sweat heaters "P"
6. Defrost cycles & defrost control "P"
7. Display case lighting hours of operation
8. Refrigerated walls/floors/ceiling insulation value "P"

4.1.3. Central Plant HVAC

III. Central Plant HVAC (Replaces Section 3)

A. Primary Heating and Cooling Systems

i. Chiller
   1. Size
   2. Full load efficiency
   3. Chiller type
   4. Condenser type
   5. Manufacturer
   6. Model #
   7. Auxiliary pump hp and efficiency “P”
   8. Auxiliary pump assignment (loop) “P”

ii. Cooling tower
   1. Capacity
   2. Fan control
   3. Number of fan/pumps
   4. Fan/pump control type
   5. Phase
   6. Horsepower
   7. Motor efficiency
   8. Rated ambient WB
   9. Rated condenser water temperature

iii. Heating system
   1. Type (steam, hot water, electric)
   2. Capacity
   3. Fuel type
   4. Efficiency
   5. Auxiliary pump horsepower “P”
   6. Phase
   7. RPM
   8. Efficiency
   9. Control type
   10. Auxiliary pump horsepower and efficiency “P”
   11. Auxiliary pump assignment (loop)”P”
   12. Usage (primary, secondary)

iv. Air handler
   1. Horsepower
   2. Control type
   3. Motor efficiency
   4. Phase
   5. Evaporative system type if applicable
   6. Supply fan flow rate
   7. Outside air control

8. Minimum outside air fraction

v. Packaged/split systems

1. Cooling and heating capacity and efficiencies
2. Supply CFM
3. Supply fan control
4. Outside air control
5. Minimum outside air fraction
6. Economizer types
7. Manufacturer/model
8. Evaporative cooling section if applicable

B. HVAC Schedules (for each system)

1. Hourly fan use schedules for full use, light use, and closed
2. Thermostat set points for heating and cooling during occupied and unoccupied periods
3. Hours during which the occupied thermostat set points apply

C. Ventilation and Zone Level HVAC

1. Equipment type (Exhaust fan, computer equipment coolers, baseboard or radiant heaters, etc.)
2. Fan HP (where applicable)
3. Motor efficiency (where applicable)
4. CFM flow rate (where applicable)

4.2. Data Collection Methods

The data collection includes an interview with the operations manager, surveying, checking operation logs, reviewing as-built plans, and looking at the facility EMCS system.

4.2.1. Interviewing Approach

The interview is held with the building operations manager or someone who has intimate knowledge of the building and its HVAC operations and controls. We record the occupancy, lighting, and HVAC schedules, as well as operation trends during the different seasons and holidays from conversations with the manager. We ask questions pertaining to fan control, overall HVAC system operations, fan control, thermostat set points, and central HVAC design and controls in order to develop the HVAC portion in our modeling software. For sites with refrigeration, questions are also asked about the system's control strategy such as suction pressure, condenser fan control strategies, and settings. Information taken from the interview helps supplement those found on building plans and what is observed on the building's energy management system if one exists.

4.2.2. Surveying Approach

A portion of the time is devoted to planning the model building approach because frequently few building plans are included in the files. Therefore, the survey includes a significant amount of time reviewing documents to help us establish how to break up the building into relevant zones for modeling purposes and to establish the details (such as a space's area) necessary to build an accurate model. This data is obtained by reviewing architectural, mechanical, lighting, and refrigeration (where applicable) plans as well as the Title 24 documentation.

Next, a walk-through of the facility is done to verify what was found on the plans and to verify that the measures have been installed. In addition, name plate information of the major end uses with implemented measures is collected to cross check the specifications found in the building plans, interview, and project file. Where applicable, surveying of the refrigeration load consists of recording the types of display cases present and measuring their unit dimensions. Each display case type has a default load per unit of measurement which can be used to estimate the load for each item surveyed.

5. Simulation & Parametric Runs

Data collected as described in Section 4 above is entered into a custom-built MS Access database tool (Survey IT) to produce an as built model. The model is completed and quality controlled (QC) checked, then run to simulate gross savings for participants on a whole building and measures only basis. The energy performance of the as-built building is simulated using the Climate Thermal Zone (CTZ) long-term average weather data from the California Energy Commission. High-quality DOE-2 models are generated from the on-site survey databases by providing input files with the following attributes:

5.1. Loads

Space definition and model zoning.

The building is defined in terms of a series of spaces that represent the principal uses of the building. For example, a number of occupancy types, including office, laboratory and cafeteria may be found within a single building. Each space may be subject to a different baseline lighting power density allowance under Title-24. Within each space, building shell and internal load characteristics are calculated from the on-site survey data. For example, lighting power density is calculated from a fixture count, a lookup table of fixture wattage, and the space floor area. Lighting schedules are developed from the survey data and associated with the appropriate space in the building. Similarly, equipment power density is calculated from the equipment counts and connected loads in the on-site surveys. A diversity factor consistent with standard engineering practice is introduced to account for the discrepancy in nameplate versus actual running load inherent in certain types of equipment. An equipment operating schedule is developed from the survey data and associated with the appropriate space in the building.

Another important element in the generation of the input files is the accurate representation of the diversity of heating and cooling loads within the building. The subdivision of spaces also takes into account the following:

- ***Unusual internal heat gain conditions***. Spaces with unusual internal heat gain conditions, such as computer rooms, kitchens, and laboratories are defined as separate spaces.
- ***HVAC system type and zoning***. HVAC systems inventoried during the on-site survey associated with the applicable space. When the HVAC systems serving a particular space are different, the spaces are sub-divided. Reasonable HVAC system zoning practices are followed by the surveyors.

Occupancy, lighting, and equipment schedules. Each day of the week is assigned to one of three day types, as reported by the surveyor, full operation, light operation and closed. Hourly values for each day of the week are extracted from the on-site database according to the appropriate day type. These values are modified on a monthly basis, according to the monthly building occupancy history. Monitored data is especially valuable in refining these variables.

Infiltration schedule. The infiltration schedule is established from the fan system schedule. Infiltration is scheduled “off” during fan system operation and “on” when the fan system was off.

Shell materials. A single-layer, homogeneous material is described containing the conductance and heat capacity properties of the exterior surfaces of the building. The thermal conductance and heat capacity of each wall and roof assembly are taken from the Title-24 documents when available. If the Title-24 documents are not available, default values for the conductance and heat capacity are assigned from the wall and roof types specified in the on-site survey and the observed R-values. If the R-values are not observed during the on-site survey and the Title-24 documents are not available, an "energy-neutral" approach is taken by assigning the same U-value and heat capacity for the as-built and baseline simulation runs.

Windows. Window thermal and optical properties from the building drawings or Title-24 documents (when available) are used to develop the DOE-2 inputs. If these documents are not available, default values for the glass conductance are assigned according to the glass type specified in the on-site survey. Solar radiation pyranometers are used during the on-site survey when possible to measure the as-built solar transmission of the glazing. The glass shading coefficient is calculated from the glass type and measured solar transmittance. The results of these calculations are input into the model. If the glass properties are not measurable during the on-site survey and the Title-24 documents are not available, an "energy-neutral" approach is taken by assigning the same U-value and shading coefficient for the as-built and baseline simulation runs.

Solar and shading schedules. The use of blinds by the occupants, as reported by the occupants, is simulated by the use of solar and shading schedules. The glass shading coefficient values are modified to account for the use of interior shading devices.

Lighting kW. Installed lighting power is calculated from the lighting fixture inventory reported on the survey. A standard fixture wattage is assigned to all fixture types identified by the surveyors. Lighting fixtures are identified by lamp type, number of lamps per fixture, and ballast type as appropriate.

Lighting controls. The presence of lighting controls is identified in the on-site survey. For occupancy sensor and lumen maintenance controls, the impact of these controls on lighting consumption is simulated as a reduction in connected load, according to the Title-24 lighting control credits. Daylighting controls are simulated using the "functions" utility in the Loads portion of DOE-2. Since the interior walls of the zones are not surveyed, it is not possible to use the standard DOE-2 algorithms for simulating the daylighting illuminance in the space. A daylight factor, defined as the ratio of the interior illuminance at the daylighting control point to the global horizontal illuminance, is estimated for each zone subject to daylighting control. Typical values for sidelighting applications are used as default values. The daylight factor is entered into the function portion of the DOE-2 input file. Standard DOE-2 inputs for daylighting control specifications are used to simulate the impacts of daylighting controls on lighting schedules.

Equipment kW. Connected loads for equipment located in the conditioned space, including miscellaneous equipment and plug loads, kitchen equipment and refrigeration systems with integral condensers are calculated. Input data are based on the "nameplate" or total connected load. The nameplate data are adjusted using a "rated-load factor," which is the ratio of the average operating load to the nameplate load during the definition of the equipment schedules. This adjusted value represents the hourly running load of all equipment surveyed. Equipment diversity is also accounted for in the schedule definition. Monitored data is used to refine these values to reflect actual field conditions.

For the miscellaneous equipment and plug loads, equipment counts and connected loads are taken from the on-site survey. To reduce audit time, the plug load surveys are done as a subset of the total building square footage. When the connected loads are not observed, default values based on equipment type are used.

For the kitchen equipment, equipment counts and connected loads are taken from the on-site survey. Where the connected loads are not observed, default values based on equipment type and "trade size" are used. Unlike the miscellaneous plug load schedules, the kitchen equipment schedules are defined by operating regime. An hourly value corresponding to "off", "idle", or "low," "medium" or "high" production rates is assigned by the surveyor. The hourly schedule is developed from the reported hourly operating status and the ratio of the hourly average running load to the connected load for each of the operating regimes.

For the refrigeration equipment, refrigerator type, count, and size are taken from the on-site survey. Equipment observed to have an "integral" compressor/condenser, that is, equipment that rejects heat to the conditioned space, is assigned a connected load per unit size.

Source input energy. Source input energy represents all non-electric equipment in the conditioned space. In the model, the source type is set to natural gas, and a total input energy is specified in terms of Btu/hr. Sources of internal heat gains to the space that are not electrically powered include kitchen equipment, clothes dryers, and other miscellaneous process loads. The surveyors entered the input rating of the equipment. As with the electrical equipment, the ratio of the rated input energy to the actual hourly consumption is calculated by the rated load factor assigned by equipment type and operating regime.

Heat gains to space. The heat gains to space are calculated based on the actual running loads and an assessment of the proportion of the input energy that contributed to sensible and latent heat gains. This, in turn, depends on whether or not the equipment was located under a ventilation hood.

Zoned by exposure. In the instance where the "zoned by exposure" option is selected by the surveyor, additional DOE-2 zones are created. The space conditions parameters developed on a zone-by-zone basis are included in the description of each space. Enclosing surfaces, as defined by the on-site surveyors, are also defined.

5.2. Systems

This section describes the methodology used to develop DOE-2 input for the systems simulation. Principal data sources include the on-site survey, Title-24 documents, manufacturers' data, and other engineering references as listed in this section.

Fan schedules. Each day of the week is assigned to a particular day type, as reported by the surveyor. The fan system on and off times from the on-site survey are assigned to a schedule according to day type. These values are modified on a monthly basis, according to the monthly HVAC operating hour adjustment. The on and off times are adjusted equally until the required adjustment percentage is achieved. For example, if the original schedule is "on" at 6:00 hours and "off" at 18:00 hours, and the monthly HVAC adjustment indicates that HVAC operates at 50% of normal in June, then the operating hours are reduced by 50% by moving the "on" time up to 9:00 hours and the "off" time back to 15:00 hours. Monitored data is used when appropriate to refine these schedules.

Setback schedules. Similarly, thermostat setback schedules are created based on the responses to the on-site survey. Each day of the week is assigned to a particular day type. The thermostat set points for heating and cooling and the setback temperatures and times are defined according to the responses. The return from setback and go to setback time is modified on a monthly basis in the same manner as the fan-operating schedule.

Exterior lighting schedule. The exterior lighting schedule is developed from the responses to the on-site survey. If the exterior lighting is controlled by a time clock, the schedule is used as entered by the surveyor. If the exterior lighting is controlled by a photocell, a schedule following the annual variation in day length is used.

System type. The HVAC system type is defined from the system description from the on-site survey. The following DOE-2 system types are employed:

- Packaged single zone (PSZ)
- Packaged VAV (PVAVS)
- Central constant volume system (RHFS)
- Central VAV system (VAVS)
- Central VAV with fan-powered terminal boxes (PIU)
- Four-pipe fan coil (FPFC)

Packaged HVAC system efficiency. Manufacturers' data is gathered for the equipment surveyed based on the make and model number observed by the surveyor. A database of equipment efficiency and capacity data is developed from an electronic version of the ARI rating catalog. Additional data is obtained directly from manufacturers' catalogs or the on-line catalog available on the ARI website (www.ari.org). Manufacturers' data on packaged system efficiency is a net efficiency, which considers both fan and compressor energy. DOE-2 requires a specification of packaged system efficiency that considers the compressor and fan power separately. Thus, the manufacturers' data is adjusted to prevent "double-accounting" of fan energy, according to the procedures described in the 2001 Alternate Compliance Method (ACM) manual.

Pumps and fans. Input power for pumps, fans and other motor-driven equipment is calculated from motor nameplate horsepower data. Motor efficiencies as observed by the surveyors is used to calculate input power. In the absence of motor efficiency observations, standard motor efficiencies are assigned as a function of the motor horsepower. A rated load factor is used to adjust the nameplate input rating to the actual running load. For VAV system fans, custom curves are used to calculate fan power requirements as a function of flow rate in lieu of the standard curves used in DOE-2, as described in the 1998 ACM manual.

Service hot water. Service hot water consumption is calculated based on average daily values from the 2001 ACM for various occupancy types. Equipment capacity and efficiency are assigned based on survey responses.

Exterior lighting. Exterior lighting input parameters are developed similarly to those for interior lighting. The exterior lighting connected load is calculated from a fixture count, fixture identification code, and the input wattage value associated with each fixture code.

Ventilation Air. Commercial HVAC systems are designed to introduce fresh air into the building to maintain a healthy indoor environment. The space type and its associated floor area are used to calculate outdoor air quantities according to Title-24 rules. Outdoor air fractions are calculated for each system from the total system airflow rate and the space outdoor air requirements.

Commercial Refrigeration. The algorithms used in the DOE-2.2 R program are used to evaluate the performance of commercial refrigeration systems found in grocery stores, commercial kitchens, schools, and so on. Refrigerated cases, compressor plant, condensers, and control system characteristics are surveyed. The automated modeling software provides DOE-2 models of both the building and the refrigeration systems, providing an accurate representation of the refrigeration system performance, and the interactions between the refrigeration system and the building HVAC system.

5.3. Plant

This section describes the methodology used to develop DOE-2 input for the plant simulation. Principal data sources included the on-site survey, Title-24 documents, manufacturers' data, program data, and other engineering references.

Chillers. The DOE-2 input parameters required to model chiller performance include chiller type, full-load efficiency and capacity at rated conditions, and performance curves to adjust chiller performance for temperature and loading conditions different from the rated conditions. Chiller type is assigned based on the type code selected during the on-site survey. Surveyors also gather chiller make, model number, and serial number data. These data are used to develop performance data specific to the chiller installed in the building. Program data and/or manufacturers' data are used to develop the input specifications for chiller efficiency.

Cooling towers. Cooling tower fan and pump energy is defined based on the nameplate data gathered during the on-site survey. Condenser water temperature and fan volume control specifications are derived from the on-site survey responses.

5.4. Model Review and Quality Checks

After the DOE-2 model is generated, the model is run using the CEC climate thermal zone (CTZ) long term average weather data corresponding to the climate zone where the project is located. The model either runs successfully generating a results page, or receives errors and/or warnings. When warnings and/or errors are encountered, modifications to the data entry database are performed and another model for the site is created and run. This process is repeated until the model runs successfully and a results page is generated.

Sites with monitored data are calibrated using concurrent actual weather files. The calibrated models are then re-run using the CEC TMY weather files.

The on-site survey data entry program contains numerous quality control (QC) checks designed to identify invalid building characteristics data during data entry. Once the models are run successfully, the surveyor/modeler and senior engineering staff review the results. A building characteristics and model results summary report is created for each site. The overall quality assurance process is outlined as follows:

A list of key physical attributes of the buildings are summarized and checked for reasonableness:

- Window to wall ratio
- Opaque wall and roof conductance
- Glazing conductance
- Glazing shading coefficient
- Lighting power density
- Equipment power density
- Floor area per ton of installed AC
- Cooling system efficiency
- Sizing ratio

The as-built characteristics are compared to Title-24 and/or common practice criteria. The energy performance of the building is also checked. Energy consumption statistics, such as the whole building EUI (kWh/sqft-yr.), and end-use shares are examined for reasonableness. The baseline model is run, and savings estimates for participants are compared to program expectations. Sites with large variances are further examined to investigate potential problems in the on-site data or modeling approach. For each site, the full set of end-use parametrics are run for each building as a component of the QC process. The measure and whole building savings by end-use are compared to program tracking system information and checked for reasonableness.

An example of some of the QC criteria utilized is shown below in Table 1. Data falling outside of the QC range is validated during the QC process.

Building Parameter	Range	Definition
Cooling Ratio	95 - 200%	capacity from annual run / capacity from sizing run
Cooling EER	8 - 14	capacity weighted cooling efficiency
Wall U-Value	0.5 - 0.033	area weighted average, includes air film
Roof U-Value	0.5 - 0.033	area weighted average, includes air film
Win U-Value	0.3 - 0.88	area weighted average, includes air film
Win-Shading Coefficient	0.35 - 0.88	area weighted average
Window to Wall Ratio	0 - 70%	percentage of gross wall area associated w/windows, expressed as a true percentage 0 –100
Skylight U-Value	0.3 - 0.9	area weighted average of glazing contained in roof
Skylight-Shading Coefficient	0.35 - 0.88	area weighted SC for all horizontal glazing
Skylight Area To Roof Area Ratio	0 - 10%	percentage of gross roof area associated with sky light, expressed as a true percentage 0 –100
Lighting Occupancy Controlled	0 - 50%	percentage of lighting watts controlled by occupancy sensors, expressed as a true percentage 0 –100
Lighting Daylighting Controlled	0 - 50%	percentage of lighting watts controlled by daylighting sensors, expressed as a true percentage 0 –100
Measures only savings relative to program expectations	50% - 150%	measures-only savings / program expectations
Total Savings relative to Baseline (Gross)	0% - 50%	savings expressed as a percentage of baseline energy consumption

Table 1: Model Quality Control Criteria

Building type specific performance data from the California NRNC Baseline study is used to develop additional QC criteria. Any site below the 25th percentile or greater than the 75th percentile for whole building EUI, end-use EUI, lighting power density, or equipment power density is flagged for closer study. The building type specific QC criteria are listed in Table 2.

Building Type	Whole Building EUI (kWh/SF)		Cooling EUI (kWh/SF)		Fan EUI (kWh/SF)		Lighting EUI (kWh/SF)		Refrigeration EUI (kWh/SF)		Other EUI (kWh/SF)		Lighting Power Density (W/SF)		Equip Power Density (W/SF)	
	25th pct	75th pct	25th pct	75th pct	25th pct	75th pct	25th pct	75th pct	25th pct	75th pct	25th pct	75th pct	25th pct	75th pct	25th pct	75th pct
C&I Storage	1.50	8.68	0.04	0.51	0.07	1.29	1.07	3.92	0.00	0.00	0.27	2.33	0.50	0.93	0.10	0.56
Grocery Store	40.30	53.62	0.38	1.19	1.77	3.61	7.38	11.77	22.88	34.65	2.60	7.12	1.25	1.70	0.04	0.19
General C&I Work	7.88	28.88	0.07	2.56	0.13	2.21	2.55	5.49	0.00	0.00	2.29	14.55	0.70	1.37	0.08	0.85
Medical/Clinical	13.26	28.65	2.13	5.82	1.71	9.18	2.97	6.59	0.00	0.00	1.74	7.88	0.94	1.45	0.63	1.79
Office	9.27	17.92	1.38	3.48	1.07	3.43	2.91	4.57	0.00	0.00	1.58	5.98	0.97	1.38	0.98	2.45
Other	6.55	29.87	0.00	4.33	0.50	4.32	2.37	5.34	0.00	0.00	1.74	18.00	0.85	1.44	0.06	1.09
Religious Worship, Auditorium, Convention	5.01	14.35	0.53	3.84	0.57	3.85	1.56	3.83	0.00	0.00	0.98	3.12	1.00	1.49	0.00	0.28
Restaurant	36.25	73.94	3.07	9.10	5.22	10.07	5.54	9.74	0.00	3.98	14.29	44.14	1.24	2.01	0.08	0.59
Retail and Wholesale Store	14.30	26.37	1.45	3.67	1.89	4.47	5.92	10.50	0.00	0.00	1.31	4.78	1.35	1.96	0.06	0.42
School	6.33	10.75	0.58	1.96	0.95	2.37	2.34	3.73	0.00	0.00	0.73	2.84	1.07	1.56	0.23	1.01
Theater	12.30	19.29	2.62	5.39	2.03	5.39	2.49	4.53	0.00	0.00	1.92	5.36	0.79	1.34	0.04	0.14
Fire/Police/Jails	9.32	18.62	0.98	2.44	1.40	3.28	3.27	5.00	0.00	0.00	2.28	5.46	0.69	1.00	0.44	1.20
Community Center	7.26	19.94	1.35	2.85	1.27	4.18	2.55	5.48	0.00	0.00	1.28	6.02	0.95	1.28	0.18	1.19
Gymnasium	7.80	13.96	0.03	2.28	0.76	5.98	2.76	4.07	0.00	0.00	1.48	2.67	1.04	1.54	0.03	0.28
Libraries	10.96	13.40	1.35	2.72	1.34	3.05	3.74	4.92	0.00	0.00	1.48	2.80	1.12	1.35	0.42	1.02

Table 2: Survey It^{tm} Quality Control EUI Reference Table

5.5. Parametric Runs

Once the models are quality checked, an automated process is used to create a series of parametric simulation runs. These runs are used to simulate gross savings for participants on a whole building and measure-class basis by subtracting the as-built energy consumption and demand from the baseline energy consumption and demand. The parametric runs used in this study are listed below:

- ***As-Built Parametric Run***

Once the models are completed and QC checked, the as-built parametric run is done. The energy performance of the as-built building is simulated using long-term average weather data from the National Weather Service.

- ***Baseline Parametric Run***

Key building performance parameters are reset to a baseline condition to calculate gross energy savings for participants. The 2001 California Building Energy Efficiency Standard (Title-24) is the primary reference for establishing baseline performance parameters. Title-24 specifies minimum specifications for building attributes such as:

- Opaque shell conductance
- Window conductance
- Window shading coefficient
- HVAC equipment efficiency
- Lighting power density

Title-24 applies to most of the building types covered in the programs covered under this project, with the exception of:

- Hospitals
- Prisons/Correctional Institutions
- Industrial projects
- Unconditioned space (including warehouses)

Incentives are also offered by the program for building attributes not addressed by Title-24. In situations where Title-24 does not address building types or equipment covered under the program, baseline parameters equivalent to those used for the program baseline efficiencies are used for participants.

Envelope

Opaque shell U-values are assigned based on Title-24 requirements as a function of climate zone and heat capacity of the observed construction. For windows, Title-24 specifications for maximum relative solar heat gain are used to establish baseline glazing shading coefficients.

Fixed overhangs are removed from the baseline building. Glass conductance values as a function of climate zone are applied. For skylights, shading coefficients and overall conductance are assigned according to climate zone.

Mechanical

Baseline specifications for HVAC equipment efficiency are derived from the Title-24 requirements as a function of equipment type and capacity. Maximum power specifications for fans are established based on Title-24 requirements, which address fan systems larger than 25 hp. Specific fan power is held energy neutral (as built W/CFM = baseline W/CFM) for fan systems under 25 hp. Additionally, all systems larger than 2500 CFM or 75,000 Btu/hr of cooling capacity (except for hospitals) are simulated with economizers in the baseline run. All variable-volume pumps are simulated with throttling valve control.

HVAC System Sizing

HVAC system sizing for the as-built case is determined by direct observation of the nameplate capacities of the HVAC equipment. The installed HVAC system capacity is compared to the design loads imposed on the system to determine a sizing ratio for the as-built building. Once established, the sizing ratio is held constant for each subsequent DOE-2 run. A separate sizing run is done prior to each baseline and parametric run, using the equipment sizing algorithms in DOE-2. The system capacity is reset using the calculated peak cooling capacity, and the as-built sizing ratio.

Lighting

The Title-24 area category method is used to set the baseline lighting power for each space as a function of the observed occupancy, except in spaces using the tailored lighting approach, where the allowed lighting power from the Title-24 documents is used. All lighting controls are turned off for the baseline simulation.

Grocery Store Refrigeration Systems

- Since there are no energy standards for grocery store refrigeration systems, the Savings by Design program baseline equipment specifications serve as the baseline or reference point for the gross impact calculations as illustrated below in Table 3.

System Attribute	**Baseline Assumption**
Evaporative condenser fan and pump power	Auxiliaries = 0.09 hp/ton, single-speed fan.
Design condensing temperature for evaporative condensers	Wetbulb + 25°F
Air-cooled condenser fan power	Auxiliaries = 0.09 hp/ton, single-speed fan

Design condensing temperature for air-cooled condensers	LT, MT cases: Drybulb + 10°F HT cases: Drybulb + 15°F
Minimum condensing temperature	82°F
Compressor efficiency	Rated compressor efficiency held energy neutral.
Compressor capacity control	Non-multiplexed, fixed capacity compressors (stand-alone).
Evaporator fan motors	Standard efficiency shaded-pole evaporator fan motor
Case lighting	Standard efficiency (T-12 w/ magnetic ballast) case lighting
Medium Temperature Doors (20°F - 35°F case temperature)	Double pane door with constant-on door heaters
Low Temperature Doors (< 20°F case temperature)	Double pane door with constant-on door heaters

Table 3. Baseline equipment design assumptions for refrigeration.

- ***Additional Parametric Runs***

Once the as-built and baseline building models are defined, an additional set of parametric runs are done to estimate the program impact on the lighting, HVAC, shell / daylighting, and refrigeration measure groups. The baseline model is returned to the as-built design in a series of steps outlined as follows:

1. *Shell, measures only*. Baseline envelope properties (glazing U-value and shading coefficient; and opaque surface insulation) for incented measures only are returned to their as-built condition.
2. *All Shell.* All baseline envelope properties are returned to their as-built condition.
3. *Lighting Power Density, measures only.* Run 2 above, plus baseline lighting power densities for spaces in the building that received incentives are returned to their as-built condition.
4. *All Lighting Power Density.* Run 2 above, plus all baseline lighting power densities are returned to their as-built condition.
5. *Daylighting Controls, measures only.* Run 4 above, plus daylighting controls that received incentives are returned to their as-built condition.

6. *All Daylighting Controls.* Run 4 above, plus all daylighting controls are returned to their as-built condition.
7. *Other Lighting Controls, measures only.* Run 6 above, plus all other lighting controls that received incentives are returned to their as-built condition.
8. *All Other Lighting Controls.* Run 6 above, plus all other lighting controls are returned to their as-built condition.
9. *Motors and Air Distribution, measures only.* Run 8 above, plus baseline motor efficiency, fan power indices (W/CFM), and motor controls for incented measures only are returned to their as-built condition.
10. *All Motors and Air Distribution.* Run 8 above, plus all baseline motor efficiency fan power indices (W/CFM), and motor controls are returned to their as-built condition.
11. *HVAC, measures only.* Run 10 above, plus HVAC parameters for incented measures only are returned to their as-built condition.
12. *All HVAC.* Run 10 above, plus all HVAC parameters are returned to their as-built condition.
13. *Refrigeration, measures only.* Run 12 above, plus refrigeration parameters for incented measures in buildings eligible for the grocery store refrigeration program only are returned to their as-built condition.
14. *All Refrigeration.* Run 12 above, plus all refrigeration parameters in buildings eligible for the grocery store refrigeration programs are returned to their as-built condition. Note: refrigeration parameters in buildings not eligible for the grocery store refrigeration programs remain at the as-built level for all parametric runs.
15. *DHW, measures only.* Run 14 above, plus hot water parameters for incented measures only are returned to their as-built condition.
16. *All DHW.* Run 14 above, plus all hot water parameters are returned to their as-built condition. *This run is equivalent to the full as-built run.*

When applicable, savings from projects participating under the “Other Systems” option are added to the applicable parametric categories defined above. For example, savings from refrigerated warehouse improvements are added to the refrigeration parametric:

6. End Use Metering

End-use metering places emphasis on capturing peak load operating condition for participant sites with large demand reduction. We will install metering equipment on a sample of sites with large demand reduction.

6.1. Development of Monitoring Plan

6.1.1. Whole Building Monitoring Plans

A site-specific monitoring plan is developed prior to the site visit. This includes information such as size of the building, types of end use equipment, list of equipment to meter, etc. For a central plant site, the majority of end uses such as cooling, ventilation, auxiliary pumps, heat rejection, and area lighting are of particular interest since many of the energy efficiency measures have a direct impact on their usage. When a site is selected for metering, efforts are directed to metering the relevant end uses that contributes the largest percentage of savings with an emphasis on capturing peak load operating conditions for measures with large demand savings. The metered data is used to calibrate the DOE-2 models.

End-uses that receive metering for this site are VSD chillers, VSD air handler fans, VSD chilled water pumps, Condenser water pumps, VSD cooling tower fans, VSD hot water pumps and lighting. The parameters to be recorded are power (kW), amperage (amps), voltage (V), and power factor (PF). True RMS measurements are performed on non-linear loads such as variable speed retrofitted pumps and fans, where as CT loggers are installed on lighting loads. Spot watt measurement is used to calculate the time series kW of the above end-user. Our data logging is carried out for a period of three weeks at an interval of five minutes. The details of monitoring points are described in Table 4 and Table 5 below. Table 6 shows details of the monitoring equipment.

Description	**Evaluation**
Equipment monitored	Split and Packaged HVAC, Lighting
Parameter measured	RMS kW & Amps
Measurement equipment	Elite Pro data logger
	OWL 400 CT Logger
	Fluke 345
Installation method	Data logging and spot measurements
Observation frequency	5 minutes
Metering duration	Three weeks

Table 4: Description of Monitoring Points (Package HVAC).

Description	Evaluation
Equipment monitored	Chiller, AHU, CHWP,CWP,CTF,HWP & Lighting
Parameter measured	RMS kW & Amps
Measurement equipment	Elite pro data logger
	OWL 400 CT Logger
	Fluke 345
Installation method	Data logging and spot measurement
Observation frequency	5 minutes
Metering duration	Three weeks

Table 5: Description of Monitoring Points (Central Plant).

Data Point	Equipment brand/model	Rated full scale accuracy	Reading accuracy	Metering interval	Duration
RMS power	Fluke 345 or equivalent	±2.5%	±2.5%	spot	N/A
RMS power	Dent/Elite Pro	±1%	±1%	5 minutes	3 weeks
Amps	ACR Corp/Owl400	±1%	±1%	5 minutes	3 weeks

Table 6: Measurement specifications and details.

Alternatively, the time series kW data for each end user can be obtained from the building's EMCS whenever possible in order to minimize metering equipment and personnel costs.

6.1.2. Refrigeration

Often lighting and cooling can be easily metered as they have dedicated electric panels for these end uses or a subset of these end uses. For instance, a panel can be solely dedicated to five out of ten of the packaged rooftop units of interest or an entire lighting zone of the building. Metering under these circumstances is justified because the result of the metering effort can be multiplied by a factor to confidently arrive at the total energy usage for that end use. However, refrigeration end use metering is more complex and has limited value. This is because many of its components (evaporator fans, compressor, condenser) are dispersed among multiple panels and are often share panels with other end uses. The result of any effort under these circumstances is questionable at best since there is no way to separate the refrigeration end uses with other end uses.

Furthermore, refrigeration loads do not vary at these types of buildings and have limited calibration leeway since the amount of installed equipment and operation hours are all set. An accurate model depends on an accurate survey of all refrigerated display cases and operation set points. Therefore, refrigeration is surveyed and not metered.

6.2. Model Calibration Procedures for C&I Whole Building Sites

In order to calibrate any model, it is re-run with real time weather data compiled for an area that is representative of the city's location obtained from California Irrigation Management Information System.

The resulting Model-IT output can be categorically separated by the building's end uses. The output is an 8,760 hourly energy profile that can be compared to metering data obtained from the metering process. Visualize-IT, an analysis tool that allows the user to identify patterns in the time series data and compare multiple data sets will be used for the analysis. It also calculates the mean bias error (MBE) and root mean square error (RMSE) when two data sets are presented.

End user data acquired from the metering process is processed into hourly profiles with the intent of comparing end user data alongside the model's end user output.

The goal is to calibrate the data until the model's output for each metered end user is below a MBE of +/- 10% and a RMSE ≤ 30. This meets the IPMVP option D's hourly modeling calibration target. Each calibration attempt is documented showing the changes made prior to the calibration attempt and the new MBE and RMSE that resulted from the modified simulation run. Parameters that can be used for calibration include adjusting the occupancy schedule, lighting schedule, and plug load equipment schedules, varying the minimum outside air fractions, and slightly changing the operation set points, to name a few. In general, the parameters allowed to be altered for calibration tend to vary throughout the year, is largely unknown/unspecified or may change as the building's needs change such that varying them slightly to get an acceptable MBE and RMSE is justified. Documented parameters such as equipment's cooling load, fan horsepower, a fixture's wattage, or other similar hard set values will not be altered during the calibration process.

If the MBE and RMSE cannot be calibrated to the desired targets after repeated attempts, we document that and provide possible explanations for the difficulties.

7. Site Results

7.1. Data Products

The evaluation is expected to produce the following data products:

- Estimated gross savings (peak kW, kWh/year, therms/year)
- Estimated net savings
- Site savings realization rate

7.2. Data Accuracy

Information from the interview and building plans is cross checked with what is found during the walkthrough to ensure that the data is indeed as specified. Metering data focuses on end uses that contribute the largest percentage of savings. This functions to increase the result's accuracy.

7.3. Quality Assurance

The models undergo review and QC by the surveyor. All discrepancies and site facts are documented for the sites within the Survey-IT database. These include but are not limited to the following:

- All log file errors either fixed or not fixable have an explanation
- Explanations provided for every input QC parameter warning as detailed in section 5.4
- Explanations provided for every simulation warning
- Lighting power density sanity checks
- Explanations provided why end-use measures realization rate is less than 50% or greater than 150% for kWh and therms
- Explanations provided if total measures realization rate is less than 50% or greater than 150% for kWh and therms
- Explanation provided for why a whole building rebate site doesn't exceed Title 24 baseline by at least 10% or is exceeding Title 24 baseline by 30% or more

This is then be transferred to the senior level reviewer for final review and approval.

7.4. Uncertainties

The largest uncertainties lie in data collected while interviewing site personnel. While the evaluation team will make every effort to cross-verify data collected in the interview during the evaluation, certain parameters such operating, fan and lighting schedules cannot be truly verified without metering. Metering also may reveal system performance that does not match specification sheets or plans. Greater uncertainties may also arise when full as-built plans are not available on site. In these instances, verification of wall insulation, window U-value, and similarly unverifiable parameters are left as their default values while modeling the site.

Appendix B. Industrial Evaluation Protocol

The Industrial Evaluation Protocol, attached below, offers an overview of the evaluation methodology for Industrial Process or Other Systems as well as Refrigerated Warehouses portions of the Savings by Design program. The section lists the incented measures evaluated and describes in detail on-site data collection and end-use metering protocols.

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Industrial Evaluation Protocol

Industrial Process or Other Systems

The Industrial Process and Other Systems portion of Savings by Design offers financial incentives to facility owners for energy efficient measures utilized in a wide range of unique industrial applications. These projects typically utilize the Systems Approach and rely on engineering calculations provided by utility engineers or independent consultants. In most cases, the industrial measures are completely isolated from commercial building sites.

The incented industrial measures include the following:

- Compressed air measures – VSD compressors, efficient air dryers, system pressure reduction, loss control
- Premium efficiency motors
- VSDs on pumping, fan, and blower applications
- LPD reduction
- Smart well completion
- Heat exchangers
- Regenerative burners
- Salt bath insulation
- High efficiency kitchen equipment
- Bi-Metallic catalyst
- Efficient specialized process equipment and design

To evaluate the industrial measures, we have developed a standard operating protocol. The procedures are enumerated as follows:

<u>File Review:</u> File review is one of the important aspects of the industrial evaluation protocol. Prior to each audit, a selected field engineer will conduct a complete file review of the project they will be visiting. The engineer will review the program file to determine:

- Incented measures
- Size of the equipment
- Location of the measures
- End use metering needs

<u>Evaluation Plan</u>: A site-specific evaluation plan will be developed prior to site visit. This will include information such as incented equipment, equipment size, discussion of ex-ante methodology and description of ex-post evaluation algorithm.

The ex-post algorithm will describe the details of the methodology that will be used to evaluate the energy savings of the measure. Typically, an engineering analysis will be performed using excel spreadsheets to estimate the energy savings of the industrial measures. The above algorithm will also include a discussion on the baseline to be used to estimate the savings. The baseline condition for each measure will be determined by conducting a baseline survey with the facility engineer and, if necessary, equipment manufacturers may also be contacted to resolve the issue. If all of the above efforts are futile, we will use the most feasible option that can be used to perform the same job as the incented equipment.

The next step is to develop a site-specific metering plan. Assignments of metering plans are based on the experience level of the engineer. Senior engineers with advanced equipment knowledge and metering skills will develop the metering plans for more complex industrial sites, while mid-level and junior engineers will be assigned to the less complex sites. When possible, KEMA engineers will speak with the site contacts in advance of the site visit in order to determine the requisite metering equipment. For these sites, two visits are necessary- one trip to gather data on the system and install the monitoring equipment and another trip to remove the equipment.

Data Collection:
Data collection will involve gathering relevant information that will serve as inputs to the evaluation algorithm. The data collection will include an interview with the facility engineer, onsite survey, and end-use metering.

- Interview: An interview will be held with facility engineer or someone who has intimate knowledge of the affected equipment and their operating schedule. We will record relevant information regarding the operation of the operation of the affected equipment. Our survey will also note the variability of the operating schedule through out the year.
- Onsite Survey: We will review the mechanical plans to obtain the technical specifications of affected equipment. We will be looking for the following information:

    Electricity Measure

    1. make
    2. model number
    3. horse power
    4. efficiency
    5. phase
    6. volts
    7. full load amps
    8. power factor
    9. efficiency
    10. rpm (motor)
    11. enclosure (motor)

12. control strategy

<u>Gas Measure</u>
1. make
2. model number
3. serial number (if available)
4. fuel type
5. rated input (MMBtu/h)
6. efficiency

End-Use Metering: End use metering will add a valuable perspective on schedules as well as power draw of the affected equipment. We will install time series kW loggers on the affected equipment for a period of three weeks. Spot measurements will be done on all the affected equipment to cross verify the logger readings. The spot measurements will comprise of the voltage, amps, power, and power factor. If the measure is a variable speed drive measure, the VSDs speed or frequency will also be recorded. We carefully identify the points and methods for end-use metering based on the results of preliminary site specific evaluation plan and analysis procedure. We aim to end-use meter those points with the largest uncertainty that will have the largest impact. The realities of field applications mean that we are not always able to monitor all the desired points.

For gas measures, temperatures and flow rates will be monitored. Either the above data will be collected from facility monitoring system, or data loggers will be installed to obtain the data. For example, for an air to air heat exchanger measure, we will collect heat exchanger entrance and exit temperature as well as the air flow going through the heat exchanger.

Many industrial sites will already be collecting trend and other specific data that is often very valuable for our evaluation. We obtain that information whenever possible, spot checking values when possible to confirm the reported values are accurate.

Frequently, impromptu modifications to the plan need to be made on-site. Often, the project file and/or the site contact phone discussion doesn't convey the situation as it exists at the facility, and the new understanding that comes with actually seeing the process requires a change in the plan. Additionally, there may be physical, regulatory or policy reasons why some equipment or temperature stream can't be measure or monitored. Often this only comes to light once when we clearly express our intentions to facility staff with instrumentation in hand. Industrial sites often involve processes that could have a very large financial impact if unforeseen disruptions are imposed by our desire for measurements. The evaluators must work within this constraint and always abide by the site contact instructions regarding what is possible to do and not do.
<u>Site Results:</u> All the data will be processed and will be used to estimate the ex-post savings of the measure.

Refrigerated Warehouses
The refrigerated warehouse component of the industrial process measures utilized a customized approach using DOE-2.2R simulation models. The measures found in the sampled projects included the following:

- Efficient condensers
- Floating head pressure, variable condenser set point, VFD on condenser fan
- VFDs on motors and pumps
- Efficient motors- compressors, supply fans, conveyor motors
- Low lighting power density (LPD)
- Occupancy sensor lighting controls- freezers, warehouses
- Waste water heat exchanger
- Increased insulation
- Evaporator fan run time strategy
- Floating suction pressure
- Hot gas defrost
- Mechanical sub cooling

Note that the refrigerated warehouse savings are reported within the "industrial' measure category.

The evaluation team will use the same approach used for industrial sites to evaluate the refrigerated warehouses. The only difference is that the analysis will be carried out with the help of DOE-2.2R simulation software.

The evaluation algorithm will comprise of creating a simplified IPMVP Option D simulation model to estimate the energy and demand savings of the site. Using the Savings by Design program baselines, we will input and adjust key operating data found during the site visit. Calibration of the models will be done using end-use metering data.

Appendix C. Industrial Site Write Ups

The Industrials site write ups, attached below, offer an overview of the evaluation methodologies used and describes in detail on-site data collection, end-use metering protocols, evaluated savings.

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1.

A. D61590 High Efficiency Lighting

Project D61590 received an incentive of $7,170.00 to reduce their parking garage's LPD. The facility installed high efficient T8 linear fluorescent fixtures. The measure baseline was determined by the Title-24 maximum allowable lighting power for the space type on a square foot basis. Therefore, the only information required for the baseline was the space type and the area in square feet. The evaluation team verified the installation of the measure and the area of the parking garage.

Ex-Ante Gross Savings

Ex-ante gross savings were determined by the Program using projected lighting hours, number of fixtures and rated lamp wattage.

Ex-Post Gross Savings

Ex-post gross savings were calculated using the same methodology as the ex-ante gross savings. The analysis flow was as follows:

1) The evaluation team first verified the parameters that were used for calculating the ex-post savings. Some discrepancies found between the projected and actual fixture counts and square footage were found. Table A-1 below compares between the ex-ante and ex-post lighting schedules. The square footage of the facility was 166,404 ft^2 versus 156,445 ft^2 as used in the ex-ante calculation.

Table A-1: D61590 Comparison between Ex-Ante and Ex-Post Lighting Schedule

Fixture type	Fixture name	Ex-ante quantity	Ex-post quantity
(2) 4' F32T8	F11	60	84
(2) 8' F59T8	F14	199	213

2) The ex-post gross savings were calculated using rated lamp wattages from the lighting schedule, number of lighting fixtures and actual annual operating hours. According to the site contact, the lights are on 18 hours each day, 365 days/year. The estimated ex-post power consumption was 27.6 kW.

3) The annual energy consumption was then calculated using the power consumption and annual operating hours. The ex-post gross power and energy were subtracted from baseline power and energy to calculate ex-post gross savings. The measure baseline was calculated using the Title 24 base case energy standard for parking garages (0.40/square foot).

The estimated baseline demand was 66.56 kW and the Ex-post gross savings were 255,662 kWh/yr with a demand reduction of 38.9 kW.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 52% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey responses are shown below in Table A-2.

Table A-2: D61590 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score -Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Reduced LPD	2 of 10	0.2	Suggested Fixture	2	3 of 10	0.9	3.1	52%

Ex-Post Net Savings

The respondent, a Director of Development, stated that SBD worked with their electrical contractor on fixture selection. SBD therefore influenced the lamp type and fixture selection process. He however gave low scores with regard to the Program's level of influence and what they may have done absent the program. He rationalized this by stating, "With parking structures, it's easy to select the fixtures since we are not as concerned with aesthetics. We want to be smart about saving energy". The site contact's combination of answers yielded a freeridership score of 3.1 out of 6, for a freeridership ratio of 48%. Hence the ex-post net savings for this project were calculated as 52% of the ex-post net savings as shown in Table A-3.

Table A-3: D61590 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Savings	Ex-Post Net Savings
Peak kW	37	38.9	105%	0.52	20.1
kWh	244,457	255,662	105%	0.52	132,092

B. D62388X High Efficiency Lighting

Project D62388X received an incentive of $11,783.00 for their improved parking garage lighting power density (LPD).. The garage was developed in two phases and therefore received two separate incentives for the single garage hence the (X) in the project id. The qualified measures included a low-LPD system with linear T8 and compact fluorescent fixtures. The measure baseline was determined by the Title-24 maximum allowable lighting power for the space type on a square foot basis. Therefore, the only information required for the baseline was the space type and area in square feet. The evaluation team verified the installation of the measure and the area of the parking garage.

Ex-Ante Gross Savings

Ex-ante gross savings were determined by the Program using projected lighting hours, number of fixtures and rated lamp wattage.

Ex-Post Gross Savings

Ex-post gross savings were calculated using the same methodology as the ex-ante gross savings. The key steps were as follows:

1) The evaluation team verified the parameters that would be used to calculate the ex-post savings. There were only minor discrepancies found with the projected number of fixtures versus those found onsite. However, the fixture wattage (Watt/fixture) was higher than originally estimated. Actual fixture wattages were found in the as-built lighting plans and the savings calculation was adjusted accordingly.

2) The ex-post gross savings were calculated using rated lamp wattage from the lighting plans, number of lighting fixtures and actual annual operating hours. According to the site contact, the lights are on 6570 hours/year. The estimated ex-post power consumption was 34.7 kW.

3) The team then calculated annual energy consumption using the power consumption and annual operating hours. Ex-post gross power and energy were subtracted from baseline power and energy to calculate ex-post gross savings. The measure baseline was calculated using the Title-24 energy standard for parking garages (0.40 W/square foot).

The estimated baseline demand was 62 kW. The ex-post gross savings were 179,668 kWh/yr with a demand reduction of 27.3 kW.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 35% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown below in Table B-1.

Table B-1: D62388X Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score -Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Reduced LPD	5 of 10	0.5	Prior Success with this measure	1	2 of 10	0.6	2.1	35%
Reduced LPD		0.5	Prior Success with this measure	1	2 of 10	0.6	2.1	35%

Ex-Post Net Savings

The respondent, a Director of Development, stated prior success with another project within this program cycle influenced the decision to install a better than baseline required lighting system. Furthermore, he said, "We tend to go the most efficient system as possible. But the program keeps us exploring the latest technology for energy efficient building design". Although his next comment was not directly related to this project, he went on to say they couldn't rely on SBD for tenant-improvement projects because the response time is too slow: "On tenant-improvement (TI) projects we really need a rapid response. And for the little amount of incentives we gain on these types of projects [TI] it doesn't justify the cost we pay to our consultants to follow up with the utility". This combination of answers yielded a freeridership score of 2.1 out of 6, for a free ridership ratio of 65%. Hence the ex-post net savings for this project were calculated as 35% of the ex-post gross savings as shown in Table B-2.

Table B-2: D62388X Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Savings	Ex-Post Net Savings
Peak kW	35.5	27.3	77%	0.35	9.6
kWh	235,664	179,668	76%	0.35	62,884

C. D62594 Parking Garage LPD Reduction

Project D62595 received an incentive for reducing the LPD in their parking garage. The facility installed high efficient T8 fixtures, as well as Metal Halide and compact fluorescent fixtures. The measure baseline was determined by T-24 energy standards LPD by space type. Therefore, the only information required for the baseline was space type and the area in square feet. The evaluation team verified the installation of the measure and the area of the parking garage.

Ex-Ante Gross Savings

Ex-ante gross savings were determined using projected lighting hours, number of fixtures and rated lamp wattages.

Ex-Post Gross Savings

Ex-post gross savings were calculated using the same methodology as ex-ante gross savings. The evaluation team verified the parameters used for calculating ex-post savings during an initial site visit. A data logger was installed on the lighting panel for a period of 3 weeks during the months of October and November 2008. The data logger recorded the power consumption of all lighting the parking structure.

The recorded data were imported into data visualization software.

Figure C-1 shows the raw data from the monitoring period. The data indicated that the facility operates on a consistent daily schedule. The raw data were then used to create an average daily profile as illustrated in Figure C-2. This profile shows that roughly half of the lights operate 24 hours a day and seven days a week. The other half operate on a timer scheduled to turn the lights off between the hours of 7 AM and 7PM each day. The timer turns half of the lights to take advantage of natural daylighting. The facility personnel confirmed the schedule reflected in the metered data.

Annual energy consumption was then calculated by integrated the average daily power consumption and scaling the daily consumption to an annual profile. Ex-post gross power and energy were subtracted from baseline power and energy to calculate ex-post gross savings. The measure baseline was calculated using Title 24 base case energy standards for parking garages (0.40W /square foot).

The estimated baseline demand was 108.5 kW and ex-post demand was 23.06 kW. The ex-post gross savings were calculated as 597,905 kWh/yr with a demand reduction of 85 kW.

Figure C-1: D62594 Metered Data

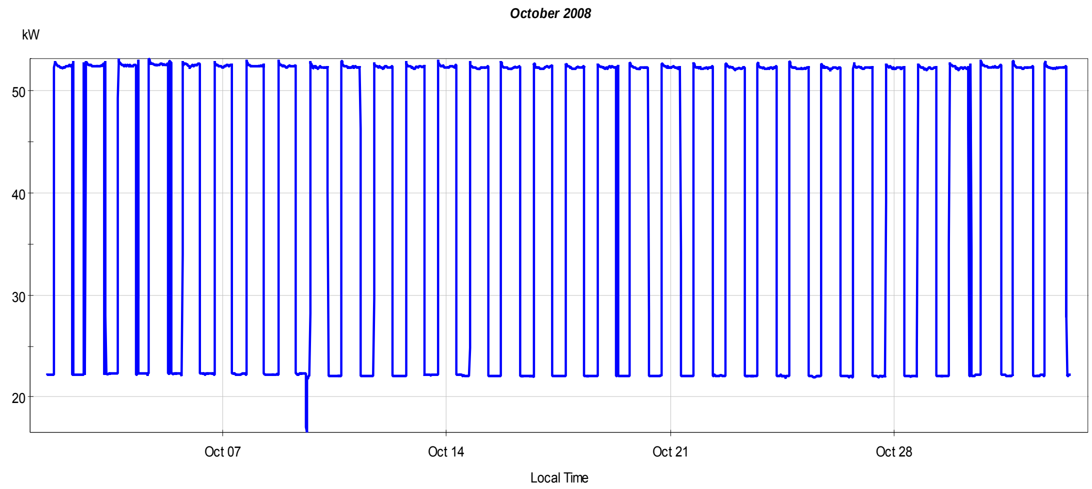
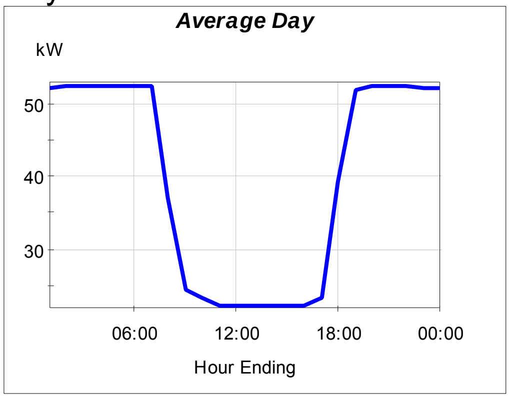


Figure C-2: D62594 Hourly Power Profile



Ex-Post Net-to-Gross Summary

A measure net-to-gross ratio of 75% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown in Table C-1 below.

Table C-1: D62594 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
LPD	10 of 10	1	Suggested Fixture	2	5 of 10	1.5	4.5	75%

Ex-Post Net Savings

The facility representative indicated that the Program was very influential in implementing the measure since an SBD representative may have first suggested it; he was unsure if his own design team or the SBD representative first suggested the measure. The site contact's combination of answers yielded a free ridership score of 4.5 out of 6, indicating 25% free ridership. Hence the ex-post net savings for this project were calculated as 75% of the ex-post gross savings as shown in Table C-2.

Table C-2: D62594 Saving Summary

	Ex-Ante Gross Savings	**Ex-Post Gross Savings**	**Gross Realization Rate**	**Site Net-to-Gross Ratio**	**Ex-Post Net Savings**
Peak kW	58.3	85	147%	0.75	64.1
kWh	511,475	597,905	117%	0.75	448,429

D. D62760 High Efficiency Lighting

Project D62760 received an incentive of $14,513.00 to install high efficiency lighting in a parking garage. The facility installed a low LPD system comprised of T8 fluorescent, CFL and metal halide fixtures. The measure baseline was determined using T-24 energy standards for maximum allowable LPD by space type. Therefore, the only information required for the baseline was space type and space square footage. The evaluation team verified the installation of the measure and calculated energy savings impacts using on-site measurements.

Ex-Ante Gross Savings

Ex-ante gross savings were determined by the Program using projected lighting hours, number of fixtures and rated fixture wattage.

Ex-Post Gross Savings

Ex-post gross savings were calculated using the same methodology as the ex-ante gross savings. The evaluation team verified the parameters that were used for calculating the ex-post savings. There were some discrepancies found between projected number of fixtures and actual number of fixtures. Table D-1 below compares the ex-ante and ex-post lighting fixture counts.

Table D-1: Ex-Ante and Ex-Post Lighting Fixtures

EX-Ante			Ex-Post		
Fixture Type	Fixture Name	Number of Fixture	Fixture Type	Fixture Name	Number of Fixtures
8' 4L F32T8	F2	165	4' 4L F32T8	F2	159
20 W CFL	F5	66	20 W CFL	F5	56
70W MH	F6	2	70W MH	F6	2
23W CFL	Fx	2	23W CFL	Fx	2

The ex-post gross savings were calculated using rated fixture wattage, number of lighting fixtures and actual annual operating hours. According to the site contact, the lights are powered on 11 hours per day, 7 days per week for a total of 4004 hours a year. The system ex-post power consumption was 19.17 kW. The annual energy consumption was then calculated using this power consumption and annual operating hours. This ex-post gross power and energy were subtracted from baseline power and energy to calculate ex-post gross savings. The baseline of this measure was calculated using Title 24 maximum allowed LPD for parking garages (0.40/square foot).

The estimated baseline demand was 161.7 kW and ex-post demand was 19.17 kW. The ex-post gross savings were 570,976 kWh/yr with a demand reduction of 142.6 kW.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 97% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown below in Table D-2.

Table D-2: D62760 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Reduced LPD	8 of 10	0.8	Investment Criteria	2	10 of 10	3	5.8	97%

Ex-Post Net Savings

The facility representative stated that the Program was very influential (8 of 10). The program was influential because it helped the company meet their investment criteria. This combination of answers yielded a net savings score of 5.8 out of 6. Hence the ex-post net savings for this project were calculated with a NTGR 97% as shown in Table D-3.

Table D-3: D62760 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Peak kW	144.4	142.6	99%	0.97	137.8
kWh	578,098	570,977	99%	0.97	553,847

E. D62807 VSDs and Premium Efficiency Motors

Project D62807 received an incentive of $46,983.00 for installing premium efficiency motors and VSDs on various pumps and fan motors for a central chilled water plant. The new premium efficiency motors include:

- Two 50-hp motors driving chilled water pumps,
- Two 125-hp motors driving condenser water pumps
- Two 75-hp motors driving cooling tower fans

All of these motors have variable speed drives, however; only the cooling tower VSDs were eligible and included in the incentive. The baselines for the new premium efficiency motors are based on current EPAct standards. The baseline cooling tower fans use constant speed motors with an on/off control strategy. The evaluation team verified the installation of these measures.

<u>Ex-Ante Gross Savings</u>

Ex-Ante gross savings were calculated as 391,524 kWh/year. Peak demand savings were estimated at 61.0 kW. No methodology for how these savings were estimated was provided in the projection. There is not even a mention of the tools used to generate these estimates.

<u>Ex-Post Gross Savings</u>

Trend data for all incented equipment was provided by the facility staff for the period of July 1, 2007 to October 21, 2009. The trend data includes VSD frequency, voltage, current, and power sampled in 5 minute intervals. Trend data was the basis for estimated motor runtimes, loads, and schedules.

The multiple mixed use buildings served by the central plant include a baseball stadium, offices spaces, and residences. Due to the variability and inconsistency of these spaces' schedules, largely driven by the randomness of the baseball schedule, a typical schedule of the central plants' operation is difficult to characterize. Likewise the weather correlation to load is weak. Therefore the evaluation team believes that this site is best evaluated using the actual usage data provided. The trend data period covers more than a year of the central plants operations. Therefore, the monitoring period is representative of the typical and somewhat random operation.

Premium efficiency motor savings were calculated from the efficiency improvement above code.

A summary of each motor is provided in

Table E-1.

Table E-1: Premium Efficiency Motor Summary

Equipment	Power (hp)	Speed (RPM)	Enclosure	Efficiency	Baseline Efficiency
Cooling Tower Fan 3	75	1800	TEFC	95.4%	94.1%
Cooling Tower Fan 4	75	1800	TEFC	95.4%	94.1%
Condenser Pump 3	125	1800	ODP	95.0%	94.5%
Condenser Pump 4	125	1800	ODP	95.0%	94.5%
Chilled Water Pump 3	50	1800	ODP	95.0%	93.0%
Chilled Water Pump 4	50	1800	ODP	95.0%	93.0%

The baseline power was calculated for each interval by multiplying the power by the ratio of the premium efficiency to the baseline efficiency.
Table E-2 provides an overview of each motor's operation during the monitoring period.

Table E-2: PE Motor Monitoring Period Operation

Equipment	Power (hp)	Percent time on	Average Operating Power (kW)
Cooling Tower Fan 3	75	56.1%	38.5
Cooling Tower Fan 4	75	58.5%	40.7
Condenser Pump 3	125	24.0%	62.2
Condenser Pump 4	125	29.0%	63.9
Chilled Water Pump 3	50	29.0%	20.7
Chilled Water Pump 4	50	25.0%	20.5

The calculated savings from the monitoring period were adjusted to annual savings by taking average daily savings for each month, and multiplying by the number of days in the month. Peak demand reduction was calculated by averaging the demand reduction between 2:00 PM to 5:00 PM during the three hottest consecutive weekdays during the monitoring period. These days are August 26th, 2009 through August 28th, 2009. A summary of energy savings and demand reductions are shown in

Table E-3.

Table E-3: Ex-Post Energy and Demand Savings, Premium Efficiency Motors

Equipment	Power (hp)	Energy Savings (kWh)	Peak Reduction (kW)
Cooling Tower Fan 3	75	2,502.8	0.6
Cooling Tower Fan 4	75	2,730.0	0.6
Condensor Pump 3	125	975.2	0.4
Condensor Pump 4	125	1,169.2	0.0
Chilled Water Pump 3	50	1,294.7	0.4
Chilled Water Pump 4	50	1,426.6	0.0
TOTAL		**10,098.6**	**2.0**

The premium efficiency motors' portion of projected ex-ante savings are comparable to the ex-post savings.

The VSD savings were calculated for each interval as the difference between baseline and as-built power. Where, baseline power assumes constant speed. The baseline power is the average power at a frequency of 60hz, divided by 1.05 to account for typical drive losses. This amounts to 40.0 kW and 41.4 kW for cooling tower fans 3 and 4, respectively. For each interval during which the motor operated, the constant baseline power was applied. If the motor was not operating, the baseline power was zero. Table **E-4** shows how the cooling tower fans operated during the monitoring period.

Table E-4: CT Fan Monitoring Period Operation

	Cooling Tower Fan 3			Cooling Tower Fan 4		
Frequency Bin (hz)	Percent of Time	Average Frequency (hz)	Average Power (kW)	Percent of Time	Average Frequency (hz)	Average Power (kW)
60	47.8%	59.9	42.0	52.2%	59.9	43.5
50	2.6%	45.5	26.2	1.5%	45.7	26.7
40	2.5%	36.6	18.5	2.2%	36.1	17.8
30	1.4%	27.2	15.3	1.0%	27.4	14.9
20	0.9%	17.2	10.6	0.8%	17.4	11.9
10	0.8%	7.4	5.2	0.9%	7.3	4.8
0	43.9%	0.0	0.0	41.5%	0.0	0.0

An annualization was performed to estimate yearly savings. A summary of cooling tower fan VSD energy savings and demand reductions are shown in below.

Table E-5: Ex-Post Energy Savings and Demand Reduction, VSDs

Equipment	Power (hp)	Energy Savings (kWh)	Peak Reduction (kW)
Cooling Tower Fan 3	75	525.7	-3.2
Cooling Tower Fan 4	75	-1,848.2	-0.5
TOTAL		-1,322.5	-3.7

The ex-post savings for the VSDs on cooling tower fans is much lower the ex-ante projected values. This is largely due to the load profile. When the cooling tower fans are operating, they are near full speed where there is no little to no power reduction from having VSD controls. Additionally, VFDs have drive losses. Therefore, the ex-post savings can be negative when the drive losses exceed the savings from modulating motor speed.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 8% was calculated for both measures based on the three free ridership questions in the decision maker survey. The free ridership survey results are shown in Table E-6 below.

Table E-6: D62807 Net-to-Gross Savings

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Premium Efficiency motors and VSD Pumps	5 of 10	0.5	No Influence	0	0 of 10	0	0.5	8%

Ex-Post Net Savings

The facility owner representative indicated that the program was not in the implementation of these measures.

When asked to quantify the influence of the Program upon the implementation of the measure, he gave both measures a 5 out of 10. When asked how the Program influenced the measure, he indicate that they did not influence the measure implementation of either measure and both would have been installed exactly the same absent any Program influence. When asked to clarify the apparent inconsistency, between the first answer and the other two, he explained that the program “reinforced that it was a good idea.” This combination of answers yielded a measure score of 0.5, indicating 92% free ridership.

Table E-7: D62807 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Peak kW	60.9	-1.6	-3%	8%	-0.1
kWh	391524.0	8776	2%	8%	731

F. D62826 High Efficiency Lighting

Project D62826 received an incentive of $16,909.00 to reduce their parking garage's LPD. The facility installed a combination of high efficiency T8 linear fluorescent and compact fluorescent fixtures. The measure baseline was the Title-24 maximum allowable lighting power for this space type on a square foot basis. Therefore, the only information required for the baseline was the space type and area in square feet. The evaluation team verified the installation of the measure and the area of the parking garage.

Ex-Ante Gross Savings

Ex-ante gross savings were determined by the Program using projected lighting hours, number of fixtures and rated lamp wattage.

Ex-Post Gross Savings

Ex-post gross savings were calculated using the same methodology as the ex-ante gross savings. The key steps were as follows:

1) The evaluation team first verified the parameters that were used for calculating the ex-post savings. Overall, the surveyed LPD was 0.071 versus an ex-ante calculation of 0.069. The change is due to a minor difference in square footage (347,911 ft^2 versus 356,056 ft^2) and fixture count found on site.

2) The ex-post gross savings were calculated using rated lamp wattage from the lighting schedule, number of lighting fixtures and actual annual operating hours. According to the site contact, the lights are on 24 hour/day for the basement through 2nd level, and on 13.25 hours/day for the 3rd to 5th floors. The estimated ex-post power consumption was 24.6 kW.

3) The annual energy consumption was then calculated using the power consumption and annual operating hours and was done on a per floor basis. This ex-post gross power and energy were subtracted from baseline power and energy to calculate ex-post gross savings. The measure baseline was calculated using the Title-24 energy standard for parking garages (0.40/square foot).

The estimated baseline demand was 139.2 kW and ex-post demand was 24.6 kW. The ex-post gross savings were 778,702 kWh/yr with a demand reduction of 114.5 kW. It should be noted that the operating hours used were significantly different than found in the project file.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 57% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown below in Table F-1.

Table F-1: D62826 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score -Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Reduced LPD	5 of 10	0.5	Suggested Fixture	2	3 of 10	0.9	3.4	57%

Ex-Post Net Savings

D62826's construction manager acknowledged SBD for enabling them to "Focus on a specific control system and a certain type of lighting fixture that ensures our buildings systems are uniform from one building to another. SBD forces us to look at what opportunities are available in the market". Although the respondent stated that the Program services were valuable to the project he declared absent the program they would have selected "something" energy-efficient because high efficiency is their standard practice. This combination of answers yielded a free ridership score of 3.4 out of 6, or indicatinig 43% free ridership. Hence the ex-post net savings for this project were calculated as 57% of the ex-post net savings. A summary of the gross and net savings is presented in Table F-2.

Table F-2: D62826 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Savings	Ex-Post Net Savings
Peak kW	118.0	114.5	97%	0.57	64.9
kWh	1,032,510	778,702	75%	0.57	441,264

G. D62885 High Efficiency Lighting

Project D62885 received an incentive of $6,002.00 to reduce their LPD in their parking garage. The facility installed high efficiency T8 fixtures and compact fluorescent bulbs. The measure baseline was the T-24 maximum allowable lighting power density as determined by space type. Therefore, the only information required for the baseline was the area type and the area in square feet. The evaluation team verified the installation of the measure and the area of the parking garage.

Ex-Ante Gross Savings

Ex-ante gross savings were determined by the Program using projected lighting hours, fixture counts and fixture wattages.

Ex-Post Gross Savings

Ex-post gross savings were calculated using the same methodology as the ex-ante gross savings. The evaluation team verified the parameters that were used for calculating the ex-post savings. Although the same lighting fixtures were found onsite, there were also a large number of other high efficiency lights present that were not accounted for in the original calculations. This increased the LPD of the garage from 0.182 W/ ft^2 to 0.295 W/ ft^2.

The ex-post gross savings were calculated using rated lamp wattages from the lighting schedule, fixture counts and the actual annual operating hours. According to the site contact, the lights operate 24 hours a day, 365 days/year. The calculated ex-post power consumption was 18.5 kW. The annual energy consumption was then calculated using the power consumption and annual operating hours. The ex-post gross power and energy were subtracted from baseline power and energy to calculate ex-post gross savings. The measure baseline was calculated using the Title 24 base case energy standard for parking garages (0.40/square foot).

The estimated baseline demand was 25.1 kW. Therefore, ex-post gross savings were 57,873 kWh/yr with a demand reduction of 6.6 kW.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 87% was calculated from the three free ridership questions on the decision-maker survey. The free ridership interview results are shown below in Table G-1.

Table G-1: D62885 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score -Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Reduced LPD	8 of 10	0.8	SBD creates the benchmark that we adhere to.	2	8 of 10	2.4	5.2	87%

<u>Ex-Post Net Savings</u>

The facility representative stated that SBD creates the benchmark that they adhere to and that without the program, they would have put in less expensive lights. This combination of answers yielded a free ridership score of 5.2 out of 6, indicating 13% free ridership. Hence the ex-post net savings for this project were calculated as 87% of the ex-post gross savings as shown in Table G-2.

Table G-2: D62885 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Savings	Ex-Post Net Savings
Peak kW	13.7	6.6	48%	0.87	5.7
kWh	120,033	57,873	48%	0.87	50,156

H. D62956 Fume Hood Occupancy VAV System

Project D62956 received an incentive of $61,919.00 for installing a variable air volume system fume hood exhaust system. Twenty-five fume hoods were fitted with occupancy controls. When sensors detect activity, the fume hood remains in the open position. When there is no activity for one minute, the fume hood's sash is lowered to a closed position. There are a total of 25 fume hoods. 23 have an open and closed sash height of 64 inches and 28 inches, respectively. The remaining two fume hoods have an open and closed sash heights of 112 inches and 56 inches, respectively. Fume hood exhaust VAV boxes are adjusted depending on the sash position. Exhaust and supply air is provided by static pressure controlled VFD fans. The exhaust and supply air volume is based on calibrated static pressures. There are two tandem 15 hp exhaust fans and one supply fan. The baseline for this measure is a constant volume system, with all fume hood sashes in the open position. The evaluation team verified the installation of this measure.

Ex-Ante Gross Savings

The ex-ante gross savings methodology was based on a reduction in cooling, heating, reheating, supply air fan power, and exhaust fan power. The assumptions made to determine the ex-ante savings are not clear. Energy savings and demand reductions are summarized in Table H-1 through Table H-5. Project file information was limited and there no documentation of the assumptions and methodologies used in these estimations.

Table H-1: Ex-Ante Peak Fan Operating Parameters, Baseline

Fan	CFM	Static Pressure	Fan Efficiency	hp	Drive Efficiency	VFD Efficiency	kW
SF 2	25,400	5.75	0.7	33.80	1.0	0.96	27.1
EF 5,6	25,400	5.00	0.7	30.75	1.0	1.00	23.7
TOTAL	**-**	**-**	**-**	**-**	**-**	**-**	**74.4**

Table H-2: Ex-Ante Peak Fan Operating Parameters, Post

Fan	CFM	Static Pressure	Fan Efficiency	hp	Drive Efficiency	VFD Efficiency	kW
SF 2	15,437	5.75	0.7	20.54	1.0	0.96	16.5
EF 5,6	15,437	5.00	0.7	18.96	1.0	1.00	14.4
TOTAL	**-**	**-**	**-**	**-**	**-**	**-**	**30.8**

Table H-3: Ex-Ante Chiller Peak Load Reduction

Value	Chiller Load (tons)	Chiller Efficiency (kW/ton)	kW
Baseline	107.0	0.69	73.8
Post	65.0	0.54	34.9
Reduction	**-**	**-**	**38.9**

Table H-4: Ex-Ante Peak Reduction

Value	kW
Baseline kW	124.6
Post kW	65.7
Reduction	**58.8**

Table H-5: Ex-Ante Energy Savings

	Baseline Energy		Post Energy		Energy Savings	
Component	**kWh**	**Therms**	**kWh**	**Therms**	**kWh**	**Therms**
Cooling	152,307.0	-	67,373.0	-	84,934.0	-
Heating	-	32,981.0	-	14,081.0	-	18,900.0
Reheating	-	51,185.0	-	18,906.0	-	32,279.0
Supply AHU	228,049.0	-	36,865.0	-	191,184.0	-
Exhaust Fan	201,236.0	-	87,221.0	-	114,015.0	-
TOTAL	**581,592.0**	**84166.00**	**191,459.0**	**32987.00**	**390,133.0**	**51,179.0**

Ex-Post Gross Savings

This measure results in a reduction in supply air and exhaust air. Ex-post savings result from the following components:

- Reduced fan motor power
- Reduced cooling loads
- Reduced need to reheat the cooled air as it enters the conditioned space
- Reduced space heating loads

Ex-post savings were calculated based on monitoring data. Frequency and airflow data recorded in 15 minute intervals for supply fan 2 (SF 2), exhaust fan 5 (EF 5), and exhaust fan 6 (EF 6) was provided by the site contact. The monitoring period covered November 1, 2009 through November 3, 2009. Also, EF 6 power was monitored for in one minute intervals from September 29, 2009 to October 14, 2009.

Volumetic airflow is dictated by the exhaust needs since it is controlled by static pressure. Therefore, airflow is dependent on a schedule rather than weather conditions.

Ex post savings were calculated for each hour of the year. Fume hoods are used throughout the week, with core business hours are 8:30 AM to 4:00 PM weekdays. Using the logged data, an hourly schedule was determined, as shown in

Table H-6. Frequency and air flow was calculated as the average for each hour by day type (weekend or weekday).

Table H-6: Basis for Fan Operating Parameter Schedule

Value	SF 2	EF 5	EF 6
Frequency (hz)	Hourly average of trend data, by day type	Hourly average of trend data, by day type	Hourly average of trend data, by day type
Volumetric Airflow (cfm)	Hourly average of trend data, by day type	Hourly average of trend data, by day type	Hourly average of trend data, by day type
Power (kW)	Applied Affinity Laws, using frequency to calculate RPMs & percent flow.	Hourly average of power monitoring data	Hourly average of power monitoring data. EF 5 and EF 6 operate in tandem, therefore EF 5 power is used

For AH 2, the frequency was used to calculate the speed as follows:

$$RPM_{freq} = \frac{(2)(freq)(60)}{\#\ Poles}$$

The speed was then used to lookup the percent full flow and percent full power in EPRI tables. AH 2 has four poles. Based on a corresponding frequency and power spot readings, the power at a given frequency was calculated as follows:

$$Power_{freq} = Power_{60hz}\left(\frac{RPM_{freq}}{RPM_{60hz}}\right)^{2.4}$$

Table H-7 summarizes how the AH 2 hourly power profile was derived.

Table H-7: SF 2 Frequency and Power Basis

	Speed (RPM)			EPRI VFD	Power (kW)	
Frequency (hz)	Value	Basis	EPRI Percent Full Air Flow	Percent of Full Power	Value	Basis
51.8	1554	Calculated from frequency spot reading	87.5%	83.4%	5.7	Spot reading corresponding to frequency
60.0	1775	Rated Speed	100.0%	105.0%	7.2	Calculated from VFD percent power, spot power and corresponding VFD percent power

The weekend and weekday hourly profiles for AH 2, EF 5, and EF are shown in

Table H-8 and Table H-9.

Table H-8: Weekday Scheduled

	SF 2			EF 5			EF 6		
Hour	Frequency (hz)	Volumetric Airflow (cfm)	Power (kW)	Frequency (hz)	Volumetric Airflow (cfm)	Power (kW)	Frequency (hz)	Volumetric Airflow (cfm)	Power (kW)
0	42.3	11,654	4.5	41.5	6,593	4.3	41.5	6,593	4.3
1	42.2	11,548	4.4	41.5	6,590	4.3	41.5	6,590	4.3
2	42.1	11,640	4.4	41.5	6,580	4.3	41.5	6,580	4.3
3	42.3	11,642	4.5	41.5	6,579	4.3	41.5	6,579	4.3
4	42.1	11,648	4.4	41.5	6,601	4.2	41.5	6,601	4.2
5	41.6	11,414	4.3	41.3	6,648	4.2	41.3	6,648	4.2
6	42.4	11,644	4.5	41.4	6,574	4.2	41.4	6,574	4.2
7	43.3	11,698	4.7	41.7	6,586	4.2	41.4	6,586	4.2
8	45.9	12,037	5.4	42.1	6,611	4.4	42.0	6,611	4.4
9	48.5	12,953	6.2	42.7	6,562	4.6	42.9	6,562	4.6
10	51.7	13,443	7.2	43.4	6,566	4.7	43.3	6,566	4.7
11	51.4	14,501	7.1	43.7	7,307	4.7	43.7	7,307	4.7
12	50.7	14,476	6.9	43.3	7,704	4.7	43.5	7,704	4.7
13	51.8	14,088	7.3	44.0	7,745	4.9	44.1	7,745	4.9
14	49.7	13,416	6.6	43.4	7,170	5.0	43.4	7,170	5.0
15	49.9	12,599	6.6	43.5	6,747	5.0	43.4	6,747	5.0
16	49.2	12,101	6.4	43.5	6,546	4.8	43.5	6,546	4.8
17	45.8	11,367	5.4	42.7	6,582	4.3	42.7	6,582	4.3
18	44.1	11,662	4.9	42.1	6,558	4.3	42.1	6,558	4.3
19	44.1	11,654	5.0	42.1	6,556	4.3	42.1	6,556	4.3
20	44.0	11,668	4.9	42.1	6,553	4.3	42.1	6,553	4.3
21	44.0	11,657	4.9	42.1	6,572	4.3	42.1	6,572	4.3
22	44.2	11,579	5.0	42.1	6,550	4.3	42.1	6,550	4.3
23	43.6	11,671	4.8	42.0	6,584	4.3	42.0	6,584	4.3

Table H-9: Weekend Scheduled

Hour	SF 2 Frequency (hz)	SF 2 Volumetric Airflow (cfm)	SF 2 Power (kW)	EF 5 Frequency (hz)	EF 5 Volumetric Airflow (cfm)	EF 5 Power (kW)	EF 6 Frequency (hz)	EF 6 Volumetric Airflow (cfm)	EF 6 Power (kW)
0	41.3	11,664	4.2	40.8	6,627	4.3	40.8	6,627	4.3
1	41.2	11,644	4.2	40.8	6,589	4.3	40.8	6,589	4.3
2	41.3	11,680	4.2	40.8	6,641	4.3	40.8	6,641	4.3
3	41.2	11,639	4.2	40.8	6,643	4.3	40.8	6,643	4.3
4	41.1	11,619	4.2	40.8	6,647	4.2	40.8	6,647	4.2
5	40.8	11,584	4.1	40.8	6,678	4.1	40.8	6,678	4.1
6	41.0	11,613	4.1	40.8	6,680	4.1	40.8	6,680	4.1
7	41.5	11,839	4.3	40.8	6,652	4.1	40.8	6,652	4.1
8	42.0	12,356	4.4	40.8	6,701	4.1	40.8	6,701	4.1
9	42.8	12,797	4.6	40.8	6,674	4.1	40.8	6,674	4.1
10	43.2	13,172	4.7	40.8	6,755	4.1	40.8	6,755	4.1
11	43.5	13,199	4.8	40.8	6,785	4.1	40.8	6,785	4.1
12	42.9	13,065	4.6	40.8	6,778	4.1	40.8	6,778	4.1
13	42.9	12,984	4.6	40.8	6,831	4.1	40.8	6,831	4.1
14	42.5	12,542	4.5	40.8	6,828	4.1	40.8	6,828	4.1
15	41.6	11,985	4.3	40.8	6,923	4.1	40.8	6,923	4.1
16	41.2	11,704	4.2	40.8	6,818	4.1	40.8	6,818	4.1
17	40.8	11,569	4.1	41.1	6,743	4.1	41.1	6,743	4.1
18	41.3	11,676	4.2	40.9	6,702	4.2	40.9	6,702	4.2
19	41.2	11,693	4.2	40.9	6,680	4.2	40.9	6,680	4.2
20	41.4	11,720	4.2	40.9	6,639	4.2	40.9	6,639	4.2
21	41.4	11,626	4.2	40.9	6,622	4.2	40.9	6,622	4.2
22	41.3	11,632	4.2	40.9	6,644	4.2	40.9	6,644	4.2
23	41.3	11,670	4.2	40.9	6,620	4.2	40.9	6,620	4.2

Figure H-1: Airflow Schedule

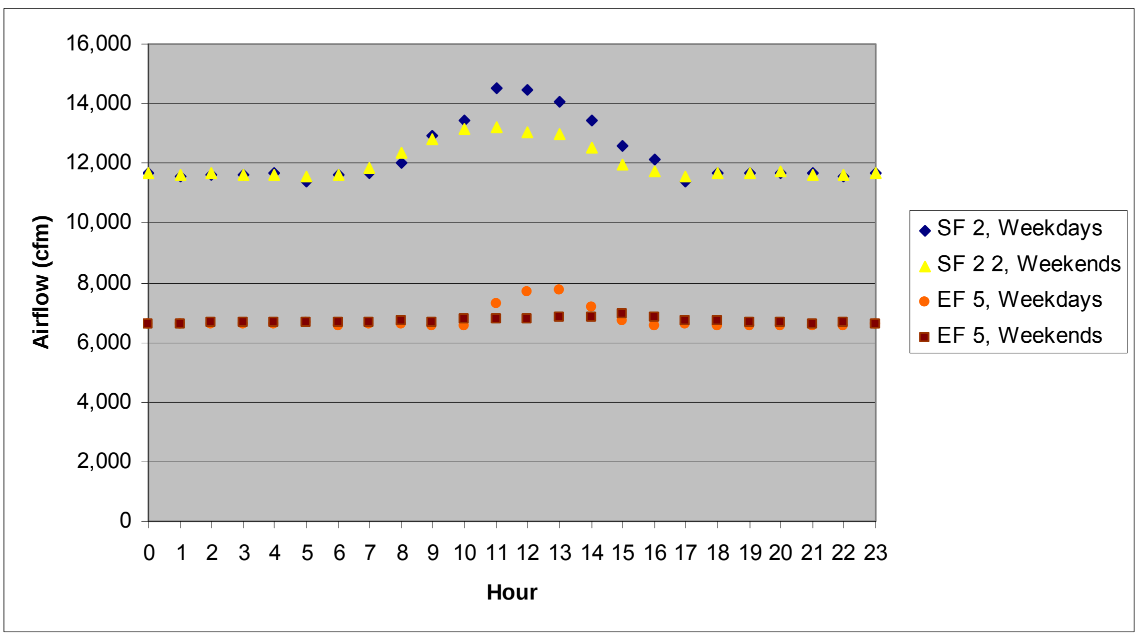
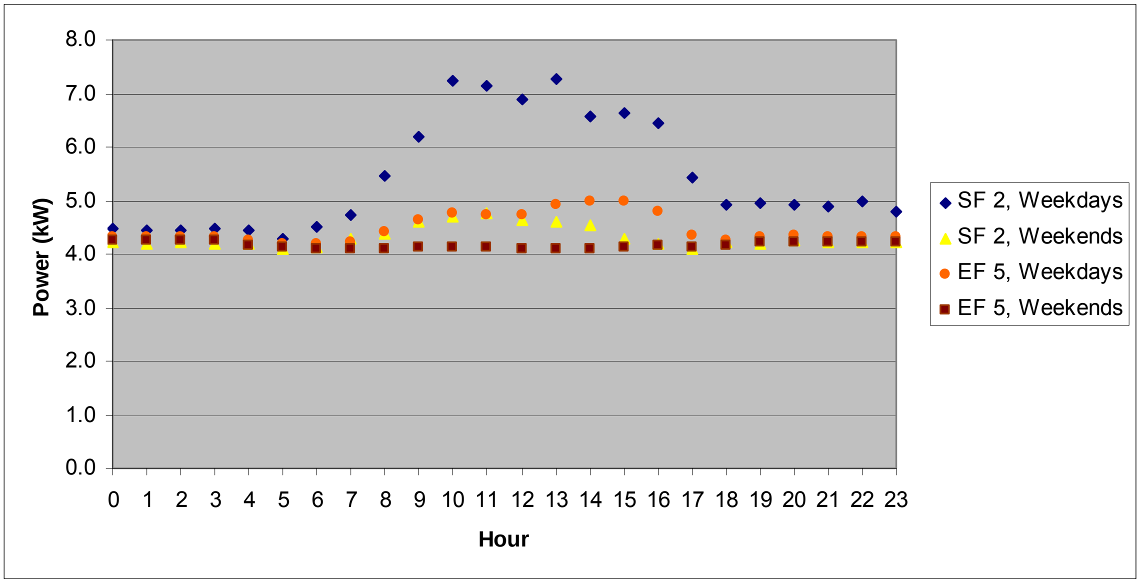


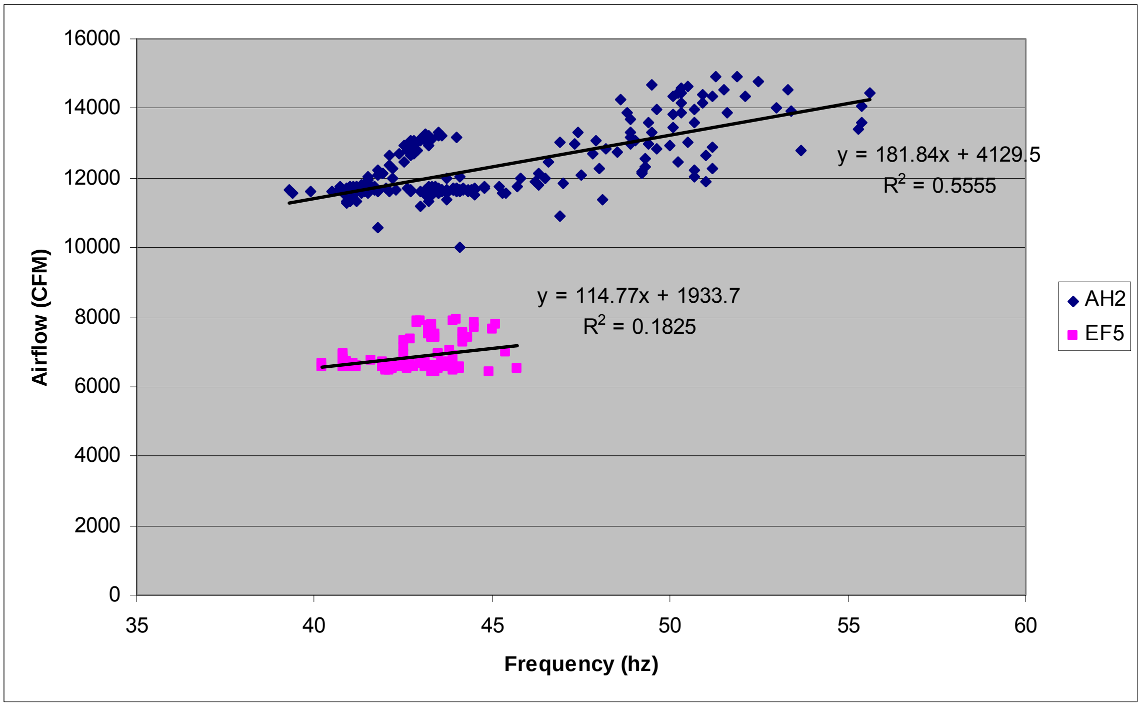
Figure H-2: Fan Power Schedule



Baseline conditions were constant speed and constant volume. The speed was the rated speed (at 60 hz). The relationship between frequency and airflow from trend data was used to determine the airflow at 60 hz.

Figure H-1 shows this relationship and the trend line used to calculate the baseline airflow. While this correlation has some distortion from other factors (indicated by the low R^2 value), it is still a good prediction for how the system performs at full flow.

Figure H-3: Airflow versus Frequency Trend Data



Baseline power was the power at full flow. As described for determining AH 2 power, the baseline power was calculated by using spot frequency and power readings to calculate the percent flow. Percent flow was looked up in EPRI tables to determine the percent power. The power fraction together with the spot measured power were then used to calculate the full power, as show in Table H-10.

Table H-10: Fan Operating Parameters

Equipment	Frequency (hz)	Speed (RPM)	Percent Full Flow	VFD Percent Full Power	VFD Power (kW)	Full Power (kW)
SF 2	51.8	1554	87.5%	83.4%	5.7	-
	60.0	1775	100.0%	105.0%	7.2	6.8
EF 5	41.9	1257	70.8%	45.2%	4.5	-
	60.0	1775	100.0%	105.0%	10.4	9.9
EF 6	41.9	1257	70.8%	45.2%	4.5	-
	60.0	1775	100.0%	105.0%	10.4	9.9

Baseline power and airflow remain constant throughout the year. A summary of baseline values is shown in
Table H-11 below.

Table H-11: Baseline Fan Power

Equipment	Percent Full Flow	Baseline Power	Baseline Airflow (cfm)
SF 2	100.0%	6.8	15,040
EF 5	100.0%	9.9	17,640
EF 6	100.0%	9.9	17,640

The reduction in motor energy savings was calculated by:

$$Motor\ Energy\ Savings\ (kWh) = \sum_{1}^{8,760} (Baseline\ Power - VFD\ Power)$$

The reduction in airflow was calculated on an hourly basis, as the difference between baseline constant volume airflow and the variable volume airflow. The reduction in airflow resulted in lower cooling, reheating, and heating loads. Climate zone 7 TMY weather data was used to calculate space conditioning savings.

This measure's cooling load savings are calculated using the following logical operator:

If,

$T_{DB} > T_{deck}$

$$Cooling\ Load\ Savings(tons) = \frac{(Airflow\ Reduction)(1.08)(T_{DB} - T_{deck})}{(12{,}000)}$$

Where,

Airflow Reduction = the reduction from baseline airflow to variable airflow schedule, cfm

T_{DB} = the outside air dry-bulb temperature from TMY weather data, °F

T_{deck} = the deck temperature setpoint, or the temperature that outside air is cooled to, °F. The deck temperature is maintained at a constant 55 °F.

Cooling energy savings were calculated as follows:

$$Cooling\ kWh\ Savings = \sum_{1}^{8,760} (Cooling\ Load\ Savings)(Chiller\ Plant\ kW / ton)$$

Where,

Chiller Plant kW/ton = the chiller plant's performance, estimated to be 0.8 kW/ton

Reheating energy savings are calculated as follows:

If,

$T_{DB} < T_{deck,}$

$$Reheating\ Savings\,(therms) = \frac{(Airflow\ Reduction)(1.08)(T_{deck} - T_{SA})}{(Heating\ Eff.)(100{,}000)}$$

where,

T_{SA} = the supply air temperature, °F. Zone temperatures are set to 74 °F - 75 °F, where the average supply air temperature is estimated to be 65 °F. (The control system resets the supply temperature to maintain set point temperature, the 65 F is an assumed average)
Heating Eff. = The heating efficiency, estimated to be 78%.

Heating energy savings were calculated as follows:

If,

$T_{DB} < T_{Deck,}$

$$Heating\ Savings\,(therms) = \frac{(Airflow\ Reduction)(1.08)(T_{deck} - T_{DB})}{(Heating\ Eff.)(100{,}000)}$$

Ex-post annual energy savings are summarized in
Table H-12. Peak demand reduction was calculated by averaging the demand reduction from 2:00 PM to 5:00 PM, during the three hottest consecutive weekdays in TMY weather data.

Table H-12: Ex-Post Savings Summary

Component	Energy Savings (kWh)	Peak Demand Reduction (kW)	Energy Savings (therms)
SF 2 Motor Power Reduction	14,707.8	0.28	-
EF 5 Motor Power Reduction	47,883.6	4.94	-
EF 6 Motor Power Reduction	47,883.6	4.94	-
Cooling Savings	12,743.5	3.93	-
Reheat Savings	-	-	2,677.2
Heating Savings	-	-	1,148.4
TOTAL	**123,218.5**	**14.09**	**3,825.6**

The ex-post savings for this measure were much lower than the ex-ante projected values. This is largely due to the ex-ante baseline assumptions. While limited details about the ex-ante savings calculations were available for review, what is available suggests that the baseline airflow and fan power were largely overstated. For the ex-ante demand reduction savings calculations, the SF 2 power was 27.08 kW, and EF 5 and EF 6 power was 23.65 kW. Based on the ex-post estimates, the measure achieved 6.8 kW in peak demand reduction for SF 2, and 9.9 kW in peak demand reduction for EF5 and EF6 combined. The ex-ante cooling demand savings of 42 tons were estimated. The evaluation found a maximum of cooling load reduction of only 9 tons.

Ex-Post Net-to-Gross Savings

A measure net-to gross ratio of 8% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown in Table H-13.

Table H-13: D62956 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
VAV Fume hoods	0 of 10	0	Prior Success with this measure	0	0 of 10	0	0	0%

Ex-Post Net Savings

For our ex-post net savings evaluation, this project received a free ridership score of 0 out of 6, or 100% free ridership. All influence of the program and utility was from spillover from a previous program cycle. Therefore, the ex-post net savings for this measure were evaluated at 0% of the ex-post gross savings as summarized in Table H-14.

Table H-14: D62956 Fume Hoods with VAV System Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Peak kW	58.8	14.1	24%	0.0	0.0
kWh	390,132	123,219	32%	0.0	0.0
Therms	51,180	3,826	7%	0.0	0.0

I. D62979 Parking Garage Lighting

The project received an incentive of $20,133.00 for reducing their LPD in the parking garage. The facility installed a Low LPD system using T8 and compact fluorescent fixtures. The measure baseline was determined by T-24 energy standards for LPD by space type. Therefore, the only information required for the baseline was space type and the area in square feet. The evaluation team verified the installation of the measure and the area of the parking garage.

Ex-Ante Gross Savings

Ex-ante gross savings were determined using projected lighting hours, number of fixtures and rated lamp wattage.

Ex-Post Gross Savings

Ex-post gross savings were calculated using the same methodology used in the ex-ante gross savings calculation. The evaluation team verified the parameters used for calculating ex-post savings on site. A data logger was installed on the lighting panel for a period of 3 weeks during the months of October and November 2008. The data logger recorded the power consumption of all lighting in the parking structure.

The recorded data were imported into data visualization software.

Figure I-1 shows the raw data for the monitoring period. The data indicate that the facility operates on a consistent daily schedule. As such, the data were used to create an average day profile as illustrate in Figure I-2. This profile shows that while the majority of the lights operate 24 hours a day and seven days a week, a few of the fixtures operate on a timer. The timer is set to turn off certain lights from 6 am to 6 pm every day. These lights are turned off to take advantage of natural daylighting. The facility personnel confirmed the schedule reflected in the metered data.

Annual energy consumption was then calculated by integrated the average daily power profile and applying it to the facility's annual schedule. Ex-post gross power and energy were subtracted from baseline power and energy to calculate ex-post gross savings. measure baseline was calculated using the Title 24 base case energy standard for parking garages (0.40 W/square foot).

The estimated baseline demand was 107.4 kW and ex-post demand was 13.8 kW. The ex-post gross savings were calculated as 1,189,117.59 kWh/yr with a demand reduction of 136.1 kW.

Figure I-1: D62979 Metered Data

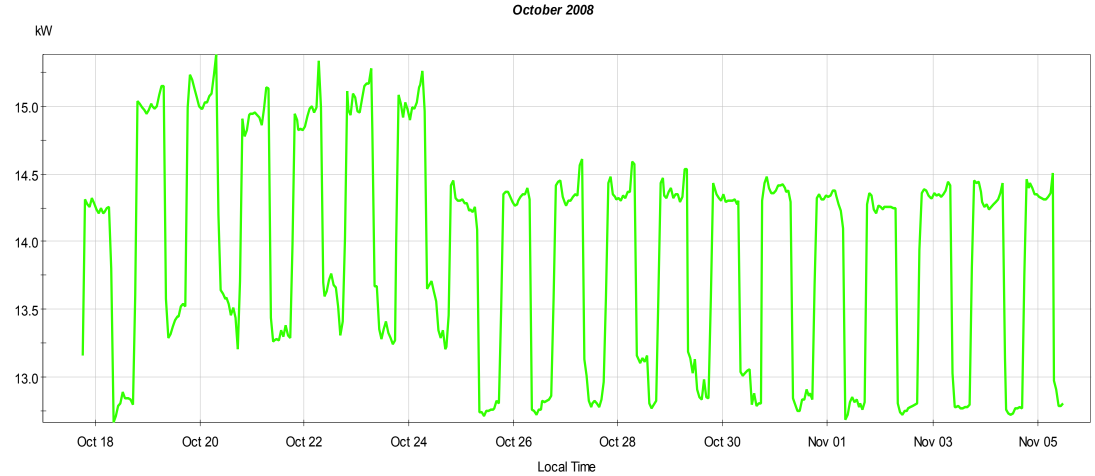
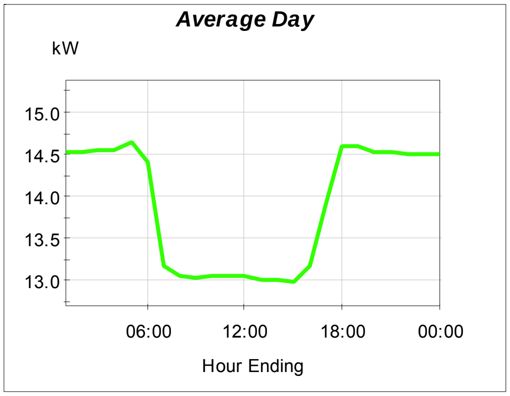


Figure I-2: D62979 Daily Profile



The savings were greater than expected because the ex-ante estimate did not calculate the timer savings associated with the installed fixtures.

<u>Ex-Post Net-to-Gross Savings</u>

A measure net-to-gross ratio of 43% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown in

Table I-1 below.

Table I-1: D62979 Net-to-Gross Savings Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
LPD	10 of 10	1	Easier Sell	1	2 of 10	0.6	2.6	43%

<u>Ex-Post Net Savings</u>

The facility representative indicated that the Program was very influential. In particular, the incentive made the high efficiency lighting an easier sell. He did however state that their standard practice is to look at all energy efficiency options and, if appropriate, apply them to save energy. He stated that the Program helps their bottom line and makes energy efficient measures more attractive. He claimed that the company is very energy conscious to begin with and that they were “half way there” on this project before ever speaking with SBD representatives. This combination of answers yielded a score of 2.6 out of 6, or 56% free ridership. Hence the ex-post net savings for this project were calculated as 44% of the ex-post net savings as shown in Table I-2.

Table I-2: D62979 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-gross Ratio	Ex-Post Net Savings
Peak kW	107.5	136.1	127%	0.43	59.0
kWh	941,329	1,189,459	126%	0.43	515,432

J. D62989 High Efficiency Lighting

Project D62989 received an incentive of $26,994 to install high efficiency lighting in their five-story parking garage. The facility installed high efficient T8 fluorescent, CFL and FL fixtures. The measure baseline was determined using T-24 energy standards for maximum allowable LPD by space type. Therefore, the only information required for the baseline was space type and the space square footage. The evaluation team verified the installation of the measure and calculated impacts using data loggers installed during the visit.

Ex-Ante Gross Savings

Ex-ante gross savings were determined by the Program using projected lighting hours, number of fixtures and rated lamp wattage. When recreating the data utilized for the baseline calculations, there was a small discrepancy between the total wattage. Our calculated total wattage was 58.1 kW, where the ex-ante estimated was 57.8 kW.

Ex-Post Gross Savings

The team determined ex-post gross savings by calculating the difference between baseline and post-installation energy and peak demand usage. A data logger installed during the site visit was used to inform the ex-post calculations. Key steps for determining gross savings were as follows:

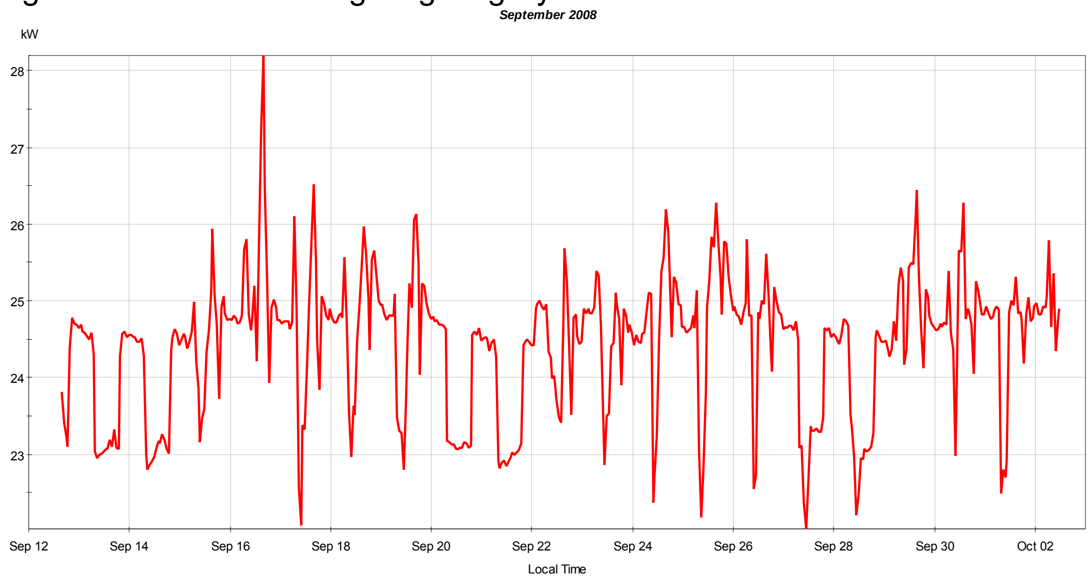
1) A data logger was installed on the lighting panel for a period of 3 weeks during the month of September 2008. The data logger recorded the energy consumption of parking structure lighting. During the site inspection, the evaluation team also found some discrepancies between projected fixture counts and actual fixture counts. Table J-1 below compares the ex-ante and ex-post lighting fixture counts.

Table J-1: Ex-Ante and Ex-Post Lighting Fixture Counts

EX-Ante			Ex-Post		
Fixture Type	Fixture Name	Number of Fixture	Fixture Type	Fixture Name	Number of Fixtures
(2) 4ft F32T8	A1	4	(2) 4ft F32T8	A1	32
(4) 4ft F32T8	A2	585	(4) 4ft F32T8	A2	585
(2) 4ft F32T8	B1	28	(2) 4ft F32T8	B1	0
(1) 42W CFL	C1	3	(1) 42W CFL	C1	3
(2) 26W FL	F1	53	(2) 26W FL	F1	53
(3) 4ft F32T8	A3	0	(3) 4ft F32T8	A3	2

2) The recorded data were imported into data visualization software. Figure J-1 shows the raw data for the monitoring period (September 2008). We observed that some of the lights in the parking garage are not on at all times. This differs from the projected lighting schedule specified in the ex-ante estimate.

Figure J-1: D62989 Garage Lighting System Power Data



3) The annual energy consumption was calculated using the power draw and annual operating hours. This ex-post gross power and energy were subtracted from baseline power and energy to calculate ex-post gross savings. The baseline of this measure was calculated using Title 24 maximum allowable LPD for a parking garages (0.40 Watts/square foot).

The estimated baseline demand was 131.1 kW and ex-post demand was 26.1 kW. The ex-post gross savings were calculated as 742,367 kWh/yr with a demand reduction of 104.9 kW.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 23% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown in

Table J-2 below. The site contact indicated that “prior success with this measure” was the source of the program’s influence. However, the “prior success” did not occur during the 2006-2008 program cycle. As such, the “source of influence score” was adjusted from 1 point to 0 in accordance with the CPUC ALJ ruling.

Table J-2: D62989 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Reduced LPD	5 of 10	0.5	Prior Success	0	3 of 10	0.9	1.4	23%

Ex-Post Net Savings Summary

The facility representative mentioned that this high efficiency lighting measure reduced their energy cost substantially. He also stated that they had prior success with this measure on previous projects. Overall, his free ridership question responses yielded a net savings score of 1.4 out of 6. Hence the ex-post net savings for this project were calculated with a NTGR of 23% as shown in Table J-3.

Table J-3: D62989 Savings Summary

	Ex-Ante Gross Savings	**Ex-Post Gross Savings**	**Gross Realization Rate**	**Site Net-to-Gross Ratio**	**Ex-Post Net Savings**
Peak kW	73.6	105.0	143%	0.23	24.5
kWh	537,630	742,368	138%	0.23	173,219

K. D63035 High Efficiency Lighting

Project D63035 received an incentive of $3,047.00 to install high efficiency lighting in a parking garage. The facility installed a low LPD system with T8 fluorescent and metal halide fixtures. The baseline of this measure was determined by T-24 maximum allowable lighting power on a square foot basis for this space type. Therefore, the only information required for the baseline was space type and the space square footage.

Ex-Ante Gross Savings
Ex-ante gross savings were determined by the Program using projected lighting hours, number of fixtures and rated fixture wattage.

Ex-Post Gross Savings
Ex-post gross savings were calculated using the same methodology as the ex-ante gross savings. The evaluation team verified the parameters that were used for calculating the ex-post savings. There were some discrepancies found between projected number of fixtures and actual number of fixtures. Table K-1 below shows compares the ex-ante and ex-post lighting fixture counts

Table K-1: D63035 Ex-Ante and Ex-Post Lighting Fixture Counts

	Ex-Ante		Ex-Post		
Fixture Type	Fixture Name	Number of Fixtures	Fixture Type	Fixture Name	Number of Fixtures
(2) 4ft F32T8	D	2	(2) 4ft F32T8	D	33
(2) 4ft F32T8	F14	2	(2) 4ft F32T8	F14	0
(1) MH100	F6	36	(1) MH100	F6	35
(3) 4ft F32T8	D1	0	(3) F32T8	D1	19

The ex-post gross savings were calculated using rated fixture wattage, number of lighting fixtures and actual annual operating hours. According to the site contact, the lights are on 24 hours a day, 7 days a weeks for a total of 8760 hours each year. The estimated ex-post power consumption was 8.0 kW. The annual energy consumption was then calculated using the power consumption and annual operating hours. This ex-post gross power and energy were subtracted from baseline power and energy to calculate ex-post gross savings. The measure baseline was calculated using Title 24 maximum allowable LPD for parking garages (0.40/square foot).

The estimated baseline demand was 13.4 kW and ex-post demand was 8.0 kW. The ex-post gross savings were 47,059.42 kWh/yr with a demand reduction of 5.37 kW.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 75% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown in Table K-2 below. The site contact indicated that "prior success with this measure" was the source of the program's influence. However, the "prior success" did not occur during the 2006-2008 program cycle. As such, the "source of influence score" was adjusted from 1 point to 0 in accordance with the CPUC ALJ ruling.

Table K-2: D63035 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Reduced LPD	10 of 10	1	Assistance & Analysis	2	5 of 10	1.5	4.5	75%

Ex-Post Net Savings

The owner representative stated the decision to install the parking garage high efficiency "could have gone either way with or without the high performance measure". SBD's "design assistance" services and the company's past experience with efficient equipment were noted as their reasons to proceed. This combination of answers yielded a net savings score of 4.5 out of 6, for 25% freeridership. Hence the ex-post net savings for this project were calculated as 75% of the ex-post net savings as shown below in Table K-3.

Table K-3: D63035 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Peak kW	7.0	5.4	77%	0.75	4.0
kWh	60,942	47,059	77%	0.75	35,295

L. D63075 High Efficiency Lighting

Project D63075 received an incentive of $13,140.00 to install high-efficiency lighting in a parking garage. The facility installed a low-LPD system comprised fo150-watt metal halide and T8 fluorescent fixtures. The measure baseline was determined by T-24 maximum allowable lighting power on a per square foot basis by space type. Therefore, the only information required for the baseline was the space type and the space square footage. The evaluation team verified the installation of the measure and calculated impacts using data loggers installed during the visit.

Ex-Ante Gross Savings

Ex-ante gross savings were determined by the Program using projected lighting hours, number of fixtures and rated lamp wattage.

Ex-Post Gross Savings

The team determined ex-post gross savings primarily by calculating the difference between installed and baseline lighting system wattage and applying the differential to the operating schedule. The operating schedule was captured using short term monitoring performed with data loggers. Key steps for determining gross savings were as follows:

1) The evaluation team installed a data logger on the lighting panel for a period of 3 weeks during the month of October 2008. The data logger recorded the power consumption of the total lighting of the parking structure. During the site inspection, evaluation team also found some discrepancies between projected number of fixtures and actual number of fixtures. Table L-1 below shows a comparison between ex-ante and ex-post lighting fixture counts.

Table L-1: Ex-Ante and Ex-Post Lighting Fixture Counts

EX-Ante			Ex-Post		
Fixture Type	**Fixture Name**	**Number of Fixture**	**Fixture Type**	**Fixture Name**	**Number of Fixtures**
MH-150	Metal Halide	132	MH-150	Metal Halide	144
T8-32	2L 4' Flourscent Fixture	30	T8-32	4' Flourscent Fixt	32

2) The recorded data were imported into a data visualization application. Figure L-1 shows the raw data for the monitoring period. It shows that the schedules are similar for all days. This profile showed approximately 30 kW of lighting was on 24 hours per day

and seven days per week, but the remainder of the fixtures were on a time clock schedule. The timer was set off from 8 am to 6 pm every day as shown by the average daily hourly profile in

Figure L-2. The facility personnel also confirmed the same schedule that was reflected in the metered data.

3) Annual energy consumption was then calculated using the power profile and annual operating hours. This ex-post gross power and energy were subtracted from baseline power and energy to calculate ex-post gross savings. The baseline of this measure was calculated using Title 24 maximum allowable LPD for parking garages, 0.40/square foot.

The estimated baseline demand was 74.2 kW and ex-post demand was 35.6 kW. The ex-post gross savings were calculated as 129,885 kWh/yr, with a demand reduction of 35.6 kW.

Figure L-1: D63075 Metered Data

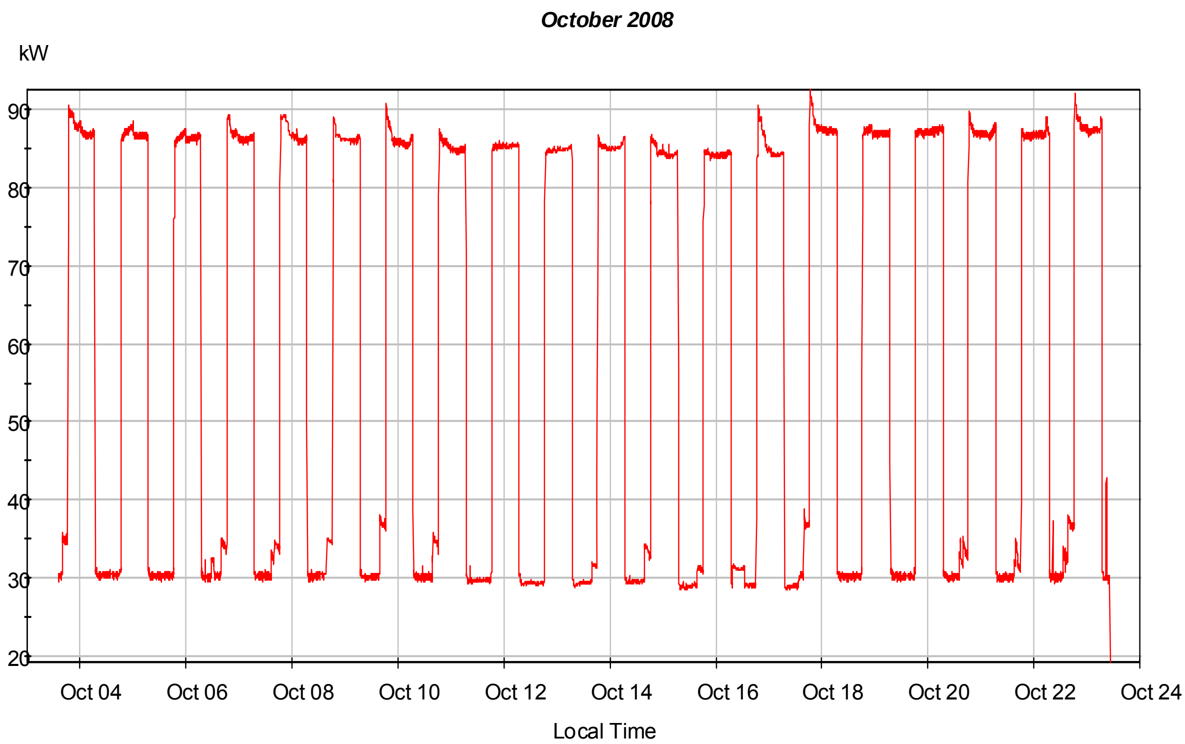
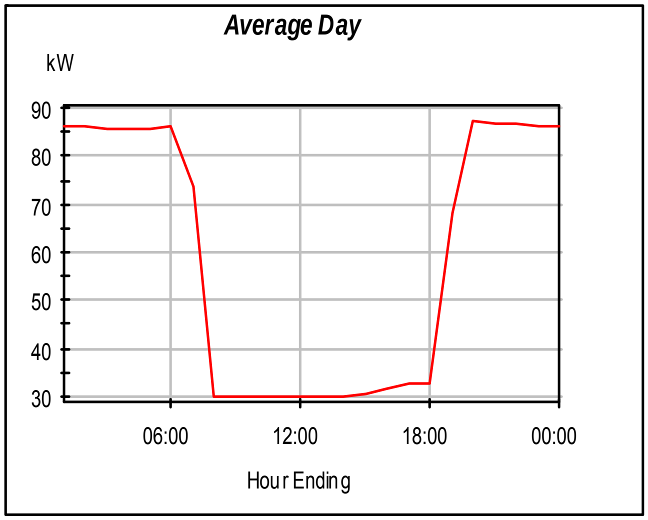


Figure L-2: D63075 Hourly Power Profile



The savings were slightly lower than expected because the installed fixtures were more wattage than the ex-ante fixtures.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 75% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown in Table L-2 below.

Table L-2: D63075 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Reduced LPD	10 of 10	1	Easier Sell	1	2 of 10	0.6	2.6	43%

Ex-Post Net Savings

The facility representative stated that they are very energy-conscious to begin with, but they did involve SBD representatives early in the design process to discuss their options. The incentive helped to sway the economics and make the project more attractive for their bottom line. The respondent also mentioned that identifying energy efficiency opportunities is a standard practice. This combination of answers yielded a net savings score of 2.6 out of 6. Hence the ex-post net savings for this project were calculated using a NTGR of 43% as shown in Table L-3.

Table L-3: D63075 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Peak kW	39.0	38.6	99%	0.43	16.7
kWh	338,031	129,885	38%	0.43	56,283

M. D63199 High Efficiency Lighting

Project D3199 received an incentive of $15,255.00 to reduce their parking garage's LPD. The facility installed high efficient T8 fluorescent fixtures and high efficient compact fluorescent fixtures. The measure baseline was determined by T-24 energy standards for lighting power by space type on a square foot basis. Therefore, the only information required for the baseline was the space type and the area in square feet. The evaluation team verified the installation of the measure and the area of the parking garage.

<u>Ex-Ante Gross Savings</u>
Ex-ante gross savings were determined using projected lighting hours, number of fixtures and rated lamp wattage.

<u>Ex-Post Gross Savings</u>
Ex-post gross savings were calculated using the same methodology as the ex-ante gross savings. The evaluation team verified the parameters that were used for calculating the ex-post savings. Fixture counts and facility square footage were found to differ from the values used in the ex-ante gross savings analysis. Table M-1 below compares between the ex-ante and ex-post lighting schedules. The square footage of the facility was 234,348 ft^2 versus 237,584 ft^2 as used in the ex-ante calculation.

Table M-1: D63199 Comparison between Ex-Ante and Ex-Post Lighting Schedule

Fixture type	Fixture name	Ex-ante quantity	Ex-post quantity
(2) 8' F96T8	A2	425	414
(2) 4' F32T8	B1	11	10
42W CFL Wall	C1	2	4

Ex-post gross savings were calculated using rated lamp wattages from the lighting schedule, number of lighting fixtures and actual annual operating hours. According to the site contact, the lights are on 100% of the time each day, 365 days/year. The estimated ex-post power consumption was 46.3 kW. Annual energy consumption was then calculated using the power consumption and annual operating hours. This ex-post gross power and energy were subtracted from baseline power and energy to calculate ex-post gross savings. The measure baseline was calculated using the Title 24 energy standard for parking garages (0.40 W/square foot).

Using the evaluated area, the estimated baseline demand was 93.74 kW. The ex-post gross savings were 415,602 kWh/yr with a demand reduction of 47.4 kW.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio was calculated from the three free ridership questions on the decision-maker survey as 87% as shown below in
Table **M-2**.

Table M-2: D63199 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Reduced LPD	8 of 10	0.8	Suggested or Introduced	2	8 of 10	2.4	5.2	87%

Ex-Post Net Savings

The facility representative stated that they wanted to be smart about energy savings and that SBD representatives worked directly with their electrical engineers to select lighting fixtures. The contact said that in the absence of the program, they would have still used some form of fluorescent lighting, but it would not have been as efficient as what was installed through the program. This combination of answers yielded a free ridership score of 3.1 out of 6, for a free ridership ratio of 48%. Hence the ex-post net savings for this project were calculated as 52% of the ex-post gross savings as shown in Table M-3.

Table M-3: D63199 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Savings	Ex-Post Net Savings
Peak kW	47.6	47.4	100%	0.87	41.1
kWh	416,605	415,602	100%	0.87	360,189

N. D63257 VAV Fume Hoods with Occupancy Sensors

D63257 received an incentive of $69,642 for installing eighteen VAV fume hoods with occupancy sensors as part of a 5,500 square foot addition to their existing laboratory. The occupancy sensor controlled VAV fume hoods reduced the exhaust fan power draw as well as the heating and cooling loads within the affected areas of the facility.

During our site visit, the evaluation team was able to verify the installation of the VAV fume hoods with occupancy sensors directly. Two Survey-It Models were built to represent the baseline and ex-as-built demand for the facility. Air handler and exhaust fan meter data were used to calibrate the as-built Survey-It Model.

<u>Ex-Ante Gross Savings</u>
Ex-ante gross savings were calculated using LabPro 1.2. Savings were determined relative to a base case consisting of a constant volume exhaust fan. The comparison took into account interactive effects between the exhaust fans and the building's HVAC system, which consists of VSD air handlers and an air cooled chiller).

<u>Ex-Post Gross Savings</u>
To determine measure savings, baseline and as-built models of the facility were constructed using Survey-It, the DOE 2.2 building modeling front-end used for "whole building" sites. For the as-built model, the VSD fume hood exhaust fans were modeled as return air fans on the system air handlers. This approach was appropriate because the system uses 100% outside air. As such, the return fans mimic the activity of exhaust fans. Before calibration, a schedule for the minimum outside air flow (MIN-OA-SCH) was defined to mimic the airflow requirements of the building as dictated by the exhaust fan (i.e., return fan) flow.

In the calibration process, this flow schedule was tweaked to generate modeled AHU power consumption profiles (which included both the air handlers and exhaust fans) that matched the metered kW profiles of the exhaust fans and air handlers. Calibrating the chiller load required tweaking the kW/ton efficiency of the chiller in the model. Because the air handlers use 100% outdoor air, the chiller load is primarily dictated by outdoor air conditions, not indoor loads. As such, tweaking plug and process loads in the model did not result in any change in chiller energy usage.

With the system calibrated, it was then necessary to model the base case. To develop the base case, the minimum flow schedule was set to 100% of maximum flow at all times. This strategy mimics the performance of constant volume exhaust fans, which operate at full speed CFM perpetually. Savings were calculated as the difference in total site kWh and peak kW use between the base case and calibrated case. Models were run with CTZ climate zone 7 data.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 100% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown in Table N-1 below.

Table N-1: D63257 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Hoods w/ Occupancy Sensors	10 of 10	1	Investment Criteria	2	10 of 10	3	6	100%

Ex-Post Net Savings

The site contact indicated that Savings by Design was critical in the implementation of the VAV fume hoods with occupancy sensors. He indicated that Savings by Design's design analysis showed a substantial increase in calculated savings from installing the specified fume hoods. The project's long term savings potential combined with the Program's incentives enabled the project to meet investment criteria. This combination of answers yielded a free ridership score of 0, indicating 0% free ridership.

Table N-2: D63257 VAV Fume Hoods w/Occupancy Sensors Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Peak kW	86.0	84.0	97.7%	1.00	84.0
kWh	505112	482197	95.5%	1.00	482197.0
Therms	40326	25374	62.9%	1.00	25374.0

O. G120001 Air to Air Heat Exchangers

Project G120013 received $57,202 for installing air to air heat exchangers on two of their cogeneration engines. The heat exchangers extract otherwise waste heat from the flue stack gases to preheat air used in a process oven. The evaluation team verified the installation of the two heat exchangers and obtained temperature and flow data for a period of 3 weeks.

<u>Ex-Ante Gross Savings</u>

Ex-ante gross savings were determined using spreadsheet calculations for the as designed heat exchangers. These were theoretical estimates based on the capacity of the design flow rate for the two cogeneration engines. It assumes 3,640 annual operating hours with the maximum heat recovery based on the heat exchanger's rated efficiency and the available waste hate from the stack gases.

<u>Ex-Post Gross Savings</u>

Ex-post gross savings was determined from direct measurement of the cold side of the heat exchanger. The facility had available, onsite, temperature probes at the inlet and outlet and a flow meter to measure the flow rate of the preheat oven air. Spot measurements were collected once each day for 3 weeks by facility personnel. Daily gas savings was determined using the following formula calculated in Excel:

$$Savings = \frac{(E_{out} - E_{in})\dot{m}\,\Delta t}{C\eta}$$

where *Savings* is the gas savings in therms. E_{out} and E_{in} are the enthalpy values of the air into and out of the heat exchanger in BTU/lbm, m is the mass flow rate lbm/hr, Δt is the hours of operation per day, η is the engine's efficiency and C is the conversion factor (100,000) from BTUH to therms. An average for the data set was taken and multiplied by the number of days in operation. The results comparing the ex-post and ex-ante gross savings are shown in Table O-2.

There were many differences in the current operation of the heat exchangers as compared to the initial design. First, due to decreased demand for their products, the cogeneration engines run only 2080 hours a year as compared to the 3640 annual hours assumed by the Progam. Second, both heat exchangers were operating at roughly 11,000 CFM each whereas the design was for 5,500 CFM. Third, due to the higher flow rate the exit air temperature at the cold side of the heat exchanger averaged 165 °F compared to the design of 250 °F.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 65% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown below in

Table **O-1**.

Table O-1: G120001 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Heat Recovery	7 of 10	0.7	Investment Criteria	2	4 of 10	1.2	3.9	65%

Ex-Post Net Savings

The facility personnel indicated that the incentives reduced the return on investment making the project more feasible. However, they also stated that the measures would have likely been installed anyways. This combination of answers yielded a free ridership score of 3.9 out of 6, indicating 35% free ridership. Therefore, ex-post net savings were 65% of the ex-post gross savings for this site. The results are summarized in Table O-2.

Table O-2: G120001 Savings Summary

	Ex-Ante Gross Savings	**Ex-Post Gross Savings**	**Gross Realization Rate**	**Site Net-to-Gross Ratio**	**Ex-Post Net Savings**
Therms	95,337	48,516	51%	0.65	31,535

P. G120006 Combustion Air Preheating

G120006 received an incentive for installing combustion air preheaters on 6 Ferry 220 rotomolding ovens and 2 Ferry 330 rotomolding ovens. During our site visit, the evaluation team was able to verify the installation of the combustion air preheaters directly.

Ex-Ante Gross Savings

To determine combustion air preheater savings, a spreadsheet analysis was used. Based on each furnace's capacity, an exhaust flow rate (CFM) was determined. The amount of energy recuperated was then calculated based on the increase in inlet combustion air temperature across the exhaust gas/combustion air heat exchangers using a specific heat based analysis. Savings were calculated as the energy recuperated by the heat exchangers divided by the heat exchanger efficiencies (95% in this case). In reality, savings should have been calculated as the energy recuperated by the heat exchanger divided by the assumed burner efficiency. The latter approach would have provided an indication of the amount of energy required to generate the energy saved by the heat exchangers in their absence.

Ex-Post Gross Savings

1) To begin the analysis, the following site level parameters were collected:

- Intake combustion air delta-T across the heat exchanger of a Ferry 220 furnace
- Intake combustion air delta-T across the heat exchanger of a Ferry 330 furnace
- Combustion % excess air measured at the stack exhaust for both furnace types
- Annual gas use for the past year for the facility
- The distribution of gas use between Ferry 330 furnaces and Ferry 220 furnaces

2) For all furnaces the same analysis was then undertaken. Using a furnace's annual gas use, the combustion % excess air was used to extrapolate that annual mass flow rate of air through the inlet side of the heat exchanger.

3) Using the calculated mass flow rate and the delta-T across the heat exchanger, the annual amount of energy recuperated by the heat exchanger was calculated.

4) Using an assumed burner efficiency of 95%, the amount of energy required to generate the recuperated energy was calculated.

5) Total measure saving were taken as the sum of savings from all 8 furnaces.

Infrared Thermometry

Ex-Ante Gross Savings

Savings from the infrared thermometry equipment were also determined using a spreadsheet analysis. The analysis was predicated on two key assumptions:

- The infrared thermometry equipment would reduce the average rotomolding cycle time from 15 to 12.8 minutes
- During any given cycle, the furnaces would operate 20% more at a 50% firing rate, and 20% less at a 100% firing rate than with baseline equipment.

Using these assumptions together with the equipment capacities and annual number of cycles, savings were calculated.

Ex-Post Gross Savings

Following repeated requests, the site contact was unable to provide the necessary information to complete this analysis before the deadline for this report. Cambro's furnace control computers do keep logs of process runtimes, which would have provided a satisfactory basis for determining if the infrared thermometry equipment actually reduces their process runtimes in practice. Because there was inadequate information to determine savings from this measure directly, savings were calculated using the gross measure realization rate from the combustion air preheating measure.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 43% was calculated for the combustion air preheating measure from the three free ridership questions on the decision-maker survey. The free ridership survey questions yielded a 0% net-to-gross ratio for the infrared thermometry measures.

Table P-1 below summarizes the free ridership survey results for both measures.

Table P-1: G120006 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Heat Recovery From Exhuast to Pre-heat Combustion Inlet Air	6 of 10	0.6	Design Analysis	2	0 of 10	0	2.6	43%

Ex-Post Net Savings

The site contact indicated that Savings by Design was somewhat influential in the implementation of the combustion air heat exchangers. He indicated that Savings by Design's design analysis was a helpful addition to the process. At the same time, he also stated that if there had not been any interaction with Savings by Design, they would have just hired someone else to complete the design analysis for them and therefore in all likelihood implemented the measure anyways. This combination of answers yielded a measure level free ridership score of 2.6, indicating 56.7% free ridership for the combustion air preheating measure.

Table P-2: G120006 Combustion Air Preheating Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Therms	125,432	15,480	12.3%	0.43	6,708

Q. G120012 Salt Bath Insulation

Project G120012 received $10,000 for replacing their salt bath insulation using vermiculite insulation. The higher insulation value vermiculate is an upgrade to the existing firebrick insulation. The evaluation team was able to visually verify the installation of this measure during the site visit.

Ex-Ante Gross Savings

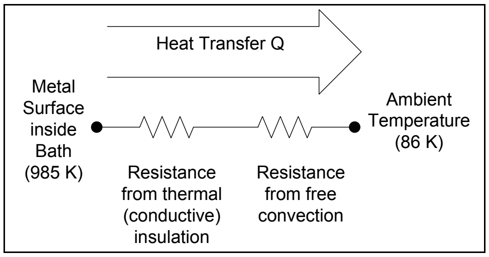
Ex-ante gross savings were determined by the Program using spreadsheet calculations. However, the detail of the methodology was not supplied in the project file and therefore, we cannot determine how the calculations were derived.

Ex-Post Gross Savings

Ex-post gross savings were determined using heat transfer principles and operational conditions determined from the onsite visit and interview. A baseline consisting of eight inch thermal ceramic firebricks SR-99, insulated between two ½" steel plates was used. The as-built condition replaces the firebricks with six inch vermiculite insulation. The material properties were taken from the material datasheets and heat transfer references[1].

The heat transfer surfaces of interest were all sides of the salt bath affected by the measure. We assumed the salt bath was at steady state and that the inner surface was at the same temperature as the fluid. An ambient temperature of 86 F was assumed. The bath temperature was assumed to remain at 985 °F. Under these assumptions the heat loss through the walls was modeled as a circuit as shown below in Figure Q-1.

Figure Q-1: Simplified Heat Transfer Model.



We assumed a convection coefficient of 3.522 BTU/(hr·ft^2·°F), which is a typical value based on the temperature conditions observed on site. Coupled with resistances from

[1] *Principles of Heat Transfer*, sixth edition, Kreith and Bohn, Brooks/Cole 2001

the thermal insulation, an overall resistance, $R_{overall}$ of the system was determined using the following equation:

$$R_{overall} = \frac{l_a}{k_a} + \frac{l_b}{k_b} + \frac{1}{h}$$

where l is the thickness of the insulating material, k is the thermal conductivity and h is the heat transfer coefficient between the outside air and the metal surface (3.522 BTU/(hr·ft^2·°F).

An overall heat loss was obtained by the formula:

$$Q = \frac{A\Delta T}{R_{overall}}$$

where A is the working area of interest, and ΔT is the difference in temperature.

These equations were applied to the baseline and as-built systems to estimate the difference in heat transfer/loss out of the salt bath. The difference provided savings on an hourly basis. This value was multiplied by the yearly operation hours to determine the ex-post gross savings.

Based on our calculations, ex-post savings were 19,375 therms, for a gross realization rate of 113%.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 90% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown below in
Table Q-1.

Table Q-1: G120012 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Salt Bath Insulation	10 of 10	1	Design Analysis	2	8 of 10	2.4	5.4	90%

Ex-Post Net Savings

The building owner stated that the program incentives were a major influence in implementing the measure because it helped his small business afford the capital costs. He stated that the design analysis further confirmed his suspicion on the energy savings. In the absence of the program, the measures might have been implemented. The contact's combination of answers and ratings yielded a free ridership score of 5.4 out of 6 for a 10% freeridership ratio. Therefore, the net savings were 90% of the ex-post gross savings as shown in Table Q-2.

Table Q-2: G120012 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
therms	17,181	19,375	113%	0.90	17,437

R. G120013 Regenerative burner

Project G120013 received $144,004 for installing regenerative burners for their aluminum melting furnace. The regenerative burners perform heat recovery from flue gases. This is accomplished by charging a regenerative media bed with hot flue gas prior to exit and then using the media to preheat combustion air. The system has two burners that operate in 40 second cycles. Each cycle allows the system to charge the media bed. Then as the burners cycle between each other, combustion air is pulled across the media and preheated. In this way, the exit flue gas temperatures are substantially reduced while preheating the combustion air. The base case for this measure is a direct fired burner with no heat recovery. The evaluation team verified the installation of this measure and calculated the impacts of the measure using measurements taken on-site.

Ex-Ante Gross Savings

Ex-ante gross savings were determined by the Program using DOE's PHAST (Process Heating and Survey Tool) software. Operation data was estimated and input into the PHAST program for both the base and proposed models. The exhaust gas temperature for the proposed case was set at 618°F. The furnace was assumed to run on the regenerative burners during all phases of the melting process.

Ex-Post Gross Savings

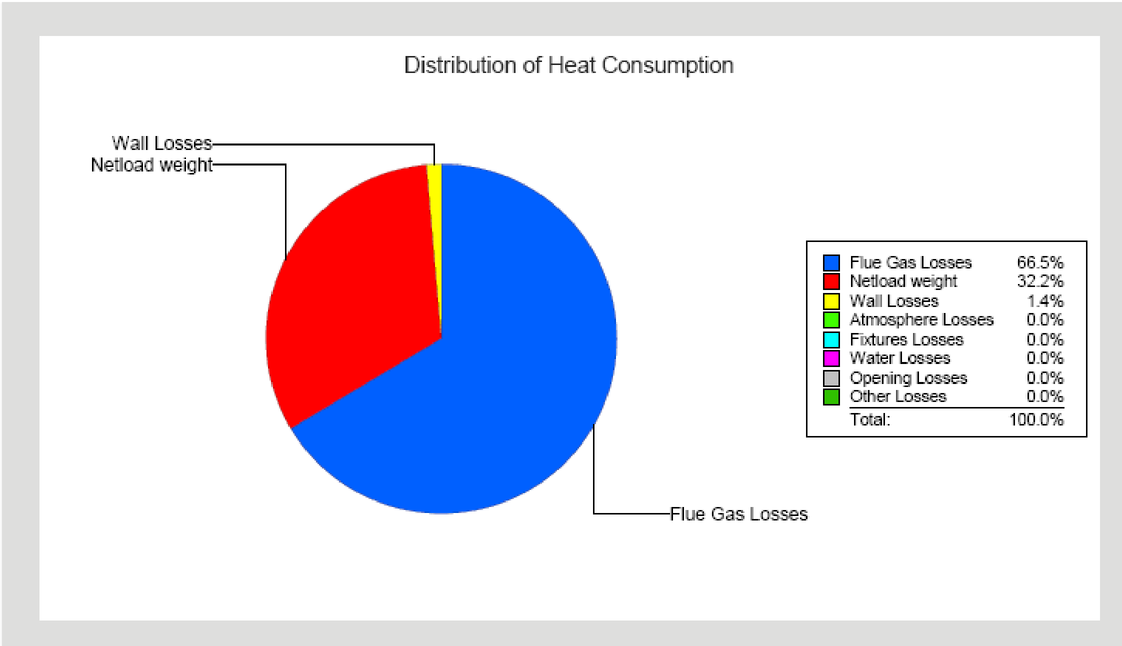
Ex-post gross savings were also determined using DOE's PHAST software due to the complexity of the measure and a lack of available trend data. Actual operation set points were collected during the site visit. Real gas usage was available for the prior 4 months and was used to compare the results. In addition, the actual operating procedure was clarified on site.

Ex-ante gross savings are based on the assumption that the burners remain in the regenerative mode for the whole duration of operations. In reality, the burners run like direct fired burners until the aluminum has reached 1180 °F. The burners then switch over to a regenerative mode until the aluminum reaches 1350 °F. This significant deviation from the ex-ante calculation in theory suggests that therm savings were overestimated.

PHAST was used to analyze the furnace's energy consumption based on operation conditions such as exit flue gas temperatures, loading, furnace dimensions, etc. The limitation is that once the operating parameters are modified, it assumes the system operates at those same conditions and at the same time interval. This was not the case based on conversations with the facility manager. Therefore, in order to accurately assess the energy consumption of the furnace we had to build two separate models because the base case operates differently from the installed case. As mentioned above, this was a mistake in the ex-ante calculations.

Known parameters collected on site were entered into the PHAST program, The baseline model, illustrated in Figure R-1, assumed the furnace ran on direct fired burners to heat the aluminum from 60 °F to 1950 °F. The as-built model, shown in Table R-1, assumed the furnace ran in a direct fired mode heating aluminum from 60 °F to 1180 °F for half the time. The other half of the time, the furnace was assumed to operate on the regenerative burners, heating the aluminum from 1180 °F to 1350 °F. The exhaust gas temperature was set to 350°F as found onsite and verified through measurements. The as-built direct fire and regenerative burner results are shown in the left and right columns of Table R-1 respectively.

Figure R-1: PHAST Output for the Baseline Model



Heat Storage (Btu) : 55,572,978 **Thermal Efficiency (%) : 32.15**

Area of Heat Consumption	Btu/hr
Flue Gas Losses	7,866,264
Netload weight	3,806,075
Wall Losses	165,530
Atmosphere Losses	0
Fixtures Losses	0
Water Losses	0
Opening Losses	0
Other Losses	0
Total	**11,837,869**

Table R-1: PHAST output for as-built model (Units in Btu/hr)

Atmosphere Losses	0	0
Fixtures Losses	0	0
Flue Gas Losses	7,206,951	191,025
Netload weight	3,473,194	1,658,475
Opening Losses	0	0
Other Losses	0	0
Wall Losses	165,530	165,530
Water Losses	0	0
Total	***10,845,675***	***2,015,030***

The heat consumption was multiplied by the operating hours to arrive at the yearly gas consumption. The total estimated gas consumption using PHAST was 25,721 therms/year, which is close to the actual 4 month gas usage data obtained on site extrapolated to an annual value (25,002 therms/year). Ex-post savings was the difference between the baseline and installed furnaces and found to be 216,301 therms.

Ex-post savings were expected to be substantially less than ex-ante savings due to the discrepancy between the projected and annual furnace operations. However, the actual gross realization remained at 90%. This was because the ex-ante calculation assumed an exhaust gas temperature of 618 °F. It was found during the site visit that the exhaust gas temperature is actually set at 350 °F, showing that the furnace runs more efficiently. It appears that the overestimated operating hours and increased operating efficiency cancelled each other out in the overall result.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 90% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown below in Table R-2.

Table R-2: G120013 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score -Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Regenerative Burners for Melting Furnace	10 of 10	1	Investment Criteria	2	8 of 10	2.4	5.4	90%

Ex-Post Net Savings

The site contact, an owner of the facility, indicated that the monetary incentive was a major catalyst in purchasing the regenerative burners. He stated that the incentive made the regenerative burners an “attractive” project. These responses resulted in a freeridership score of 5.4 out of 6, indicating 10% free ridership. The ex-post net savings were 90% of the ex-post savings for this site as shown in Table R-3.

Table R-3: G120013 Savings Summary

	Ex-Ante Gross Savings	**Ex-Post Gross Savings**	**Gross realization Rate**	**Site Net-to-Gross Ratio**	**Ex-post Net Savings**
Therms	240,007	216,301	90%	0.90	194,671

S. G120015X Heat Transfer Fluid System, Counterflow Heat Exchanger with Slurry Recycle, Direct Dyer with HTF Heat Recovery, Regenerative Thermal Oxidizer, Biogas Utilization from Anaerobic Digesters

Heat Transfer Fluid System
Counterflow Heat Exchanger with Slurry Recycle
Direct Dyer with HTF Heat Recovery
Regenerative Thermal Oxidizer
Biogas Utilization from Anaerobic Digesters

G120015X received incentives under five different coupons for the installation of energy efficient equipment used in their "SlurryCarb" biofuel generation process. The gross incentive for the installation of all five measures was $1,052,629.50.

During the site visit to this especially important site, the evaluation team was able to verify the installation of all the equipment associated with the incented measures. However, the evaluation team learned that G120018 was still in the start up phase and has been experiencing many of the growing pains associated with using a new process at a first-of-its-kind facility. As such, equipment associated with two of the five measures was either not functioning properly or had already failed due to significant design flaws. Equipment associated with a third measure was only partially operational because the facility was not yet working anywhere near its operational capacity. The analysis methodologies, savings, and problems associated with each process are subsequently discussed in individual process discussions.

Heat Transfer Fluid System (G120015)

<u>Ex-Ante Gross Savings</u>
G120015 uses a process heat transfer fluid system in lieu of a boiler to deliver heat to SlurryCarb (i.e. biosolids) process heat exchanger. The HTF saves energy by removing the blowdown and flash steam losses associated with running a high pressure steam boiler.

To develop a baseline boiler process efficiency, the following assumptions were made:

- 80% efficient boiler
- 60% condensate return
- Process steam temperature of 600 F at 150 psig required
- Make up feedwater supplied at 70 F

Based on these parameters, a baseline process efficiency—taking into account the boiler's thermal efficiency and the blowdown and flash losses—of 66% was defined.

The baseline boiler system was compared to the HTF system, which operates at 85.4% efficiency. Savings were calculated as the difference in energy required for the two processes to meet the heat exchanger's annual load.

Ex-Post Gross Savings

1) To begin the analysis, the baseline chosen in the site report was rejected in favor of a more reasonable estimate of 92% condensate return. For any high pressure steam industrial process, condensate losses of 40% are unreasonable. Furthermore, blowdown losses would generally be minimal due to the use of an RO system.

2) Using the adjusted condensate return figure, a new process efficiency of 78% was calculated.

3) The same HTF process efficiency used by the implementers was assumed. Measurements could not be done to verify this efficiency because the equipment was not operational during the site visit.

4) Using the actual process load—which was determined based on the biosolids daily mass flow and process inlet and outlet temperatures—the energy required for the baseline and as built processes was calculated. Savings were calculated as the difference in energy required for the baseline and as-built process.

The gross savings calculation revealed that savings were considerably less than anticipated for two primary reasons:

- The process flow was less than 19% of the original estimate. The low flow rate was primarily due to process failures associated with some of the installed heat exchangers (discussed later) and other start up issues with G120015's newly patented process
- The efficiency of the baseline process was increased by 12% from the ex-ante savings calculation.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 88% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown in Table S-1 below.

Table S-1: HTF System Net-to-Gross Savings Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
HTF system for process heating	9 of 10	0.9	Design Analysis	2	8 of 10	2.4	5.3	88%

Ex-Post Net Savings

The site contact indicated that Savings by Design was extremely influential in theirdecision to implement the process HTF system. The design analysis and savings estimate provided by Savings by Design heavily factored into the decision making process. Therefore, if Savings by Design had not been involved, there is a very good chance the measure would not have been installed as designed. This combination of answers yielded a free ridership score of 5.3 for 11.7% free ridership.

Table S-2:G120015X Heat Transfer Fluid System Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Therms	493,172	30,794	6.2%	0.88	27,201

Counterflow Heat Exchanger with Slurry Recycle (G120016)

Ex-Ante Gross Savings

This project consisted of using secondary process heat exchangers to preheat incoming biosolids with energy for biosolids exiting the SlurryCarb process. The preheaters were designed to increase the temperature of incoming biosolids 32 F with essentially free energy. The net effect was that the load of the primary heat exchangers (connected to the HTF described above) would be reduced considerably.

Savings from installing the heat exchangers were calculated using a spreadsheet analysis. Savings were calculated as the energy recuperated by the preheater divided by the HTF efficiency.

Ex-Post Gross Savings

During the site visit, it was determined that there were no savings associated with the installation of the preheat heat exchangers. At the time of the audit, the heat exchangers on both of the facility's processing lines had failed. The site contact indicated that there was a serious design flaw in the heat exchangers which resulted in broken seals when the equipment operated under high pressure. As such, the heat exchangers were decommissioned indefinitely until a fix or new solution was found. To handle the increased load placed on the other process heat exchangers due to the absence of the preheaters, the facility recycled more of their processed SlurryCarb to bring the inlet biosolids to a suitable temperature for the functioning heat exchangers.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 77% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown in Table S-3 below.

Table S-3: Counter Flow Heat Exchanger Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Counterflow heat exchanger with slurry recycle	8 of 10	0.8	Investment Criteria	2	6 of 10	1.8	4.6	77%

Ex-Post Net Savings

The site contact indicated that Savings by Design was very influential in the installation of the counterflow heat exchangers. He stated that the incentive provided by Savings by Design helped the project meet investment criteria. If Savings by Design had not been involved, the equipment may not have been installed in the same way. This combination of answers yielded a free ridership score of 4.6, indicating 23% free ridership.

Table S-4:G120015X Heat Exchanger with SlurryCarb Recycle Savings Summary

`	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Therms	462,718	0.0	0.0%	0.77	0.0

Direct Dyer with HTF Heat Recovery (G120018)

Ex-Ante Gross Savings

The facility's direct drying process is composed of a natural gas fired furnace and a tumbling drum. Air is heated in the furnace to 659 F and then blown through a tumbling drum where biosolids are dried from 55% solids by mass to 92% solids by mass before exiting the process. The initial process design also included recycling 120 F air from the dryer back into the furnace to reduce the furnace's load. To further reduce the furnace load, 627 F flue gases from the HTF system were also intended to be routed to the furnace.

As a baseline for this direct drying process, an indirect dryer was chosen. The baseline indirect drying process consisted of using heat exchanger hot plates connected to the HTF system to dehydrate the load. Savings were calculated using energy balances on the direct and indirect dryer systems.

Ex-Post Gross Savings

During the site visit, it was learned that the HTF exhaust flow component of the installed dryer system was not currently operational. Due to start up issues with the HTF process, the load on the HTF had been insufficient to warrant using it to provide a heat flow to the furnace. The dryer's own recycle heat flow however was active.

To begin the analysis, the following information regarding the as-operating dryer configuration was collected on site:

- The dryer currently produces 150 tons/day of 92% solid SlurryCarb
- 80% of the dryer's feed comes in at 15% solids
- 20% of the dryer's feed comes in at 55% solids
- Since the dryer was designed to operate at inlet conditions of 55% solids, roughly 50% of the flow through the dryer at any given time is recycled product used to achieve the desired inlet conditions
- Dryer feed enters the dryer at 155 F
- The infiltration air flow into the dryer is 1500 SCFM
- The dryer's burner operates at 40% excess air
- The recycle air flow from the dryer returns to the furnace at 107 F
- The average infiltration and combustion air temperature is 76 F (assumed based on implementation report)
- All steam leaving the dryer exits saturated at 0 psig
- All remaining products (solids, remaining liquids and air) leave the dryer at 180 F

- Heated furnace air enters the dryer at 659 F

This collection of parameters was sufficient to fully define the problem.

2) To begin the analysis, the daily mass flow rate of solids through the dryer was determined based on the moisture content of the raw biosolids, the required recycle biosolids flow fraction to achieve the desired inlet composition, and the daily production of dry biosolids.

3) Using the mass flow rate of the biosolids together with the inlet and outlet conditions of the dryer product flows, the required air flow rate from the furnace was determined using an energy balance on the dryer.

4) A combined energy and mass balance was next performed on the furnace. The following equations were solved simultaneously to determine the required fuel flow into the dryer:

where:

- m_r = Recycle dryer air mass flow rate (lb)
- f = Combustion air to fuel mass ratio
- m_f = Fuel mass flow rate (lb)
- Cp_a = Specific heat capacity of air (Btu/lbF)
- Cp_f = Specific heat capacity of methane (Btu/lbF)
- ΔT_1 = Temperature change of the recycle heat flow (659 F – 107 F)
- ΔT_2 = Temperature change of the fresh air and combustion gases (659 F – 107 F)
- HHV = Higher heating value of methane (Btu/lb)
- m_{dryer} = Total mass flow rate of hot gas into the dryer (lb)

In the above equations, the two unknowns were the mass flow rate of fuel and the mass flow rate of the recycle air flow. Solving the system provided the daily fuel flow rate (lbs) required to produce 150 tons of biosolids per day.

5) To calculate the daily gas usage for the baseline case, an energy balance was performed on the baseline indirect dryer using an assumed dryer efficiency of 1623 Btus per pound of water evaporated. The added energy required to heat the biosolids and remaining water to the outlet temperature of 180 F was also considered as part of the energy balance. With the process heat requirement determined, the total gas used for the base case was determined by dividing the process load by the HTF system efficiency (85.4%).

6) Savings were calculated as the difference in energy use for the same product load between the baseline and as-built cases.

The gross savings for this measure actually exceeded the ex-ante estimate in spite of the fact that heat recovery from the HTF system was not yet functional. Savings were amplified because the facility currently runs 80% bypass product and 20% SlurryCarb. What that means in practice is that 80% of the boisolids going directly to the dryer are 15% solids by mass, while the other 20% is 55% solids by mass. The facility was designed to run in the opposite fashion—80% SlurryCarb and 20% bypass—but due to start up issues with their SlurryCarb process, the bypass flow rate has been considerably higher than designed. As such, the dryer has been processing more biosolids (and removing more water) than initially calculated. This more than made up for the reduction in savings associated with not using heat recovery from the HTF system.

Ex-Post Net-to-Gross Summary

A measure net-to-gross ratio of 68% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown in Table S-5 below.

Table S-5: Direct Dryer Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Direct dryer w HTF heat recovery	6 of 10	0.6	Suggested Measure	2	5 of 10	1.5	4.1	68%

Ex-Post Net Savings

The site contact indicated that Savings by Design was somewhat influential in their decision to implement the direct dryer. He stated that without Savings by Design, they would have still installed the direct dryer, but they would not have installed the HTF flue gas heat recovery component of the system. The site contact's combination of answers yielded a free ridership score of 3.1, indicating 48% free ridership.

Table S-6:G120015X Direct Dryer with HTF Heat Recovery Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Therms	1,540,740	2,613,855	169.6%	0.68	1,786,134

Regenerative Thermal Oxidizer (G120017)

Ex-Ante Gross Savings

Savings from installing a regenerative thermal oxidizer were calculated relative to a baseline recuperative thermal oxidizer. Savings were calculated using the following assumptions:

- Air enters the RTO at 120 F
- Air leaves the regenerative thermal oxidizer at 200 F
- Air leaves the baseline recuperative thermal oxidizer at 612 F
- The VOC stream consists of combustible solvents which account for .075% of the mass flow
- The combustible solvents have a higher heating value of 15,090 Btu/lb
- 95% of the solvents in the flow combust
- The burners associated with both RTOs operate at 10% excess air

Savings were calculated based on the difference in the gas required to achieve the respective outlet temperatures of the regenerative thermal oxidizer and the recuperative thermal oxidizer.

Ex-Post Gross Savings

1) Ex-Post Gross Savings were calculated using an energy balance similar to that conducted by the utility. The process flow rate was determined as the difference between the air flow entering the dryer and the recycle air flow. Any air not recycled in the dryer must past through the RTO for treatment before passing to the atmosphere.

2) Using the VOC flow rate together with the process assumptions made by the utility allowed calculation of savings. RTO gas inlet and outlet temperature could not be verified while on site because the RTO was not operational during the site visit.

3) The following equation was used to determine the fuel flow rate, and thus the annual energy use of the as built process:

$$f_a m_f Cp_a \Delta T_1 + m_f Cp_f \Delta T_1 + m_v Cp_a \Delta T_2 = m_f HHV_f + m_v f_s f_d HHV_v$$

Where:

f_a = Combustion air to fuel mass ratio

m_f = Combustion fuel mass flow rate (lbs/hr)

m_v = VOC laden air stream mass flow rate (lbs/hr)

Cp_a = Specific heat of air (Btu/lbF)

Cp_f = Specific heat of fuel (Btu/lbF)

ΔT_1 = Temperature change of combustion air and fuel (200 F – 76 F)

ΔT_2 = Temperature change of inlet process air (200 F – 109 F)

HHV_f = Higher heating value of natural gas (Btu/lb)

HHV_v = Higher heating value of the combustible solvents in the VOC air stream (Btu/lb)

f_s = Mass fraction of combustible solvents in the VOC air stream

f_d = Fraction of VOC solvents that combust

4) A final correction was made to the fuel flow rate to account for the assumed burner combustion efficiency (95%)

5) An identical procedure was then followed to determine the gas use of the recuperative thermal oxidizer. In the above equation, the only parameters that were changed for the base case calculation were delta-T estimates.

Savings from the regenerative thermal oxidizer were considerably higher than originally estimated in the ex-ante calculation. This increase in savings is primarily attributable to an increase in the VOC flow to the RTO relative to the ex-ante estimate. Flow has increased because dryer load been higher than expected for reasons previously discussed.

Ex-Post Net-to-Gross Summary

A measure net-to-gross ratio of 78% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown in Table S-7 below.

Table S-7: RTO Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Regenerative thermal oxidizer	9 of 10	0.9	Design Analysis	2	6 of 10	1.8	4.7	78%

Ex-Post Net Savings

The site contact indicated that Savings by Design was very influential in their decision to implement the RTO. Savings by Design provided design analysis and peer reviewed RTO reports showing the benefit of installing regenerative thermal oxidizers. As such, there is a good chance difference equipment would have been installed in the absence of the program. The site contact's combination of answers yielded a free ridership score of 4.7, indicating 22% free ridership.

Table S-8: Regenerative Thermal Oxidizer Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Therms	342,107	666,132	194.7%	0.78	521,803

Biogas Utilization from Anaerobic Digesters (G20533)

Ex-Ante Gross Savings

This project consists of using microorganisms in an anaerobic sludge bed to generate CH4 from contents of wastewater generated in the facility's biosolids processing operations. The CH4 generated by the anaerobic digesters was then intended to be used as fuel for the direct dryer's furnace. Savings from this measure were calculated relative to a baseline in which the direct dryer uses natural gas from the utilities as its only fuel for operation. Energy savings were therefore calculated directly as the amount of energy generated through the anaerobic digestion process.

Ex-Post Gross Savings

During the site visit, the site contact openly admitted that the anaerobic digestion process was still in the testing phases. He stated that it was not yet producing enough gas to be of any use in the facility's operations. He believed the equipment would be operating at capacity within the next year. Because the anaerobic digestion equipment was not yet operational, there were no savings achieved from this measure.

Ex-Post Net-to-Gross Summary

A measure net-to-gross ratio of 37% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown in Table S-9 below.

Table S-9: Anaerobic Digesters Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Biogas Utilization from anaerobic digester	3 of 10	0.3	Easier Sell	1	3 of 10	0.9	2.2	37%

Ex-Post Net Savings

The site contact indicated that Savings by Design had little influence on the installation of the anaerobic digesters. He stated that the equipment would have likely been installed regardless of the program, but having the incentive available nonetheless made the project an easier sell. This combination of answers yielded a free ridership score of 2.2, indicating 63% free ridership.

Table S-10: Biogas Utilization from Anaerobic Digesters Savings Summary

	Ex-Ante Gross Savings	**Ex-Post Gross Savings**	**Gross Realization Rate**	**Site Net-to-Gross Ratio**	**Ex-Post Net Savings**
Therms	394,723	0	0.0%	0.37	0

The table below provides a summary of the savings achieved through all five SBD projects undertaken at G120015X.

Table S-11: G120015X All Measures Savings Summary

	Ex-Ante Gross Savings	**Ex-Post Gross Savings**	**Gross Realization Rate**	**Site Net-to-Gross Ratio**	**Ex-Post Net Savings**
Therms	3,233,460	3,310,781	102.4%	0.71	2,335,139

T. G20488 Combustion Air Preheating

G20488 received $55,580 for installing intake air/ flue gas heat exchangers on four burner sections of their new paper drying oven. The baseline system does not include intake air preheating. The evaluation team verified the installation of the measure during a site visit and took spot measurements to calculate energy savings.

<u>Ex-Ante Gross Savings</u>

Savings determined by the Program were calculated using the anticipated air intake and exhaust rates for the entire oven (all four burner set ups), the expected exhaust gas temperature pre- and post- heat exchanger, and the heat transfer efficiency of the heat exchanger. The allowable burner turndown was then calculated for the oven and the turndown savings was then applied to an anticipated operating schedule of 24/360. It should be noted that in the ex-ante calculations, an air flow rate of 6,333 CFM was assumed for the intake air. Nowhere in the body of the report does it indicate how this CFM value was arrived upon. As discussed below in the ex-post savings calculation, the air flow rate estimate was excessively high.

<u>Ex-Post Gross Savings</u>

Ex-post gross savings were determined using a spreadsheet analysis informed by spot measurements and schedules collected during the site visit. Key steps for determining gross savings were as follows:

1) During the site visit, our team measured the temperature differential of the intake air across each of the four heat exchangers.

2) Because the intake air blowers were constant volume, a steady air intake rate was assumed for all hours of operation. Three of the installed blowers were found to have rated capacities of 170 CFM. The fourth blower was rated at 420 CFM, for a total capacity of 930 CFM.

3) Using a constant specific heat analysis for each heat exchanger, the amount of energy transferred to the intake air was calculated on an hourly basis. A constant specific heat analysis was deemed valid because of the small range of temperatures dealt with in this instance.

4) The amount of energy saved was then scaled to account for the burners' 80% nominal operating efficiency. In other words, the fuel input to the burner required to produce equivalent intake air heating was determined.

5) Yearly gas savings were calculated using an annual operating schedule provided by the facility owner. Ex-Post gross savings analysis yielded 17,073 Therms in gas savings.

<u>Ex-Post Net-to-Gross Savings</u>
A measure net-to-gross ratio of 58% was calculated from the three free ridership questions on the decision-maker survey. The survey results are presented below in Table T-1.

Table T-1: G20488 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Pre-heat Combustion Air Intake	10 of 10	1	Easier Sell	1	5 of 10	1.5	3.5	58%

<u>Ex-Post Net Savings</u>
Discussions with the facility owner indicated that Savings by Design was extremely influential in the implementation of the measure and made it an easier sell. He also indicated that there was a decent chance the measure would not have been installed the same way without Savings by Design. The site contact's combination of answers yielded a net savings score of 3.5 out of 6, or 41.7% free ridership. Site net savings were therefore 58.3% of gross savings. Table T-2 below summarizes the results.

Table T-2: G20488 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Therms	109,590	17,073	16%	0.58	9,954

U. G20515 High Efficiency Egg Incubators

The project received an incentive of $12,797 for installing high efficiency incubators at an egg hatchery. The incubators were considered high efficiency because they use chilled and hot water loops to heat and cool the eggs. Also, VSD controlled exhaust fans are used to draw air out of the incubation rooms and bring in ventilation air from the conditioned incubator rooms. In baseline incubation systems, resistance heat is used to heat incubators and cooled air from the incubation rooms is used to cool the incubators as well as ventilate them. The existing incubators at the new facility were chosen as the baseline equipment for this measure because they were the most efficient of all the resistance heat incubators at all of G20515 Hatcheries. The evaluation team verified the installation of the measure during a site visit and calculated the impacts using logged data provided by G20515.

<u>Ex-Ante Gross Savings</u>

According to the program file, ex-ante savings were calculated on the basis of the amount of therms and kWh saved per chick hatched at the new facility. The poultry producer was able to provide data on the amount of energy required to hatch a chick for a full year preceding the installation of the new equipment. Because the supplied data did not differentiate between the energy used in the egg rooms, incubators and hatchers, the ex-ante Savings were determined using a spreadsheet model of the whole incubation process. Savings were taken as the reduction in therm and kWh use per chick in the new incubation equipment multiplied by the anticipated number of chicks processed in the new incubators. This calculation strategy yielded savings of 21,329 Therms and 698,165 kWh.

<u>Ex-Post Gross Savings</u>

The facility continued to log the kWh and Therms in 4 week periods following the installation of the high-efficiency incubation equipment. They also tracked the number of chicks hatched in the new and old incubation equipment in each period. kWh, therm, and hatched chick data provided from both 2007 and 2008 were used to determine the average values of these parameters for each of the 13 yearly periods the poultry producer defines. The facility also provided baseline data for the same parameters from 2005. The baseline data was used to calculate the kWh and therm use of the baseline process on a "per chick hatched" basis. Using these kWh/chick and therm/chick values together with the 2007 and 2008 old-incubator production records allowed calculation of the amount of energy used in the old incubation process in those years. Accordingly, the remaining energy use in the facility was related to the new incubation process. By using the remaining energy use together with records of chicks hatched in the new incubation equipment allowed calculation of kWh/chick and therm/chick values for the new equipment.

Taking the number of chicks per period hatched in the new incubators and multiplying by the amount of energy required per chick in the old incubation process yielded the amount of energy hatching an equivalent number of chicks would have taken using the old equipment. Savings were therefore the theoretical therm and kWh use in the old incubation process minus the actual use in the new incubation process. This methodology of savings calculation was deemed valid because the two incubation processes were identical (same type of egg rooms and hatchers) with the exception of the incubation equipment itself. Using this methodology, ex-post gross savings were calculated as 4,252 therms and 1,113,637 kWh.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 0% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown in Table U-1 below.

Table U-1: G20515 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
High Efficiency Burner and Economizer	0 of 10	0	No Influence	0	0 of 10	0	0	0%

Ex-Ante Net Savings

Discussions with the project engineer revealed that the measure would have been installed exactly the same way if Savings by Design had not been involved. His verbatim comment was: “We had already planned to install the measure”. He indicated the measure was installed in the interest of saving energy and that the monetary incentive was more or less a nice bonus. According to the site contact, plans for the project had already been developed when SBD became involved and the design assistance and analysis services we’re not at all important. This combination of answers yielded a 100% free ridership score and no net savings. Table U-2 below summarizes the results.

Table U-2: G20515 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
kWh	698,165	1,113,637	160%	0.00	0
peak kW	N/A	N/A	N/A	0.00	N/A
Therms	21,329	4,252	20%	0.00	0

V. G20516 Heat Loss Reduction, Combustion Air Preheating, and Load Preheating

G20516 received an incentive of $55,103.00 for installation of four independent measures at their metal processing facility: heat loss reductions for an indexing furnace and an age oven (1), combustion air preheating for the indexing furnace (2), combustion air preheating for two crucible furnaces (3), and load preheating for a jet melter (4). The heat loss reduction measure was implemented through the use of a continuous indexing oven as opposed to a baseline batch process. The baseline for both air preheating measures was identical systems without air preheating. For the load preheating measure, the melting process without load preheating was chosen as the baseline. During a site visit, the evaluation team verified the installation of the heat loss reduction and load preheating measures. The site visit revealed that the combustion air preheating measures had not been installed.

Ex-Ante Gross Savings

Ex-ante savings were calculated by the Program using DOE's PHAST software to model both the base and proposed cases. Annual operating schedules supplied by the client were applied to each piece of equipment to yield the savings estimates. PHAST analysis yielded the following savings estimates:

Table V-1: Ex-Ante Measure Gross Savings Estimates

Measure	Savings (therms)
1	1,337
2	9,016
3	17,182
4	64,306

Ex-Post Gross Savings

Savings were determined using monitored gas consumption data provided by facility personnel in conjunction with facility staff reported annual operating schedules for the equipment.

Heat Loss Reduction

For the heat loss reduction measure, monitored data was made available for the indexing furnace and age oven indicating the amount of gas consumed while ramping (i.e., starting the furnace cold start with unheated load), running production, and idling.

The installed continuous process achieved a reduction in heat loss by minimizing the amount of time spent in the ramping phase where gas use is highest. By places smaller bins of metal into the indexing furnace every 75 minutes as opposed to larger batches at greater time intervals, the temperature of the furnace is not altered substantially and the furnace can maintain steady state operation.

The facility staff was able to provide logged data from past operation of the furnace when material had been processed as a batch load. The time series temperature data demonstrated that introducing metal into the furnace as a single batch caused a 350 F drop in furnace temperature and required roughly 2.75 hours to bring the furnace back up to heat treat temperature. Similar information was not available for the age oven, which had never run in batches. Instead, a facility operator with considerable industry experience was interviewed. He indicated that if a single batch were placed in the aging oven, it would require about 2 hours to reach operating temperature.

Based on these time requirements, use schedules for baseline batch processing were developed by altering the installed equipment schedules to account for the increased time spent ramping the furnace and oven. Comparing the gas consumption of the baseline and installed equipment yielded an annual savings of 2784 therms for the heat loss reduction measure.

Combustion Air Preheating

As mentioned before, no savings were realized for either of the combustion air preheating measures because they were never installed. The evaluation team inspected the equipment for installation and also asked facility staff if the measures were ever implemented. The staff stated with certainty that combustion air preheating was never implemented.

Load Preheating

The fourth measure, load preheating for a Jet Melter, was analyzed by comparing the melting efficiency of the Jet Melter and a reverberatory furnace processing the same material, in a similar quantity over a similar amount of time. A comparative analysis was decided upon because access locations to measure inlet and outlet stack temperatures were not available. Secondly, the operations manager indicated that reverberatory furnaces are much more commonly used, making them a suitable standard practice baseline.

The jet melter and reverberatory furnace were compared using gas consumption and metal processing data from 28 days for the reverb furnace and 24 days for the jet melter. The operations manager described a schedule for the jet melter that was clearly demonstrated in the daily recorded data. The schedule demonstrated in the data was therefore extrapolated to an annual profile to establish the yearly load in pounds of aluminum. Savings from using the load preheating jet melter were then determined by comparing the gas consumption of the jet melter and reverberatory furnace for equivalent metal loads. This analysis yielded an annual savings of 105,209 therms.

Ex-Post Net-to-Gross Savings

A net-to-gross ratio of 57% was calculated for both installed measures from the three free ridership questions on the decision maker survey. The free ridership survey results are shown in Table V-2 below.

Table V-2: G20516 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Load Preheat Jet Melter	9 of 10	0.9	Easier Sell	1	5 of 10	1.5	3.4	57%
Heat Storage Reduction: Furnace & Oven	9 of 10	0.9	Easier Sell	1	5 of 10	1.5	3.4	57%

Ex-Post Net Savings

The respondent, an Executive Vice President, indicated that Savings by Design was influential in the implementation of the measure. SBD made the measures an "easier sell". There is a good chance the measures would not have been installed the same without the incentives. The respondent's combination of answers yielded a free ridership score of 3.4 out of 6 for a 43.3% free ridership ratio. Summaries of the total and measure specific results are presented in the tables below.

Table V-3: G20516 Measure 1 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Therms	1,337	2,784	208%	0.57	1,577

Table V-4: G20516 Measure 2 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Therms	9,016	0	0%	0.57	0

Table V-5: G20516 Measure 3 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Therms	17,182	0	0%	0.57	0

Table V-6: G20516 Measure 4 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Therms	64,306	105,209	164%	0.57	59,618

Table V-7: G20516 Total Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Therms	91,841	107,992	118%	0.57	61,195

W. G20526 Reduced Excess Air and Improved Refractory Performance of Forging Furnaces

G20526 received a capped incentive of $500,000 for installing oxygen trim systems on 17 700 series furnaces and 3 400 series furnaces. The oxygen trim system uses a PID control scheme to reduce combustion excess air. Reducing the furnace excess air use results in a hotter flame and minimizes the amount of energy needed to heat the combustion air itself. Consequently, reducing excess air results in higher combustion efficiencies and saves natural gas.

G20526 also installed ceramic fiber insulation in the same furnaces. Energy savings from using ceramic fiber insulation instead of firebrick alone are twofold. Ceramic fiber insulation has a higher R-value than fire brick, resulting in reduced heat loss during furnace operation. Furthermore, the specific heat capacity of ceramic fiber insulation is also less than firebrick's, meaning that less energy is required to bring the furnace to temperature during start up.

During the site visit, the evaluation team was unable to directly verify the installation of the measures due to concurrent equipment operation. The surface temperatures of two furnaces were measured however to confirm the surface temperature conditions specified in the implementation report. The site contact ultimately provided combustion gas analysis results indicating the reduced excess air set point of the installed system.

Reduced Excess Air Savings

Ex-Ante Gross Savings

Ex-ante savings calculations were performed using the DOE's PHAST software. The report does not contain any information documenting the PHAST inputs. Ex-ante savings were determined using an assumed operating schedule of 6912 hours/year at an average loading of 60% for all ovens. For the base case, an excess air input of 40% was assumed. The installed case was assumed to run at 16% excess air. Beyond this information, the report contains no information on the actual calculation methodology.

Ex-Post Gross Savings

Ex-post savings from the excess air trim system were calculated using a spreadsheet energy analysis. The goal of the analysis was to determine the functional operating efficiency of the installed and baseline furnaces based on exhaust gas temperatures and excess air content. Using annual gas use records, savings were then extrapolated based on the difference in the amount of gas required for the baseline and as-built furnaces to satisfy the load.

To complete this analysis, the following information was collected either during the site visit or through a data request following the site visit:

- Gas consumption for 5 of the affected furnaces (4 700 series, 1 400 series) over a 6 month period during 2008
- Combustion gas analysis results (including exhaust temperature and % excess air) for both furnace types at the two primary fire settings (bleed and ratio)

The provided data indicated that the 400 series furnace operates at exhaust gas temperature of roughly 1529 F for the bleed setting and 1627 F for the ratio setting. Excess air for the bleed and ratio settings was measured at 22% and 20% respectively. The tested 700 series furnace operated at 1987 F with 27% excess air on the bleed setting. When running ratio, the 700 series furnace operated at 1447 F with 18% excess air.

Using the exhaust gas temperature and excess air percentage together with the higher heating value of methane (assumed roughly equivalent to that of natural gas), the combustion efficiencies for both furnaces' bleed and ratio settings were determined. To develop the baseline efficiencies, the exhaust temperatures were assumed equivalent to the installed cases, while the excess air percentages were increased to 40% for both run settings. Overall efficiencies for both the baseline and as-built equipment were determined using a weighted average of the bleed and ratio efficiencies, where % operating time at each setting was used as the weighting factor.

With the efficiencies of both the baseline and as-built equipment determined, the process load of each furnace was next calculated by multiplying the annual gas use of the furnaces by their as built operating efficiency. The baseline energy required to meet the load was then calculated by dividing the process load by the baseline equipment efficiency. Savings were calculated as the difference in annual gas usage between the baseline and as-built furnaces. Since data was only provided for 5 of the furnaces, savings were scaled by furnace type to the total number of affected furnaces.

Improved Refractory Performance Savings

<u>Ex-Ante Gross Savings</u>

PHAST software was used to calculate savings from installing ceramic fiber insulation. The report contains no information regarding the baseline assumptions. The only specification provided in the implementation report indicates that the ceramic fiber insulation was installed to achieve furnace surface temperatures to 150 F. Baseline and as-built insulation properties and thicknesses were not provided.

Ex-Post Gross Savings

While onsite, the surface temperatures of both furnace types were verified to be below 150 F as specified. The site contact was highly uncooperative during the evaluation team's attempts to collect sufficient data to analyze this measure. After repeated attempts to gather sufficient information through follow up emails to the site contact, a data request was made through the utility. The site contact did comply with the data request, although the information provided in response to one of the key questions was insufficient. We asked "What is the standard practice firebrick thickness (when used instead of 16" of ceramic fiber insulation)?" He responded by providing the average dimensions of individual firebricks, not the wall thickness of the furnace as desired. Due to the time and effort already expended trying to gather information from the site, a second round data request was not made.

Savings were therefore calculated by applying the same gross realization rates determined for the oxygen trim measures to the insulation measures by furnace type.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 58% was calculated from the three free ridership questions on the decision-maker survey for all measures. The free ridership survey results are shown in Table W-1 below.

Table W-1: G20526 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
400 series excess air measure	10 of 10	1	Easier Sell	1	5 of 10	1.5	3.5	58%
400 series insulation measure	10 of 10	1	Easier Sell	1	5 of 10	1.5	3.5	58%
700 series excess air measure	10 of 10	1	Easier Sell	1	5 of 10	1.5	3.5	58%
700 series insulation measure	10 of 10	1	Easier Sell	1	5 of 10	1.5	3.5	58%

Ex-Post Net Savings

The site contact indicated that the Savings by Design program was highly influential because the possibility of an incentive made both of the installed measures an easier sell to management. However, the site contact also indicated that there was a decent chance the installed equipment would have been implemented in absence of the program. This combination of answers yielded a free ridership score of 3.5, indicating 42% free ridership.

Table W-2: G20526 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Therms	1,214,789	584,521	48.1%	0.58	340,971

Table W-3: G20526 Reduced Excess Air Measure Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Therms	613,300	291,942	47.6%	0.58	170,299

Table W-4: G20526 Improved Refractory Performance Measure Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Therms	601,489	292,580	48.6%	0.58	170,671

X. G20548 Warm Mix Asphalt Dryer and Lower Combustion Excess Air

G20548 received an incentive of $119,000 for installing a warm mix asphalt system and reducing the burner excess air fed into the asphalt dryer. The warm mix asphalt system is designed to save energy by allowing the drum mixer to operate at 260 F as opposed to 325 F—the standard temperature for hot mix applications. Reducing dryer combustion excess oxygen saves energy by increasing the amount of heat available to the process.

During the site visit, the evaluation team verified the installation of the proposed double barrel drum mixer with warm mix capabilities. Flue gas analysis tests were performed on site to spot check the combustion air excess O2. AQMD test results and instantaneous monitoring system readouts were also provided to verify the measured O2 readings.

Warm Mix Asphalt Dryer

Ex-Ante Gross Savings

Savings from running warm mix asphalt were calculated using a spreadsheet analysis with the following parameters:

- Anticipated annual warm mix production
- Warm mix mixing temperature
- Hot mix mixing temperature
- Aggregate moisture content before entering the drum mixer and after leaving the drum mixer

Based on these parameters, a constant specific heat analysis was performed to calculate the energy required to remove the moisture and heat the aggregate to the mixing temperature for the warm mix and hot mix cases. Savings were calculated as the annual difference in the process energy requirement for the warm mix and hot mix cases.

Ex-Post Gross Savings

During the site visit, the evaluation team learned that G20548 has not received any orders for warm mix asphalt from their customers. As such, in the past year, only hot mix asphalt has been produced --excepting the 3 to 4 truck loads of warm mix used to pave the small road running through their facility. This usage represents roughly .01% of their annual production. As such, no appreciable energy savings have been achieved through the installation of equipment capable of running warm mix asphalt. The site contact indicated that the company has been trying to sell warm mix asphalt to their clients but is having trouble convincing them to use it due to quality concerns (warm mix asphalt is a relatively new product).

Lower Combustion Excess Air

Ex-Ante Gross Savings

Savings from reducing the excess combustion O2 were calculated using a spreadsheet analysis. In this analysis, the amount of extra energy available to the process was computed by taking into account the added energy required to heat the excess air associated with running at a higher % excess O2.

Ex-Post Gross Savings

Tests and information provided on site proved that savings were not achieved from this measure either. While on site, three readings (taken roughly 1 minute apart) of combustion excess O2 were taken. The results were: 12.9%, 12.8%, and 12.8% excess O2. AQMD test results provided by the site contact contained excess O2 readings of 13.2%, 13.2% and 13.4%. An instantaneous computer readout also showed excess O2 running slightly greater than 13%. Since the measured readings were confirmed from two other independent tests, it was determined that the dryer runs at the baseline excess O2 of 13% claimed in the site report, not the reduced 10% setting used for the savings calculation. As such, no savings were attributed to this measure.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 17% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown in Table X-1 below.

Table X-1: G20548 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Double Barrel Drum Mixer w/ Warm Mix Asphalt and Reduced Excess Air	0 of 10	0	Easier Sell	1	0 of 10	0	1	17%

Ex-Post Net Savings

The site contact indicated that the program had little influence on installation of either measure. He stated that the equipment would have been installed anyways, but the presence of an incentive made it an easier sell to management. This combination of answers yielded a free ridership score of 1, indicating 83% free ridership.

Table X-2: G20548 Warm Mix Asphalt Dyer Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Therms	92,117	0	0.0%	0.17	0

Table X-3: G20548 Lower Combustion Excess Air Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Therms	106,217	0	0.0%	0.17	0

Table X-4: G20548 Savings Comparison Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Therms	198,334	0	0.0%	0.17	0

Y. G70010 High Efficiency Double Rack Ovens

Project G70010 was implemented at a wholesale retail grocery store. The store owners received an incentive of $6,000.00 for installing three high-efficiency double-rack convection natural gas ovens. Double rack ovens are tall stainless steel boxes capable of high production in a compact space. Energy savings were realized through increased oven efficiency. Increased oven efficiency was realized through burner excess air reduction and the use of "power burners". Power burners reduce cooking time, thereby reducing overall energy use during the cooking process. The installed ovens are rated at 55.7% baking efficiency. The measure baseline ovens are rated at 50% oven efficiency under heavy loads. The evaluation team verified the installation of the three high efficiency Hobart double rack ovens during the on site inspection.

EX-Ante Savings

The project file indicates the therm savings associated with this measure but does not indicate the methodology used to estimate the savings. The only information quoted in the project file is the oven efficiency relative to the baseline efficiency. The evaluation team believes that the energy savings were calculated based on the efficiency difference and annual operating hours.

Ex-Post Gross Savings

Ex-Post gross energy consumption was calculated based on the rack oven energy input rate, rate of energy consumption at different load conditions, and annual operating hours at each of these load conditions. The evaluation team's site inspection involved a comprehensive interview with the oven operator. The oven operator had intimate knowledge of the ovens and their operating schedules. During the interview, daily, weekly and annual oven operating schedules were collected. We also collected relevant information such as preheat time, oven operating temperature, oven idle time, and cooking times for heavy load (full capacity), medium load (half capacity) and light load (quarter capacity) conditions.

The above collected parameters along with the energy consumption at various load conditions were used to estimate annual energy use of the rack ovens. The equation used for calculating the annual energy consumption of the rack oven is as follows:

Equation 1

$$DR_{T\text{-}EX\text{-}Post} = [(P_{HE} \times P_{HT}) + (I_{DE} \times I_{DT}) + (H_{LE} \times H_{LT}) + (M_{DE} \times M_{LT}) + (L_{LE} \times L_{LT})] \times d/yr$$

where

$DR_{T\text{-}EX\text{-}Post}$ = annual Ex-Post energy consumption (therms/ yr)

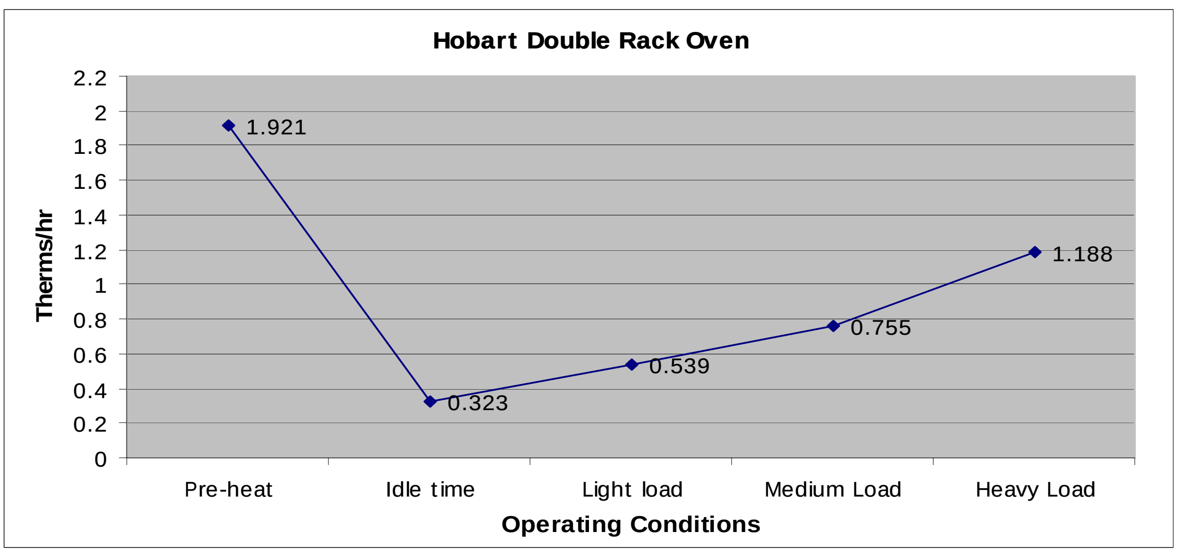
$P_{HE,}$ $I_{DE,}$ $H_{LE,}$ $M_{DE,}$ $L_{LE\ =}$ rate of energy consumption for preheat, idle, heavy load, medium load and light load conditions (therms/minutes)

$P_{HT,}$ $I_{DT,}$ $H_{LT,}$ M_{LT} and L_{LT} =preheat time for idle, heavy load, medium load and light load respectively (minutes/day)

d/yr = operating days in an year (358 days)

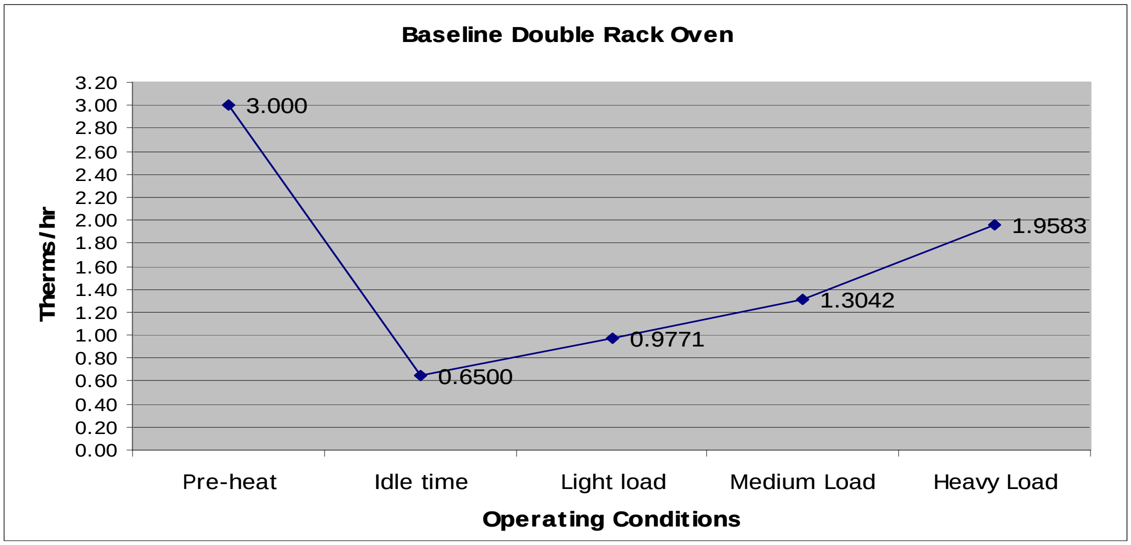
Rated energy input rates for various loading conditions as well as pre-heat and idle energy consumption were obtained from the Food Service Technology Center. The technology center had performed tests on the incented Hobart double rack ovens in which they recorded the energy required to preheat the oven from room temperature to 400 °F. These tests also included recording energy consumption at different load conditions as well as energy consumption at idling. Figure Y-1 details the energy required to operate the Hobart double rack oven at various operating conditions.

Figure Y-1: Energy Input Rate of the Hobart Double Rack Oven at Various Operating Conditions



Similarly, baseline energy consumption data was also obtained from Food Service Technology Center. The data obtained was an average energy consumption based on the test performed on multiple baseline rack ovens. Baseline oven energy consumption rates at various operating conditions are provided below in Figure Y-2.

Figure Y-2: Energy Input Rate of the Baseline Double Rack Oven at Various Operating Conditions



Baseline energy consumption was estimated using the same equation (Equation 1) used to calculate the ex-post energy consumption. In this equation, operating hours at different load conditions were held constant for the proposed oven. Energy input rates at each of the five operating conditions were changed to reflect the baseline conditions according to the values in Figure Y-2.

Ex-post gross energy savings were simply the difference between the baseline energy consumption and ex-post energy consumption of the oven. The calculated energy savings for each double rack oven was 2,624.95 therms per year. The oven operator indicated that all three ovens have equivalent load and operating schedule. Therefore, the gross oven savings is simply three times the single oven savings.

The energy efficiency measure saved more than expected. The evaluation team believes that two potential reasons for this discrepancy exist. Either the ex-ante calculation was performed with a shorter schedule, or the baseline used for the ex-ante calculation was different that used for the ex-post estimation.

<u>Ex-Post Net-to-Gross Savings</u>

A measure net-to-gross ratio of 67% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown below in

Table Y-1.

Table Y-1: G70010 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Ovens	5 of 10	0.5	Design Assistance	2	5 of 10	1.5	4	67%

Ex-Post Net Savings

Discussions with the facility owner indicated that while SBD was influential in the implementation of the measure. The site contact said the Program is particularly useful because it verifies the validity of energy efficiency ideas generated within the company. The site contact stated that SBD representatives are helpful because they either "confirm what we think [about an energy efficiency project], refute it, or cause us to rethink it". The site contact also indicated that in the absence of the program, there is a "50/50" chance they would have gone with different equipment because the installed ovens were very expensive. The site contact's combination of answers yielded a free ridership score of 4.0 out of 6, or 33.0% free ridership. Site net savings were therefore 67.0% of gross savings.

Table Y-2 below summarizes the results.

Table Y-2: G70010 Savings Summary

	Ex-ante Gross Savings	**Ex-Post Gross Savings**	**Gross Realization Rate**	**Site Net to Gross Ratio**	**Ex-Post Net Savings**
Therms	6,312	7,875	125%	0.67	5,250

Z. P29205 Variable Speed Drives on Pumps

P29205 received an incentive of $4,583 for installing VSD controls on three waste water pumps at their pumping station. During the site visit, the evaluation team verified the installation of VSD controls on two 75-hp dry weather pumps and one 250-hp wet weather pump and spoke to the plant operator to gather information used to calculate energy savings. The baseline specification for pumping stations is level control with constant volume waste water pumps.

Ex-Ante Gross Savings

Ex-ante savings were calculated by the Program using ASD Master software. The Program assumed that the dry weather pumps operate for seven months of the year during which a fixed number of gallons would need to be pumped. Similarly, it was assumed that the wet weather pumps operate for the remaining five months of the year and are required to pump a fixed amount of water. The ex-ante savings calculations for both the dry and wet weather pumps aimed to determine the ideal VSD controlled pump flow rate that would maximize pumping efficiency while minimizing head losses. Once this flow rate was determined, the pumps were then assumed to operate at the optimal speed for the number of hours it would take to pump the required number of gallons. The dry weather pumps' optimum efficiency was found to be at 93% speed. The wet weather pump was calculated to operate most efficiently at 87% speed.

For the base case, it was assumed that the dry weather pumps operate at full power for the number of hours it takes to pump the annual dry weather flow. Similarly, the baseline wet weather pump was assumed to function at full speed for the number of hours required to pump the wet weather flow.

Ex-Post Gross Savings

The evaluation team spoke with the plant operator to determine the pump operating schedules. These discussions revealed that the two dry weather pumps alternate in operation. When a dry weather pump can no longer meet demand, it shuts off and the wet weather pump turns on. The plant operator was also able to provide 9 months (January to September 2008) of instantaneous pump flow and power readings spaced in roughly 3 hour intervals from which to conduct the savings analysis. Figure Z-1 and Figure Z-2 below exhibit the raw power data:

Figure Z-1: P29205 Dry Weather Pump (75-hp) Monitored Load Profile (Jan-Sept 2008)

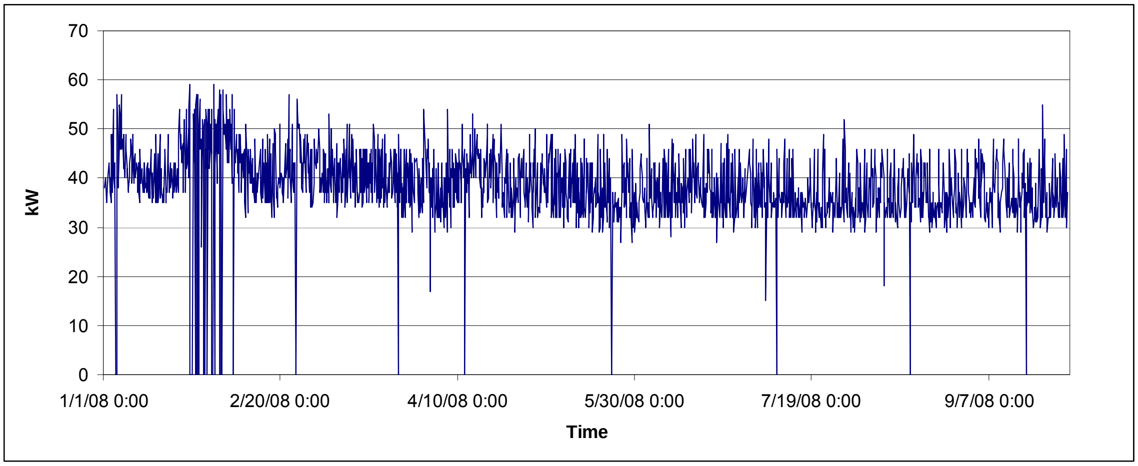
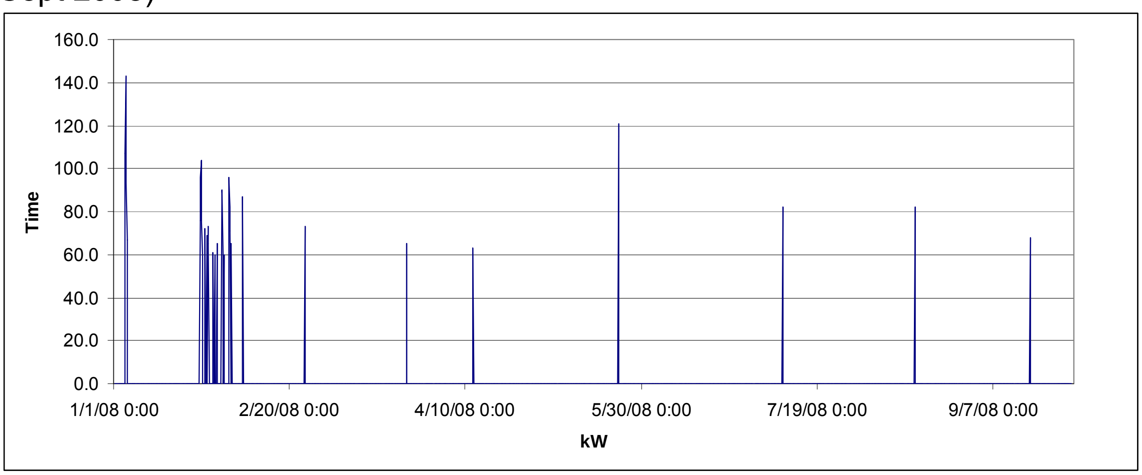


Figure Z-2 : P29205 Wet Weather Pump (250-hp) Monitored Load Profile (Jan-Sept 2008)



To begin the analysis, the power and flow data for both the wet and dry weather pumps was used to calculate the pumping efficiency as a function of flow rate. The intended purpose of this exercise was to find the pumping efficiency at full speed operation for both pumps (i.e., the baseline condition efficiency). However, when the efficiency versus flow data was plotted, it became clear that the motor efficiency was positively correlated to flow rate.

Based on the available data, pumping efficiency was defined as motor power input divided by flow rate in millions of gallons per day (MGD).

Figure **Z-3** and Figure Z-4 below show the pumping efficiency curves for both the dry and wet weather pumps.

Figure Z-3: Dry Weather Pump Efficiency as a Function of Flow Rate

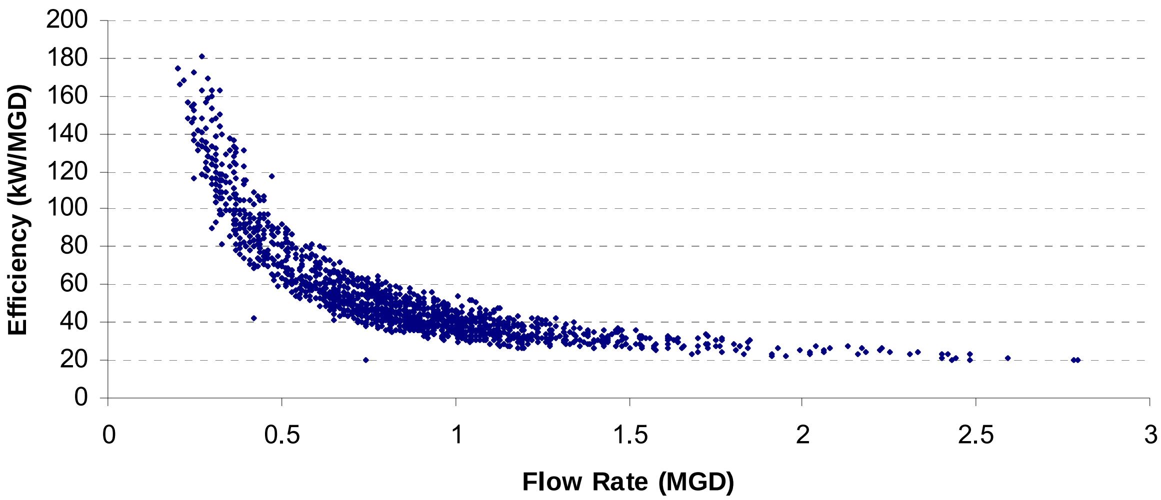
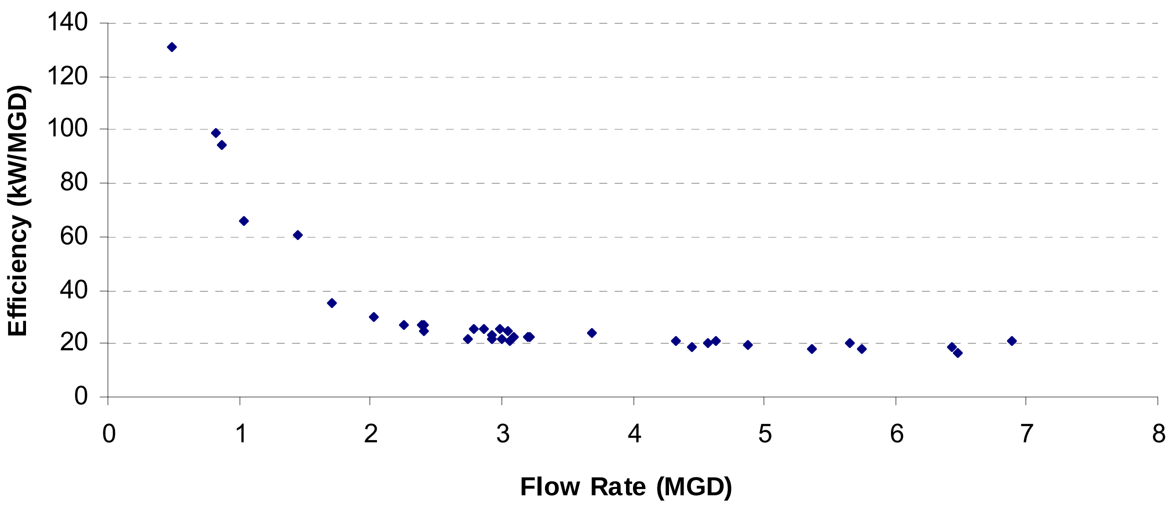


Figure Z-4: Wet Weather Pump Efficiency as a Function of Flow Rate



Notice that the pumping efficiency increases with flow rate for both pumps. Also, the data indicate that both the dry and wet weather pumps generally operate at low loads.

Clearly, the pumps due not maintain operation at an optimum efficiency set point as assumed by the Program for the ex-ante calculations.

If a level control strategy had been implemented at this site, the pumps would always operate near their optimum efficiency, at higher flows, and for less hours each year. The VSD control strategy as currently implemented does not save any energy because the pumps rarely operate at their peak efficiency.
Although the data in
Figure **Z-3** and Figure **Z-4** clearly indicate that the pumps do not operate near their peak efficiency using the current VFD control strategy, negative measure savings were still calculated.

1) To begin the analysis, the as-built energy use over the nine month monitoring period was determined by integrating the kW profile.

2) To determine baseline energy use, the full load efficiencies (kW/MGD) of both the baseline and as-built pumps were first determined. The dry weather pumps' efficiency was determined from the metered data by isolating the data points where the dry weather pumps were operating near peak capacity (between 57 and 59 kW) and finding the average flow rate. The wet weather pump efficiency could not be taken from the metered data because the wet weather pump never ran at full speed. As such, the full load flow of the wet weather pump was determined based on the intersection of the pump and system flow vs. head curves (contained in the project file).

3) The total facility flow was next calculated by integrating the flow rate measurements taken over the monitoring period. This allowed calculation of the number of hours that the baseline dry weather and wet weather pumps would have to run continuously to meet the facility's load.

4) The baseline energy use was compared to the as-built energy use to determine savings on a month by month basis over the nine month monitoring period. Savings were extrapolated to an annual schedule by assuming that the October's flow was equivalent to September's, November flow was half way between September's and January's, and December's flow was equivalent to January's.

Using the above methodology resulted in *negative* savings of 137,331 kWh. This result only confirmed what was clear from
Figure **Z-3** and Figure **Z-4**: the pumps do not typically operate in their efficient range, and thus lose money with the VSD control strategy.

Because the implemented control strategy operates less efficiently and uses more energy than an equivalent system with level control, no savings were achieved through the VSD measures implemented at this facility.
‘

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 50% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown in Table Z-1 below.

Table Z-1: P29205 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
VSD on Pump Motors	0 of 10	0.5	Easier Sell	1	0 of 10	1.5	3	50%

Ex-Post Net Savings

The site contact indicated that Savings by Design was somewhat influential in both the implementation process and the decision to implement the proposed measures. He stated that “we probably would have considered it [the VSDs] anyways, but the incentive helped ensure that we had the latest and most efficient equipment.” The site contact’s combination of answers yielded a net savings score of 50%. Since our analysis yielded zero ex-post gross savings, there were no net savings for this project. Table Z-2 summarizes the results.

Table Z-2: P29205 VSD Pump Motors Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net to Gross Ratio	Ex-Post Net Savings
peak kW	0.0	0.0	N/A	0.50	0
kWh	45,826	0.0	0%	0.50	0

AA. P36334 Efficient Compressed Air Distribution System

Project P36334 received an incentive of $30,000 for installing a new, more efficient compressed air system. The new compressed air system consists of a 200-hp two-stage variable speed drive air compressor, a variable speed air dryer and four no-loss drains. The baseline system consists of a 200-hp constant speed screw compressor with inlet modulation and a standard dryer that operates continuously. The evaluation team verified the installation of the measures and evaluated the impacts using data from loggers installed during the visit.

Air Compressor Savings

<u>Ex-Ante Gross Savings</u>

Ex-ante gross savings were estimated by the Program using DOE's Air Master^{+} Software. The baseline and as-built compressed air models were simplified to fit the modeling constraints of the software. Savings were calculated as the difference between the baseline and as-built systems' energy use.

<u>Ex-Post Gross Savings</u>

The team determined ex-post gross savings primarily by calculating the difference between baseline and post-installation usage with the assistance of AirMaster^{++} software. A data logging approach was used to provide the software with accurate load profiles. Key steps for determining gross savings were as follows:

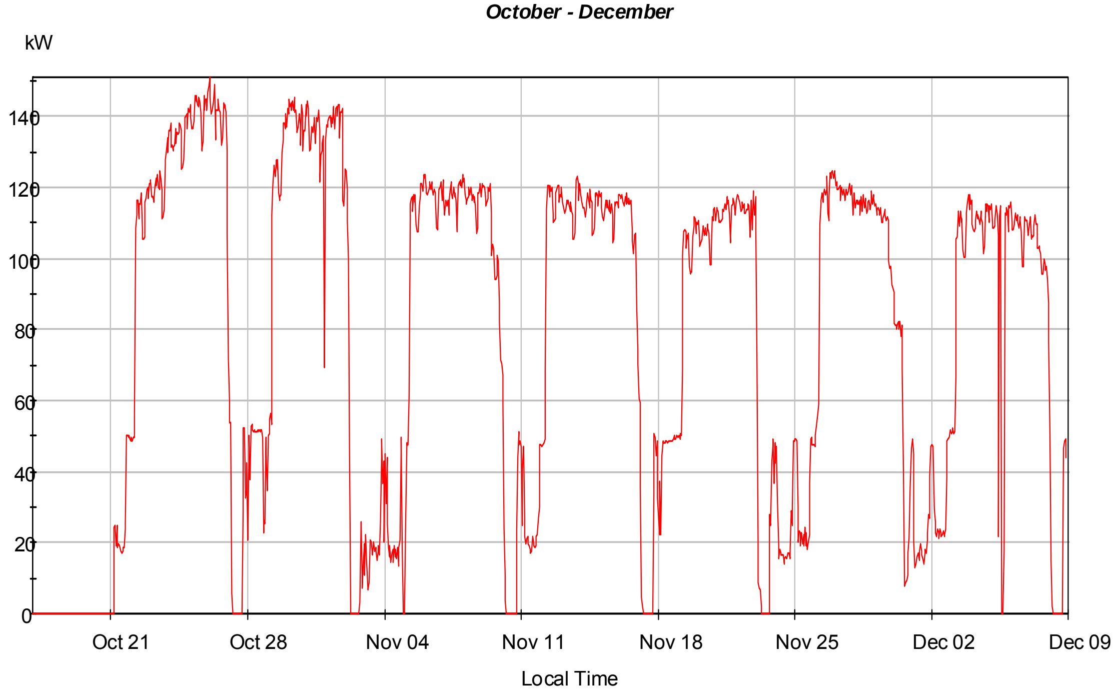
1) Data loggers were installed on both the 200-hp VSD compressor and variable speed dryer for six weeks during November and December 2008. The metered parameters are shown in Table AA-1 below.

Table AA-1: P36334 Metered Equipment

Incented Equipment	Metered
200 hp VSD Air Compressor	Yes
VSD Air Dryer	Yes
4-Air Loss Valves	Verified

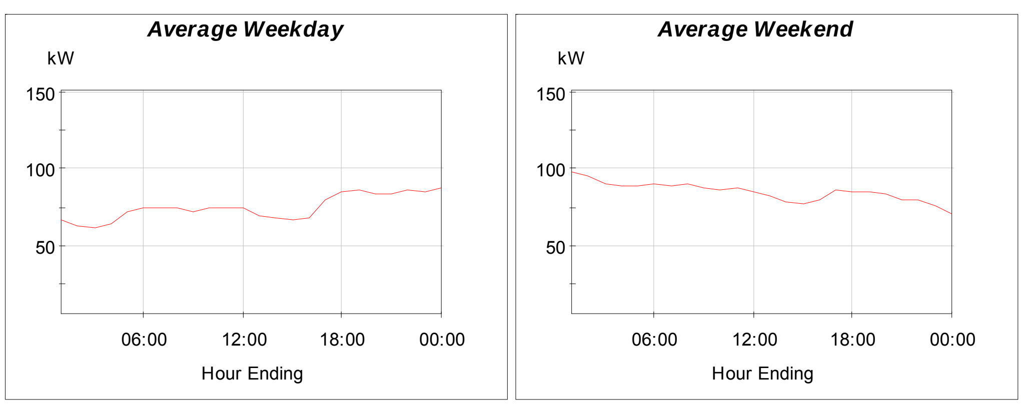
Figure AA-1 displays the metered air compressor data collected over the course of the monitoring period.

Figure AA-1: P36334 Air Compressor Power Profile for Monitored Period



1) Hourly power profiles for weekdays and weekends were generated from raw data (Figure AA-2). Logged data indicate that the compressor operates 24 hours per day and 7 days per week, Hourly power profiles reveal that the compressor operates at higher load on weekends than on weekdays.

Figure AA-2: P36334 Hourly Power Profile of the Air Compressor



2) Data collected during the site visit was next used to inform an AirMaster+ compressor model. The software inputs included facility elevation, air system pressure, air storage capacity (receivers), and air flow profiles by production day types. Two day types were created to reflect the difference between the weekday and weekend operating profiles

3) Next, the compressor type was selected from the Air Master+ database based on operating pressure and rated power. The system automatically assumed an airflow range for the selected compressor based on its operating pressure pressure. The as-built compressor controls were selected as inlet modulation with unloading since AirMaster+ does not currently have a VSD control option. The AirMaster+ compressor power vs. flow curve was then modified to reflect VSD controls. Note that air flow remains unchanged for both baseline and as-built conditions.

4) Finally, the logged hourly power data was input for each day type. Once all of these options were selected, the program modeled the energy consumption of the compressor.

5) For the baseline model all inputs except for the compressor controls were left unchanged. The control type was set to a baseline strategy of constant volume with unloading. The unloading point was changed from 20% load for the as-built compressor to 50% load for the base case. Furthermore, while the as-built compressor unloads at roughly 25% power, while the baseline compressor unloads at 70% power. The modeling software was then used to calculate the power draw of the baseline compressor using the airflow profile generated from the as-built model.

Figure AA-3 and Figure **AA-4** show the flow percentage vs. power percentage curves for the 100-hp baseline compressor and as-built 100-hp VSD air compressors respectively. For purposes of comparison, the as-built and baseline weekday power profiles are presented below in

Figure AA-5 and Figure **AA-6**.

Figure AA-3: P36334 Baseline Compressor Performance Profile

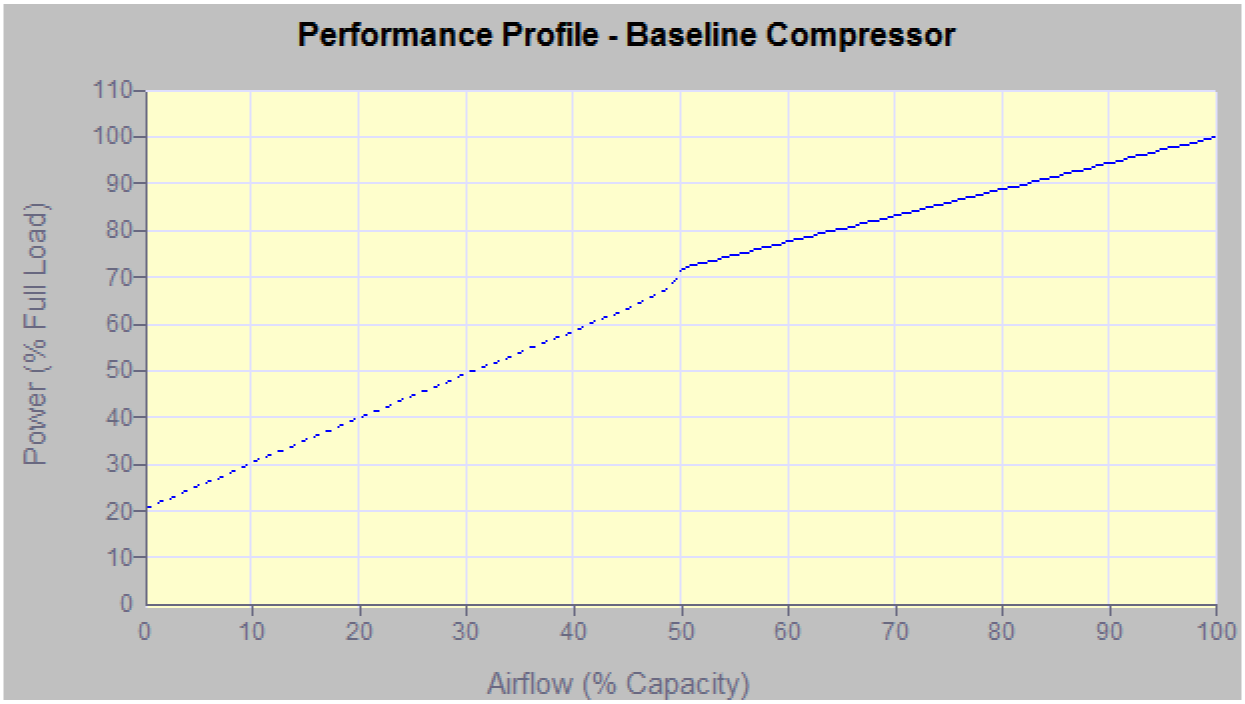


Figure AA-4: P36334 VSD Compressor Performance Profile

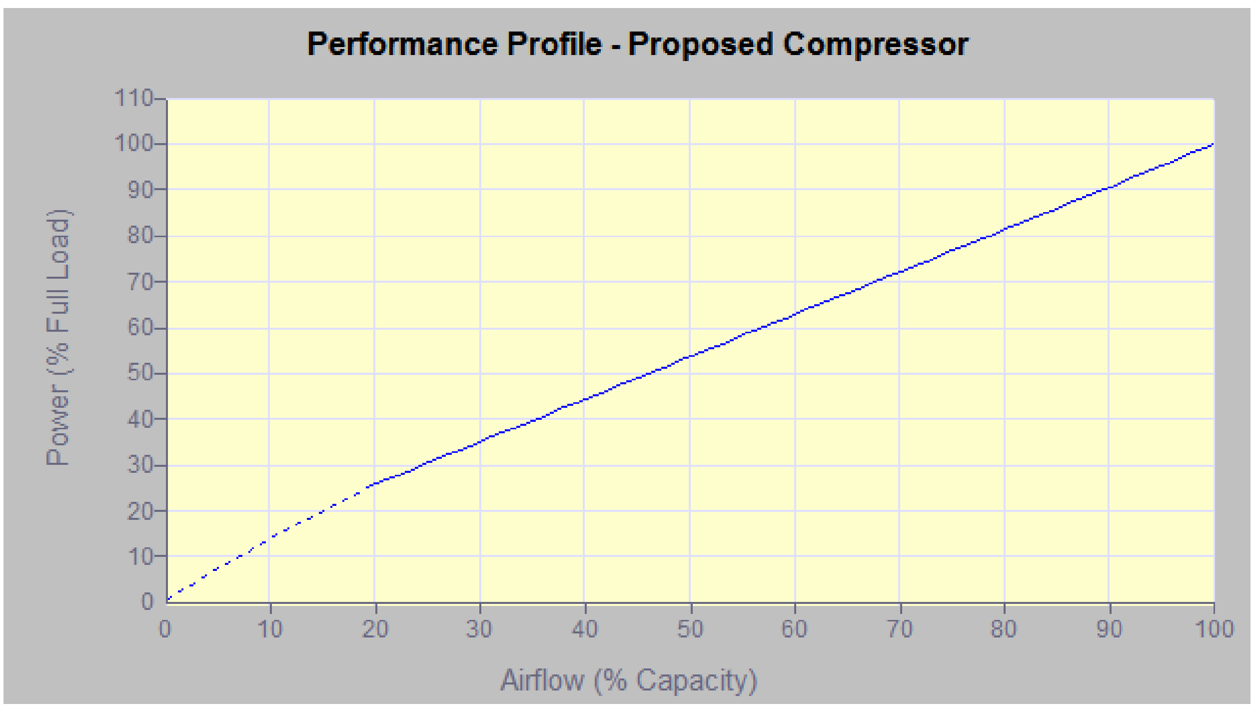


Figure AA-5: P36334 200 hp VSD Compressor Power Profile

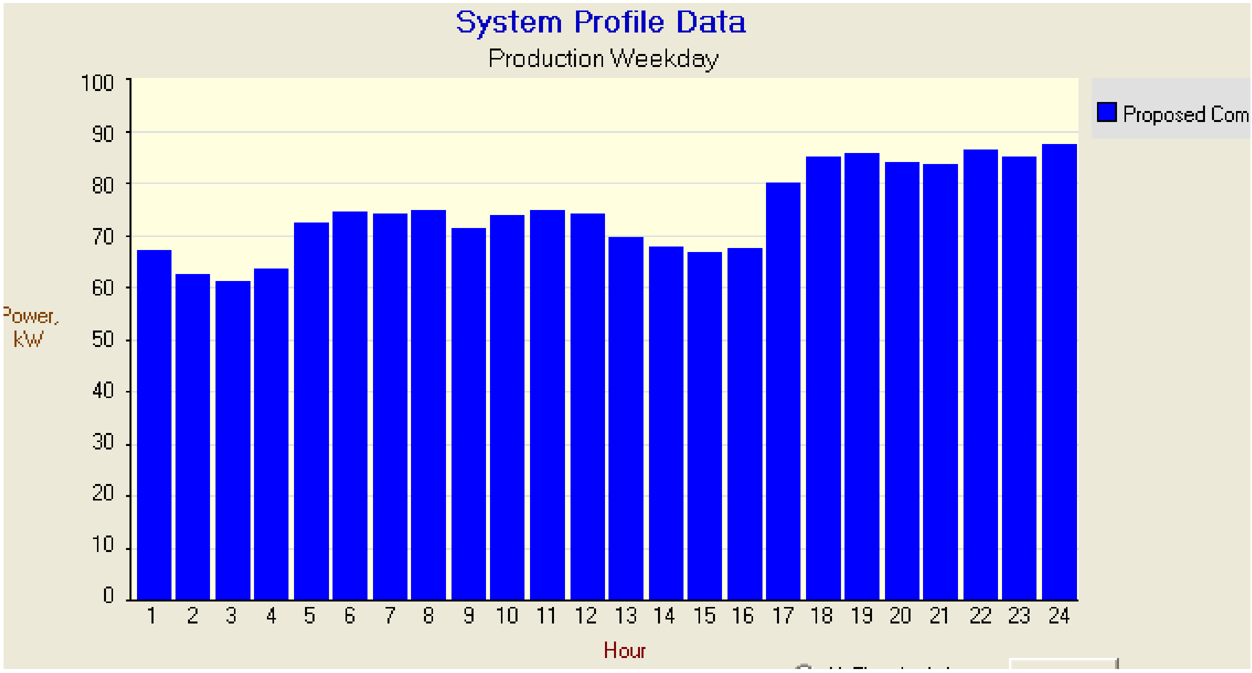
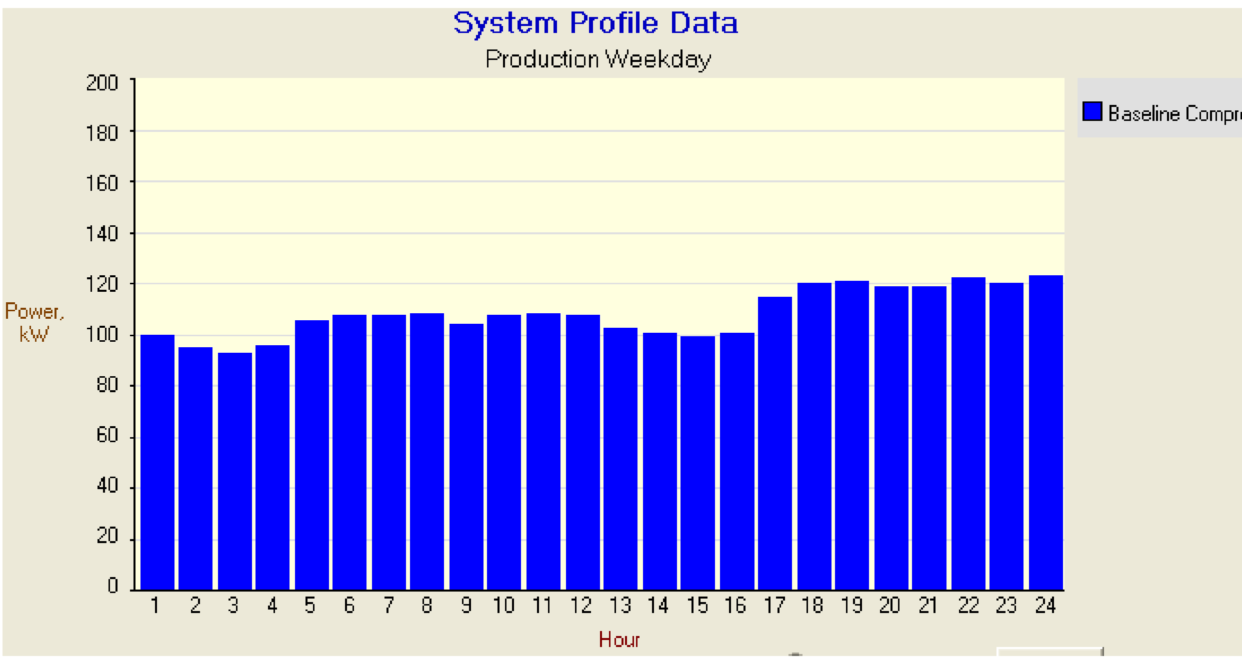


Figure AA-6: P36334 200 hp Baseline Compressor Power Profile



6) Savings were calculated using the annual energy and peak demand usage estimates generated with the AirMaster+ software. Savings were simply the difference between the baseline and as-built usage.

Dryer Savings

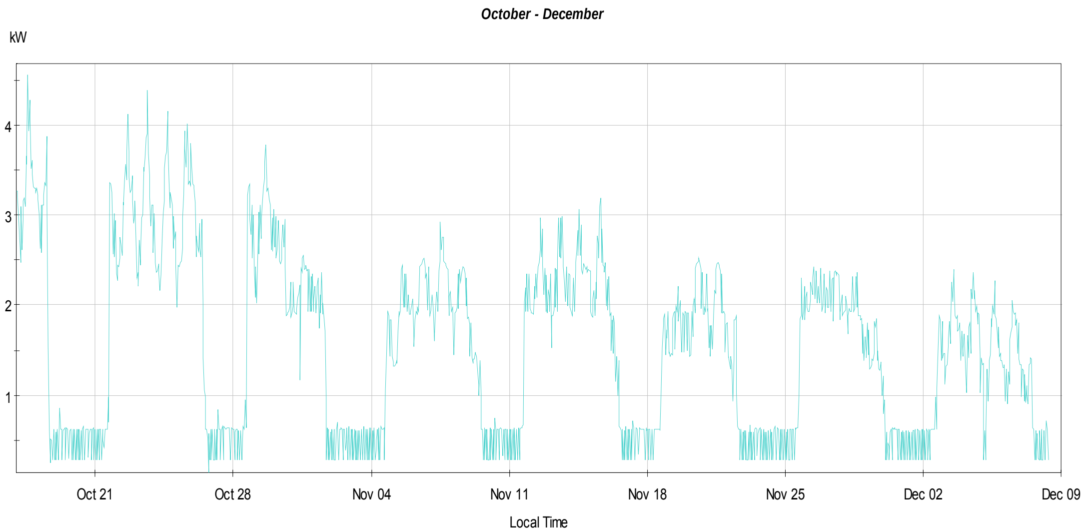
Ex-Ante Gross Savings

Ex-ante gross savings were also estimated by the program using DOE's AirMaster+ Software as part of the overall compressed air model.

Ex-Post Gross Savings

We calculated the dryer savings using the average metered dryer power and the annual operating schedule. Data was logged in 15-minute intervals over a 6 plus week period coinciding with the air compressor's monitoring period. The logged dryer data collected over the monitoring is shown in Figure AA-7 below.

Figure AA-7: P36634 VSD Dryer Metered Data



Simple spreadsheet analysis was carried out to estimate the energy savings of the VSD dryer. The above metered data showed the dryer to be modulating to match changing compressed air demands of the facility. As this site is a 24-hour facility and the production process is same throughout the year, metered data should be representative of the typical power profile of the dryer.

1) To begin the analysis, the metered data was imported into data visualization software and re-sampled to an hourly profile.

2) This hourly power profile was then input into a spreadsheet and extrapolated to an annual profile. The as-built dryer's annual energy usage was determined by integrating the hourly kW profile. The peak power draw of the dryer was calculated based on the average power draw of the dryer during weekdays between the hours of 2 and 5 PM.

The dryer baseline was simply taken as the full load power of the dryer running at all hours of as-built dryer operation. Ex-Post gross savings were calculated by subtracting ex-post energy consumption from baseline energy consumption.

Project Impacts

Both energy efficiency measures saved less energy than projected. For the VSD air compressor measure, the ex-ante savings estimate was based on a 200-hp VSD compressor in comparison to 250-hp constant speed baseline compressors, whereas our gross savings model compared a 200-hp VSD compressor to a 200-hp constant speed compressor. In the case of the air dryer, ex-ante savings were estimated based on the assumption that the dryer load would be less than it is in practice. As such, the higher dryer load reduced the savings relative to the constant speed baseline.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 92% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown below in Table AA-2.

Table AA-2: P36334 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
VSD on Air Compressor; VSD on Air Dryer & No Air-Loss Drains (4)	10 of 10	0.8	Investment Criteria	2	9 of 10	2.7	5.5	92%

Ex-Post Net Savings

The facility representative indicated that the program was very influential in their implementation of an efficient compressed air system. A SBD representative first suggested this measure. The site contact also stated that the measure would not have installed in the absence of the program. This combination of answers yielded a net savings score of 5.5 out of 6, or 8% free ridership. Therefore, the ex-post net savings for the air compressor and the variable speed dryer were evaluated at 92% of the ex-post gross savings as summarized in Table AA-3 and Table **AA-4**.

Table AA-3: P36334 Air Compressor Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net to Gross Ratio	Ex-Post Net Savings
peak kW	75.1	36.0	48%	0.92	33.1
kWh	337,911	302,509	90%	0.92	278,308

Table AA-4: P36334 Air Dryer Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net to Gross Ratio	Ex-Post Net Savings
peak kW	10.1	6.3	62%	0.92	5.8
kWh	63,279	37,066	59%	0.92	34,101

BB. P40920 Variable Frequency Drives on Pumps, High Efficiency Lighting, Low Solar Heat Gain Coefficient Glazing

Variable Frequency Drives on Pumps
High Efficiency Lighting
Low Solar Heat Gain Coefficient Glazing

Project P40920 received an incentive of $53,687 for installing variable frequency drives on three 100-hp membrane feed pumps, three 30-hp dissolved air flotation (DAF) recycle pumps, two 10-hp rev filtration pumps and two 2-hp recycle pumps. The baseline equipment for this measure was constant volume pumps of similar capacities and was also confirmed from the facility engineer. The evaluation team verified the installation of the measure and calculated its impacts using data from loggers installed during the visit. During the evaluation we found that all three installed membrane pumps were 125 hp instead of 100 hp and all DAF pumps were 40 hp instead of 30 hp as indicated in the file.

Ex-Ante Gross Savings

Ex-Ante savings were determined by the Program using a simple engineering equation that is used for determining the power of Pumps. The primary parameters used in the equation were pump hp, efficiency, operating hours and load factor. The assumed load factors in the estimation were 80 % for membrane pumps, 75% for DAF pumps, 90% for rev filtration pumps and 60% for recycle pumps. Ex-ante gross savings for the lighting measure were determined using projected lighting hours, number of fixtures and rated lamp wattage

Ex-Post Gross Savings

Variable Speed Drive

The evaluation team calculated ex-post gross savings by comparing the annualized energy use of the baseline and as-built systems. Data logging was used to inform spreadsheet calculations performed for this analysis. The following steps were undertaken to determine gross savings:

1) The evaluation team installed data loggers on two 125-hp membrane pumps and two 40-hp DAF pumps for a period of 4 weeks during the month of October 2008. According

to facility personnel, the other 125-hp and 40-hp pumps served as back up pumps and never ran.

Table BB-1 below presents the metered pumps. The data loggers recorded kW data in five minute intervals.

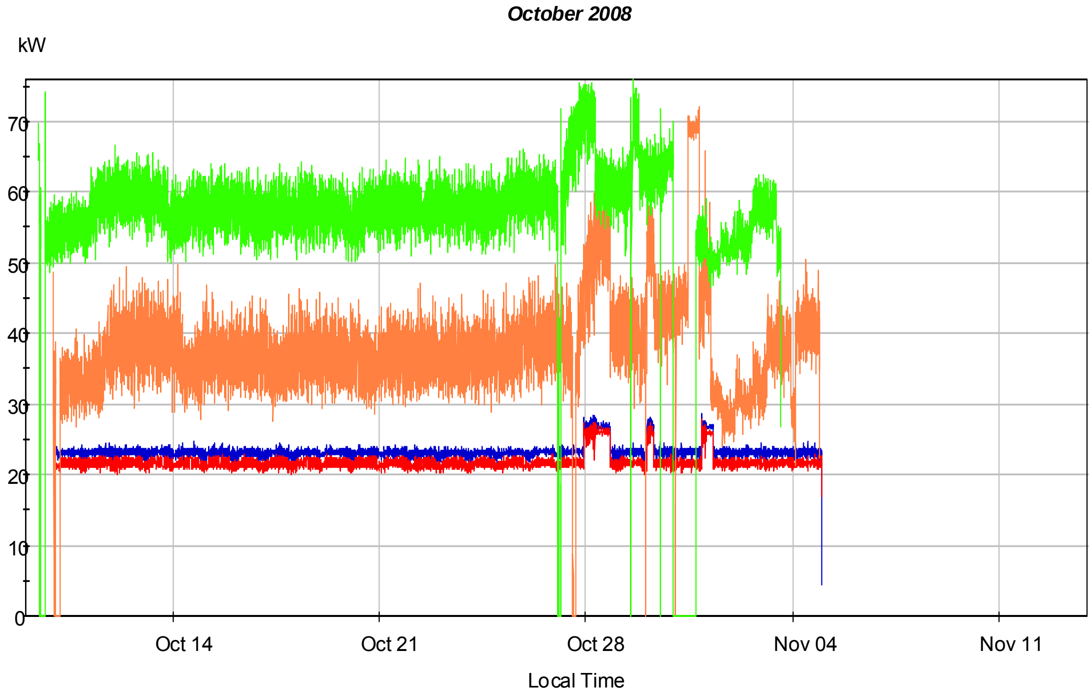
Table BB-1: P40920 Incented Pumps

Incented Equipment	Metered
VFD 125 hp Membrane Pumps (3)	2
VFD 40 hp DAF Pumps(3)	2
VFD 10 hp Rev Filterration Pumps	0
VFD 2 hp recycle pumps	0

2) The evaluation team imported the recorded data into a data visualization application. Figure BB-1 displays the raw data for two 125-hp membrane pumps and two 40-hp DAF pumps for the monitoring period. The power profile indicates that all the pumps were continuously running during the monitoring period. Facility personnel confirmed that the schedule remains consistent throughout the year.

The graph below shows that there was little variation in the power draw of both DAF pumps throughout the monitoring period.

Figure BB-1: P40920 Raw Data of the Pumps for the Monitoring Period (DAF P-1: Blue, DAF P-3: Red, Membrane #2: Orange, Membrane # 3: Green)



3) By correlating the hourly kW values with pump speed using an EPRI VSD curve (kW vs. Speed); we found that the DAF pumps were modulating between 60% and 70% of their full load speed. The membrane pumps were fond to modulate between 25% and 55% of full load speed.

4) Energy consumption over the 624 hour (26 days) monitoring period was found by integrating the monitored power profiles.

5) Annual kWh usage was determined by multiplying the metered kWh by 14 (8760/624). Peak demand was simply the average monitored kW between 2 PM and 5 PM on weekdays. The assumed baseline condition consisted of constant volume pumps operating continuously.

Ex-post gross savings were calculated by subtracting ex-post power consumption from baseline power consumption. DAF pumps saved 101,173 kWh annually and achieved 3 kW in peak demand reduction. Membrane pumps saved 474,505 kWh per year with a demand reduction of 6.4 kW.

High Efficiency Lighting

The evaluation team used a simple spreadsheet method to estimate the lighting savings for this project. During the site visit we verified the installation of the high efficiency lighting and confirmed the annual operating hours. Following equation was used to estimate the lighting savings for this project.

$$kWh_{LTG\text{-}SVG} = [((ft^2 \times T\text{-}24\ W/ft^2)/1000) - ((\#\ Fix \times W/Fix)/1000)] \times hr/yr$$

where,

$kWh_{LTG\text{-}SVG}$ = annual lighting energy savings (kWh)
ft^2 = area of the affected building (ft^2)
T-24 W/ft^2 = title 24 watt per square feet (1.1 w/ft^2)
Fix = number of installed fixtures
W/Fix = watts consumed per fixture (watts)
hr/yr = annual operating hours of the lighting fixtures.

Project Impacts

While high-efficiency lighting measures ex-post savings matched ex-ante savings, the VSD measures saved less energy than projected because load factors used in the ex-ante estimation were higher than the actual load factor.

Ex-Post Net-to-Gross Savings

Measure net-to-gross ratios of 33%, 90% and 100% were calculated for the VFD induction motor, LPD, and low SHGC measures respectively. The free ridership survey results are presented in
Table **BB-2** below.

Table BB-2: P40920 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Induction motors with VFD	10 out of 10	1	Easier Sell	1	0 of 10	0	2	33%
LPD	10 out of 10	1	Suggested or Introduced	2	8 of 10	2.4	5.4	90%
Low Solar Heat Gain Coefficient Glass	10 out of 10	1	Suggested or Introduced	2	10 of 10	3	6	100%

Ex-Post Net Savings

The facility owner indicated that the program was very influential in the implementation of all three measures. He stated that the incentive made the VFD project an easier. An SBD representative first suggested the LPD and SGHC measures. The owner also stated that they definitely would not have installed thee SHGC measure without interaction with the SBD Program. For our ex-post net savings evaluation, this combination of answers yielded a free ridership score of 4 out of 6, or 33% free ridership for the VFD measure. Therefore, the ex-post net savings for the VFD pumps were estimated as 67% of the ex-post gross savings as summarized Table BB-3. The net savings from the lighting measure were estimated as 90% of ex-post gross savings. Since the SHGC definitely would not have been installed in the absence of the program, net savings were 100% of ex-post gross savings. The savings summaries for the LPD and SHGC measures are presented in
Table **BB-4** and Table **BB-5** respectively.

Table BB-3: P40920 VFD Pumps Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to Gross Ratio	Ex-Post Net Savings
Peak kW	79.6	71.61	90%	0.67	47.7
kWh	680,323.0	605,107.3	89%	0.67	403,404.9

Table BB-4: P40920 Lighting Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Peak kW	0.7	0.70	100%	0.90	0.6
kWh	2,052.0	2,052.0	100%	0.90	1,846.8
Therms	-13	-13	100%	0.90	(11.7)

Table BB-5 P40920 Glazing Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
kWh	(260.0)	(260.0)	100%	1.0	(260.0)
Therms	4	4	100%	1.0	4.0

CC. P41498X Variable Speed Drives and Premium Efficiency Motors on well Pumps

P41498X received an incentive for installing premium efficiency motors and variable speed drives on two of their well pumps. 1992 EPACT standard efficiency motors were used as the motor efficiency measure baseline. Constant volume pumps with throttle valve control were used as the VSD measure baseline. The evaluation team verified the implementation of the measure with a site visit. During the verification, one pump was operating at very low load and the other pump was not operating at all. Hence, the evaluation team collected flow and kW data from the facility monitoring system to evaluate this measure.

Ex-Ante Savings

ASD Master Software was used to evaluate the energy savings for the variable speed drive measure. The program created a baseline energy model with throttled valve control and an as-built energy model with VSD control in ASD Master. Savings were estimated simply by subtracting the as-built model usage from the baseline model usage. Premium efficiency motor savings were calculated by assigning different motor efficiencies to the baseline and as-built motors in the model.

Ex-Post Gross Savings

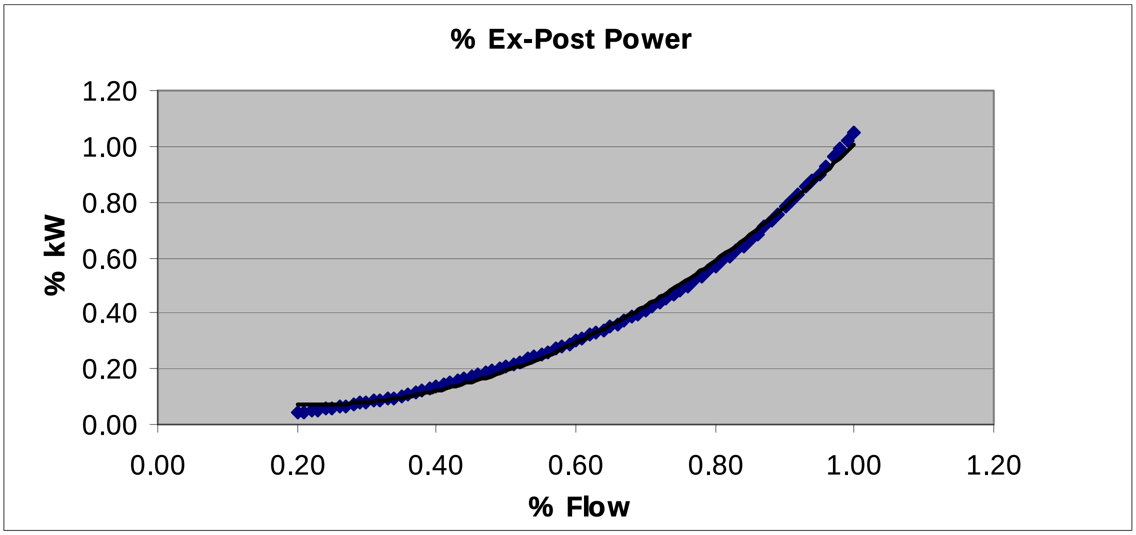
The evaluation team determined measure savings using a spreadsheet analysis. The calculations were based on as-built pump flow rate data provided by the facility engineer. As-built pump power consumption was calculated from flow rate data using EPRIs pump % flow vs % kW table. To begin this analysis, a curve fit was performed on the table data to develop a functional relationship between flow and power. The regression curve is illustrated in

Figure CC-1**.**

The site contact was able to provide simultaneous spot measurements of flow and power consumption for a few operating points. Mapping one of these specified state points to the EPRI curve using the power percentage (calculated based on the spot measurement and the rated motor power) provided a means of determining the system flow at 100% pump power. Maximum system flow was simply the measured flow divided by the flow percentage at that point on the EPRI curve.

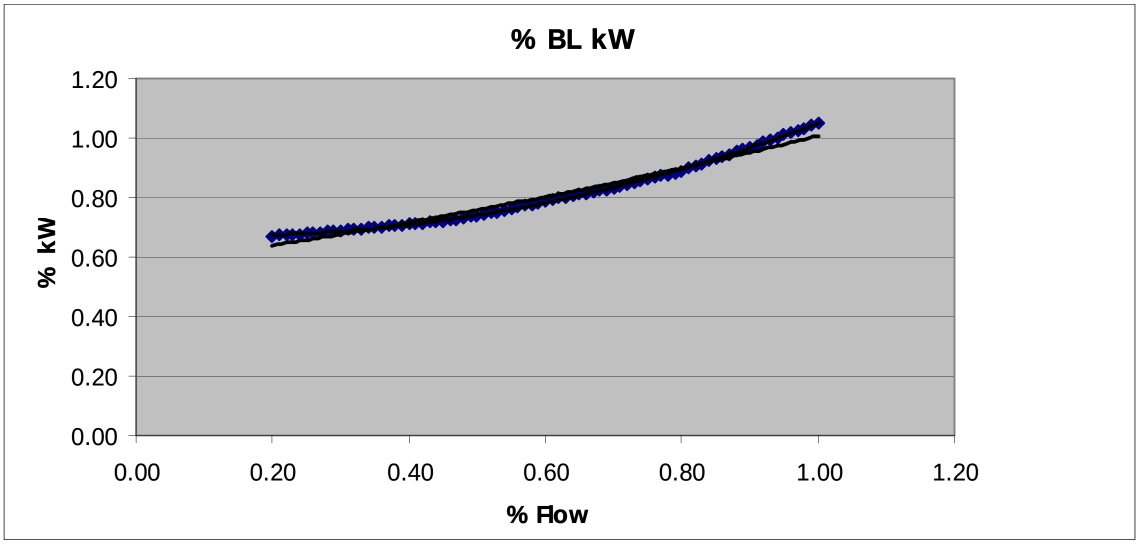
With the maximum flow determined, it was then possible to map all metered flows to a % flow rate and determine their corresponding power %. In this way, a complete power profile was generated from the metered data. The annual energy consumption of the pumps was determined based on the number of hours the pumps spent at each of the specified flow rates.

Figure CC-1: Regression Trend for % Speed versus % VFD kW of The Pumps



Baseline energy consumption was determined using an identical procedure with EPRIs % speed vs % power curve for throttle valve controlled pumps. The regression trend used for the baseline pumps is illustrated in Figure CC-2.

Figure CC-2. Regression Trend for % Speed vs % Baseline kW of The Pumps



Energy savings were simply the difference between baseline energy consumption and ex-post energy consumption. Similarly, peak demand savings were calculated by subtracting ex-post demand from baseline demand.

Demand savings for the premium efficiency motor measures were calculated by estimating the difference in power draw between standard efficiency and premium efficiency pumps. This demand savings was then multiplied by the annual operating hours to calculate the energy savings from the premium efficiency motor measure. The following equation was used to calculate the savings.

$kW_{SVG\text{-}PE} = ((kW_{VSD\text{-}BL} \times \eta_{PE}) / \eta_{SE}) - kW_{VSD\text{-}BL}$

where,

$kW_{SVG\text{-}PE}$ = demand savings due to installation of premium efficiency motor (kW)
$kW_{VSD\text{-}BL}$ = power draw of constant volume pump (kW) baseline kW of the VSD measure
η_{PE} = efficiency of 300 hp premium efficiency motor
η_{SE} = efficiency of 300 hp standard efficiency motor

<u>Project Impacts</u>

The evaluation team determined that the savings from the VSD measure were nearly identical to the projected ex-ante savings. The pumps were operating at lower load than expected hence one should expect a lower energy savings but the operating hours associated with it was higher than the ex-ante estimate which resulted in higher energy savings.

Motor efficiency savings were however considerably less than predicted in the ex-ante estimate. The well pumps were found to run at lower loads than originally projected, resulted in lower demand savings as compared to ex-ante estimate which explains the discrepancy in efficiency savings.

Ex-Post Net-to-Gross Savings

Measure net-to-gross ratios of 35% and 50% were calculated for the VSD pump and premium efficiency motor measures respectively based on the three free ridership questions in the decision maker survey. The free ridership survey results are shown below in

Table CC-1.

Table CC-1: P41498X Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Load Preheat Jet Melter	9 of 10	0.9	Easier Sell	1	5 of 10	1.5	3.4	57%
Heat Storage Reduction: Furnace & Oven	9 of 10	0.9	Easier Sell	1	5 of 10	1.5	3.4	57%

EX-Post Net Savings

The facility representative indicated that Savings by Design was influential in implementing the premium efficiency motor measure. The incentive made upgrading to higher efficiency motors an easier sell and was the prime driver for installing premium efficiency motors because there is a substantial cost difference between standard efficiency and premium efficiency motors.

SBD had no influence on the variable speed drive measure and they would have exactly installed the same variable speed drives on the waste water pumps without the program incentive. This above combination of answers yielded a free ridership score of 3 for the premium efficiency motor measure and 2.1 for the variable speed drive measure. Hence, ex-post net savings from the PE motors were calculated as 50% of ex-post gross savings, where as ex-post net savings for the VFD measure were calculated as 35 % of the ex-post gross savings. Table CC-2 and Table CC-3 show the savings summaries for both measures.

Table CC-2: P41498X Savings Comparison of Premium Efficiency Motors

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net to Gross Ratio	Ex-Post Net Savings
kW	-	1.3	0%	0.50	0.6
kWh	30,789	7,700	25%	0.50	3,850

Table CC-3: P41498X Savings Comparison of Variable Speed Drive Pumps

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net to Gross Ratio	Ex-Post Net Savings
kW	-	27.7	0%	0.35	9.7
kWh	589,496	599,239	102%	0.35	209,734

DD. P41556 High Efficiency Almond Pasteurizer

P41556 received an incentive of $18,796.56 for installing a high efficiency almond pasteurizer. The pasteurizer uses a proprietary process that steams almonds in a vacuum chamber to an internal temperature of 150 F. The process saves energy by removing the need for oven drying, a process typically required in almond pasteurization applications.

<u>Ex-Ante Gross Savings</u>

Ex-Ante savings were determined relative to a baseline presumably developed through industry research. Because almond pasteurization is still a relatively nascent industry, the implementers developed a baseline from commercially available equipment. They arrived upon a baseline process whereby almonds are continuously fed through a 30' long 5'x5' uninsulated (R-1) pasteurization steam chamber. This process, which occurs at atmospheric pressure, increases the moisture content of the almonds from an average of 5.5% to 10%, necessitating the use of a dryer to remove the moisture content from the almonds.

This process was compared to the as built process, in which batches of almonds are fed into a vacuum chamber with R-38 insulation in the walls and roof and R-19 insulation in the floor. Drying is not required because steam does not condense on almonds in the vacuumed environment. Savings were calculated based on an assumed annual production volume of 164,736,000 lbs of almonds.

<u>Ex-Post Gross Savings</u>

To calculate ex-post savings, a second round of baseline research was conducted. At no point during the course of research was any information found regarding the use of uninsulated (R-1) chambers for the steam pasteurization process. For this reason, the baseline chosen by the implementers was rejected. Instead, savings were based on the key component of the process that differentiates the installed process from standard pasteurization processes: the lack of a separate drying component.

To calculate savings from the use of the vacuum process, the amount of energy required to remove the moisture typically added to almonds in standard pasteurization processes was calculated. To complete this analysis the following assumptions were made:

- The baseline process utilizes an 80% efficient drying oven (as assumed by the implementers)
- The amount of energy required to remove moisture from almonds is equal to water's latent heat of vaporization

Using these assumptions together with actual production data from a year following the project implementation (39,863,369 lbs/year), therm savings from removing the drying process were calculated.

At the same time, it was necessary to calculate the negative savings associated with using vacuum pumps continuously while running the as-built process. To calculate the vacuum pump energy usage, an annual operating schedule of 6552 hours/year was provided by the site contact. Since the pumps are constant volume, energy use was calculated based on the pump's full load power draw. A load factor of .8 was applied to the pumps to account for fluctuations in power draw associated with changes in the pressure vacuum pulled by the pumps.

It should be noted that the Program did account for energy use associated with the pumps in their calculation. However, they used a fuel switching factor of 10 kWh/therm to account for the reduction in energy savings associated with the vacuum pumps. Since fuel switching is not allowed by the program, negative kWh and peak kW savings are explicitly accounted for in the ex-post analysis.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 63% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown in Table DD-1 below.

Table DD-1: P41556 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Pasteurization Machine	7 of 10	0.7	Easier Sell	1	7 of 10	2.1	3.8	63%

Ex-Post Net Savings

The site contact indicated that Savings by Design was definitely influential in their decision to implement the as-built almond pasteurizer. He stated that there was a good chance a different pasteurizer would have been used in the absence of the program and the available incentive made his decision easier. The table provided below summarizes the savings results from P41556.

Table DD-2: P41556 Measure Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	-	-75.2	-	0.63	-47.6
kWh	-	(394,156)	-	0.63	(249,632)
Therms	23,496	24,177	102.9%	0.63	15312

EE. P42456 High Efficiency Boiler, VSD Boiler Blower and VSD Feed Water Pump

Project P42456 received an incentive of $16,249 for installing a high efficiency boiler system comprised of a high efficiency Hurst boiler and variable speed drives on both the boiler blower and feed water pump. During the site visit, the evaluation team verified the installation of the high efficiency boiler and VSD blower. However, a VSD was not found on the feed water pump. The team used a data logging approach to inform the savings calculation.

An 80% efficient industrial boiler was used as the baseline for the boiler measure. VSD boiler blower savings were calculated relative to an outlet damper baseline.

<u>Ex-Ante Gross Savings</u>

Natural gas savings for the high efficiency boiler were determined by the Program using a spreadsheet analysis to calculate the gas consumption for both the high efficiency and standard efficiency units. The calculation assumed the same steam load for both cases. The steam load was estimated from plant natural gas bills. Energy savings for both variable speed drive measures were estimated based on the average kWh consumption difference between the fan with an outlet damper and the fan with a variable speed drive, but there was no information available on the details of the calculation.

<u>Ex-Post Gross Savings</u>

Ex-post gross savings for the boiler were estimated using spreadsheet calculations. The input parameters used for the calculation were boiler gas flow rate, measured efficiency, load fraction and plant seasonal variations. According to facility personnel, the plant operates twenty-four hours a day and 360 days a year. The boiler runs at peak load from September through February. During the off-season the boiler operates at 70% of the peak season load.

Flue gas analysis performed on the 19.95 MMBtu Hurst Boiler yielded a combustion efficiency of 80.9%. Flow rates recorded by the plant monitoring system indicated that the boiler operates at 38% of full load during off peak times and ramps up to 54% of the full load during peak season. Our calculation takes into account the seasonality of the facility.

The evaluation team verified the installation of blower VSD, but did not identify a VSD-controlled feed water pump while on site. Savings were therefore zeroed out for the feed water pump measure.

Blower motor savings were calculated using metered data collected over a three week period. The key steps in the analysis were as follows:

1) A data logger was installed on the boiler blower for a period of three weeks during February 2009. The data logger recorded RMS blower power sampled in 15 minutes intervals.

2) The recorded data were imported into a data visualization and analysis application. Figure EE-1 gives the raw power data for the blower during the monitoring period. In addition,

Figure EE-2 illustrates the average day power profile of the blower. The data indicate the facility operates twenty-four hours a day. According to plant personnel, the blower has the same schedule throughout the year apart from some routine maintenance days. Maintenance days are reflected in Figure EE-1 between February 21 and 23.

Figure EE-1: P42456 Power Profile of the Blower for Monitoring Period

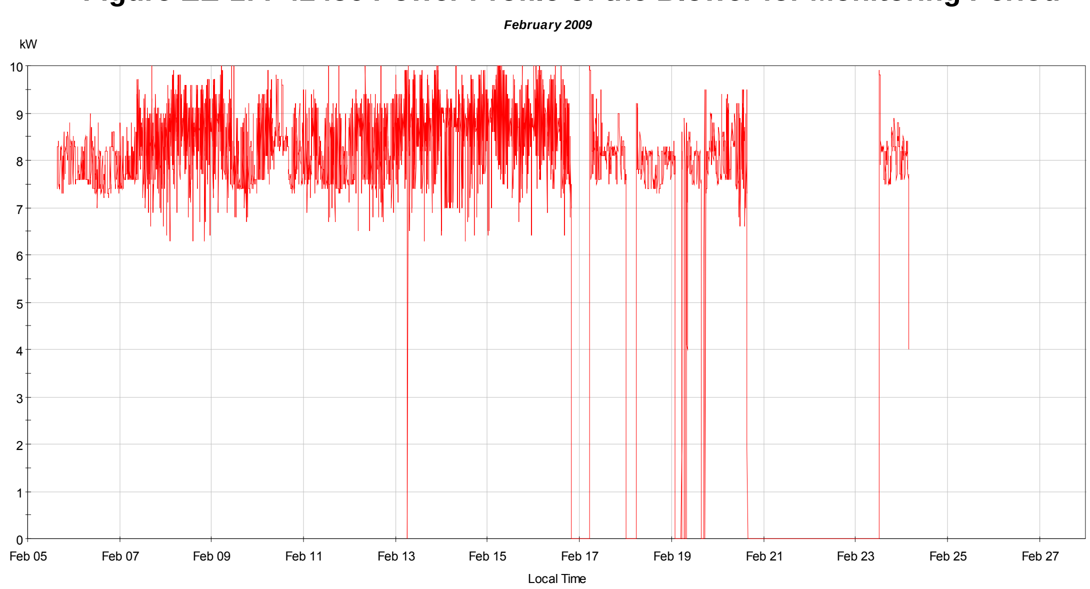
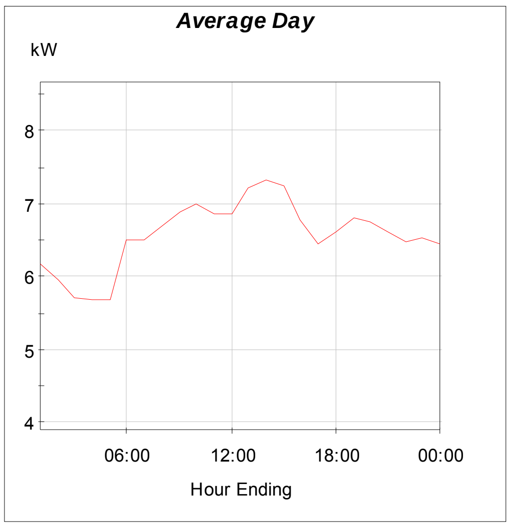


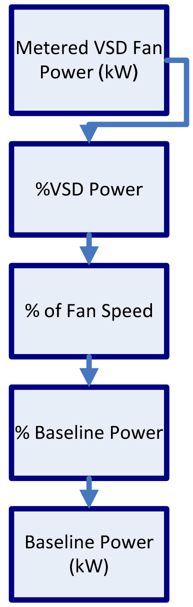
Figure EE-2: P42456 Average Daily Power Profile of the Blower



3) The evaluation team was provided with manufacturer fan curves for the baseline fan. The VSD fan curves were generated from kW v/s Hz data provided by the site contact. The VSD fan curve was used to calculate the actual speed of the blower.

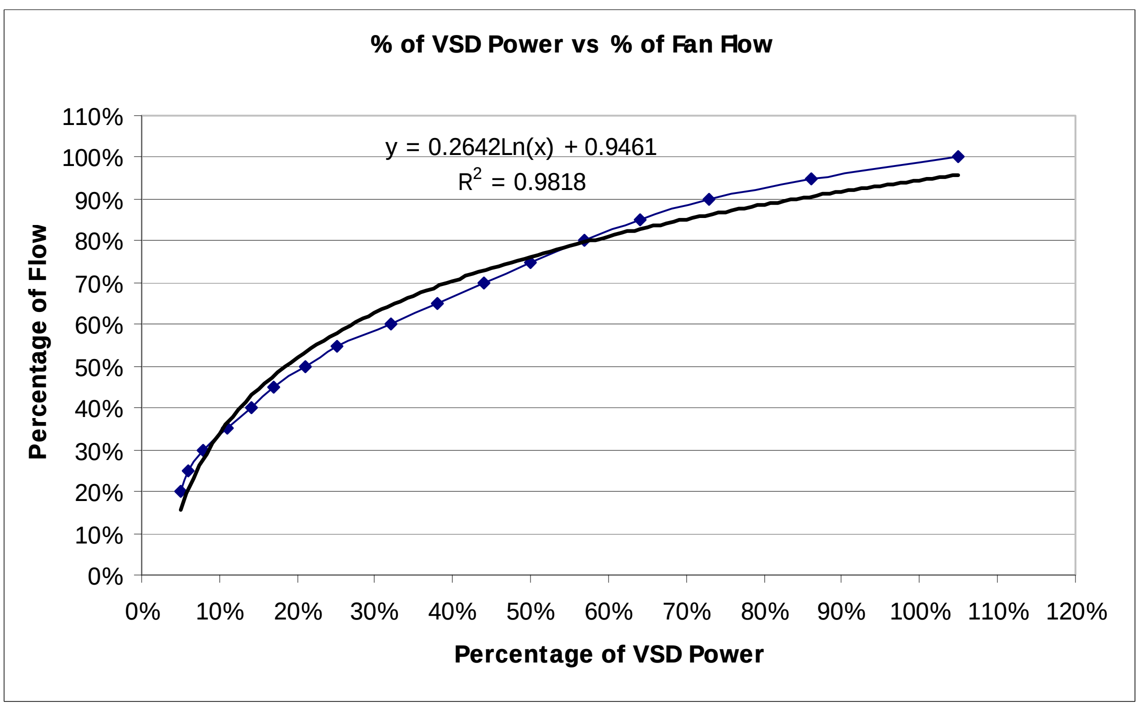
4) Using the baseline fan's HZ v/s kW curve, we next calculated baseline power. Figure EE-3 illustrates the blower motor analysis flow.

Figure EE-3: P42456 Blower Baseline Power Consumption Calculation Sequence



To begin the above analysis, the power fraction was calculated by dividing the logged power by the rated motor power. This process was repeated for all metered data points (sampled in 5 minute intervals). Next, the VFD percent speed was calculated using the fan curve shown in Figure EE-4.

Figure EE-4: P42456 %VFD Blower Power vs. % Speed Curve



The air flow (i.e. motor speed) was held constant between the baseline and as-built conditions. Therefore, the speed ratios calculated in the previous step were used in the power/speed curve for the baseline fan motors. This curve is presented in Figure EE-5.

Figure EE-5: P42456 % Blower Speed vs. % Baseline Power

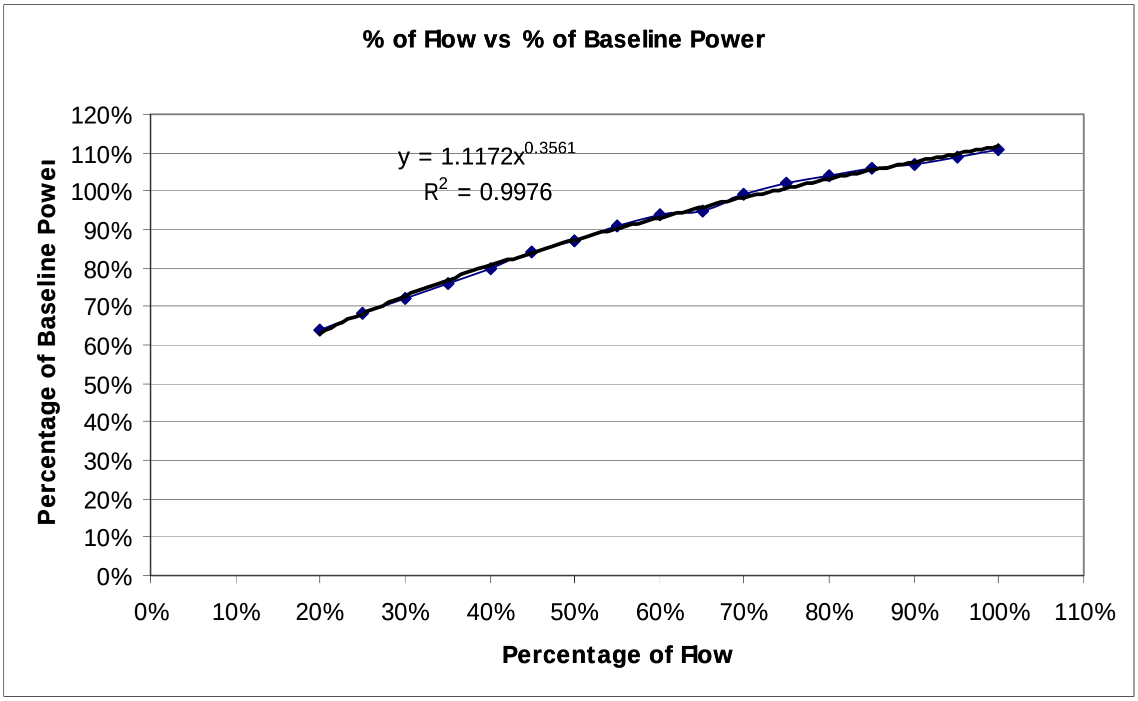
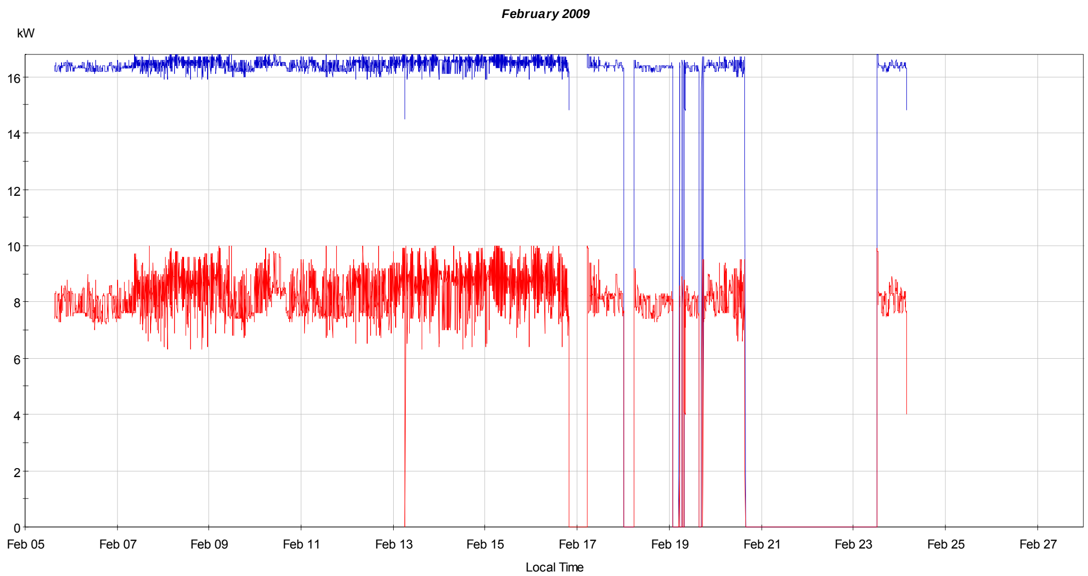


Figure EE-6 compares the evaluated and baseline power profiles over the monitoring period.

Figure EE-6: P42456 Comparison between Baseline and Evaluated Power Profile (Baseline-Blue & Red- Evaluated)



5) Savings were calculated by taking the difference between the metered as-built condition and calculated baseline condition. Savings were extrapolated from the monitoring period to an annual profile using scheduling information provided by the site contact.

Project Impacts

The energy savings for this measure were greater than expected because the blower was operating at at lower loads than claimed in the ex-ante estimate. Since variable speed drive motors are more efficient at lower loads, the savings were greater than expected. On the other hand, the high efficiency boiler saved less energy than expected because the load was less than predicted in the ex-ante calculation.

Ex-Post Net-to-Gross Savings

Measure net-to-gross ratios of 50% and 75% were calculated for the boiler and VFD measures respectively from the three free ridership questions on the decision-maker survey. The free ridership interview results are presented in Table EE-1 below.

Table EE-1: P42456 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
High Efficiency Boiler	5 of 10	0.5	Easier Sell	1	5 of 10	1.5	3	50%
VFD on Boiler Fan & Pump	10 of 10	1	Suggested or Introduced	2	5 of 10	1.5	4.5	75%

<u>Ex-Post Net Savings</u>

The facility owner indicated that the program was very influential in the implementation of these measures., The SBD representative first brought introduce the VFD measure. The San Joaquin Valley Air Pollution Control District had however already recommended a high efficiency boiler before the interaction with SBD representative. For our ex-post net savings evaluation, this combination of answers yielded a net savings score of 4.5 out of 6, or 25% free ridership for the VSD fan and 3 out of 6 or 50% free ridership for the high efficiency boiler measure. Therefore, the ex-post net savings for the VSD blower fan and the high efficiency boiler were evaluated at 75% and 50% of their ex-post gross savings as summarized in

Table EE-2 and

Table EE-3 respectively.

Table EE-2: P42456 VSD Boiler Blower Savings Summary

Boiler Blower and feed water pump	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	9.0	7.9	88%	0.75	5.9
kWh	79,638	60,733	76%	0.75	45,550

Table EE-3: P42456 High Efficiency Boiler Savings Summary

High Efficiency Boiler	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Therms	12,348	8,961	73%	0.50	4,481

FF. P43314 Variable Speed Drive Dust Collector and Daylighting

P43313 received an incentive of $8,590 for installed a dust collection system with variable speed drive control, and skylights with automatic lighting controls. The VSD dust collector savings were realized via two separate mechanisms. One, savings resulted from reduced dust collector fan motor energy usage. Two, the reduced exhaust air flow of the dust collector relative to the baseline constant volume dust collector decreased the make-up intake of outside air to the building, thereby reducing the heating and cooling loads. . Lighting savings were determined relative to a baseline building without skylights and daylighting controls. The evaluation team verified the installation of the measure during a site visit and calculated impacts using data from loggers installed during the site visit.

<u>Ex-Ante Gross Savings</u>

According to the program file, savings calculations for the VSD Dust Collector were made using a spreadsheet model constructed with one week's worth of kW data logged by the control system in 5 minute intervals. Energy consumption was compared to that of the constant volume base case using an EPACT high efficiency motor (as opposed to the installed premium efficiency motor) and extrapolated using an assumed operating schedule of 3,120 hours per year. Using the average power draw of the baseline dust collector and the VSD controlled dust collector, the relation that power is proportional to CFM cubed was used to determine an estimate of air flow for the VSD case. Interactive cooling and heating savings were then determined based on the amount of energy it would take to heat and cool the required make up air. A bin analysis was used to complete this analysis. Direct savings from the VSD measure were estimated as 76,018 kWh/yr. Interactive effects saving were calculated as 3,871 kWh/yr for cooling and 2,659 therms/yr for heating

Lighting savings from the 5 skylights and the associated daylighting controls were determined using an NCCalc (2006) simulation model of the space. Simulated savings were 1,790 kWh/yr with .9 kW in peak demand reduction.

<u>Ex-Post Gross Savings</u>

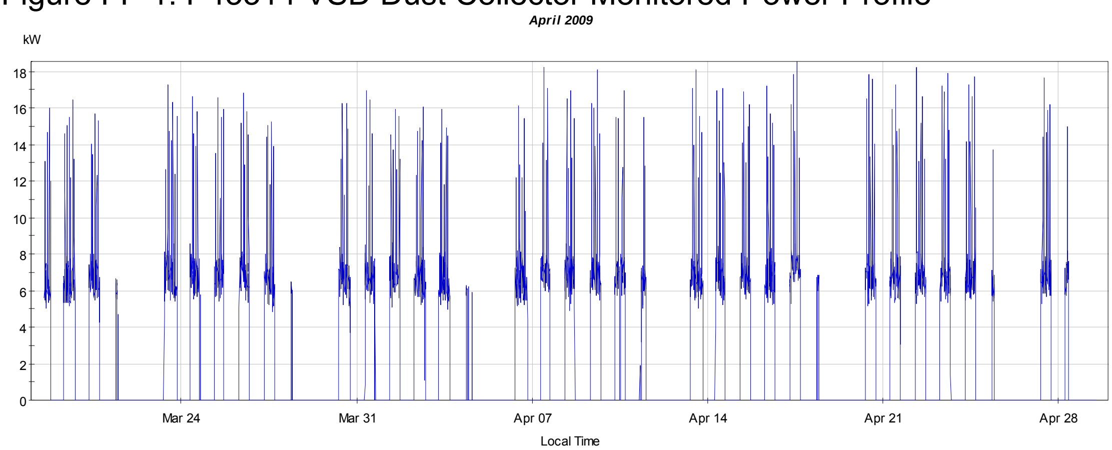
VSD Dust Collector

The team determined ex-post savings using spreadsheet calculations informed by metered data collected between site visits. Key steps for determining gross savings were as follows:

1) A data logger was installed on the dust collector to monitor energy consumption over a one month period from late March to late April 2009.

2) The monitored kW data, displayed in Figure FF-1 below, was imported into a data visualization and analysis application and extrapolated to a yearly operating schedule. The data logged at the facility was representative of the yearly operating usage because the facility operates year round on a standard schedule. Savings were taken as the difference in energy consumption between an equivalently sized constant volume dust collector (assumed to operate at full speed during all operating hours) and the VSD controlled dust collector. Savings from the use of a premium efficiency motor versus a high efficiency baseline motor were also considered in the energy savings calculation.

Figure FF-1: P43314 VSD Dust Collector Monitored Power Profile



3) Dust collector savings resulting from interactive effects with the AC systems were calculated based on the CFM exhausted from the zones served by the dust collector. A VSD fan curve was used to calculate the CFM draw of the dust collector fan at each of the hourly averaged kW loads measured. An overall average system draw of 4769 CFM was then calculated.

4) The required replacement air load was then divided among the packaged AC units according to dust collector usage rates in the various zones. These usage rates were approximated based on discussions with the facility operator.

5) A bin analysis was then performed to determine the cooling and heating loads as a function of changes in outdoor temperature and the added outdoor air load of the dust collector.

6) To establish system efficiency data for the analysis, cooling efficiency (EER) vs. return dry bulb curves were made based on available manufacturer performance data. Return dry-bulb temperatures for each outdoor air temperature bin were calculated based on an energy balance of the mixed return air volumes, comprised of both outdoor makeup air and indoor air. Using the aforementioned cooling efficiency curves, the efficiency of each AC unit was determined for each bin and used to calculate the associated peak kW and yearly kWh draw.

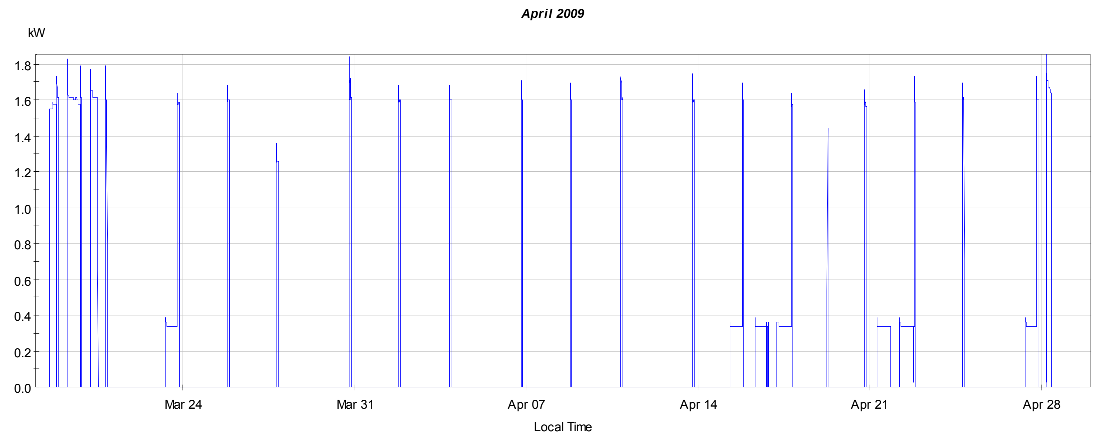
7) A second bin analysis (identical in methodology) was done for heating using the published AFUE of the packaged units in the dust collector served zones. The analysis for both heating and cooling was then repeated for the base case's constant volume requirement of 12,000 CFM. An extra 10 ton system (identical to the one already installed) was modeled to meet the airflow demands of the constant volume system. The energy use of the constant volume system was then compared to the energy use of the variable volume system to determine AC savings associated with the dust collector.

Peak demand kW savings associated with the interactive effects of the dust collector are weather dependent in nature. As such, kW savings were calculated using the 9 hottest hours from the bin analysis. This method was selected because it most closely approximates the kW draws that would be found during peak time on the three hottest consecutive days of the summer.

Daylighting

1) Lighting savings were determined by logging the energy consumption of daylighting controlled lights from late March to late April. The data from this logging interval is provided below in Figure FF-2.

Figure FF-2: P43314 Automatically Controlled Lighting Associated with Skylights



2) The kWh consumption was then compared to the baseline kWh consumption comprised of identical lighting without skylights or daylighting controls. For this case, the lights were assumed to be on at all times during normal operating hours in addition to the extra hours observed during the monitoring interval. Comparing the energy consumption of the actual and base cases yielded 5925 kWh in yearly savings.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio was calculated from the three free ridership questions on the decision-maker survey as shown below in Table FF-1.

Table FF-1: P43314 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
VSD Dust Collection System	0 of 10	0	No Influence	0	0 of 10	0	0	0%
Daylighting controls	0 of 10	0	No Influence	0	0 of 10	0	0	0%

Ex-Post Net Savings

One of the building owners requested the facility representative complete the decision-maker survey and aid in the on-site inspection. Unfortunately the project lead, also an owner, referenced in the SBD program file was not available for this purpose. Discussions with the facility representative indicated the measures would have been installed exactly the same absent SBD. The lack of program influence was partly due to high efficiency equipment being a standard practice Also, SBD was not involved early enough in the project to be of any influence. According to the owner, who was not the project lead, “We received the incentive after the building was built”. The owner and facility representative's combination of answers yielded a free ridership score of 0 out of 6, or 100% free ridership. As such, net savings were 0% of gross savings. Summaries of the savings results for the daylighting control and VSD dust collector measures are provided below in Table FF-2 and

Table FF-3 respectively.

Table FF-2: P43314 Lighting Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
kWh	1,790	5,925	331%	0.0	0.0
peak kW	0.9	1.8	204%	0.0	0.0

Table FF-3: P43314 VSD Dust Collector and
Air Conditioning Interactive Effects Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
kWh	79,889	67,910	85%	0.0	0.0
peak kW	25.6	34.7	136%	0.0	0.0
therms	2,659	2,753	104%	0.0	0.0

GG. P48486 High Efficiency Lighting

Project P48486 received an incentive of $1,903.00 for installing high efficiency lighting in the unconditioned portion of the building. The facility installed high efficiency T8 fluorescent fixtures and high efficiency compact fluorescent fixtures. The measure baseline was determined using Title 24 standards for allowable LPD by space type. Therefore, the only information required to develop the baseline was space type and the area in square feet. The evaluation team verified the installation of the measure and the area of the building.

Ex-Ante Gross Savings

Ex-ante gross savings were determined using projected lighting hours, number of fixtures and rated lamp wattage.

Ex-Post Gross savings

Ex-post gross savings were calculated using the same methodology as the ex-ante gross savings. The evaluation team verified the parameters that were used for calculating the ex-post savings. The fixture counts and facility square footage were found to differ from the ex-ante projection. Table GG-1 below compares the ex-ante and ex-post lighting schedules.

Table GG-1: P48486 Comparison between Ex-Ante and Ex-Post Lighting Schedule

Ex-Ante				Ex-Post		
Fixture Type	**Lamps/ Fix**	**# Fixtures**	**Annual hours**	**Lamps/Fi x**	**# Fixtures**	**Annual hours**
T832	6	8	8,760	6	8	7,488
T832	4	4	8,760	4	4	7,488
T832	6	12	8,760	6	11	7,488

The ex-post gross savings were calculated using rated lamp wattages from the lighting schedule, fixture counts and actual annual operating hours. According to the site contact, the lights operate 100% of the time for six days a week, 52 weeks/year. The estimated ex-post power consumption was 3.9 kW. The annual energy consumption was then calculated using the power consumption and annual operating hours. Ex-post gross power and energy were subtracted from baseline power and energy to calculate ex-post gross savings. The measure baseline was calculated using Title 24 base case energy standards for unconditioned storage space (0.70 W/square foot).

Using the evaluated area, the estimated baseline demand was 9.1 kW. Ex-post gross savings were 39,540kWh/yr with a demand reduction of 5.2 kW.

Project Impacts

Our evaluation team determined that the energy efficiency measure saved more energy than projected because the number of lamps installed was less than what was indicated in the program file.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 30% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown in Table GG-2 below.

Table GG-2: P48486 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
LPD	8 of 10	0.8	Easier Sell	1	0 of 10	0	1.8	30%

Ex-Post Net Savings

The facility representative stated that Savings by Design Program was influential in implementing this measure. In particular, the incentive made the measure and easier sell. The site contact indicated that he worked with the lighting manufacturer and their electrical contractor to design the lighting system. The contractor then ran the design by SBD to get approval for the incentive. Without the program, the lighting system would have been installed exactly the same way. This combination of answers yielded a free ridership score of 1.8 out of 6, indicating 70% free ridership. Hence the ex-post net savings for this project were calculated as 30% of the ex-post net savings as shown in Table GG-3.

Table GG-3: P48486 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net To Gross Ratio	Ex-Post Net Savings
kW	4.3	5.3	123%	0.30	1.6
kWh	38,056	39,540	104%	0.30	11,862

HH. P49006 VSD Air Compressor and TMS Dryer

Project P49006 received an incentive of $14,239.00 for installing a new, more efficient compressed air system. The new compressed air system consists of a 100-hp variable speed drive air compressor, a thermal mass dryer, and three no air-loss drains. The baseline system consists of a 100-hp constant speed screw compressor with inlet modulation control, a standard dryer that runs continuously even when cooling is unnecessary, and solenoid valves for draining. The evaluation team verified the installation of the measures during a site visit and conducted an impact analysis using data loggers installed during the visit.

Air Compressor Savings

Ex-Ante Gross Savings

Ex-ante gross savings from both the dryer and compressor were determined by the Program using Air Master+ software. The baseline and as-built compressed air system models were simplified and input into Air Master+. Savings were calculated as the difference between the baseline and as-built modeled energy usage.

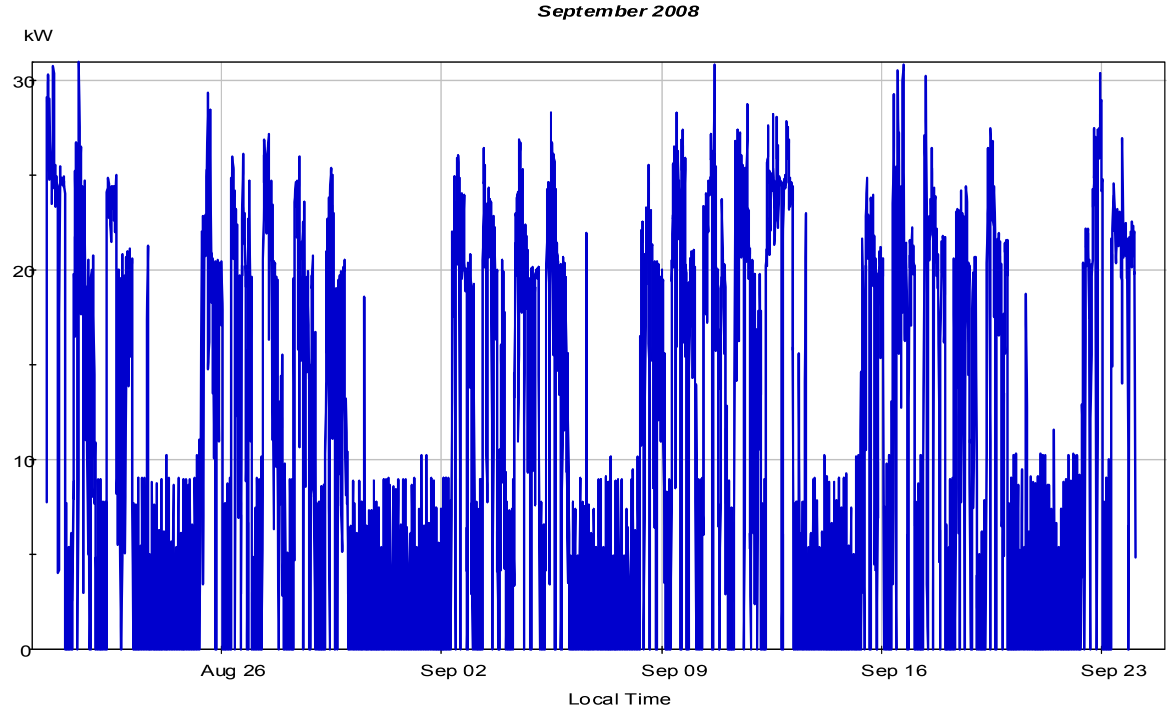
Ex-Post Gross Savings

The team determined ex-post gross savings with AirMaster+ system models. Data logging performed over a four week period was used to inform the modeling effort. Key steps for determining gross savings were as follows:

1) Data loggers were installed on both the 100-hp VSD air compressor and the TMS dryer for a period of four weeks during August and September 2008.

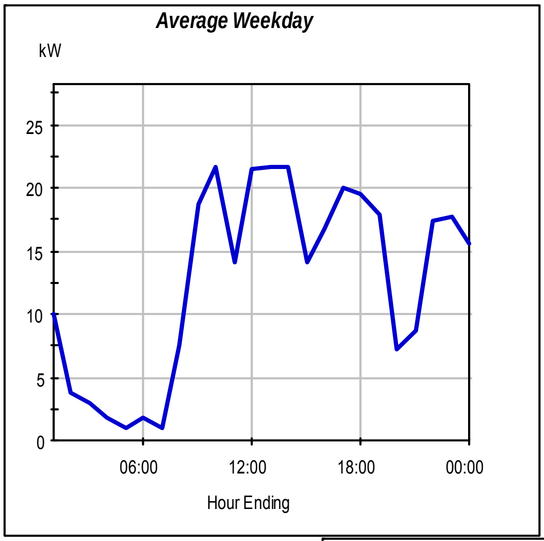
Figure HH-1 shows the 100-hp air compressor power draw for the monitoring period.

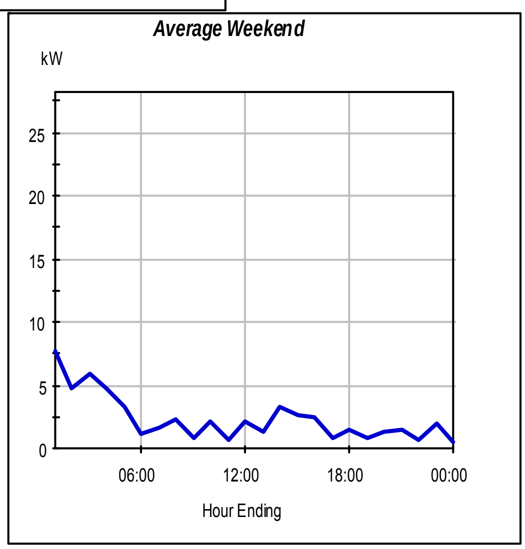
Figure HH-1: P49006 Air Compressor Power for Monitored Period



Hourly profiles for weekdays and weekends are shown in Figure HH-2. Logged data indicates that the compressor operates at significantly higher loads on weekdays than on weekends.

Figure HH-2: P49006 Air Compressor Hourly Power Profile (Weekdays & Weekends)





2) Hourly power profiles for average weekdays and weekends were generated from the raw data.

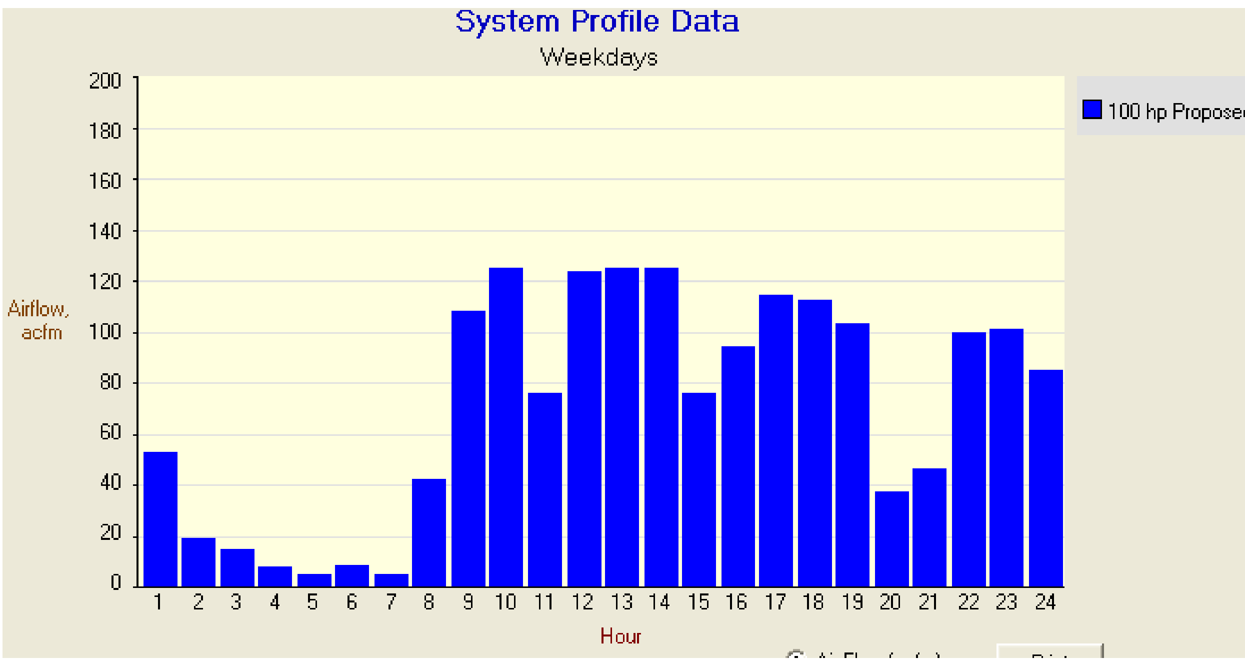
3) Next, we constructed a model using AirMaster+. Software inputs included facility elevation, air system pressure, air storage capacity (receivers), and production day types. The number of production day types depends on the different load profiles across

the monitoring period. In this project the compressor had two different load profiles; hence two day types were created.

4) Next, the type of compressors were selected from Air Master+ inventory database according to operating pressure and the system automatically assumed an airflow range based on this pressure. The compressor controls were selected as inlet modulation with unloading since AirMaster+ does not currently have a VSD control option. The AirMaster+ compressor profile was then modified to reflect VSD controls.

5) Finally, the hourly power data recorded by the meter was input for each day type. With the as-built model inputs complete, the program was then used to model the supply flow of the as-built compressor on an hourly basis for the two day types. The air flow was held constant both baseline and as-built condition. **Figure HH-3** shows the daily flow profile for both baseline and as-built compressors.

Figure HH-3: P49006 As-built Compressor System Profile



6) For the baseline model all inputs except for the compressor controls were left unchanged. The control type was set to a baseline strategy of constant volume with unloading. To model this strategy, the unloading point was changed from 20% in the as-built condition to 50% load in the baseline model. Furthermore, the baseline system model was set to unload at 80% of full load power as opposed to 20% for the as-built model. Figure HH-4 and Figure HH-5 show the flow percentage vs. power percentage

curves for the as-built 100 hp VSD air compressor and 100 hp baseline compressors respectively. Using the curve in Figure HH-5, the software calculated the baseline compressor power profile from the airflow profile generated by the as-built model

Figure HH-4: P49006 100 hp VSD Compressor Performance Profile

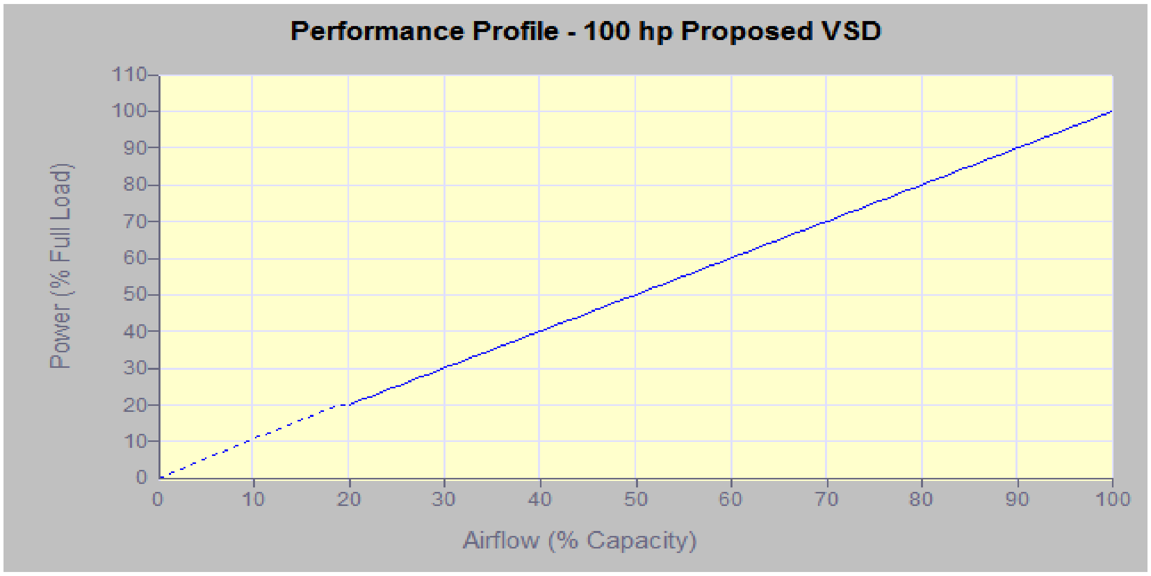
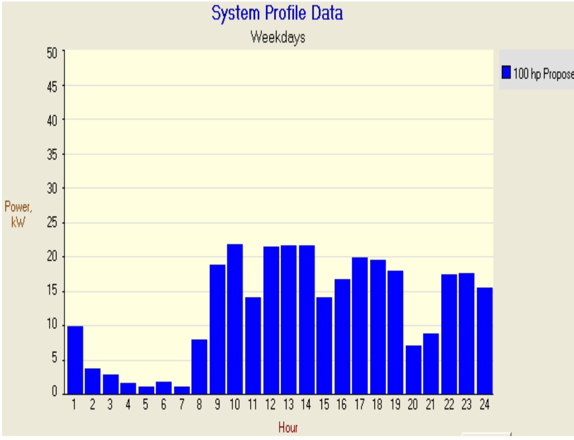
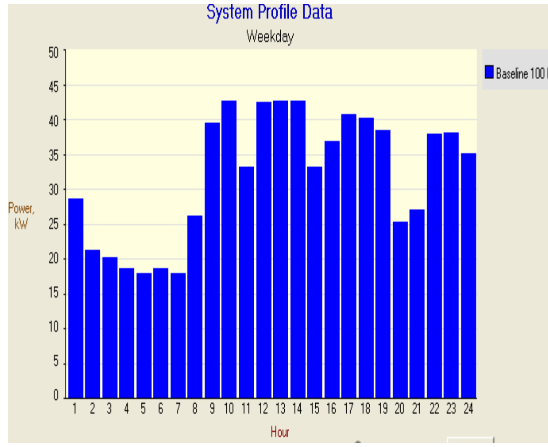


Figure HH-5: P49006 100 hp Baseline Compressor Performance Profile

7) Savings were calculated using the annual energy and peak demand usage estimates generated with the AirMaster+ software. Savings were simply the difference between the baseline and as-built usage. Figure HH-6 compares the daily power profiles of the as-built and the baseline compressors.

Figure HH-6: P49006 Power Profile Comparison: As-Built (Left) and Baseline (Right) Compressors





Dryer Savings

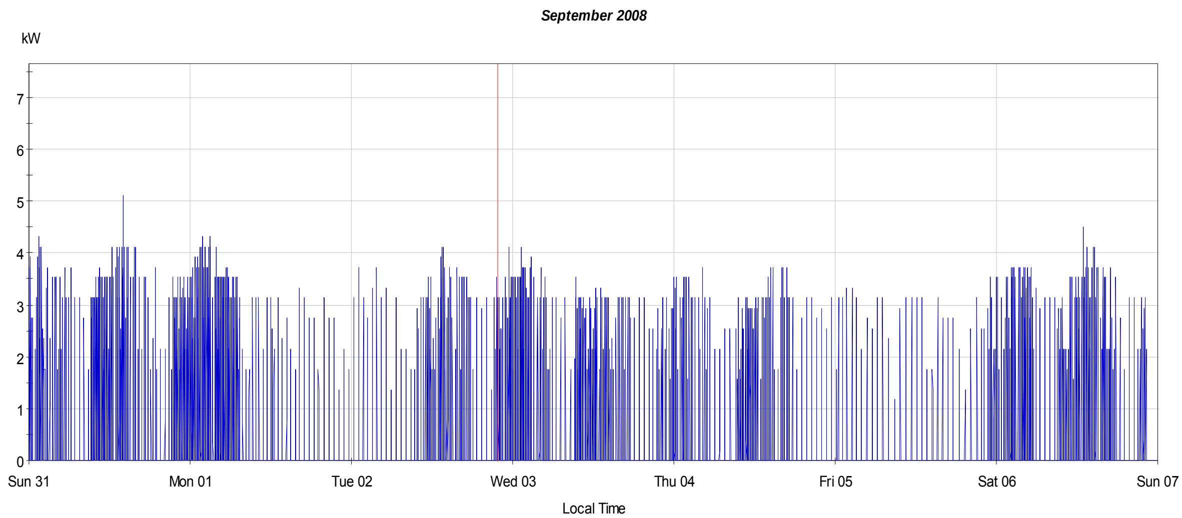
We calculated the TMS dryer savings using the average metered dryer power and the annual operating schedule.

Figure HH-7 displays the logged dryer power data for one week during the monitoring period. A review of logger data determined the operating schedule and load profile of the TMS dryer.

For baseline dryer condition, we assumed a standard non-cycling refrigerated dryer of equivalent capacity operating continuously during facility operations. Refrigerant-type, non-cycling dryers cool the air in a refrigerant-to-air heat exchanger and operate continuously. Non-cycling dyers only turn off to avoid freezing when the evaporator temperature goes below 32°F, which happens only on rare occasions. Hence our base case was a standard dryer running continuously.

Ex-post savings were estimated by subtracting TMS dryer energy consumption from baseline dryer energy consumption.

Figure HH-7: P49006 TMS Dryer Power Profile



Project Impacts

The energy efficiency measures saved less energy than projected because the evaluated air compressor was running 308 days a year as compared to 325 days a year as stated in the ex-ante estimate. Peak savings were higher than calculated in the ex-ante gross analysis because the compressor never operates at peak load. Since the efficiency differential between VSD and constant volume control strategies is greatest at lower load conditions, peak demand savings were amplified.

The incented TMS dryer saved more energy than expected because the dryer cycled on and off during the monitoring period. Cyclic behavior was not anticipated in the ex-ante calculation.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 83% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown in Table HH-1 below. .

Table HH-1: P49006 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
VSD Air Compressor; Thermal Mass Air Dryer, and No Air-Loss Drains (3)	10 of 10	1	Easier Sell	1	10 of 10	3	5	83%

Ex-Post Net Savings

The facility owner indicated that the SBD program was very influential in the implementation of all three measures (VSD Air Compressor, Thermal Mass Air Dryer and No Air Loss Drains). The program made the measures an "easier sell". The site contact also stated that the same equipment would not have been installed without interaction from SBD. He stated, "we would have installed a non-VSD compressor and standard refrigerated dryer." This combination of answers yields a net savings score of 5 out of 6, or 17% free ridership. Therefore, the ex-post net savings for the air compressor and the TMS dryer were 83% of the ex-post gross savings as summarized in Table HH-2 and Table **HH-3** respectively.

Table HH-2: P49006 VSD Air Compressor Savings Summary

COMPRESSORS	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	15.3	21.6	141%	0.83	17.9
kWh	152,390	144,248	95%	0.83	119,726

Table HH-3: P49006 TMS Dryer Savings Summary

DRYER	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	2.2	3.6	160%	0.83	3.0
kWh	25,604	36,031	141%	0.83	29,906

II. P49006 High Efficiency Lighting

P49006 also received an incentive of $1,875 for installing high efficiency lighting throughout the facility. The evaluation team verified the measure installations during site visits. The team calculated program impacts using data from data loggers installed during the site visits.

Ex-Ante Gross Savings

Ex-Ante gross savings were determined by the Program using spreadsheet calculations. Anticipated hours of operation were used in conjunction with calculated space lighting power densities (LPD) and floor areas to determine lighting energy savings relative to the Title 24 baseline in each of the distinct occupancy zones. The Title 24 baseline for each zone was determined using the maximum allowable LPD as defined by space type.

Ex-Post Gross Savings

The evaluation team attempted to verify the installed lighting during site visits. However, lighting types and totals at the site were considerably different from those listed in the ex-ante gross savings calculations. Table II-1 below catalogs all fixed lighting in the facility and illustrates the discrepancy between the proposed and installed lighting.

Table II-1: P49006 Comparison of Proposed and Installed Lighting

Type	Quantity	
	Planned	Installed
4' T8 (2)	22	20
4' T8 (3)	14	59
4' T8 (4)	17	0
2' T8 (2)	42	0
2' T8 (3)	0	2
Wraparound T8	8	1
400 W MH	44	46
120 W Incandescent	9	28
Par 30 Halogen	68	166
4' T5 (6)	0	8

The evaluation team installed lighting ON/OFF status data loggers in four zones of the facility. Each zone—the warehouse, the first floor display area, the second floor office space, and a second floor private office—had different occupancy and lighting schedules.

LPDs for the different occupancy zones of the facility were adjusted using the surveyed lighting data. By using the logged operating schedules together with the calculated space LPDs, we calculated annual power consumption savings for each distinct space. We determined peak demand savings by comparing the average peak time lighting load of the facility to the Title 24 baseline lighting load for an equivalent peak time operating profile. Peak kW savings were found to be much less than the ex-ante estimate because the installed LPD in the display portion of the facility was 5.8 W/sf as opposed to the anticipated 2.6 W/sf.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 83% was calculated from the three free ridership questions in the decision-maker survey. The free ridership survey results are shown below in Table II-2.

Table II-2: P49006 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Reduced LPD	10 of 10	1	Easier Sell	1	10 of 10	3	5	83%

Ex-Post Net Savings

The facility owner indicated that the SBD program was very influential. Without the SBD program, the owner indicated the proposed lighting would not have been installed. The site contact's combination of answers yielded a 5 of 6 score, indicating 17% free ridership based on our site evaluation survey. As such, net savings were 83% of gross savings. Table II-3 below summarizes these results.

Table II-3: P49006 High Efficiency Lighting Savings Summary

Lighting	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	9.4	3.2	34%	0.83	2.7
kWh	37,496	51,118	136%	0.83	42,428

JJ. P49006 VSD on Dust Collector Fans

P49006 received an incentive of $6,274.00 for installing VSDs on two 10-hp dust collector fans. The new VSD retrofitted blowers modulate their speed based on the flow demand to reduce energy consumption. The measure baseline was a constant speed blower. The evaluation team verified the installation of the measure during the site visit and calculated impacts using metered data collected over a month long period.

Ex-Ante Gross Savings

Ex-ante gross savings were calculated by the program using an estimated operating schedule and blower power ratings. The program assumed that the blower typically operates at 40% speed to meet the facility's load. Savings were therefore calculated as the difference in energy use between the baseline blower and as-built blower when operating at 40% speed over the annual operating schedule.

Ex-Post Gross Savings

The team calculated ex-post gross savings based on metered blower energy usage. A meter was installed on both the blowers for four weeks during August and September 2008. The data loggers recorded the power draw of both blowers in fifteen minute intervals.

The recorded data were imported into data visualization software to facilitate analysis.

Figure JJ-1 shows the combined power draw of both blowers during the monitoring period. Additionally, Figure JJ-2 shows average weekday power profile for combined blowers. The output reflects the operating hours and load factors of both blowers during the monitoring period. The data indicate the facility operated eighteen hours per day on weekdays and nine hours per day on weekends. According to the plant personnel the fans have the same schedule throughout the year. A review of data also revealed that the blowers modulate between 80 to 90% of the flow. There was no lower load condition observed during the monitoring period and the facility engineer also confirmed the same load profile throughout the year.

Figure JJ-1: P49006 Power Profile of Both Blowers for the Monitoring Period

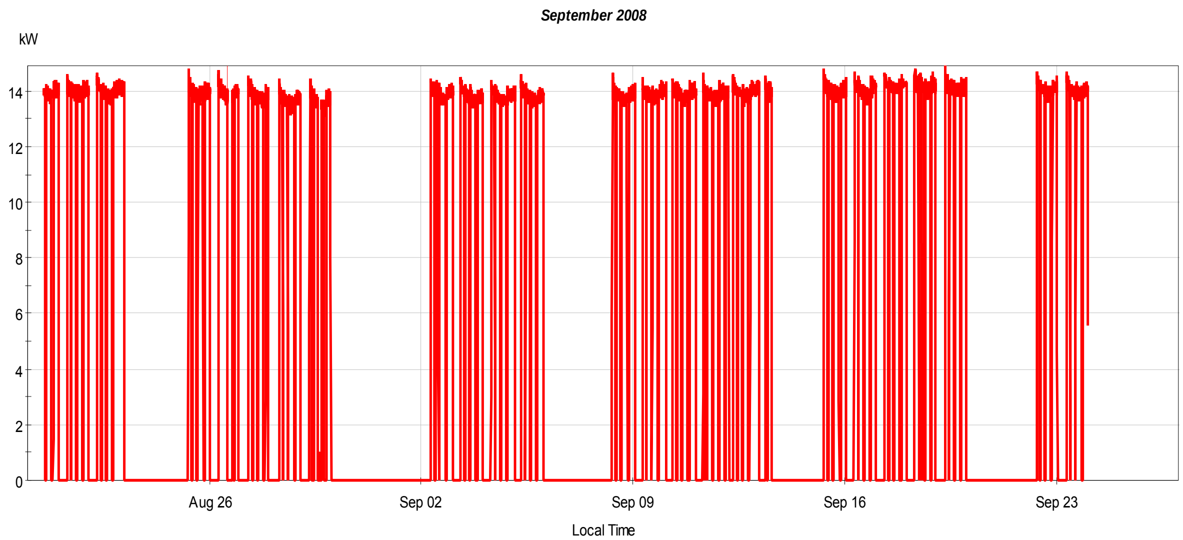
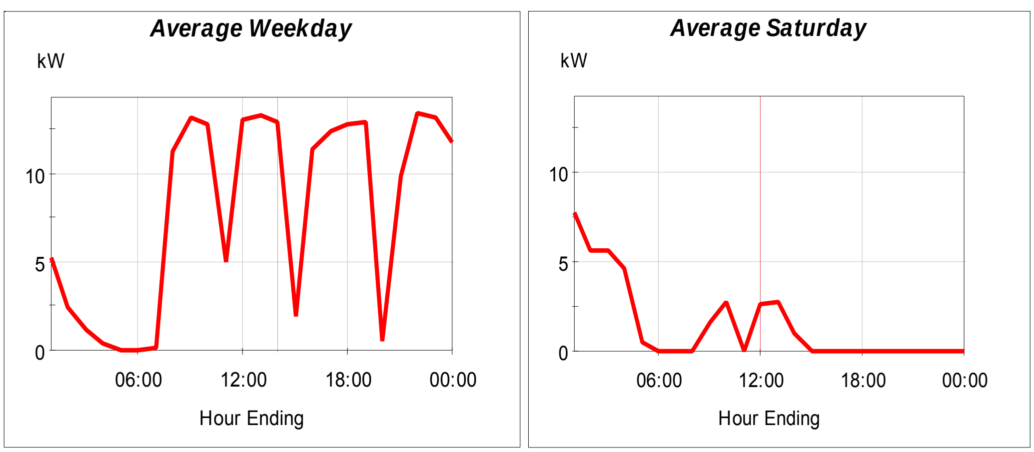


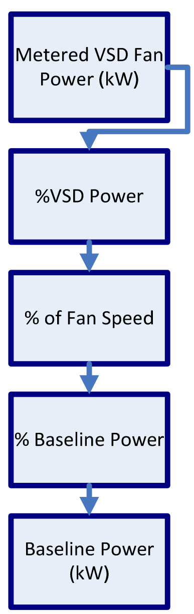
Figure JJ-2: P49006 Hourly Weekday and Weekend Power Profiles of two VSD Dust Collector Fans



The evaluation team was provided with manufacturer fan curves for baseline fans. VSD fan curves were generated from the kW versus Hz data collected from the site. The team first used the VSD fan curve to calculate actual speed of the dust collector fans. The manufacturer's baseline fan HZ v/s kW curve was then used to calculate baseline power.

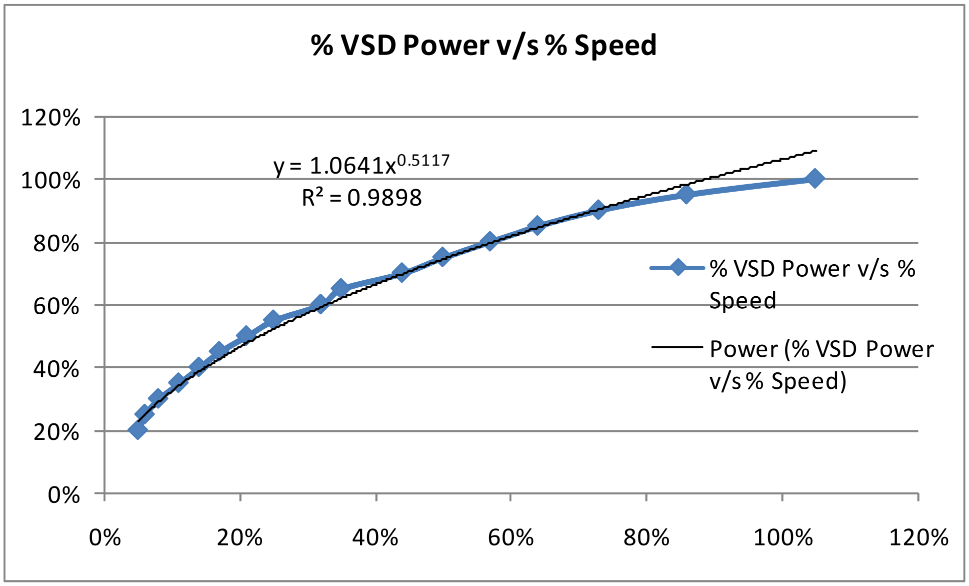
Figure JJ-3 illustrates the analysis flow for the fans.

Figure JJ-3: P49006 Blower Baseline Power Consumption Calculation Sequence



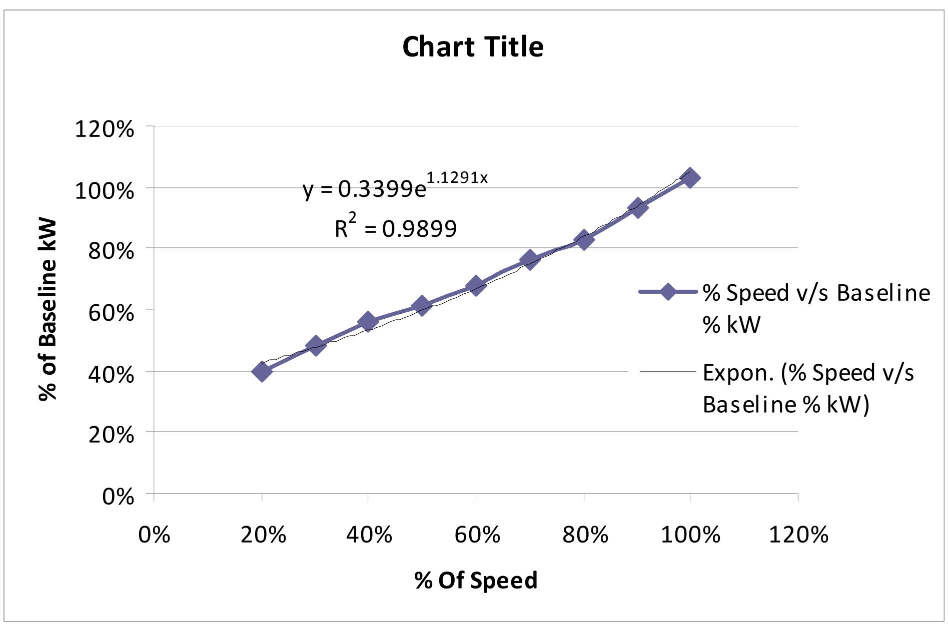
The evaluation team calculated the VFD power fraction by dividing the metered power by the rated motor power. This was not done for the average power draw, but for every metered data point. Data were logged in 5 minute sampling intervals. Next, the team calculated the VFD percent speed using the fan curve shown in Figure JJ-4.

Figure JJ-4: P49006 %VFD Blower Power vs. % Speed Curve



The air flow (i.e. motor speed) was held constant between the baseline and as-built conditions. Therefore, the speed ratios calculated in the previous step were used in the power/speed curve for the baseline fan motors. This curve is presented in Figure JJ-5.

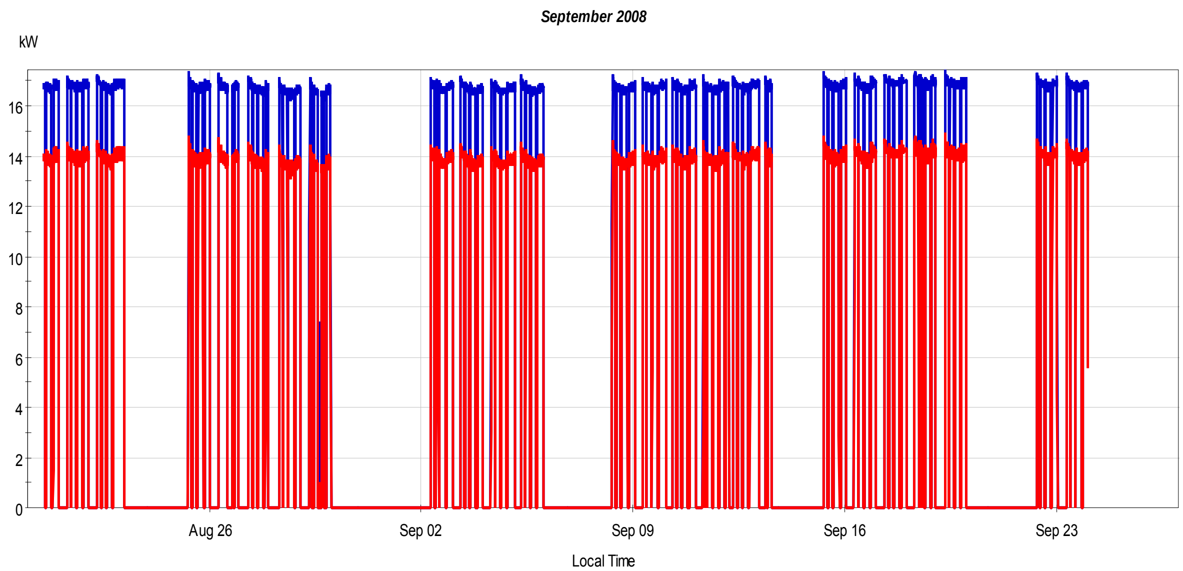
Figure JJ-5: P49006 % Blower Speed vs. % Baseline Power



The final step in the blower analysis was simply converting the power ratio to actual baseline power by multiplying the rated motor power and the power ratio.

Figure JJ-6 shows the comparison between evaluated and baseline power profiles over the monitoring period.

Figure JJ-6: P49006 Comparison between Baseline and Evaluated Power Profile (Baseline-Blue & Red- Evaluated)



Using data visualization software, average day power profiles were generated for both the base case blowers and as built blowers. Savings were calculated by extrapolating the daily savings to an annual profile.

The measure saved less energy than projected because the dust collector fans operated at 83% of full load as compared to 40% of capacity as indicated in the project file. Gross realization rates were roughly 20% for peak demand and 15% for energy.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 0% was calculated from the three free ridership questions in the decision-maker survey. as 0%. The free ridership interview results are shown below in Table JJ-1.

Table JJ-1: P49006 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
VSD dust collector	0 of 10	0	No Influence	0	0 of 10	0	0	0%

Ex-Post Net Savings

This measure was not part of the original savings estimate. The field inspector found the VFD dust collectors installed during the post verification visit and revised the savings estimate to incorporate VSD dust collector savings. Since the VFD dust collectors were an independent install and was not influenced by the Savings by Design Program, this measure received a net savings score of 0 out of 6, or 100% free ridership. There is not enough evidence to indicate that this measure was in any way influenced by the program. Therefore, the ex-post net savings for the dust collectors were evaluated as 0% of the ex-post gross savings as summarized in Table JJ-2.

Table JJ-2: P49006 Dust Collector Savings Summary

Dust Collector	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	14.0	2.8	20%	-	0.0
kWh	78,428	11,435	15%	-	0.0

KK. P50027 Whole Building

P50027 received an incentive of $377,700.00 for installing multiple high efficiency measures at their new blast chilling and cold storage facility. The facility is approximately 188,000 square feet in total, of which roughly 180,600 square feet are conditioned. Incentives were received for the installation of the following energy efficiency measures:

- Cascade CO2/Ammonia Refrigeration System
- VSD evaporative condenser fan motors, floating head pressure control, and a wet bulb following control strategy for the ammonia loop
- Flash economizer on the ammonia system
- VSD air unit fans
- VSD blast freezer fan controls
- Efficient compressor and air unit motors
- Increased cold storage insulation and a cool roof
- Lighting controls in the refrigerated spaces
- High speed freezer doors
- Low loss dock doors
- Reduced office LPD

The baselines for the proposed measures were Title 24 when applicable, and refrigerated warehouse standard practice otherwise.

Ex-Ante Gross Savings

Ex-Ante gross savings were calculated using DOE 2.2R hourly simulation software. Savings estimates were generated by modeling both the base case and as-built condition in the software. To accomplish this, unique load schedules, equipment schedules and equipment performance parameters were input for the as-built and baseline cases. Savings were calculated as the difference in energy use between the baseline and as-built models.

Ex-Post Gross Savings

The same approach was used to determine ex-post gross savings. However, based on the onsite evaluation, a number of scheduling parameters were changed to reflect the reality of the facility's usage. In particular, the following adjustments were made:

- Temperature setpoints in two of the convertible rooms were adjusted from 40 F to -5 F.
- Dock temperature setpoints were changed from 35 to 40 F
- Loads in the convertible rooms were adjusted to account for the product load increase associated with changing the temperature setpoint from 40 F to -5 F.
- Adjusted the wet bulb following delta-T from 10 F to 15 F based on the observed programmed control strategy
- Blast chiller fans were set to run at 54 Hz (90% power) based on the blast chill fan control set point currently being used at the facility. According to the ex-ante report, the fans were intended to modulate based on schedules set for different

blast chiller products. The site contact indicated that flow schedules corresponding to individual product “recipes” are still in development and have not yet been implemented.

Aside from these adjustments, the model was left unchanged. The site visit revealed that all equipment was installed as proposed and the blast chillers (the largest load source) operate on a schedule very closely matching that provided in the ex-ante model.

Ex-Post Net-to-Gross Savings

Net to gross ratios ranging from 17% to 40% were calculated for each of the measure based on the three free ridership questions in the decision maker survey. The free ridership survey results are shown in Table KK-1 below. All measures are not included in the table because the free ridership questions were not specifically asked for the missing measures. For these measures, the net-to-gross ratio was taken as the average of the surveyed net-to-gross ratios.

Table KK-1: P50027 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Floating head pressure with variable set point and vsd condenser control	10 of 10	0.3	No Influence	1	0 of 10	0	1.3	22%
Flash Economizer on Ammonia Refrigeration System	0 of 10	0	No Influence	1	0 of 10	0	1	17%
VSD on evaporator fan motors	5 of 10	0.5	Easier Sell	1	0 of 10	0	1.5	25%
HE compressor and air unit motors	5 of 10	0.5	Easier Sell	1	3 of 10	0.9	2.4	40%
Increased Refrigeration Box Insulation	3 of 10	0.3	No Influence	1	0 of 10	0	1.3	22%
Reduced LPD with Controls in Refrigerated box areas	3 of 10	0.3	No Influence	1	0 of 10	0	1.3	22%
Reduced LPD with Occupancy Sensors (office area)	3 of 10	0.3	No Influence	1	0 of 10	0	1.3	22%

Ex-Post Net Savings

The site contact indicated that Savings by Design was not very influential in their decision to implement a majority of the measures. He indicated that he actually helped the program by providing a baseline for cascade CO2 refrigeration systems—a first of its kind system in California at the time of implementation. The site contact stated that the majority of the equipment would have been installed the same way in the absence of the program. The site contact did however indicate that the availability of incentives helped justify the expense of installing high efficiency compressor motors. This combination of answers resulted in free ridership scores of 1.5 for both kWh and kW, indicating 75% free ridership for both kWh and kW. Note that free ridership scores can differ between kWh and kW because individual measure level scores are applied to the modeled savings from each measure to develop the overall kWh and kW free ridership scores. Since the relative magnitudes of the kWh and kW savings can differ from measure to measure, the free ridership scores are not usually consistent for both parameters (in this case they were).

Table KK-2: P50027 Savings Summary

	Ex-Ante Gross Savings	**Ex-Post Gross Savings**	**Gross Realization Rate**	**Site Net-to-Gross Ratio**	**Ex-Post Net Savings**
peak kW	450.2	369.3	82.0%	0.25	91.4
kWh	3,719,449.0	3,289,163	88.4%	0.25	812,247

LL. P50606 Refrigerated Warehouse (Non-Metered)

Project P50606 received an incentive of $152,170 to install a series of energy efficient measures in their 102,200 square foot refrigerated warehouse addition. The installed measures included:

- VSD compressors
- VSD evaporative condenser with floating head pressure and variable set point control
- VSD air unit motors
- Reduced LPD with motion sensors
- Increased insulation

The baselines for the proposed measures were Title 24 when applicable, and refrigerated warehouse standard practice otherwise.

<u>Ex-Ante Gross Savings</u>

Ex-Ante gross savings were calculated using DOE 2.2R hourly simulation software. Savings estimates were generated by modeling both the base case and as-built condition in the software. To accomplish this, unique load schedules, equipment schedules and equipment performance parameters were input for the as-built and baseline cases. Savings were calculated as the difference in energy use between the baseline and as-built models.

<u>Ex-Post Gross Savings</u>

DOE-2.2R was also used to produce ex-post gross savings. The evaluation team performed a field inspection at the site and observed a few discrepancies in schedules. These changes were incorporated in the DOE-2.2R model to calculate ex-post gross savings. No equipment was monitored. Consequently, the savings were 99% of the ex-ante gross estimate.

<u>Ex-Post Net-to-Gross Savings</u>

A measure net-to-gross ratio of 75% was calculated for all measures with the exception of the VSD condenser measure, which received a 100% net-to-gross ratio. Net-to-gross ratios were calculated from the three free ridersip questions on the decision-maker survey. The free ridership survey results are shown in
Table **LL-1** below.

Table LL-1: P50606 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Compressors with VSD	10 of 10	1	Design Analysis	2	5 of 10	1.5	4.5	75%
Evaporative condenser with VSD & Floating head pressure with variable set point	10 of 10	1	Design Analysis	2	10 of 10	3	6	100%
Evaporative Motors with VSD	10 of 10	1	Investment Criteria	2	5 of 10	1.5	4.5	75%
Lighting Power Density with Motion Sensors	10 of 10	1	Investment Criteria	2	5 of 10	1.5	4.5	75%
Increased Insulation	10 of 10	1	Design Analysis	2	5 of 10	1.5	4.5	75%

<u>Ex-Post Net Savings</u>

The facility personnel indicated that Savings by Design was very influential in implementing each of the measures. He stated that the program performed the design for each component of the project. They would not have installed the evaporative condenser VSD or the associated floating head pressure controls in the absence of the program. This above combination of answers yielded a free ridership score of 6 out of 6 for the above two measures, indicating no free ridership.

The site contact stated that they may have installed the remaining measures in the absence of the program. He also indicated that their typical simple pay back policy for installing energy efficiency equipment is three years or better. This combination of answers yielded a score of 4.5 out of 6, indicating 25% free ridership for the remaining measures.

The above free ridership scores were applied individually to the modeled ex-post gross savings for each measure. Using this approach, the net savings for the whole building were calculated as 79% of ex-post gross kW savings and 84% of ex-post gross kWh savings. Table LL-2 summarizes the net-to-gross savings for this project.

Table LL-2: P50606 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net to Gross Ratio	Ex-Post Net Savings
Peak kW	153.6	140.0	91%	0.79	110.2
kWh	1,359,199	1,331,200	98%	0.84	1,114,253

MM. P50966 VSD Air Compression, TMS Air Dryer, and 3 No Air Loss Drains

Project P50966 received an incentive of $7,502 for installing a 75-hp VSD controlled air compressor, a cycling air dryer and 3 no air loss drains. The baseline for this measure was an equivalently sized constant speed compressor controlled with inlet modulation, an air dryer running constantly even when cooling is not needed, and solenoid valves for drains.

Ex-Ante Gross Savings

Ex-Ante gross savings for the VSD controlled air compressor were determined by the Program using DOE's Air Master$^+$ software. Savings were based off of estimated load and operating hour profiles. Savings from the cycling air dryer and no-air loss drains were calculated using spreadsheet models.

The ex-ante savings estimators changed their anticipated load following the first year of equipment operation based on the assumption that a second production line would be installed. As such, savings for the VSD air compression and cycling air dryer dropped relative to their respective inlet modulated and constant speed counterparts. Gross savings were taken as 20% of year 1 annual savings plus 80% of year 2-5 annual savings.

Ex-Post Gross Savings

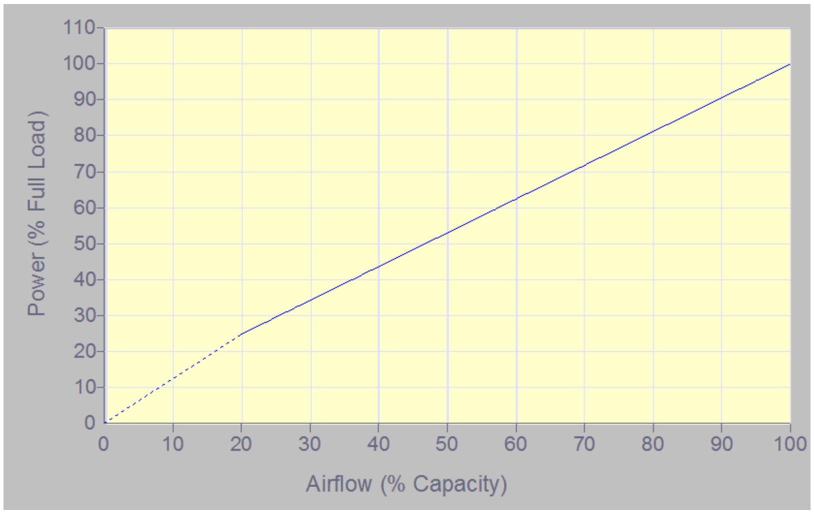
Air Compressor Savings

The team determined ex-post gross savings by modeling the as-built and baseline compressor systems with AirMaster$^+$. The savings calculation was informed by logged data collected between site visits. Key steps for determining gross savings were as follows:

1) Data loggers were installed for a six week period during March and April of 2009. Air compressor power data was recorded in 5 minute intervals. Current from one line of the air dryer was monitored every 88 seconds and used in conjunction with spot voltage and power factor measurements to determine power consumption.

2) Power data from VSD air compressor was used to inform a model built using Air Master+. The current iteration of Air Master+ does not provide a VSD option. The behavior of the compressor was therefore approximated using a modified inlet modulation with unloading control curve. The modified percent power vs. percentage flow curve is presented below in Figure MM-1.

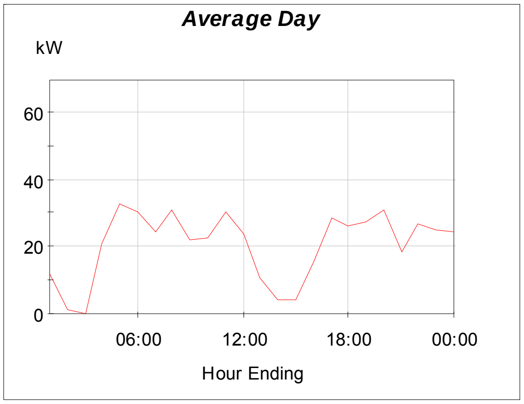
Figure MM-1: VSD Air Compressor Model % Power vs. % Flow Curve

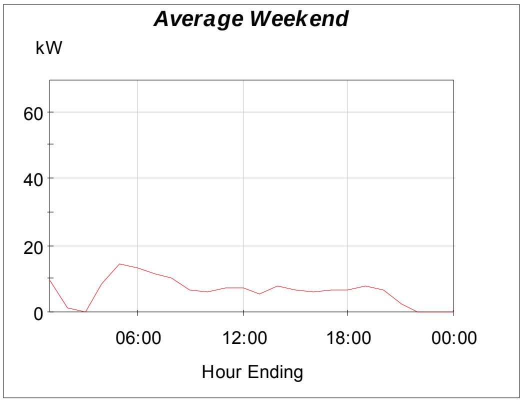


Notice that the modeled VSD compressor does not unload (dotted line) until the flow-rate decreases to 20% of the maximum at approximately 25% of the maximum power.

3) The logged kW data were next re-sampled to an hourly profile capable of being input into Air Master+. Weekday and weekend profiles were markedly different, necessitating the use of the two power schedules illustrated in Figure MM-2.

Figure MM-2: P50966 VSD Air Compressor Weekday and Weekend Average Load Profiles





4) Air Master+ was used to calculate the CFM output of the compressor at the logged kW values for the two load profiles. A number of inputs--including elevation, average outdoor temperature and operating pressure—were used to inform the model estimate. Figure MM-3 and Figure MM-4 below illustrate the hourly CFM profiles generated from the weekday and weekend power schedules respectively.

Figure MM-3: Weekday Airflow Profile Generated by AirMaster+

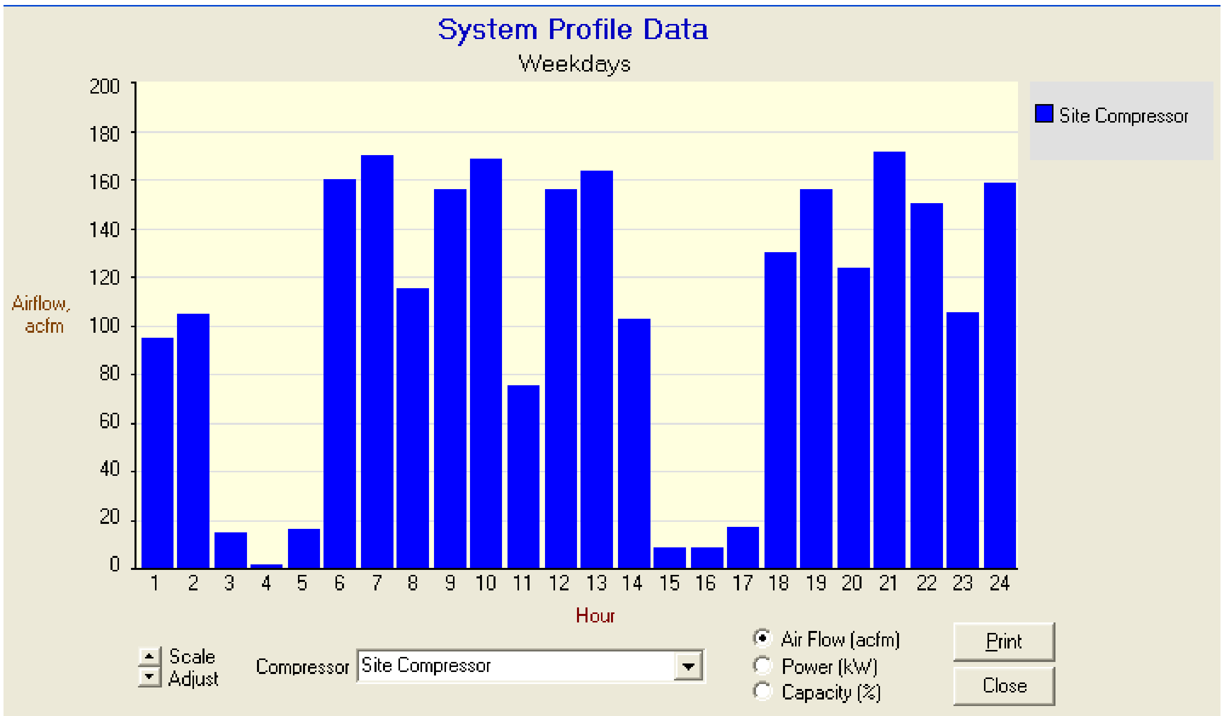
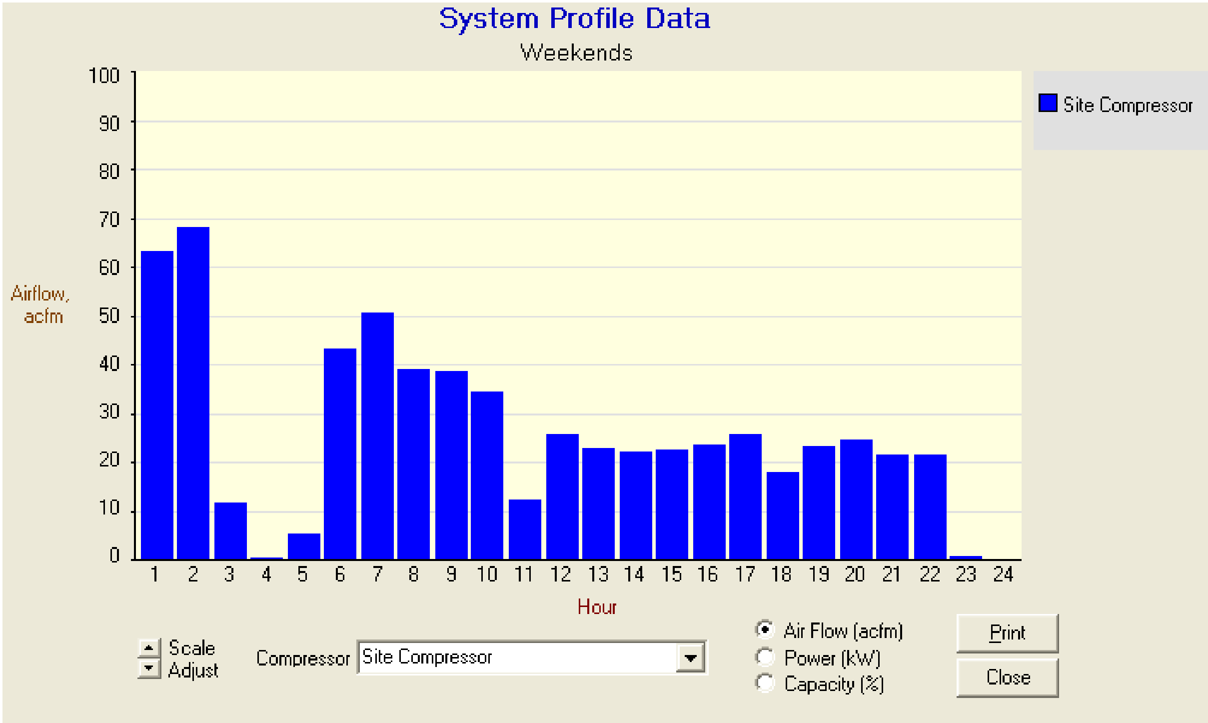
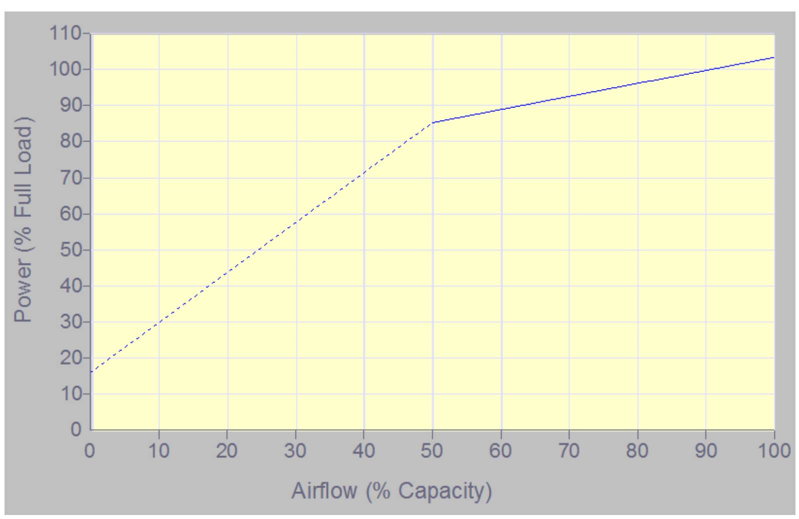


Figure MM-4: Weekend Airflow Profile Generated by AirMaster+



5) An identical compressor controlled using inlet modulation with unloading control was taken as the baseline. The hourly CFM rates calculated for the as-built model were then input into the baseline model. AirMaster+ was then used to calculate the power that would be required for the baseline system to deliver the desired flow. The baseline compressor's percent power versus percent flow curve is provided below in Figure MM-5.

Figure MM-5: Baseline Compressor Model % Power vs. % Flow Curve



Relative to the VSD compressor, the baseline compressor's load curve is considerably flatter in the operational range. Also, the baseline compressor unloads at 50% capacity while still operating at roughly 85% of full power.

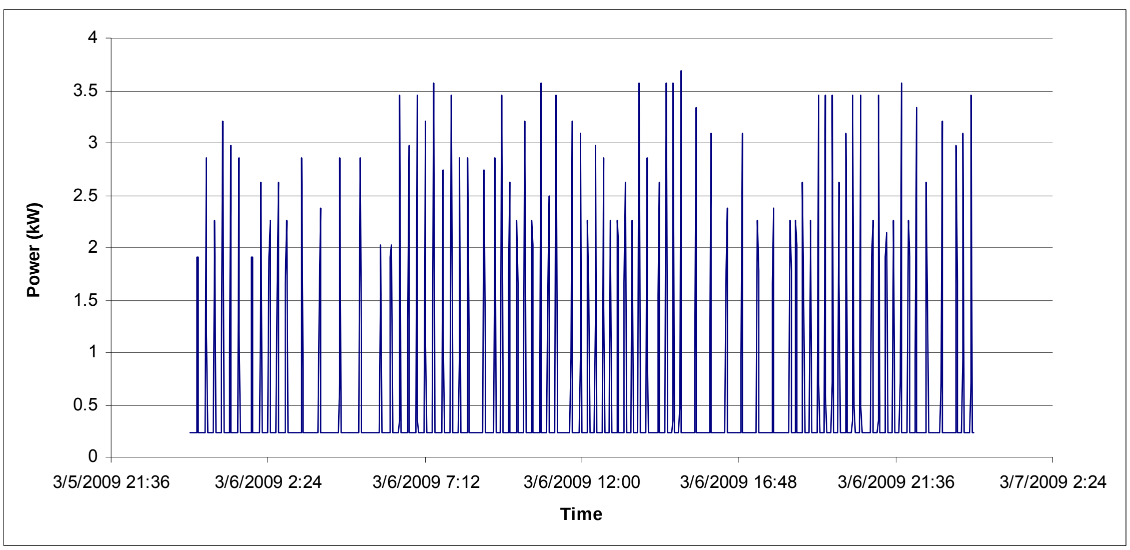
6) Savings were calculated by comparing the as-built and baseline model outputs using a yearly operating schedule determined from discussions with facility personnel.

Cycling Air Dryer Savings

1) Determining savings from the installation of the cycling air dryer began by extrapolating the logged kW load profile to the entire year.
Figure MM-6 below provides the power consumption data over the logged interval. The measured peak kW consumption was taken as the power consumption of an equivalently sized continuously running baseline air dryer.

2) Savings were then calculated using the measured operating schedule and the load differential between the actual and baseline systems.

Figure MM-6: P50966 Cycling Air Dryer Monitored Power Schedule for a 24 Hour Period



Project Impacts

Gross savings from the VSD compressor was calculated as 101,674 kWh and 16.1 kW peak demand savings. Analysis of the installed cycling air dryer yielded 30,471 kWh per year in savings and .12 kW in peak demand savings.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio could not be calculated from the three free ridership questions on the decision-maker survey as shown in Table MM-1.

Table MM-1: P50966 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Cycling Air Dryer	0 of 10	0	N/A	0	0 of 10	0	0	53%
No Air-Loss Drains	0 of 10	0	N/A	0	0 of 10	0	0	53%
VFD AirCompressor	0 of 10	0	N/A	0	0 of 10	0	0	53%

Ex-Post Net Savings

The decision-maker survey for this site could not be completed as the decision-maker had left the company and the employee who replaced him in this position was completely unaware of the SBD program. Furthermore, the replacement contact was both unresponsive and lacking in cooperation throughout the analysis. Contact information within the SBD file contained an installation company, but unfortunately their representative was also unable to address the decision-maker questions. An overall sample average net-to-gross was therefore applied to this site to approximate ex-post net savings.

Table MM-2: P50966 VSD Air Compressor Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
kWh	69,624	101,674	146.03%	0.53	53,887
peak kW	6.5	10.67	164.10%	0.53	5.7

Table MM-3: P50966 TMS Dryer Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
kWh	24,152	30,471	126%	0.53	16,150
peak kW	1.6	3.8	239%	0.53	2.0

NN. P57373 Premium Efficiency Motors and VSD on Waste Water Pumps

Project P57373 received an incentive of $33,288.00 for installing variable speed drives on three 300-hp wastewater pumps. Premium efficiency pump motors were also installed for wet well fans, influent grinders, and water pumps. 1992 EPACT standard efficiency motors were used as the baseline for the premium efficiency motors measures. Constant speed pumps with cyclic on/off wet well level control were used as the VSD measure baseline. The evaluation team verified the installation of the measures and collected data from the facility's *SCADA* system while on site.

Ex-Ante Gross Savings

Ex-Ante savings were estimated using a simple energy analysis based on pump Bhp, motor efficiency, operating hours and flow rate.

Ex-Post Gross Savings

The evaluation team determined ex-post gross savings using a spreadsheet based analysis informed by 10 months of metered motor speed and water flow data provided by the facility contact. The evaluation methodologies for the VSD and premium efficiency measures are provided separately below.

Variable Speed Drive Pumps

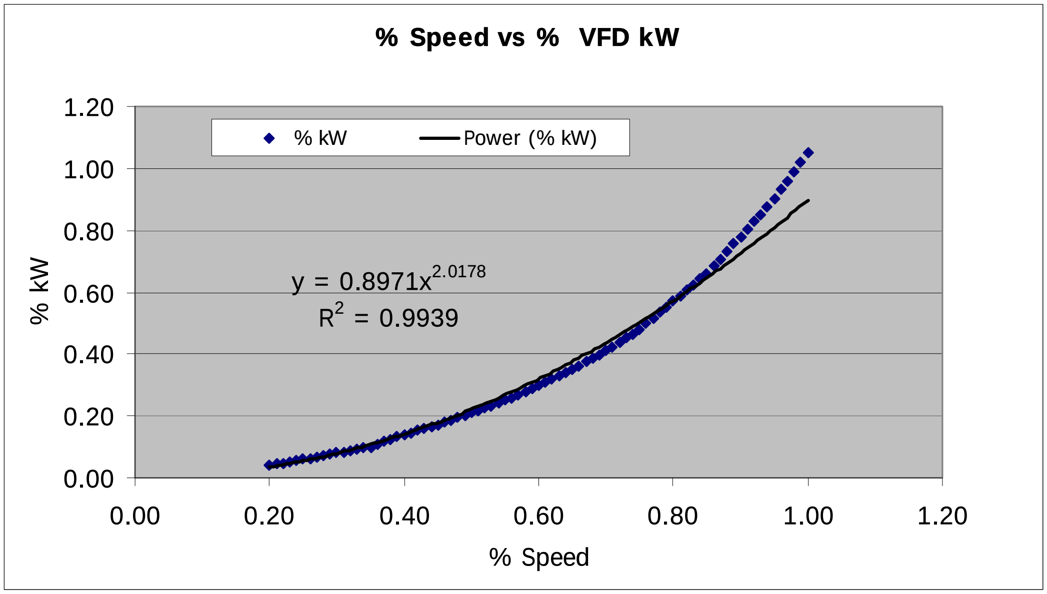
VFD savings were calculated using the following steps:

1. Hourly % pump motor speed and flow data were collected from the facility's SCADA system for the three 300 hp VFD pumps. The collected data encompassed a 10 month time frame starting 12/1/2008 and ending 10/1/2009. Motor nameplate information was also collected for each pump. A discussion with the facility engineer also revealed that the pumps operate at a roughly 80% load factor under full load conditions. Using this collection of parameters, it was possible to calculate each pump's load on an hourly basis using EPRI's Pump % Speed vs. % Power tables.

2. First, an exponential regression curve was generated from the EPRI table to develop a functional relationship between % motor speed and % VFD power. The results of the regression are shown in

3.
4. Figure NN-1 below.

Figure NN-1: P57373 Regression Trend for % Speed vs. % VFD kW of The Pumps

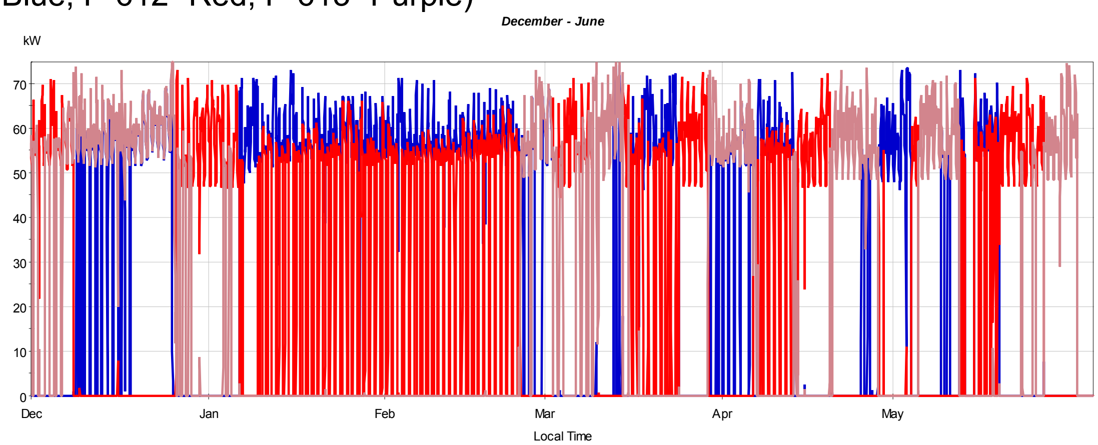


5. The hourly % motor speed data was then used to calculate % power for each of the pump motors. Motor power was calculated by multiplying the full load motor power (taking into account 5% VFD losses and an 80% load factor) by % power.
6.
7.

8. Figure NN-2 below shows the power profiles from seven months during the monitoring period (December 2008 through June 2009). According to facility personnel, two of the three pumps are "primary" and the third is for back up use only. The site contact also indicated that they do not run the same two primary

pumps all the time. They instead rotate the three pumps occasionally to increase the life expectancy of the pumps. A detailed examination of the data revealed that the pump operating schedules depend on the waste water flow rates. During higher flows, two pumps operate simultaneously. However, during periods of low flow, only one pump remains active. The data also showed instances where all pumps were off due to very low flow conditions.

Figure NN-2: P57373 Hourly Power Profiles of 3- 300 hp VFD Pumps (P-611- Blue, P-612- Red, P-613- Purple)



9. The power profile calculated from the metered data was next extrapolated to an annual profile based on information gathered from the site contact.

10. The baseline power consumption for each of the pumps was calculated on an hourly basis using the provided flow data. The amount of time each baseline pump would need to operate during each hour to pump the full water load was calculated as follows:

$$H_{frac} = kW_{FL}\left(\frac{Q}{Q_{FL}}\right)$$

Where,

H_{frac} = Fraction of the hour during which the pump needs to operate (0 to 1)

kW_{FL} = Full load power draw of the pump (kW)

Q = Water flow during the hour (gallons/hr)

Q_{FL} = Full load pump flow (gallons/hr)

11. The baseline pump operating hours were then multiplied by the full load pump power and scaled using an 80% load factor to calculate baseline power consumption.

12. Ex-post gross energy savings were calculated as the difference between baseline energy usage and ex-post energy usage.

13. Peak demand savings were calculated based on the average demand savings during the DEER defined peak period of 2 to 5 pm on weekdays.

Premium Efficiency Motors

The evaluation team verified the installation of premium efficiency motors during a site visit. The facility engineer provided peak power draw, efficiency and operating schedule data for each pump. Table NN-1 provides further detail regarding each of the six incented pumps.

Table NN-1: P57373 Incented Equipment

Incented Equipment	HP	QTY	Measures Verified
Industrial Fan	3	1	Premium Efficiency Motor
Industrial Fan	1	1	Premium Efficiency Motor
Misc	10	1	Premium Efficiency Motor
Misc	10	1	Premium Efficiency Motor
Pump	7.5	1	Premium Efficiency Motor
Pump	7.5	1	Premium Efficiency Motor

Demand savings from the premium efficiency motor measures were calculated by estimating the difference in power draw between standard efficiency and premium efficiency motors. The following equation was used to calculate the demand savings:

$kW_{Svg\text{-}PE}$ = (hp*0.7456) x LFx (η_{PE}/η_{SE})

where,

$kW_{Svg\text{-}PE}$ = Demand savings [kW]

hp = output power of the motor [HP]

LF = operating load factor

η_{PE} = efficiency of the PE motor

η_{SE} = efficiency of the standard efficiency motor

The demand savings were then multiplied by the annual operating hours to calculate energy savings. The annual operating hours were obtained from facility personnel. Table NN-2 shows the incented premium efficiency motor applications and the operating hours associated with them.

Table NN-2: P57373 Premium Efficiency Motor Operating Hours

Incented Equipment	Qty	Annual Operating Hours hrs/yr)
3 hp Wetwell EF	1	8,760.0
1 hp Wetwell SF	1	8,760.0
10 hp Influent Grinder 1	1	8,760.0
10 hpInfluent Grinder 2	1	8,760.0
7.5 Water Pump 1	1	365.0
7.5 Water Pump 2	1	365.0

Project Impacts

Trend data revealed that the incented VFD pumps operated for fewer hours than estimated in the ex-ante calculation. As such, energy savings were less than originally estimated. Peak demand savings were also lower than anticipated because the pumps typically operated at higher loads than projected in the ex-ante calculation.

The premium efficiency motors were found to operate according to the same schedule anticipated in the ex-ante calculation. However, discrepancies between the baseline efficiencies used in the ex-ante calculation and ex-post calculation resulted in a slight reduction in the savings estimation.

Ex-Post Net-to-Gross Savings

Measure net-to-gross ratios of 82% and 20% were calculated for the premium efficiency motor and VFD measures respectively based on the three free ridership questions in the decision maker survey. The free ridership survey responses are shown below in Table A-2.

Table NN-3: P57373 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Premium Efficiency Pump, Grinder, and Fan Motors	8 of 10	0.8	Investment Criteria	2.0	7 of 10	2.1	4.9	82%
VFDs on Pump Motors	3 of 10	0.3	No Influence	0.0	3 of 10	0.9	1.2	20%

EX-Post Net Savings

The facility representative indicated that Savings by Design was influential in implementing the premium efficiency motor measures. The availability of an incentive justified the cost of choosing premium efficiency motors. In the absence of the program, premium efficiency motors would not have been installed. The site contact also stated that the Program had no influence on the variable speed drive measures. They would have installed the same variable speed drives without the program incentive. The above combination of answers yielded free ridership scores of 4.9 and 1.2 for the premium efficiency motor and variable speed drive measures respectively. Hence, ex-post net savings for the PE motors measures were calculated as 82% of ex-post gross savings, whereas ex-post net savings for the VFD measures were calculated as 20% of the ex-post gross savings. Table NN-4 and
Table NN-5 show the savings comparisons for the premium efficiency motor and VFD measures respectively.

Table NN-4: P57373 Premium Efficiency Motor Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
kW	0.3	0.5	163%	0.82	0.40
kWh	2,642	2,826	107%	0.82	2,308

Table NN-5: P57373 Variable Speed Drive Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
kW	171.5	64.4	38%	0.20	12.9
kWh	412,706	305,932	74%	0.20	61,186

OO. P59926 VSD Air Compressor, High Efficiency Lighting and HE Blow molder

Project P59926 received an incentive of $91,840.00 for installing a 75 hp VSD air compressor and a TMS dryer. The incentive also included installation of high-efficiency lighting throughout the facility and installation of two high-efficiency blow molders with an air recovery system. During the site visit, the evaluation team verified the installation of the measures but did not find any air recovery system installed on the blow molders. The facility contact indicated that an initial plan was made to install an air recovery system on the blow molders; however the equipment was never installed. The base case air compressor system consisted of a constant speed compressor and a regular refrigerated dryer running in tandem with the compressor. The lighting measure baseline was determined using the title 24 maximum allowable lighting power by space type on a square foot basis. Therefore, the only information required for the lighting baseline was space type and square footage.

VSD Air Compressor and TMS Dryer

Ex-Ante Savings

Ex-ante gross compressed air system savings were estimated using DOE's Air Master Software. The baseline and as-built compressed air systems were modeled with AirMaster+ using assumed load schedules. Savings were calculated as the different in modeled energy usage between the baseline and as-built cases. Ex-ante gross savings for the lighting measure were determined using projected lighting hours, number of fixtures and rated fixture wattage.

Ex-Post Gross Savings

The team determined ex post gross savings primarily by modeling the as-built and baseline systems using AirMaster+ software. The as-built model's load profile was informed by metered data collected over a four week period between site visits. Key steps for determining gross savings were as follows:

Air Compressor

1) Data loggers were installed on both the 75 hp VSD compressor and the TMS dryer for a period of four weeks during February and March 2009. Figure OO-1 shows monitored raw data of the 75 hp VSD air compressor.

Figure OO-1: P59926 75 hp VSD Air Compressor Power Profile for the Monitoring Period

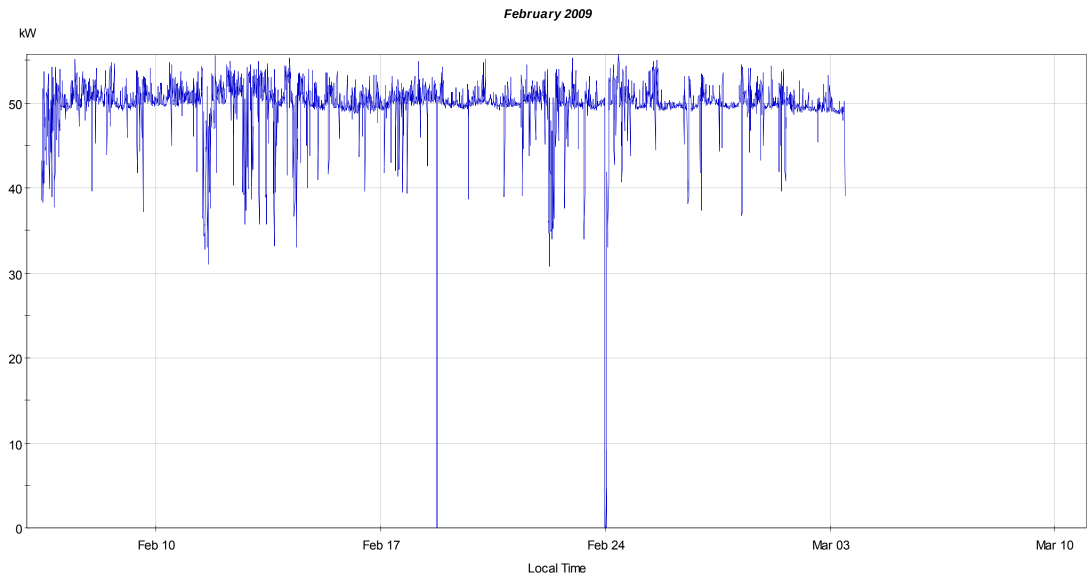
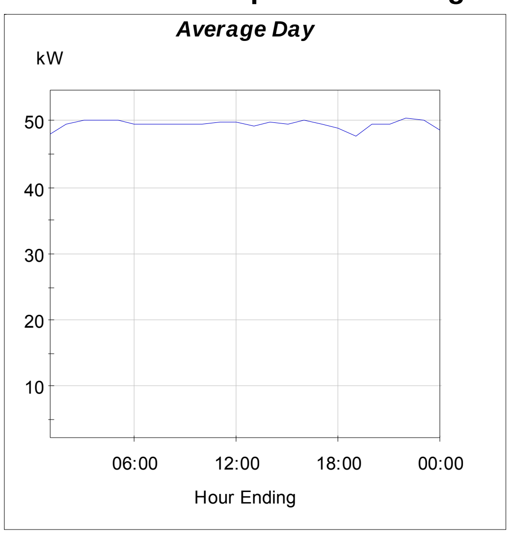


Figure OO-2: P59926 VSD Air Compressor Average Day Power Profile



The hourly profile for an average day is shown in Figure OO-2. Metered raw data showed that the compressor operates 24 hours a day and 7 days a week.

2) Ex-Post gross savings were calculated using AirMaster+ software. Model inputs included facility elevation, air system pressure, air storage capacity (receivers), and

production day types. The metered data indicated that weekday and weekend load profiles were identical. Therefore, an hourly kW profile was created for an average day representative of all operating days throughout the year.

3) Next, the type of compressors was selected from AirMaster+ inventory database according to operating pressure and rated power. Based on these parameters, the system automatically assumed an airflow range. The compressor controls were selected as inlet modulation with unloading since AirMaster+ does not currently have a VSD control option. The AirMaster+ compressor profile was then modified to reflect VSD controls.

4) Finally, the hourly power profile derived from data recorded by the meter was input for average day. Once all of these options were selected, the program modeled the actual behavior of the compressor.

5) For the baseline model all inputs except for the compressor controls were left unchanged. The control type was set to a baseline strategy of constant volume with unloading. The system airflow was held constant between the baseline and evaluation model. The hourly power profile was input in the as-built model and the program calculated hourly airflow rates based on that profile. Those same hourly airflows were put into the baseline model instead of a power profile to estimate the baseline power profile.   Figure OO-3 and
Figure **OO-4** show airflow percentage vs. power percentage for both the baseline and as-built air compressors.

Figure OO-3: P59926 Performance Profile of Baseline Air Compressor

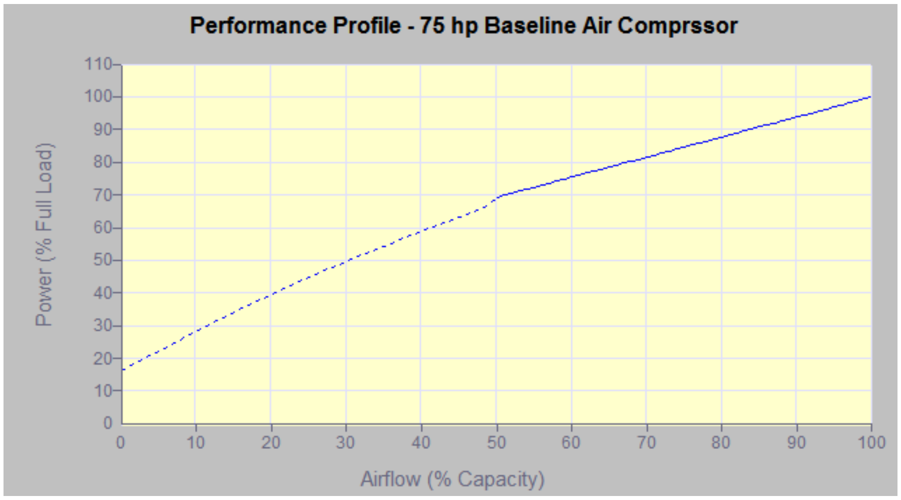
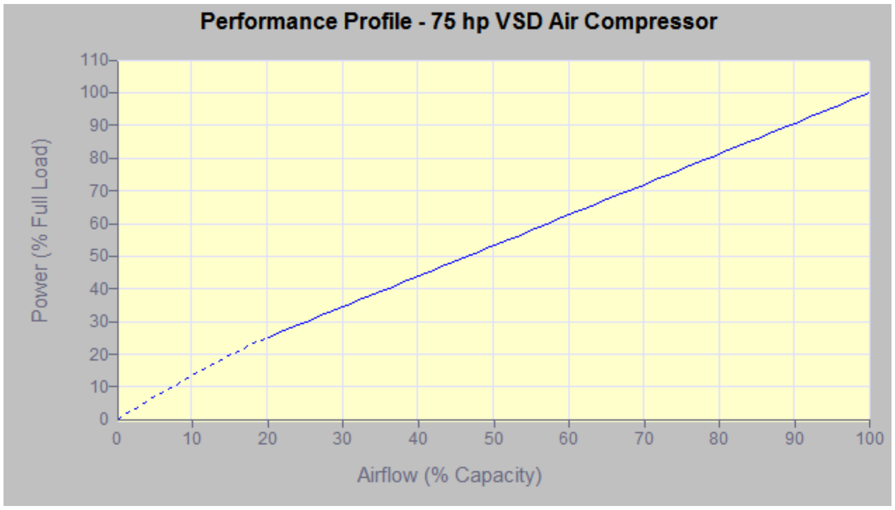


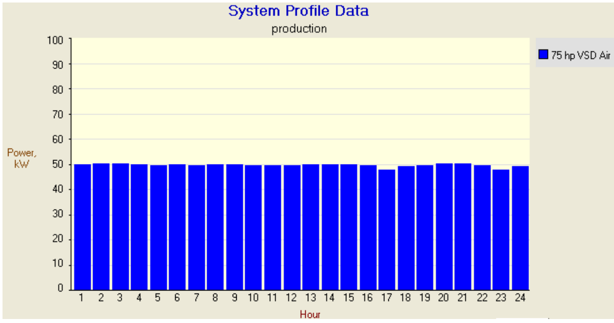
Figure OO-4: P59926 Performance Profile of As-Built Air Compressor

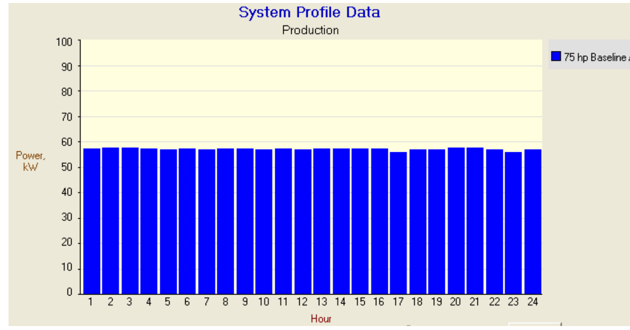


Note that no other energy efficiency measures were included in the models, since a separate model was built for the baseline and evaluation models. The change made to the as built compressor to generate the baseline control strategy was the unloading point. The as-built system unloads at 20% capacity and 25% full load power. The baseline system on the other hand unloads at 50% capacity and 70% of full load power.

6) Savings were calculated using the annual energy and peak demand usage estimates generated with the AirMaster+ software. Savings were simply the difference between the baseline and as-built usage. Figure OO-5 shows the daily power profiles for both baseline and as-built air compressor.

Figure OO-5: P59926 Power Profiles of As-Built (Left) and Baseline Air Compressors

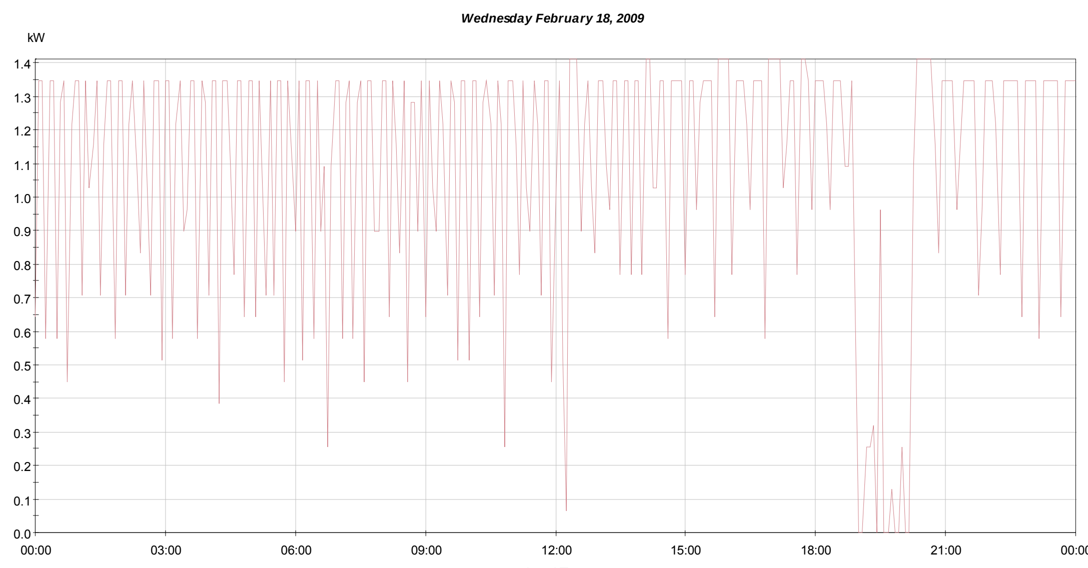




TMS Dryer

1) TMS Dryer savings were calculated by using the average metered dryer power and the annual operating schedule. The metered data for the dryer during one day of the metering period is shown in Figure OO-6.

Figure OO-6: P59926 TMS Dryer Power Profile for One Day during the Monitoring Period



Simple spreadsheet analysis was carried out to estimate TMS dryer energy savings. The dryer was monitored for a period of four weeks at a sampling interval of 15 minutes. The above metered data showed that the dryer cycles on and off based on the changing air demand from the compressor. As this site is a 24-hour facility and the production process is same throughout the year. Facility engineer stated that the dryer operates all the time in a year and also indicated that the metering period is the representation of the whole year.

2) These data were imported into a data visualization and analysis application; the program calculated the average power draw by hour for the monitoring period. This hourly power profile was then input into the spreadsheet extrapolated to an annual profile. In other words, four weeks data were input 13 times to represent one year.

The annual TMS dryer kW profile was then integrated to determine the hourly energy usage. The dryer's peak kW draw was calculated based on the hourly maximum power draw of the dryer during peak periods (2 pm to 5pm) on weekdays. The dryer baseline was simply the full load power of the dryer running continuously. Ex-post gross savings were calculated by subtracting ex-post energy consumption from baseline energy consumption.

Project Impacts

The air compressor measure saved less energy than projected. Peak savings were also lower than anticipated, indicating that the compressor is running at higher loads than anticipated in the ex-ante gross estimate.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 50% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown in Table OO-1 below.

Table OO-1: P59926 Air Compressor Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
VSD Air Compressor	8 of 10	0.8	Easier Sell	1	4 of 10	1.2	3	50%

Ex-Post Net Savings

The facility representative indicated that Savings by Design Program was influential in the implementation of the measures. In particular, he stated that the measures made the project an easier sell. He also stated that long term savings are the most motivating factor for the implementation of any energy efficiency measure. They prefer to install energy efficiency equipment which has a simple pay back of less than five years. The above responses yielded a free ridership score of 3 out of 6, indicating 50% free ridership. Hence, the ex-post net savings were calculated as 50% of ex-post gross savings as summarized in Table OO-2 and Table **OO-3**. High efficiency blow molders were not installed as planned; hence both ex-post gross and ex-post net savings were zero for this measure. Table OO-4 presents the blow molder results summary.

Table OO-2: P59926 VSD Air Compressor Savings Summary

COMPRESSORS	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	10.0	8.0	80%	0.50	4.0
kWh	85,392	67,295	79%	0.50	33,648

]

Table OO-3: P59926 TMS Dryer Savings Summary

DRYER	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	0.0	0.3	0%	0.50	0.14
kWh	3,580	3,736	104%	0.50	1,868

Table OO-4: P59926 HE Blow Molder Savings Summary

HE Blow Molder	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	22.0	0.0	0%	-	0.0
kWh	154,677	0.0	0%	-	0.0

High Efficiency Lighting

The evaluation team verified the installation of the measure during a site visit and calculated impacts using data loggers installed during the visit.

<u>Ex-Ante Gross Savings</u>

Ex-ante gross savings for the lighting measure were determined using projected lighting hours, number of fixtures and rated lamp wattage. The Program used a simple spreadsheet calculation to estimate savings.

<u>Ex-Post Gross Savings</u>

The team determined ex-post gross savings with spreadsheet calculations informed by data logging performed between site visits. Key steps for determining gross savings were as follows:

1) A data logger was installed on the lighting panel for a period of 3 weeks during the month of February 2009. The recorded circuit on the lighting panel comprised 20% of the total incented lighting fixtures. During the site inspection, the evaluation team also found some discrepancies between projected fixture counts and actual fixture counts. Table OO-5 below shows a comparison between ex-ante and ex-post lighting schedule.

Table OO-5: P59926 Comparison between Ex-Ante and Ex-Post Lighting Schedule

Lighting Type	Ex-Ante # of Fixtures	Ex-Post # of fixtures
4L F54T HO highb	241	317
6L F54THO highba	210	211
1000W MH highba	5	5
6L F32T8	3	3
3L F32T8	3	3
2L f32T8	12	12

2) A spreadsheet analysis was performed to evaluate this measure. The input parameters fed to the spreadsheet model were actual fixture counts, annual operating hours, and watts per fixture. Annual operating hours of fixtures were determined from the recorded circuit amps and the schedule obtained from the facility personnel. Recorded data show the facility operates 24 hours per day and seven days per week, less holidays, totaling 8,500 hours per year.

3) The annual energy consumption was then calculated using the lighting power and annual operating hours. This ex-post gross power and energy were subtracted from baseline power and energy to calculate ex-post gross savings. The measure baseline was calculated using Title 24 minimum compliance energy standards for industrial facilities (0.85 W/square foot). The breakdown of wattage per square feet for different areas in the facility is shown in Table OO-6.

Table OO-6: P59926 Verified Wattage per Square Feet

Area	Verified Ft2	T-24 W/ft2	kW
Production	173,130	1.1	190.4
Warehouse	175,875	0.6	105.5
Lab	595	1.3	0.8
Total	**349,600**	**0.85**	**296.7**

The estimated baseline demand was 296.7 kW and ex-post demand was 147.74 kW. The ex-post gross savings were calculated as 1,351,107.60 kWh/yr with a demand reduction of 149 kW

Project Impacts

This demand savings for this measure were less than expected because fixture counts were greater than claimed by the Program. Lighting energy savings were less than expected because more numbers of fixtures were controlled by occupancy sensors than what was estimated in ex-ante estimate. This reduced the number of operating hours, thereby decreasing the energy usage of the lighting and resulting in a lower gross realization rate than projected.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 85% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown in Table OO-7 below.

Table OO-7: P59926 Lighting Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Reduced LPD	7 of 10	0.7	Investment Criteria	2	8 of 10	2.4	5.1	85%

Ex-Post Net Savings

A facility representative indicated that Savings by Design Program was very influential in implementing the measures. The availability of incentives help the project meet investment criteria. The representative also stated they had previous experience with Savings by Design program and were aware of the benefits of the program. The above responses yielded a free ridership score of 5.1 out of 6, indicating 10% free ridership. Hence, the ex-post net savings were calculated as 90% of ex-post gross savings summarized in Table OO-8.

Table OO-8: P59926 Summary of LPD Reduction Savings

Lighting	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	90.0	74.5	83%	0.85	63.3
kWh	1,446,968	1,351,108	93%	0.85	1,148,441

PP. P60806 Steam Plant Expansion

P60806 received an incentive of $144,903 for installing a series of measures related to their steam plant expansion. The steam plant expansion consists of a new 150,000 lb/hr boiler and auxiliary equipment that serves both the new boiler and the existing portion of the plant. To increase the efficiency of the plant, the following measures were implemented:

1. *High efficiency pumps*:
   - Two 100-hp feedwater pumps serving both the existing and new boilers
   - Two 7.5-hp treated water booster pumps serving both the existing and new boilers
2. *Premium efficiency motors for:*
   - Two 100-hp feedwater pumps (same pumps as in measure 1)
   - Three 15-hp condensate transfer pumps serving both the existing and new boilers
   - Five 7.5-hp boiler room exhaust fans
   - One 350-hp boiler forced draft fan serving the new boiler
   - Two 7.5-hp treated water booster pumps (same pumps as in measure 1)
3. *VFD control of feedwater pumps:*
   - Variable Frequency Drives were installed on both 100-hp feedwater pumps
4. *Blowdown heat recovery:*
   - Blowdown heat recovery equipment was installed for the entire plant to preheat boiler feedwater
5. *VFD control of the Boiler Combustion Blower with an Oxygen Trim System*
   - VFD control was installed on the new 150,000 lb/hr boiler

During the site visit, it was learned that all plant equipment associated with the new boiler was not functional. At the time of reporting, the new boiler was still not operational. As such, the new boiler's premium efficiency 350-hp blower motor (part of measure 2) and the associated VFD (measure 5) did not save any energy. The remaining measures were found to be installed as intended.

Ex-Ante Gross Savings

Savings were calculated independently for each measure. High efficiency pump savings were calculated based on the efficiency differential between the baseline and as-built pumps. An appropriate baseline was calculated using the "Pump System Assessment Tool" (PSAT) software, which defines pumping efficiency for a given pump type at a "specific speed" rating (defined as a function of system head and flow). As-built feedwater pump efficiency was calculated based on manufacturer's literature. Booster pump as-built efficiency was based on the "maximum attainable efficiency" in PSAT since information on the booster pumps was not supplied in the equipment schedules. Savings were calculated based on assumed facility load profiles because actual load profiles were not available.

Motor savings were calculated based on the efficiency difference between the baseline and as-built motors. Baseline motor efficiencies were taken from 1992 EPAct and NEMA specifications. EPAct specifications alone could not be used since they only provide standards up to 200 hp. Savings were calculated for each motor using load profiles generated from estimated load factors and operating schedules.

VFD feedwater pump savings were calculated relative to a constant volume on/off controlled baseline system. Load profiles for the plant were estimated from an unidentified similar facility since actual facility load profiles were unavailable. Loads were broken up into 10 separate % load bins, which were each assigned a distinct number of operating hours. For a given bin, the base case pumps were assumed to operate continuously at full load for the amount of time necessary to meet the feedwater load. The VFD pumps on the other hand were assumed to operate at a lower flow rate, but for a longer period of time. This approach minimizes the system's dynamic head to save pumping energy. For each bin, the VSD pump was assumed to operate at a constant efficiency irrespective of motor speed because efficiency curves for different motor speeds were not available.

Blowdown heat recovery savings were generated relative to a baseline system without any blowdown heat recovery. The blowdown steam load profile was generated based on the same profile assumed for the VFD feedwater pump measure. Savings were calculated based on the enthalpy increase of the feedwater, taking into account the amount of energy the plant would require to generate an equivalent enthalpy increase.

Electricity and gas savings from installing VFD control and an oxygen trim system on the new boiler were calculated independently. VFD savings were calculated using tables relating % load to % flow for constant volume and VFD controlled fans. For each of 10 hourly load bins, kWh savings were calculated by comparing the motor energy usage between the baseline constant-volume blower and the installed VFD blower. Gas savings from the oxygen trim system were calculated based on an assumed 2.5% boiler efficiency increase associated with operating at lower excess O_2.

Ex-Post Gross Savings

The new boiler has suffered a host of start up issues, and continues to be non-operational as of December 16, 2009. By CPUC rule, there are no savings for boiler specific measures, which include the combustion blower VSD and premium efficiency motors on the combustion blower and exhaust fans for the boiler room.

The pumps installed for this project serve the entire plant, not just the new boiler. Therefore they are currently realizing savings. The ex ante savings assumed a peak load of 313,600 lbs/hour for the entire facility, however the plant manager stated that the current peak load of the facility is 240,000 lbs/hour. The ex ante load profile was calibrated to the 240,000 lbs/hour peak load and applied to all measures to estimate the pumping loads. Peak load impacts were less than anticipated for all of the pump measures. The plant manager estimated that the system returns 92% of condensate, indicating 8% system losses.

Table PP-1: Plant Load Profile

Load Profile				
% of total Plant load	Hours/Per Year	klbs/hr	lbs/min	gpm
100%	16	240	4,000	479.31
90%	23	216	3,600	431.38
80%	66	192	3,200	383.44
70%	83	168	2,800	335.51
60%	152	144	2,400	287.58
50%	313	120	2,000	239.65
40%	486	96	1,600	191.72
30%	873	72	1,200	143.79
20%	3297	48	800	95.86
10%	3451	24	400	47.93

EEM 1 consisted of the high efficiency feedwater and treated water pumps. Pumping efficiencies of 0.735 and 0.672 were used for the two pump types respectively. The baselines for comparison were 0.728 and 0.47. Each bin was calculated with,

$$kW = Q * H * .746/3960/eff_p/eff_m$$

where,

Q = flow (GPM)

H = head (ft)

eff_p = pump efficiency

eff_m =installed motor efficiency

The annual usage was calculated by multiplying the number of hours in each bin by the corresponding kW draw for each bin. The demand savings was simply the annual savings divided by 8760.

Table PP-2 High-Efficiency Pump Savings

HE Pumps	Feedwater kW		Treated Water kW	
Hours/Per Year	**Power-he**	**Power- Bl**	**Power-he**	**Power- Bl**
16	63.2	63.9	1.5	2.1
23	54.9	55.4	1.3	1.9
66	47.2	47.7	1.2	1.7
83	40.1	40.5	1.0	1.5
152	33.4	33.8	0.9	1.3
313	27.2	27.5	0.7	1.1
486	21.4	21.6	0.6	0.9
873	15.8	15.9	0.4	0.6
3297	10.4	10.5	0.3	0.4
3451	5.2	5.2	0.1	0.2
Annual Energy (kWh)	98,591	99,539	2,760	3,946
kWh Savings	948		1,186	
kW Reduction	0.11		0.14	

The discrepancy between the evaluated and ex ante savings is mostly due to a difference in forecasted pump load. The ex ante calculation used a “typical” load factor and utility factor for these pumps, whereas the evaluated savings used a load profile to estimate pump load. Almost all of the time, one pump of each type can handle the ex-post calculated load, which means that overall, pump utility factors are less than 0.5.

EEM 2 was premium efficiency pump motors. There were no savings from the 350-hp boiler blower fan motor since the boiler is not operating. The bin calculations were similar to the pump efficiency bin calculation. However, the installed pump efficiencies were used in all cases and EPACT baseline and installed motor efficiencies were used for the comparison. The premium 100 hp feedwater, 7.5 hp treated water, and 15 hp condensate pump efficiencies were 0.954, 0.922 and 0.918 respectively. The EPACT baselines were 0.938, 0.900 and 0.883 respectively, taking into account motor size, enclosure type and RPM for determination of baseline efficiency. The feedwater pump used 100% of the steam load profile, the condensate pumps used 92% of the steam profile to account for 8% losses, and the treated water pumps used 8% of the steam profile since the losses equal the treated make-up water.

Table PP-3 PE Motor Savings

	Feedwater kW		Treated Water kW		Condensate kW	
Hours/Per Year	Power PE	Power EPACT	Power PE	Power EPACT	Power PE	Power EPACT
16	63.2	64.3	1.49	1.55	12.6	12.9
23	54.9	55.9	1.34	1.39	11.3	11.6
66	47.2	48.0	1.19	1.24	10.1	10.3
83	40.1	40.8	1.04	1.08	8.8	9.0
152	33.4	34.0	0.89	0.93	7.6	7.7
313	27.2	27.7	0.74	0.77	6.3	6.4
486	21.4	21.7	0.59	0.62	5.0	5.2
873	15.8	16.0	0.45	0.46	3.8	3.9
3297	10.4	10.6	0.30	0.31	2.5	2.6
3451	5.2	5.3	0.15	0.15	1.3	1.3
Annual Energy (kWh)	98,591	100,272	2,760	2,870	23,363	23,934
kWh Savings	1,682		109		571	
kW Reduction	0.19		0.01		0.07	

Discrepancies from the ex ante calculation are largely due to the difference in forecasted pump loads as discussed above.

EEM 3 was VSD controls on the feedwater pumps. To estimate the VSD savings for the feedwater pumps, the facility load profile was used along with an assumed system curve. The assumed system curve for head as a function of flow was the same curve utilized in the ex ante calculations.

Table PP-4: Feedwater Pump VSD Savings

Hours/Per Year	GPM	VSD kW	LC kW
16	479	63.25	63.10
23	431	54.91	56.79
66	383	47.21	50.48
83	336	40.08	44.17
152	288	33.44	37.86
313	240	27.22	31.55
486	192	21.36	25.24
873	144	15.77	18.93
3297	96	10.40	12.62
3451	48	5.17	6.31
	Annual Energy (kWh)	98,591	117,117
	kWh Savings	18,526	
	kW Reduction	2.11	

The discrepancy between ex post and ex ante estimates is once again due to less than forecasted feedwater loads. Although the ex ante calculation used a load profile for this estimate, the peak load is nearly a third greater than the plant manager reported during the evaluation site visit.

During the site visit, the blowdown heat recovery system was observed to be imparting a four-degree lift to the incoming feedwater. This effect was assumed to be typical operation, The calculation below show the annual saving of the four-degree lift.

Savings = IM * lift/100,000 / eff_b

Where,

IM = incoming mass (lbs of water)

lift = rise in temperature from blowdown heat recovery, 4F

eff = boiler efficiency, assumed 0.82

Table PP-5: Blowdown Heat Recovery Savings

Hours/Per Year	lbs/hr	Annual lbs	Therm Savings
16	19,200	307,200	15
23	17,280	397,440	19
66	15,360	1,013,760	49
83	13,440	1,115,520	54
152	11,520	1,751,040	85
313	9,600	3,004,800	147
486	7,680	3,732,480	182
873	5,760	5,028,480	245
3297	3,840	12,660,480	618
3451	1,920	6,625,920	323
8760	**105,600**	**35,637,120**	**1,738**

This blowdown heat recovery savings is considerably less than the ex ante estimates. One reason is that the ex ante estimate assumed a five percent blow down rate. The facility has reverse osmosis equipment treating all incoming water to reduce impurities, which reduces the need for blowdown. The plant manager assumes that somewhere around a 2 to 3% blowdown is taking place, but since it isn’t measured, it could be even less. Additionally, the heat exchanger may not be as effective as assumed.

The final measure was the VSD/O2 trim for the combustion blower, by CPUC rule, this measure has no savings associated with it since boiler has not been operating as intended.

Table PP-6: Gross Savings Summary

		ex ante kWh	ex ante kW	ex ante therms	ex post kWh	ex post kW	ex post therms
EEM 1	HE Pumps	20,900	2.4		2,134	0.24	
EEM 2	PE Motors	10,249	0.8		2,362	0.27	
EEM 3	VSDs Pump Controls	27,461	3.1		18,526	2.11	
EEM 4	Blowdown Recovery			22,712			1,738
EEM 5	VSD Boiler Blower	993,755	113.4	53,180			
	Total	**1,052,365**	**119.7**	**75,892**	**23,022**	**2.63**	**1,738**

Ex-Post Net Savings

The site contact, construction project manager, and the mechanical designer were all interviewed to determine the influence of the Program upon the implementation of the measure. None were willing to answer how influential the Program was for any measure. Ultimately, the site contact relayed that there was no interaction between the design team and Savings By Design, and the SBD recommendation report was likely never reviewed by the design team. According to the construction manager, the date of the report was after construction had begun on this project and there were no change orders for energy-efficient equipment. This indicates there was no possible way that the measures were influence by SBD, therefore there were no net savings.

This is consistent with the SBD report that clearly states that three of the six recommended measures were “included in the original design” that was submitted to the SBD consultant. The three measure not “included in the original design”, one was not installed, and the other two (PE Motors and VSD pump controls) were partially installed, but not to the specifications given in the SBD report. According to the mechanical designer, the facility’s policy was to install VSDs on all pumps over 15 hp.

Table PP-7: Site Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Peak kW	119.7	2.6	2%	-	-
kWh	1,052,365	23,022	2%	-	-
Therms	75,892	1,738	2%		

QQ. P61867 Upgrade to Bi-metallic Catalyst in Naphtha Reforming Unit

Project P61867 received an incentive of $125,650 for installing Bi-metallic catalysts in naphtha reforming units. The baseline reforming units use a Mono-metallic catalyst. Bi-metallic catalysts have higher stability and result in higher yield in the regeneration process. Because of the increased stability, Bi-metallic catalysts have longer lifetimes than Mono-metallic catalysts. The shorter regeneration cycles of Bi-metallic catalysts reduce annual reactor run times relative to Mono-metallic catalysts, which in turn reduces the natural gas consumption of the reactor. Reducing the regeneration time in the reactors also reduces the operating hours of the regeneration gas compressor and regeneration wash pump, which in turn saves electric energy.

Ex-Ante Savings

Ex-ante savings were estimated based on the difference in regeneration time between baseline and proposed conditions. The implementer collected average daily regeneration furnace natural gas usage from facility records and used the following equations to calculate the therm savings of the reactor.

MMBtu/ yr = mscf / yr x HV

Where,

MMBtu/ yr = Gas consumption per year in MMBtu/yr

mscf/yr = million cubic feet per year

HV = heating value (1075 btu/scf x 0.91)

The number of preexisting regeneration cycles per year was divided into the MMBtu/yr to determine the MMBtu required per regeneration cycle. Then this MMBtu/cycle was multiplied by the number of baseline regeneration cycles per year and the number of proposed regeration cycles per year to calculate the baseline and post retrofit MMBtu/yr.

Therms Saved/ yr = (MMBtu/ yr $_{\text{Baseline}}$ - MMBtu/yr $_{\text{Post-Rtrofit}}$)*10 therms/MMBtu

Electric savings for the regeneration compressor and wash pump were calculated simply by reducing the operating hours of the motors based on expected frequency and duration of regeneration.

Ex-Post Gross Savings

Natural Gas Savings

The evaluation team verified the installation of the measure in February 2009 and collected time series data for both pre and post retrofit periods from the facility's energy management system. Our collected data consisted of time series natural gas input data for the regeneration furnace and amp data for the regeneration compressor.

Pre data was collected from July 2006 to December 2006 and post data was collected from July 2007 to December 2007. The facility engineer indicated that the pre and post data can be directly compared based on throughput, feed quality, and octane. These are the parameters which affect the regeneration frequency of the catalysts and which in turn can affect the gas consumption of the reactor.

A review of this data clearly revealed that the pre retrofit condition had longer operating hours than the post retrofit condition. The pre retrofit operating hours were estimated as 6,650 hours a year, where as the post retrofit condition was calculated as 4,210 hours a year for similar throughput. The facility engineer indicated that the pre-retrofit condition used aged mono-metallic catalysts, which increased the regeneration frequency relative to new mono-metallic catalysts. If the pre-retrofit mono-metallic catalysts had been newer, the regeneration frequency would have decreased.

We used the post-retrofit hourly gas consumption and estimated operating hours to calculate the annual gas consumption of the regeneration furnace.

The implementer's assumed baseline regeneration cycle length was 73.3% of the preretrofit regeneration cycle length measured by the evaluation team. The evaluation team believes this to be a fair assumption since the measured mono-metallic catalysts were aged. Hence, the baseline operating hours were calculated as 73.3% of the measured pre-retrofit operating hours. Baseline gas consumption to the reactor was calculated by multiplying the average post-retrofit gas consumption by the baseline annual operating hours.

Therms savings for this measure was calculated simply by subtracting the post- retrofit gas consumption from the baseline gas consumption.

Electric Savings

We used time series amp data to calculate the average kW draw of the regeneration compressor. The following equation was used to calculate the energy savings.

$$kWh_{Savings\text{-}Regen} = kW_{Avg} \times (hr_{BL} - hr_{PR})$$

where,

$kWh_{Savings\text{-}Regen}$ = energy savings of the regeneration compressor

hr_{BL} = annual operating hours of the regeneration compressor, baseline

hr_{PR} = annual operating hours of the regeneration compressor, proposed

The same methodology was used to calculate the energy savings of the 100 hp wash pump.

Project Impact

The evaluation team determined that this project saved more natural gas than expected because the ex-ante estimate was based on lower annual furnace gas consumption than indicated in the time series data.

This project saved less electric energy than expected. Time series amperage data revealed that the regeneration compressor operates at a lower load factor than estimated in the ex-ante calculation.

Ex-Post Net Savings

The facility contact indicated that the Savings by Design program had no influence on implementing this measure. He stated that the mono-metallic reactors had reached their effective useful life and they were planning change them with Bi-metallic catalysts. He also said that the incentive amount is very small relative to the cost of the bi-metallic catalysts. The above answers yielded a free ridership score of 0 out of 6, indicating 100% free ridership. Hence ex-post net savings for this project was calculated as 0. The savings results are summarized in Table QQ-1.

Table QQ-1: P61867 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realiazation Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
kW	0.0	49.5	0.0	0.0	0.0
kWh	552,660	433,816	78%	0.0	0.0
Therms	101,796	145,072	143%	0.0	0.0

RR. P63626 VFD and Premium Efficiency Irrigation Pump Motor

P63626 received an incentive of $1,182 for installing a premium-efficiency well water pump with VFD control for irrigating their grape vines. The baseline for this application is a standard efficiency pump motor with throttle control. The evaluation team verified the installation of the proposed measures during their site visit and calculated impacts using data loggers installed during the visit.

<u>Ex-Ante Gross Savings</u>

Ex-Ante savings were calculated by the Program using spreadsheet tools. The efficiencies for the baseline and premium efficiency motors were determined using MotorMaster+4.0. Estimates were made for operating hours and GPM requirements, presumably based on discussions with facility personnel. Savings were then calculated at each of four expected operational set-points based on parameters governing performance at each of those set-points, including: total head, pump efficiency, motor efficiency, and VFD efficiency. Using this methodology, ex-ante gross savings were calculated as 15,757 kWh/year. Peak demand savings were estimated at 0 kW.

<u>Ex-Post Gross Savings</u>

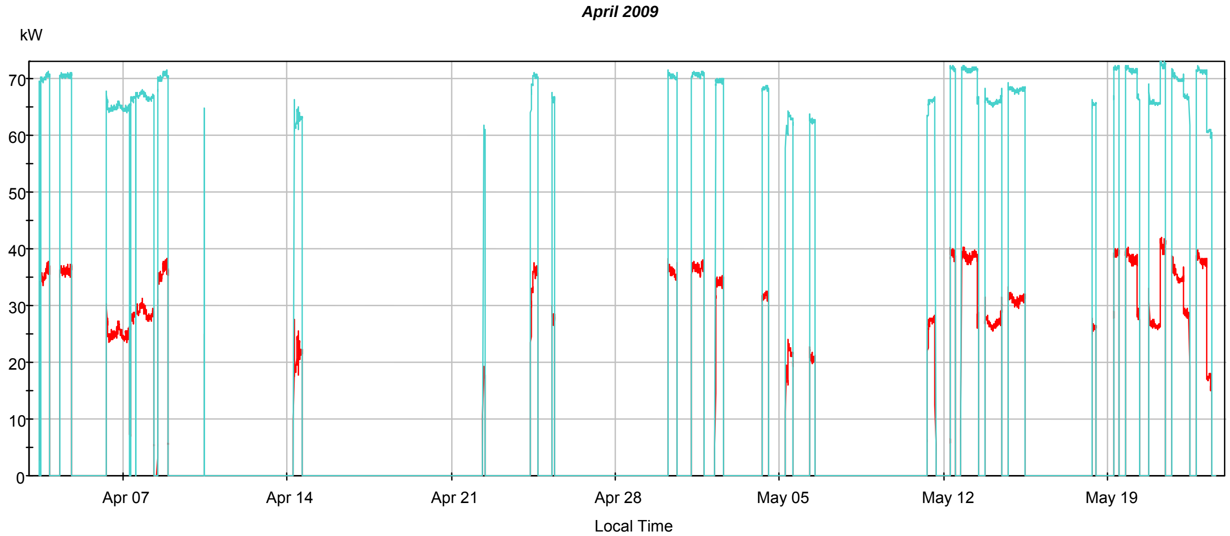
The team determined ex post gross savings primarily using a spreadsheet analysis informed by data logging performed between site visits. Key steps for determining gross savings were as follows:

1) A power logger was placed on the VFD pump motor control panel to monitor energy consumption for 51 days during April and May, 2009. For the first month 36 days of monitoring, motor voltage, amperage, power factor and kW were recorded at 5 minute intervals. Thereafter, only current was monitored because the voltage clamps were displaced during operation. For the remaining 15 days of the logging interval, power factor was calculated using a polynomial curve fit of amperage and power factor data from the prior 36 days of fully metered operation. Voltage for each of the three legs was calculated as the average of the voltage measured during the preceding 36 days.

2) Using an EPRI VFD pump motor power versus speed curve, the team converted power output from the motor into motor speed. Motor speed, which is proportional to flow rate, was then used to calculate required motor power from an equivalent throttling valve controlled motor. The power draw of the throttle valve controlled motor was then scaled

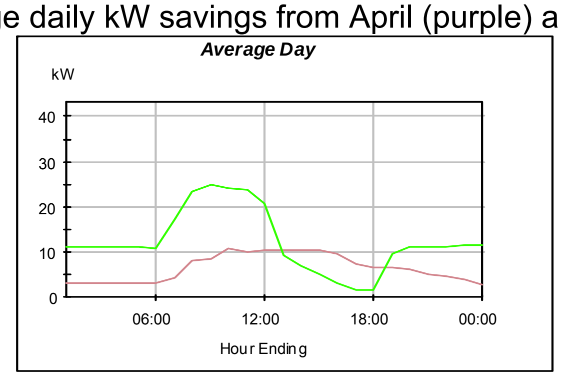
in proportion to the decrease in efficiency associated with using a standard motor in the base case. A comparison of the power draw for the installed and base cases over the monitoring period is presented in Figure RR-1 below.

Figure RR-1: P63626 Comparison of Installed (Red) and Baseline (Light Blue) kW profiles



3) Discussions with the facility staff revealed that the pump generally operates on a more active schedule from May to the October harvest. The pump is used to a lesser degree during the off peak months of March and April and is left unused for the rest of the year. As such, the daily metered savings in April were applied to March, and the daily metered savings from May were applied to June through October. Average daily savings from the April and May monitoring periods are presented in Figure RR-2 below. Peak savings were taken as the average kW savings during May in the 2-5 PM weekday time frame. Final analysis of the metered data indicated annual gross savings of 53,851 kWh and peak demand savings of 4.0 kW.

Figure RR-2: Average daily kW savings from April (purple) and May (green)



Project Impacts

The ex-post savings estimate likely exceeds the ex-ante savings estimate by such a large degree because the installed 100 HP motor never exceeded a roughly 55 HP power draw. This had a large bearing on the savings estimate because VFD savings are inversely proportional to the amount of load placed on the motor. As demonstrated in Figure RR-2, the motor clearly operated primarily in a low load range where VFD savings were maximized.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 53% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown below in Table RR-1.

Table RR-1: P63626 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score -Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Premium Efficiency Motor & VFD	0 of 10	0	Not Available	0	0 of 10	0	0	53%

Ex-Post Net Savings

The decision-maker as referenced by PG&E was unfortunately laid off and the alternate site contact was extremely difficult to reach and communicate with since English was his second language. KEMA contacted PG&E to determine alternate contacts they may have worked with, but we were ultimately unsuccessful in completing a decision-maker survey. However, PG&E's contact information was instrumental in facilitating an on-site visit. As a result, the net savings for this site were taken as the current sample average. The results are presented in Table RR-2 below and could vary depending on possible changes in the sample average.

Table RR-2: P63626 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	0	4.0	-	0.53	2.1
kWh	15,757	63,139	401%	0.53	33464

SS. P65106 VSD Air Compressor

Project P65106 received $7,168.00 for installing a new 75-hp VSD air compressor and three no air loss drains. The measure baseline was a constant volume 75-hp screw compressor with inlet modulation control. The evaluation team verified the installation of the measure during a site visit and calculated the impacts of the measure using data loggers installed during the visit.

<u>Ex-Ante Gross Savings</u>

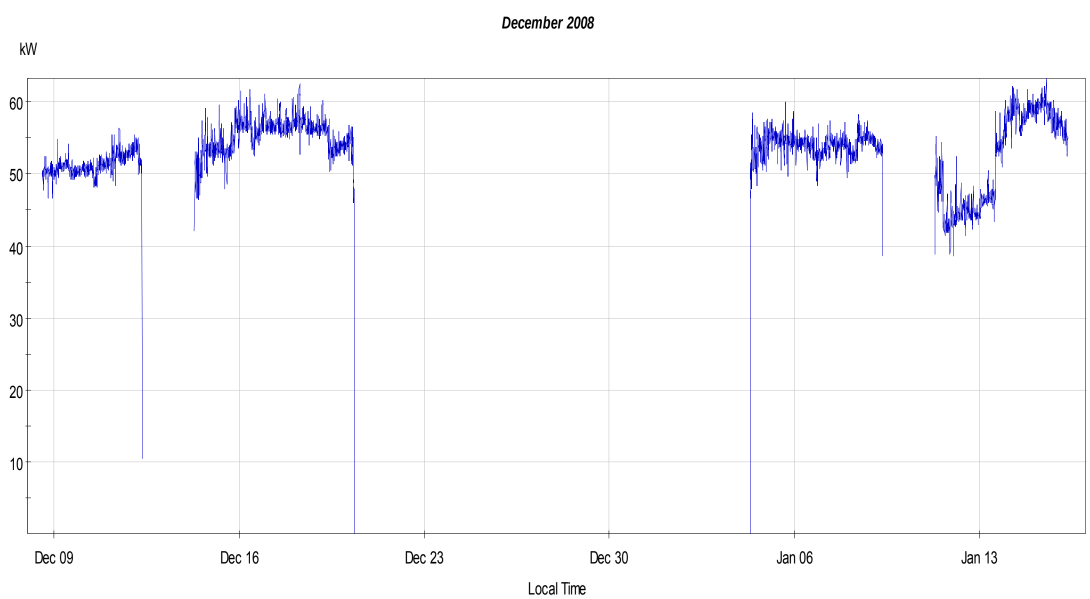
Ex-ante gross savings were determined by the Program using DOE's AirMaster Software. The compressed air baseline and as-built models were simplified and run with AirMaster+.

<u>Ex-Post Gross Savings</u>

The team determined ex-post gross savings primarily by calculating the difference between baseline and post-installation usage. A data logging approach was used to assist in this effort. Key steps for determining gross savings were as follows:

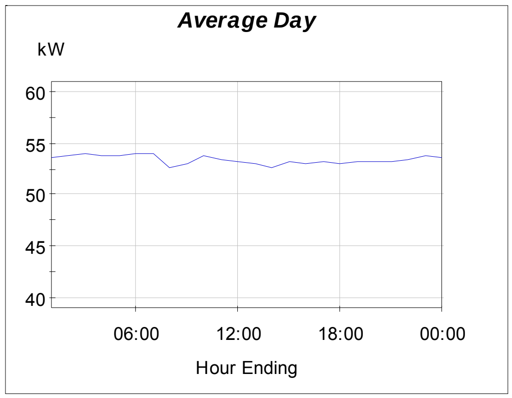
1) A data logger was installed on the 75-hp VSD compressor for a period of five weeks during December 2008 and January 2009. Figure SS-1 shows raw kW data for the 75-hp compressor sampled in 5 minute intervals.

Figure SS-1: P65106 75-hp VSD Air Compressor Raw data for the Monitoring Period



2) Figure SS-2 shows the average kW profile for an average day. Metered data showed that the compressor ran 478 hours of the 930 logged hours. According to plant personnel, the plant shuts down for fifteen days during the holiday season. These days clearly coincided with our monitoring period. Outside of that time frame, the primary site contact stated that the facility operates 24 hours a day, 6 days per week, and 52 weeks per year. Taking all of the above factors into consideration, we estimated the plant operates 7,010 hours per year.

Figure SS-2: P65106 Average Day kW Profile for the Air Compressor



3) Ex-post gross savings analysis was done using AirMaster+ software. An hourly power profile for an average day was generated from the raw data.

4) A series of input parameters were then used to define the facility's operating conditions. Facility elevation, air system pressure, air receiver capacity, and production day types were all defined in the model. Since the metered data indicated that the facility operates on equivalent weekday and weekend schedules, only one day type was defined in the model. The number of production day types depends on the different load profiles across the monitoring period. In this project the compressor had one load profiles; hence one day type was created.

5) Based on the rated compressor power and operating pressure, AirMaster+ defined an airflow range for the compressor. To complete the as-built system model, compressor controls were selected as inlet modulation with unloading since Air Master+ does not currently have a VSD control option. The Air Master+ compressor power vs. flow curve was then modified to reflect VSD controls. It may be noted that the air flow for both baseline and as-built conditions remain unchanged.

6) Finally, the processed average day kW profile was input into the model on an hourly basis. With the as-built model inputs complete, the program was then used to model the supply flow of the as-built compressor on an hourly basis.

7) For the baseline model all inputs except for the compressor controls were left unchanged. The control type was set to a baseline strategy of constant volume with unloading. To model this strategy, the unloading point was changed from 20% in the as-built condition to 50% load in the baseline model. Furthermore, the baseline system model was set to unload at 80% of full load power as opposed to 20% for the as-built model. Figure SS-3 and Figure **SS-4** illustrate the compressor performance profiles for the baseline and as-built compressors respectively. The modeling software was then used to calculate the power draw of the baseline compressor using the airflow profile generated from the as-built model.

Figure SS-3 P65106 Baseline Compressor Performance Profile

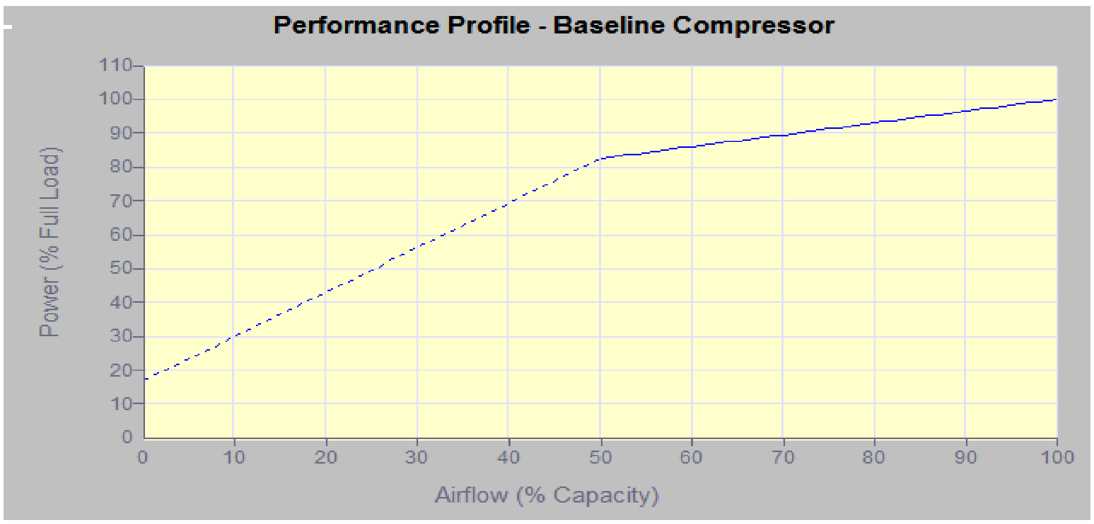
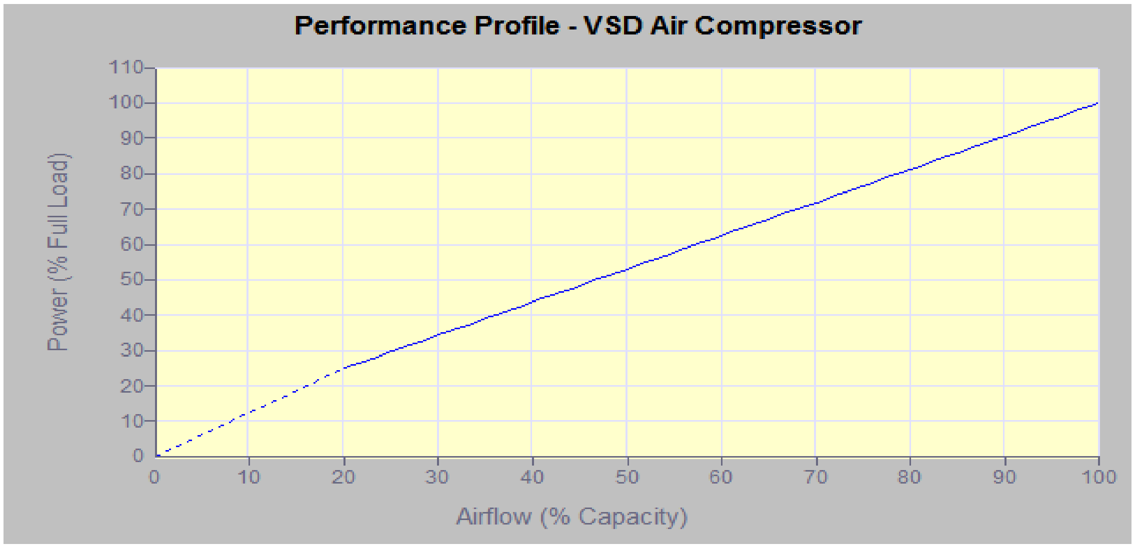
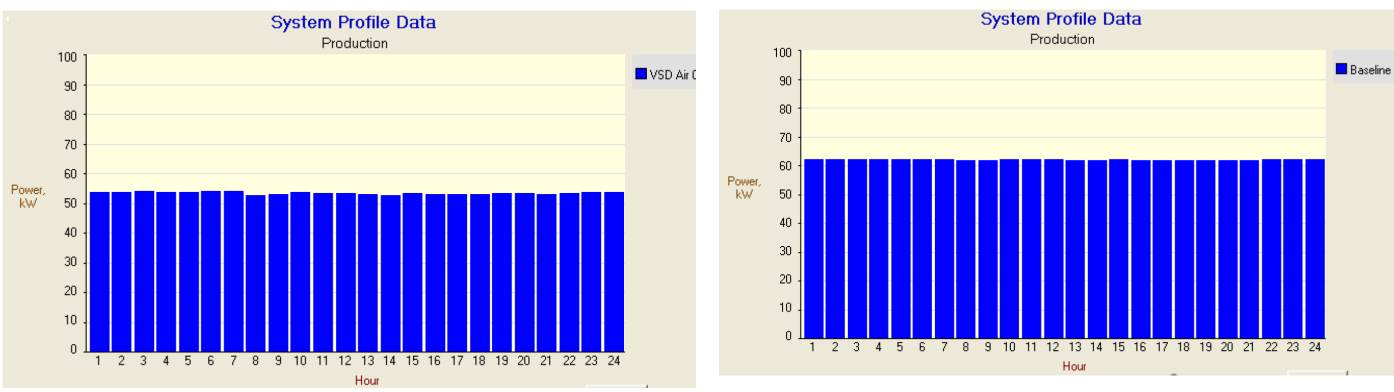


Figure SS-4 P65106 As-Built Air Compressor Performance Profile



8) Savings were calculated using the annual energy and peak demand usage estimates generated with the AirMaster+ software. Savings were simply the difference between the baseline and as-built usage. Note that the peak demand savings were estimated based on CPUC guidelines. Figure SS-5 shows the hourly power consumption of both as-built and baseline compressors.

Figure SS-5: P65106 Power Porfile Comparison of As-built (left) and Baseline Compressors



Program Impacts

Our evaluation team determined that this energy efficiency measure saved less energy than projected because ex-ante savings were based on a lower load. The team found that the compressor was running at 80- 84% of the load at all times which justified the lower gross realization rate.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 70% was calculated from the three free ridership questions on the decision-maker survey for both measures. The free ridership interview results are shown below in

Table SS-1.

Table SS-1: P65106 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
VSD on Air Compressor	8 out of 10	0.8	Easier Sell	1	8 of 10	2.4	4.2	70%
No Air-Loss Drains	8 out of 10	0.8	Easier Sell	1	8 of 10	2.4	4.2	70%

Ex-Post Net Savings

The facility representative indicated that the program was very influential in the implementation of the measure made it an easier sell. He also stated that without the program they would have installed a constant speed air compressor. This combination of answers yielded a net savings score of 4.2 out of 6, or 30% free ridership. Therefore ex-post net savings for the air compressor were evaluated at 70% of the ex-post gross savings as summarized in Table SS-2.

Table SS-2: P65106 Air Compressor Savings Summary

COMPRESSOR	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	14.5	9.7	67%	0.70	6.8
kWh	89,601	64,452	72%	0.70	45,116

TT. P69506 Whole Building

P69506 received an incentive of $158,696 for installing a series of energy efficiency measures in their high temperature refrigerated warehouse. A total of five energy efficiency measures were installed in the 343,000 square foot facility. Roughly 282,000 square feet of the facility is refrigerated. Measures installed at the facility include the following:

- Efficient rooftop packaged units for the refrigerated space
- VFD motors on the packaged systems
- Reduced LPD and motion sensors in the refrigerated space
- Increased insulation and a cool roof
- Lowered office space LPD

The baselines for the proposed measures were Title-24 when applicable, and refrigerated warehouse standard practice otherwise.

Ex-Ante Gross Savings

Ex-Ante gross savings were calculated using DOE 2.2R hourly simulation software. Savings estimates were generated by modeling both the base case and as-built condition in the software. To accomplish this, unique load schedules, equipment schedules and equipment performance parameters were input for the as-built and baseline cases. Savings were calculated as the difference in energy use between the baseline and as-built models.

Ex-Post Gross Savings

The same approach was used to determine ex-post gross savings. However, based on the onsite evaluation, a number of scheduling parameters were changed to reflect the reality of the facility's usage. In particular, the following adjustments were made:

- The facility load, lighting and infiltration schedules were adjusted from 24/7 to 24/5 based on current usage
- The human load schedule was adjusted to reflect higher usage during summer months
- The warehouse temperature deadband was adjusted from 60/55 F to 57/53 based on the current setpoint of 55 F
- Adjusted the economizer low limit temperature to correspond with the adjusted temperature set points
- Adjusted the office and cooling set points

Aside from these adjustments, the model was left unchanged. The site visit revealed that all equipment was installed as proposed.

Ex-Post Net-to-Gross Savings

Measure level net-to-gross ratios varied from 0% to 100%. Net-to-gross ratios were calculated based on the three free ridership questions contained in the decision maker survey. The free ridership survey results are presented in Table TT-1 below.

Table TT-1: P69506 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Rooftop HVAC units, indoor fan motors	0 of 10	0	No Influence	0	0 of 10	0	0	0%
VSD on Blower Motors	10 of 10	1	Analysis	2	10 of 10	3	6	100%
Warehouse LPD and control; office LPD	10 of 10	1	Analysis	2	8 of 10	2.4	5.4	90%
Cool Roof; Insulation	0 of 10	0	No Influence	0	0 of 10	0	0	0%

Ex-Post Net Savings

The site contact indicated that the influence Savings by Design had on their decisions varied from measure to measure. He indicated that Savings by Design was not influential at all in their decision to install the high efficiency rooftop units or the cool roof and insulation measures. He stated that the HVAC design was finalized before the Program ever got involved and that cool roofs are part of their standard building practice. He did however indicate that the program was the primary reason they installed the VSD motors on the packaged units. SBD also provided useful design analysis that brought the savings potential of the lighting LPD and control measures to their attention. Without the program's interaction, the lighting measures probably would not have been installed. Overall, the site contact's answers yielded free ridership scores of 5 on kWh, and 3.9 on kW, indicated 17% and 35% free ridership on kWh and kW respectively. Note that free ridership scores differ between kWh and kW because individual measure level scores were applied to the modeled savings from each measure to develop the overall kWh and kW free ridership scores. Since the relative magnitudes of the kWh and kW savings differ from measure to measure, the free ridership scores are not consistent across both parameters.

Table TT-2: P69506 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	278.7	287.4	103%	0.65	187.7
kWh	1,639,902	1,428,181	87%	0.83	1,187,008
Therms	-73	-1664	2279%	1.18	(1,962.82)

Note in

Table TT-2 that the therm net-to-gross ratio is greater than 1. This anomaly occurred because two measures resulted in negative therm savings, while two other measures resulted in positive therm savings. The site contact's answers to the free ridership questions magnified the weight of the negative savings measures relative to the positive savings measures. As such, ex-post net savings were actually *more* negative than ex-post gross savings for therms, hence the higher realization rate. Since the magnitudes of both the therm usage and savings at this site were minimal relative to the electricity usage, the high therm realization rates were not taken as a cause for concern.

UU. P71966 VSD Air Compressor and Cyclic Dryer

Project P71966 received an incentive of $6,949.00 for installing a new, more efficient air distribution system. The new compressed air system consists of a 100 hp variable speed drive air compressor, a cyclic dryer and two no air-loss drains. The baseline system is a 100 hp constant speed screw compressor with inlet modulation control, a standard dryer that runs continuously even when cooling is unnecessary and solenoid valves for drains. The evaluation team verified the installation of the measures during a site visit and conducted an impact analysis using data logged between visit visits.

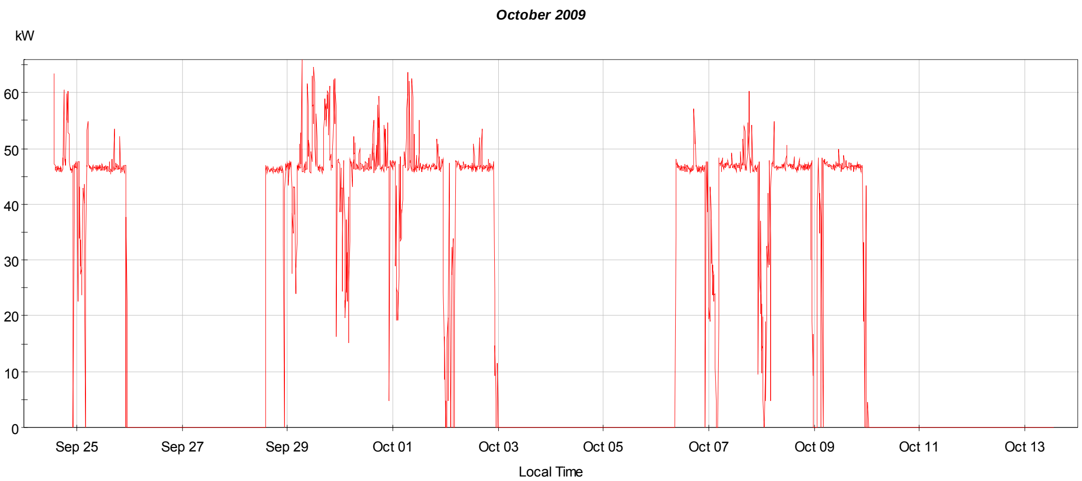
Air Compressor Savings

<u>Ex-Ante Gross Savings</u>
Ex-ante gross savings were estimated by the Program using Air Master+ software. The baseline and as-built compressed air systems were simplified and modeled with AirMaster+.

<u>Ex-Post Gross Savings</u>
The team determined ex-post gross savings using AirMaster+ and spreadsheet analyses informed by data logged at the site. Key steps for determining gross savings were as follows:

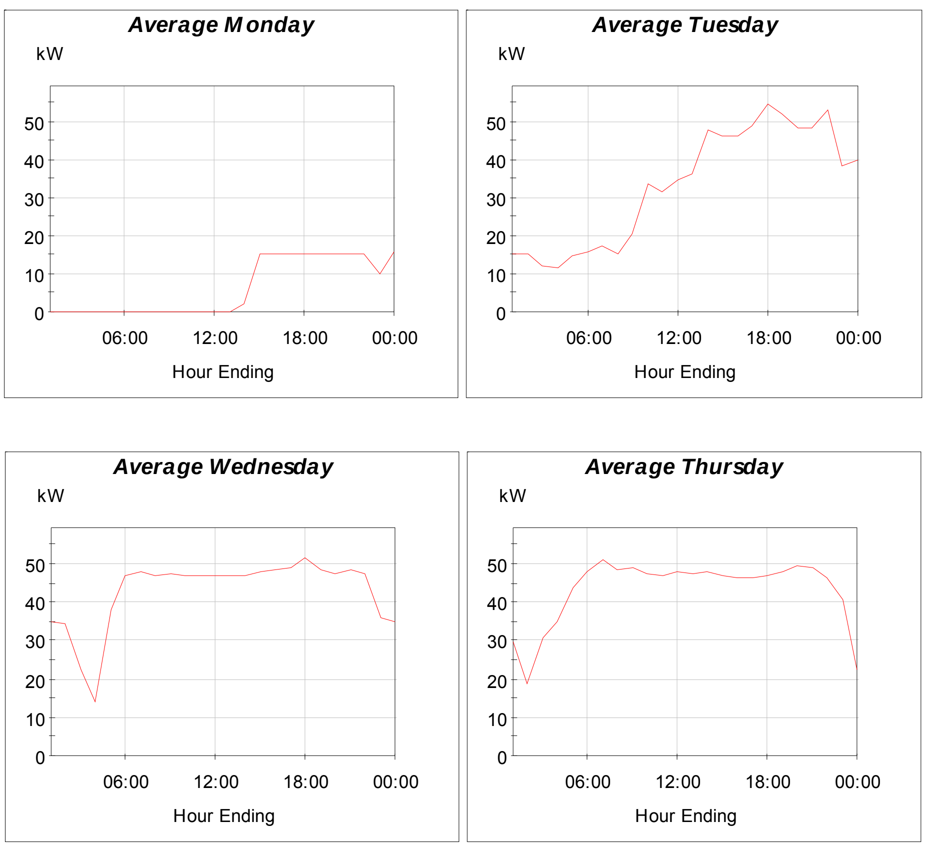
1) Data loggers were installed on both the 100 hp VSD air compressor and TMS dryer for a period of four weeks during August and September 2008. Figure UU-1 shows the 100 hp air compressor power draw for the monitoring period.

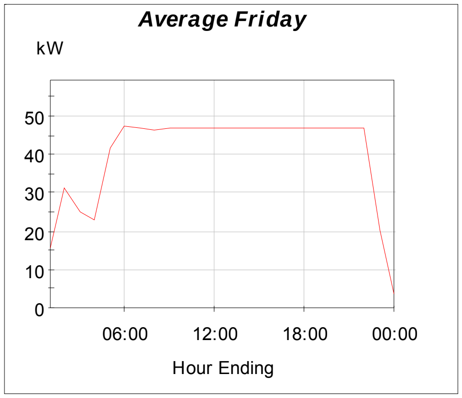
Figure UU-1: P71996 Air Compressor Power for Monitored Period



Hourly profiles for weekdays are shown in Figure UU-2. Logger data reflected an operating schedule of 24 hours a day on weekdays and no operation during weekends.

Figure UU-2: P71996 Air Compressor Hourly Power Profiles (Different Weekdays)



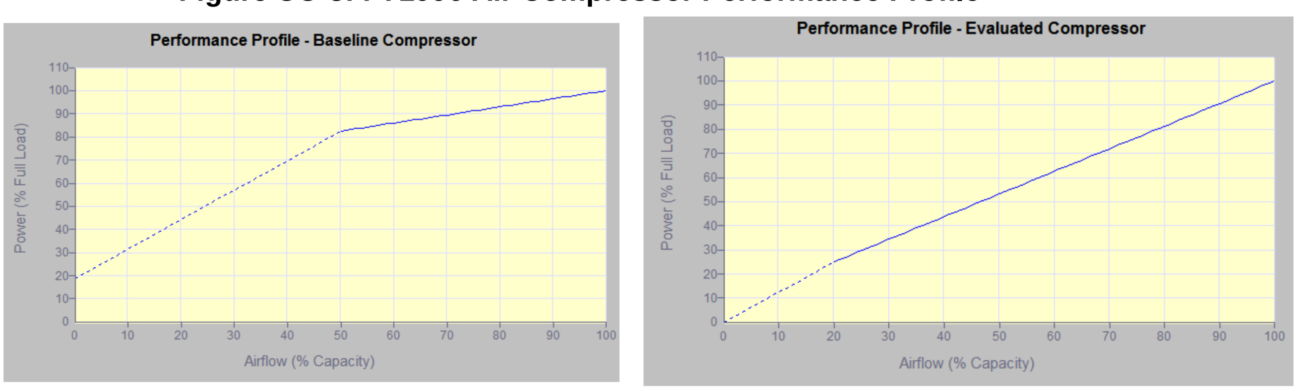


2) An hourly power profile for weekdays was generated from the raw data. The figure above shows that the load profile was different from one day to another. The raisin cleaning process' random load demands were confirmed by the facility engineer.

3) Next, we constructed a compressor model using AirMaster+. Model inputs including facility elevation, air system pressure, air storage capacity (receivers), and production day types. In this project five day types were created because the metered data indicated that the air compressor had a different load profile each weekday.

4) The AirMaster+ compressor model was then selected based on the as-built compressor's rated capacity and operating pressure. AirMaster+ automatically defined an airflow range based on these parameters. The compressor controls were selected as inlet modulation with unloading since AirMaster+ does not currently have a VSD control option. The AirMaster+ compressor profile was then modified to reflect VSD control. The change made to the as-built compressor was the unloading point. The compressor was set to unload at 20% capacity and 25% of full load power. Figure UU-3 shows the relationship between percentage of air flow and percentage of power for both baseline and as-built air compressor.

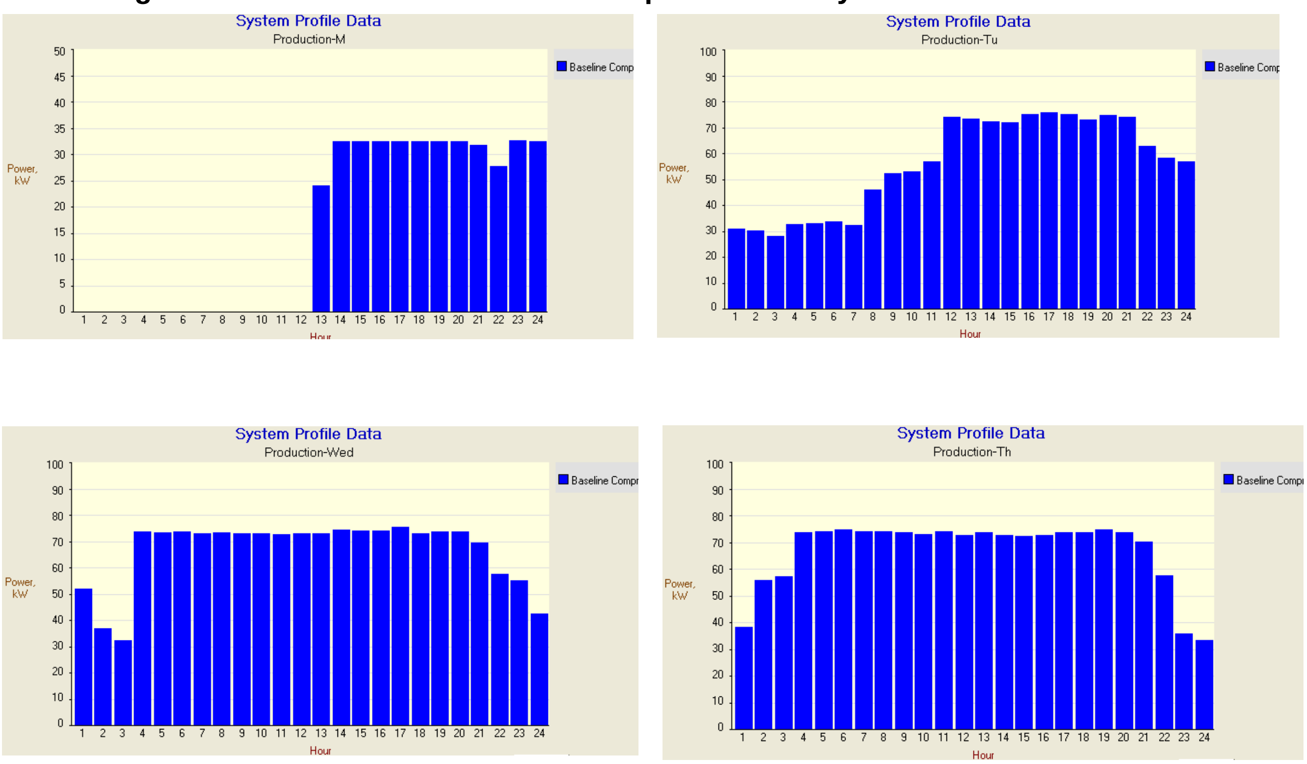
Figure UU-3: P71996 Air Compressor Performance Profile



5) Finally, the logged power data was re-sampled to hourly profiles and input into the model for each day type. Once all of these options were selected, the program modeled the actual behavior of the compressor.

6) For the baseline model all inputs except for the compressor controls were left unchanged. The control type was set to a baseline strategy of constant volume with unloading. The baseline unloading point was changed to 50% capacity at 80% of full load power (see Figure UU-3: **P71996 Air Compressor Performance Profile**). The modeling software was then used to calculate the power draw of the baseline compressor using the airflow profile generated from the as-built model.
Figure **UU-4** shows the hourly power profiles of the modeled baseline air compressor for the operating weekdays.

Figure UU-4: P71996 Baseline Air Compressor Hourly Power Profile



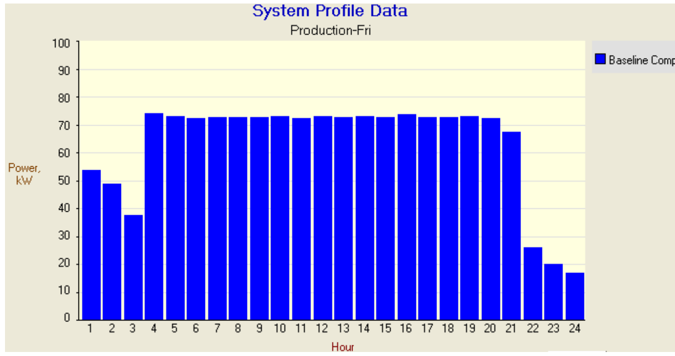
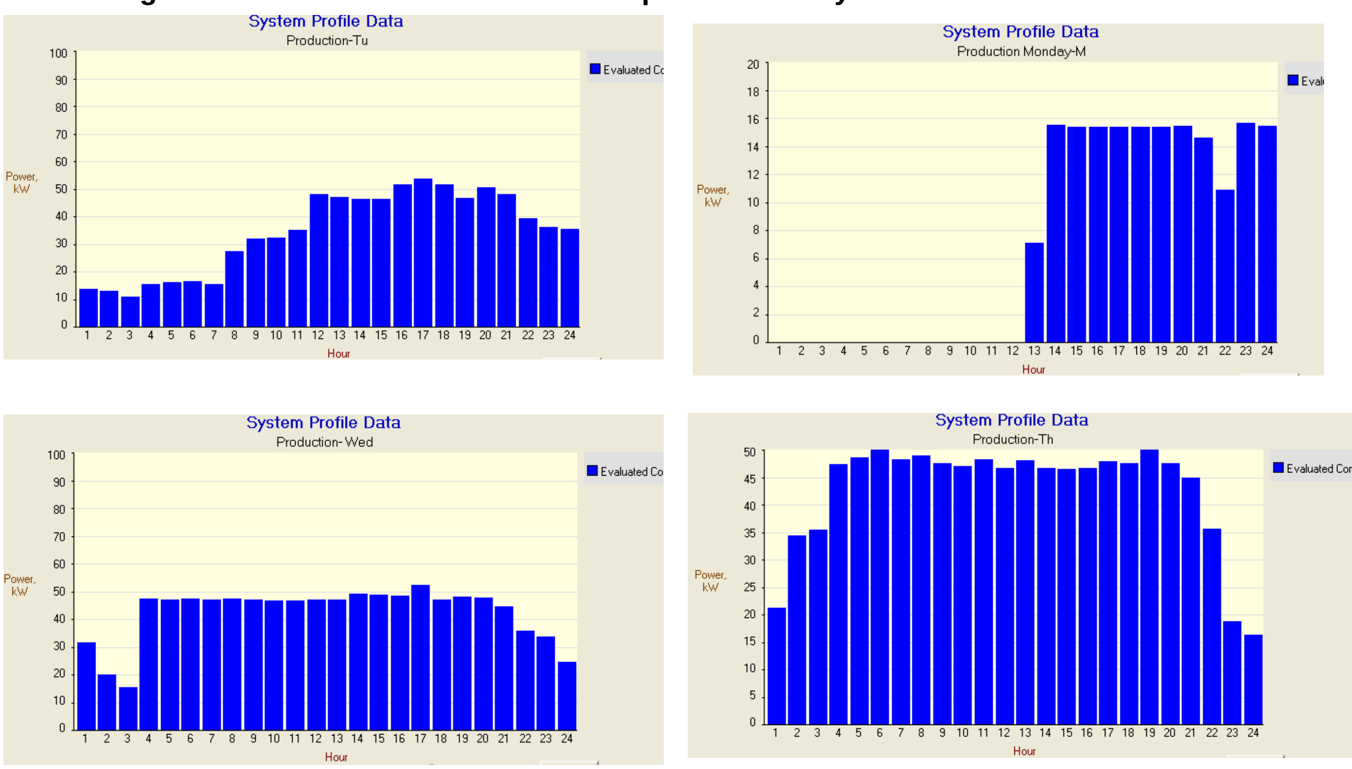
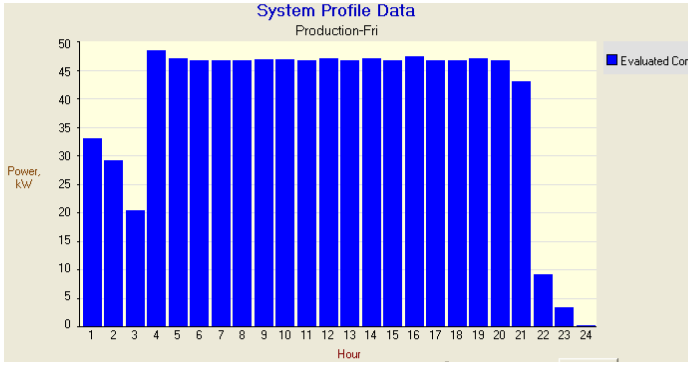


Figure UU-5 shows hourly power profiles of the as-built air compressor for the operating weekdays.

Figure UU-5: P71996 As-Built Air Compressor Hourly Power Profile



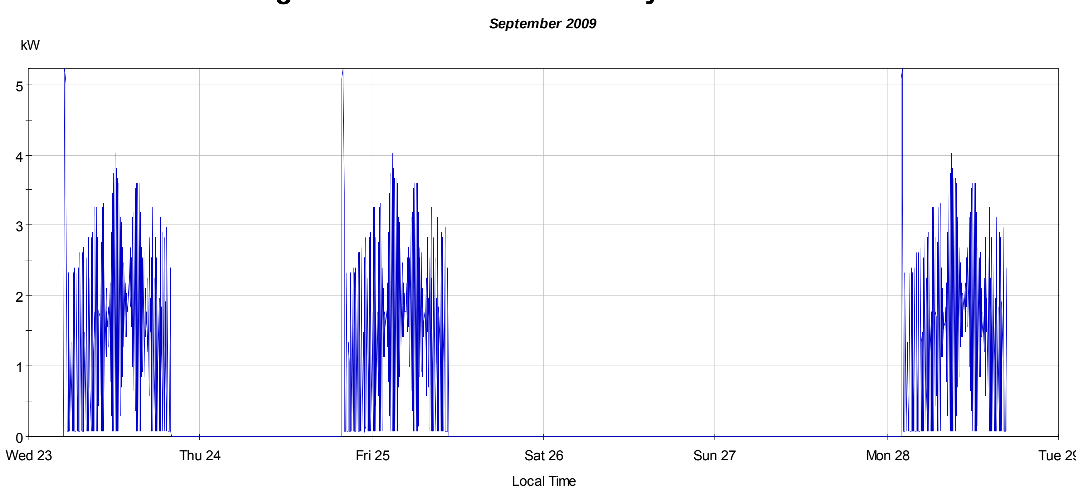


7) Savings were calculated using the annual energy and peak demand usage estimates generated with the AirMaster+ software. Savings were simply the difference between the baseline and as-built usage.

Dryer Savings

We calculated the dryer savings by using the average metered dryer power and the annual operating schedule. Figure UU-6 displays the metered dryer power profile from a 6 day portion during the metering period.

Figure UU-6: P71966 TMS Dryer Power Profile



Project Impacts

The energy efficiency measures saved less energy than projected but saved more in peak demand. The energy savings discrepancy occurred because the evaluated air compressor ran 4,402 hours a year as compared to the forecasted 5,832 hours per year used in the ex-ante estimate. Peak demand savings were higher than calculated in the ex-ante gross analysis because the compressor does not run at full load. At lower loads, the efficiency differential between the baseline and VSD compressor is magnified, therefore savings were greater than expected.

Ex-Post Net-to-Gross Savings

A measure net-to-gross ratio of 82% was calculated from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown below in

Table UU-4.

Table UU-1: P71966 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score -Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
No Air-Loss Drains	8 of 10	0.8	Suggested or Introduced	2	7 of 10	2.1	4.9	82%
HE Cycling Compressed Air Dryer	8 of 10	0.8	Suggested or Introduced	2	7 of 10	2.1	4.9	82%

Ex-Post Net Savings

The facility owner indicated that the program was very influential in the implementation of the measures since an SBD representative first suggested them. He also mentioned that they definitely would not have installed either measure in the absence of the program. For our ex-post net savings evaluation, this combination of answers yielded a free ridership score of 4.9 out of 6, or 18% free ridership. Therefore, the ex-post net savings for the air compressor and the cyclic dryer were evaluated at 82% of the ex-post gross savings as summarized in

Table UU-2 and Table **UU-3** respectively. The total savings for the project are presented in

Table UU-4.

Table UU-2: P71966 VSD Air Compressor Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Gross Realization Rate	Ex-Post Net Savings
peak kW	11.8	24.1	204%	0.82	19.7
kWh	129,437	66,262	51%	0.82	54,114

Table UU-3: P71966 TMS Dryer Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Netto Gross Realization Rate	Ex-Post Net Savings
peak kW	1.7	4.1	243%	0.82	3.4
kWh	28,746	26,607	93%	0.82	21,729

Table UU-4: P71966 Total Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Gross Realization Rate	Ex-Post Net Savings
peak kW	13.5	27.7	200%	0.82	22.6
kWh	158,183	90,281	57%	0.82	73,730

VV. P75627 Whole Building

P75627 received an incentive of $55,536 for the installation of energy efficient measures at their refrigerated warehouse expansion. The expansion consists of roughly 31,500 square feet of new refrigerated space. The measures installed at the facility consist of the following:

- VSD condenser fans, floating head pressure control, and wet-bulb following control strategy
- VSD pre-cooler fans with premium efficiency motors
- Floating suction temperature
- Increased Insulation
- Efficient compressor motor
- Increased LPD *(negative savings)*

The baselines for the proposed measures were Title 24 when applicable, and refrigerated warehouse standard practice otherwise.

<u>Ex-Ante Gross Savings</u>

Ex-Ante gross savings were calculated using DOE 2.2R hourly simulation software. Savings estimates were generated by modeling both the base case and as-built condition in the software. To accomplish this, unique load schedules, equipment schedules and equipment performance parameters were input for the as-built and baseline cases. Savings were calculated as the difference in energy use between the baseline and as-built models.

<u>Ex-Post Gross Savings</u>

The same approach was used to determine ex-post gross savings. However, based on the onsite evaluation, a number of scheduling parameters were changed to reflect the reality of the facility's usage. In particular, the following adjustments were made:

- During the site visit, it was learned that the facility operates on a 12 month schedule as opposed to the six month schedule originally included in the model. The product load schedule was also found to vary dramatically from peak conditions at the beginning of the year to off-peak conditions towards the end of the year; product load and equipment schedules were adjusted according to these two finds.

Aside from adjusting the equipment operating and load schedules, the model was left unchanged. The site visit revealed that all equipment was installed as proposed.

<u>Ex-Post Net-to-Gross Savings</u>

A measure net-to-gross ratio of 60% was calculated from the three free ridership questions on the decision maker survey. The LPD measure free ridership question responses yielded a net-to-gross ratio of 58%. The free ridership survey results are presented in Table VV-1 below.

Table VV-1: P75627 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Refrigeration Measures	5 of 10	0.5	Easier Sell	1	7 of 10	2.1	3.6	60%
LPD in Cold Storage	6 of 10	0.6	Design Analysis	2	3 of 10	0.9	3.5	58%

Ex-Post Net Savings

The site contact indicated that Savings by Design was somewhat influential in their decision to implement the installed refrigeration measures. In particular, the rebates helped offset the higher cost of the high efficiency equipment. In the absence of the program, it is probable that less efficient equipment would have been installed. With regard to the lighting measures, the site contact indicated that the program had little influence on their decision to implement the installed lighting. He stated that because of their storage environment, they had limited lighting choices. The site contact's combination of answers yielded a free ridership score of 3.6 for both kWh and peak kW. These scores indicate 40% free ridership. Note that free ridership scores can differ between kWh and kW because individual measure level scores are applied to the modeled savings from each measure to develop the overall kWh and kW free ridership scores. Since the relative magnitudes of the kWh and kW savings can differ from measure to measure, the free ridership scores are not usually consistent for both parameters (in this case they agree to two significant digits).

Table VV-2: P75627 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	122.9	89.3	72.6%	0.60	53.8
kWh	396,685	366,898	92.5%	0.60	220,708

WW. S18014 Variable Speed Drives and Premium Efficiency Motors on Pumps and Fans

Project S18014 received an incentive of $150,000 for installing variable speed drives on 4 cooling tower fans, 2 150-hp boiler feed water pumps, and 2-200 hp chilled water pumps. The incentive also included installing premium efficiency motors on all of the above pumps and fans as well as 6 condenser water pumps. Constant volume control was used as the baseline for the variable speed drive pump and fan measures. Standard efficiency motors were used as the baseline for the premium efficiency motor measures. The evaluation team was able to verify the installation of all measures on site.

Ex-Ante Savings

The project file didn't provide any specific information about how the savings were calculated for these measures. It only quoted that the estimate used NCCalc for a typical building of this type.

Ex-Post Gross Savings

The evaluation team determined ex-post gross savings using data collected from several loggers installed on selected incented pumps and fans during the site visit. Our selection of metering was based on the facility personnel's recommendation. Table WW-1 shows the incented equipment as well as the subset that were metered during our evaluation. Facility personnel indicated that the sample metered sample is representation of the whole population.

Table WW-1: S18014 Incented Equipment

Incented Equipment	Quantity	Metered
VFD 75 hp Cooling Tower Fans with PE Motors	4	1
VFD 150 hp Hot Water Pumps with PE Motors	2	1
VFD 200 hp Chilled Water Pump with PE Motors	2	1
VFD 20 hp Condenser Water Pumps with PE Motors	2	1
200 hp Condenser Water Pumps with PE Motors	4	1

Key steps for determining ex-post gross savings were as follows:

1. Data loggers were installed on one 75-hp cooling tower fan, one 150-hp hot water pump, one 200-hp chilled water pumps, one 20-hp condenser water pump,

and one 200-hp condenser water pump for a period of three weeks during November and December 2008. The data loggers recorded data at an interval of 10 minutes. Facility personnel also provided us twelve months of flow data for all of the above equipment.

2. The evaluation team imported the recorded this data into data visualization software. Figure WW-1 and Figure WW-2 show the raw data for all of the metered equipment except the 20-hp condenser water pump.

Figure WW-1: S18014 Raw Metered Data for VFD 200 hp Chilled water Pump (Red) and VFD 75 hp Cooling Tower Fans (Blue)

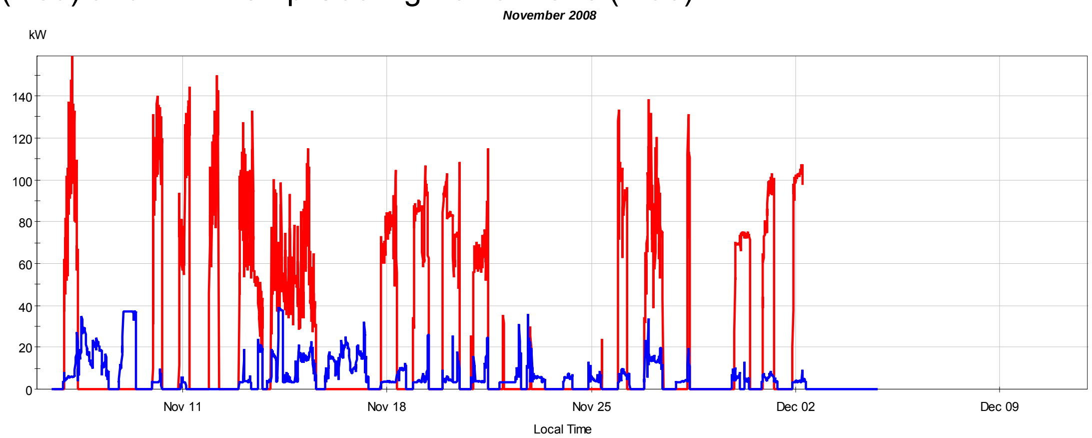
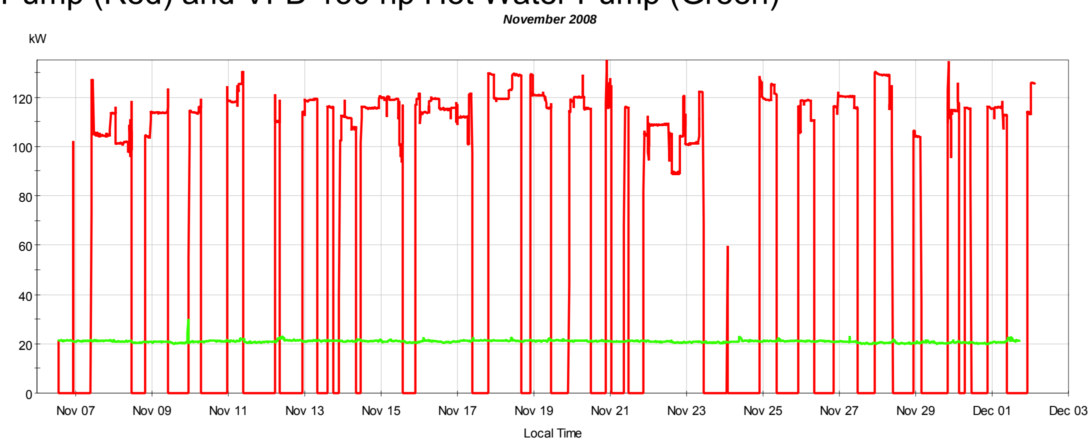


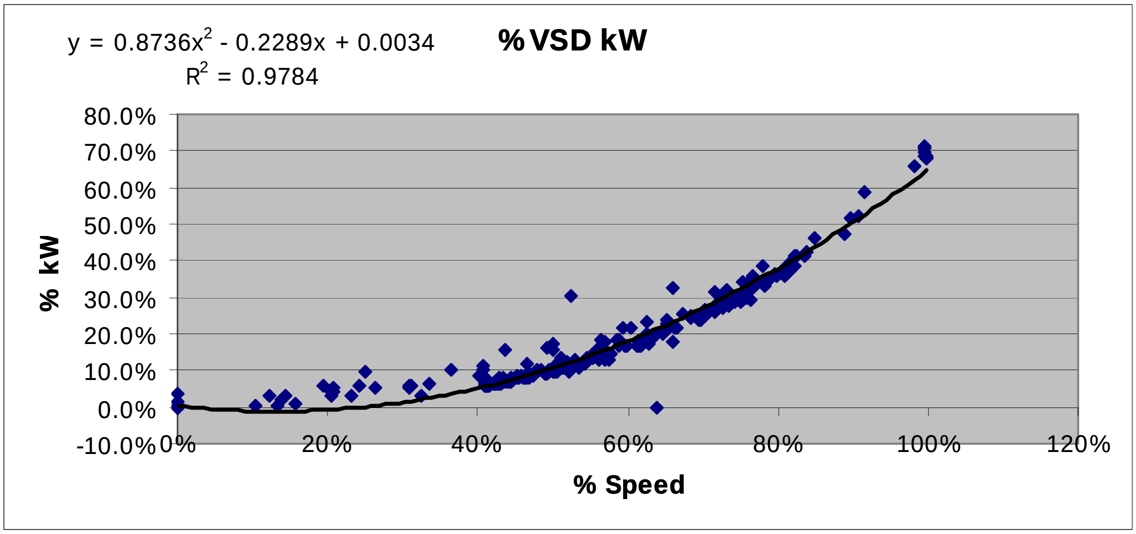
Figure WW-2: S18014 Raw Metered Data for VFD 200 hp Condenser Water Pump (Red) and VFD 150 hp Hot Water Pump (Green)



3. Time series hourly kW data was divided by full load kW to calculate % kW. Then % kW and the respective % speed (obtained from facility) for that period were used to create a regression model. This model relates % VFD kW to a specific % flow. The regression model used for the 75 hp cooling tower fan is shown in
4.
5.

6. Figure WW-3.

Figure WW-3: Regression Trend of % Flow vs. % Speed for the Cooling Tower Fan



7. Using the regression models recreated for all of the affected equipment, the annual flow data provided by the facility personnel was used to calculate the % power draw of each piece of equipment. The % values were then multiplied by the full load power of each piece of equipment to generate hourly kW profiles. The annual kW profiles were then integrated to determine annual kWh usage.

8. Since the baseline condition for all of the affected equipment was constant volume control, the base case power was simple the full load operating power of the equipment. Baseline energy usage was therefore determined by multiplying the baseline power and annual operating hours of the affected equipment.

9. Ex-post VSD energy savings were calculated as the difference between baseline energy usage and ex-post energy usage.

Energy savings from the premium efficiency motors were evaluated using the following equation:

$KWh_{PE\text{-}Savings} = ((kW_{MFLP} \times \eta_{PE})/\eta_{SE}) \times hrs/yr$

where,

$KWh_{PE\text{-}Savings}$ = annual ex-post energy savings for premium efficiency measure
kW_{MFLP} = measured kW of the premium efficiency motor
η_{PE} = proposed efficiency of the motor
η_{SE} = standard efficiency of the motor
hrs/yr = annual operating hours of the premium efficiency motor

The variable speed drive measure saved nearly the same amount of energy projected in ex-ante estimate. Demand savings were however greater than projected. Review of the data and engineering analysis determined that the incented fans and pumps were running at lower loads than expected, hence the higher demand savings. Operating at lower loads should have also saved more energy, but the evaluation team believes that the annual operating hours used in the ex-ante calculation were longer than those found in our evaluation. The combination of lower loads and shorter operating hours in post condition made the ex-post savings nearly equal ex-ante savings.

Similarly, the premium efficiency motor measures saved more energy than expected because the incented equipment had longer annual operating hours than originally claimed in ex-ante estimate.

Ex-Post Net-to-Gross Savings

Measure net-to-gross ratios of 53% and 63% were calculated for the premium efficiency motor and VSD measures respectively based on the three free ridership questions in the decision maker survey. The free ridership survey results are shown below in Table WW-2

Table WW-2: S18014 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Premium Efficiency Motors	7 of 10	0.7	Easier Sell	1	5 of 10	1.5	3.2	53%
VSD's on Hot Water Pumps and Tower Fans	7 of 10	0.7	Easier Sell	1	7 of 10	2.1	3.8	63%

EX-Post Net Savings

The facility representative indicated that Savings by Design was influential in implementing both measures and them an easier sell. He also indicated that they may have installed the premium efficiency motors without the incentive. According to the site contact, they always look for energy efficiency equipment, but the incentive helped insure that the VSDs would be installed on the pumps. The above combination of answers yielded free ridership scores of 3.2 and 3.8 for the PE motor and VSD measures respectively. Hence, ex-post net savings were 53% of ex-post gross savings for the PE measure and 63% of ex-post gross savings for the VSD measure.

Table WW-3 and Table WW-4 and show the savings summaries for each measure.

Table WW-3: S18014 Savings Comparison for Premium efficiency motors

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	12.1	14.9	123%	0.53	8.0
kWh	51,186	82,849	162%	0.53	44,186

Table WW-4: S18014 Savings Comparison for Variable Speed Drive Measure

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
Peak kW	63.4	413.9	653%	0.63	262.2
kWh	930,028.0	961,548.8	103%	0.63	608,980.9
Therms	39,041	40,364	103%	0.63	25,564

XX. S18022 Reduced Production Warehouse and Cold Storage LPD, VSD Evaporative Condenser w/ Fixed Set Point Floating Head Pressure Control

S18022 received an incentive of $27,431 for installing VSD controls on their 10 and 7.5 HP evaporative condensers, which serve both the existing and newly expanded portions of their fruit cold storage warehouse. As part of the project, LPD reduction measures were also undertaken in the cold storage and production areas of the facility. During the site visit, the evaluation team verified the installation of both proposed measures directly.

<u>Ex-Ante Gross Savings</u>

To determine savings from the VSD evaporative condenser portion of the project, an 8760 hourly spreadsheet analysis was undertaken using CTZ weather data. The following list of steps illustrates the analysis flow for determining the energy draw of the as-built system.

1) To begin the analysis, hourly storage and production load was determined. Production load was determined as a function of the fruit processing rate, which directly correlates to the rate fruit is brought into the cold storage. Storage loads (not related directly to products brought into the cold storage) were calculated as a function of the outdoor air temperature and the % of lights on within the space at any given time.

2) Next, a check was performed to verify that the load at the desired saturated suction temperature (SST) and saturated condensing temperature (SCT) was below the capacity of the installed compressors. Not once over the 8,760 schedule did the load exceed the compressors' capacity.

3) For a given SST and SCT (fixed at 85 F for the as-built case), each compressor's power draw was next calculated. The kW draw of the compressors was then scaled in proportion to the compressors' load factor during that hour.

4) Using the combination of the process load and the heat load from the compressors, the total heat rejected by the condensers was next calculated.

5) Based on the SCT and the outdoor wet-bulb temperature, the condenser's capacity factor was next calculated. Using the total heat rejected, the condenser capacity factor, and the condenser's capacity at design conditions, the % condenser load for a given set of conditions was calculated.

6) Percent condenser load was then assumed to be equivalent to percent (%) fan speed. Using the affinity laws, the power draw of the condenser was calculated for the VSD control case based on the fan speed and rate fan motor power.

To develop the baseline case, the system's SCT temperature was switched from 85 F to 110 F (affecting steps 3 and 4 above), and the fan control strategy was switched to cycling (meaning condenser load was essentially linearly proportional to fan power).

Refrigeration savings were calculated as the difference in power draw between the baseline and as-built cases, taking into account savings from both the compressors and condensers.

Lighting measure savings were calculated using a spreadsheet analysis based on the baseline Title 24 LPD as determined by space type versus the installed LPD. Hourly kWh savings were summed over the assumed operating schedule of the lighting.

Ex-Post Gross Savings

Ex-post gross refrigeration savings were calculated using the same spreadsheet approach undertaken for the ex-ante calculations. However, the following changes were made to the load schedules supplied to the spreadsheet using information collected on site:

- The production load schedule was changed to reflect the actual peak months (November-May) determined during the evaluation. For off peak months, the hourly production load was reduced and Saturday operations were removed
- Hourly production schedules for all months were reduced to 17 hours per day from 24 hours per day as previously modeled
- Lighting schedules were shortened to reflect the shorter production schedules.
- The cooling set point temperature for the cold storage was adjusted from 40 F to 39 F

Aside from these changes, the core analysis flow of the spreadsheet was left unchanged.

Lighting savings were calculated based on the hours of operation using a simple spreadsheet analysis. The same savings factor used in the ex-ante calculation to account for the added savings associated with the occupancy sensors in the refrigerated spaces was applied. The evaluation revealed that there were three more lights in the production portion of the facility than indicated in the project file. Peak savings were calculated based on the average kW draw of the lights found during the DEER defined peak.

Ex-Post Net-to-Gross Savings

Measure net-to-gross ratios of 95% and 90% were calculated fro the VSD condenser and lighting measures respectively. These values were determined from the three free ridership questions on the decision maker survey. The free ridership survey results are presented in Table XX-1 below.

Table XX-1: S18022 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
VSD Condener Fans w/ FHP and fixed setpoint	7of 10	0.7	Investment Criteria	2	10 of 10	3	5.7	95%
LPD	7 of 10	0.7	Suggested or Introduced	2	9 of 10	2.7	5.4	90%

Ex-Post Net Savings

The site contact indicated that Savings by Design was influential in their decision to implement the VSD condenser controls and the lighting measures. He stated that Savings by Design originally suggested the lighting measures and that the program helped the VSD control measures meet investment criteria. In the absence of the program, neither measure would have likely been installed. The site contact's combination of answers yielded a free ridership score of 5.4 for the lighting measures and 5.7 for the VSD condenser measures, indicating 10% free ridership for the lighting measures and 5% free ridership for the VSD measures.

Table XX-2: Reduced Production Warehouse and Cold Storage LPD Savings Summary

	Ex-Ante Gross Savings	**Ex-Post Gross Savings**	**Gross Realization Rate**	**Site Net-to-Gross Ratio**	**Ex-Post Net Savings**
peak kW	13.9	5.4	38.5%	0.90	4.8
kWh	33,812	40,012	118.3%	0.90	36,010

Table XX-3: VSD Evaporative Condenser w/ Fixed Set Point Floating Head Pressure Control Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	44.4	52.1	117.3%	0.95	49.5
kWh	321,745	213,331	66.3%	0.95	202,664

Table XX-4: S18022 Saving Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	58.3	57.5	98.5%	0.95	54.3
kWh	355,557	253,343	71.3%	0.94	238,675

YY. S18112 Variable Speed Drives Installed on 45 Pump Motors

S18112 received an incentive of $150,000 for installing VSD controls on 45 motors in its milk processing plant. The measure baseline was throttle valve controlled constant speed pumps. The evaluation team verified the installation of the measure during a site visit and calculated impacts using data logged over a month.

Ex-Ante Gross Savings

Savings were initially calculated by the Program using motor data in conjunction with anticipated monthly schedules and motor load profiles. The data analysis was done with spreadsheets. Each pump was assigned an expected number of monthly operating hours. Those operating hours were then divided amongst expected load profiles in terms motor speed percentage. At each speed, a given motor's power consumption was compared between the throttle valve and VSD power consumption profiles (% power as a function of % speed). Savings were then extrapolated over the course of the year with the implicit assumption of equivalent loads in every month. Total savings were estimated at 1,987,538 kWh.

Ex-Post Gross Savings

The team determined ex-post gross savings by using a spreadsheet based analysis. The analysis was informed by true power and current data collected over a month between site visits. The following steps were undertaken to complete the analysis:

1) Data loggers were installed on 12 motors. Pumps were sampled with two goals in mind:

- Meter at least one pump of every size
- Meter at least one pump for every unique facility task

Table YY-1 below lists the twelve unique combinations of pump size and function found at the facility. One pump from each of these groups was metered.

Table YY-1: Incented VSD Controlled Pumps

Type #	Service Area/Function	Size (HP)	Quantity	Efficiency	Metered Load Factor
1	25% solids milk pumping	7.5	2	91.7%	0.48
2	Silo pumping	15	1	92.4%	0.13
3	25% solids milk pumping	25	1	93.0%	0.46
4	Milk separation	10	1	91.0%	0.39
5	Milk separation	20	2	93.0%	0.12
6	Reverse Osmosis System 1	25	1	91.0%	0.32
7	Reverse Osmosis System 2	25	5	91.0%	0.84
8	Reverse Osmosis System 2	30	4	91.0%	0.18
9	Reverse Osmosis System 3	25	1	91.0%	0.72
10	Reverse Osmosis System 3	50	1	94.1%	0.08
11	Reverse Osmosis System 3	30	1	91.0%	0.15
12	Ultrafiltration System	25	25	86.5%	0.22

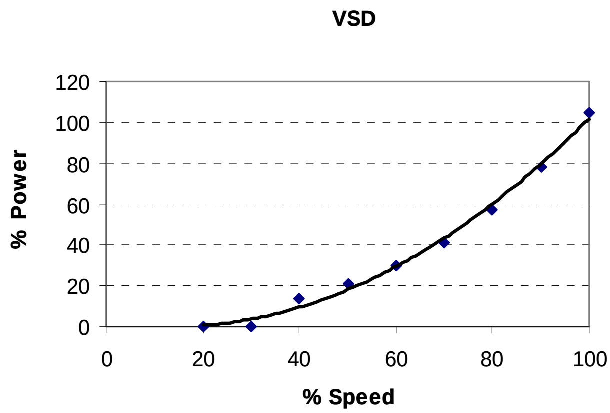
Of the metered pumps, four were monitored with true power loggers, (types 5, 8, 10 and 11). The remaining eight were monitored with current loggers. Spot voltage and power factor measurements were taken on the current-logged pumps to develop power profiles from the logged current data. All twelve data loggers recorded data in five minute intervals for a 26 day period in February 2009. The metered plant operating profiles were assumed representative of average load conditions. A facility representative stated that the facility produces milk year round at a nearly constant rate with little fluctuation in load. Extrapolating the metered load profiles to yearly load profiles was therefore considered a sound approach.

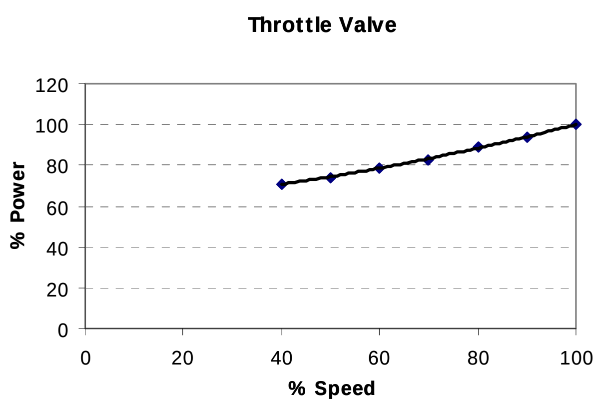
All unmetered pumps were assumed to have equal load profiles to pumps of an equivalent type, as defined in Table YY-1. The site contact stated that all pumps of an equivalent type handle similar loads, thereby justifying this method of extrapolating the sample profiles to the population. As demonstrated in Table YY-1, load factors varied significantly from one pump size and function to the next.

Savings calculations were done using percent speed vs. percent power profiles for throttle valve and VSD controlled pumps. Percent power (relative to rated-hp) was determined from logger data for the VSD controlled pumps and converted to percent speed. Speed percentage was then converted to percent power for the throttle valve controlled pumps. In this way, complete load profiles were generated for a theoretical throttle valve controlled system.

Percent speed vs. percent power curves for both the throttle valve and VSD control pump systems were taken from the program documentation supplied in the project file. By using the same curves as the Program, a more precise calculation of gross realization rate was possible. The speed vs. power curves used for the analysis are displayed below.

Figure YY-1: VSD and Throttle Valve Controlled % Speed vs. % Power Curves





Savings were determined for each combination of pump task and motor model and summed to determine gross savings using spreadsheets and data visualization software. The results were extrapolated to a 12 month time frame to capture yearly kWh savings. Figure YY-2 and Figure YY-3 below provide the load profile for all pumps over the logging period and over an average day, respectively. Baseline data are provided in both figures for comparison.

Figure YY-2: S18112 load profiles for the actual (blue) and baseline (red) pump systems

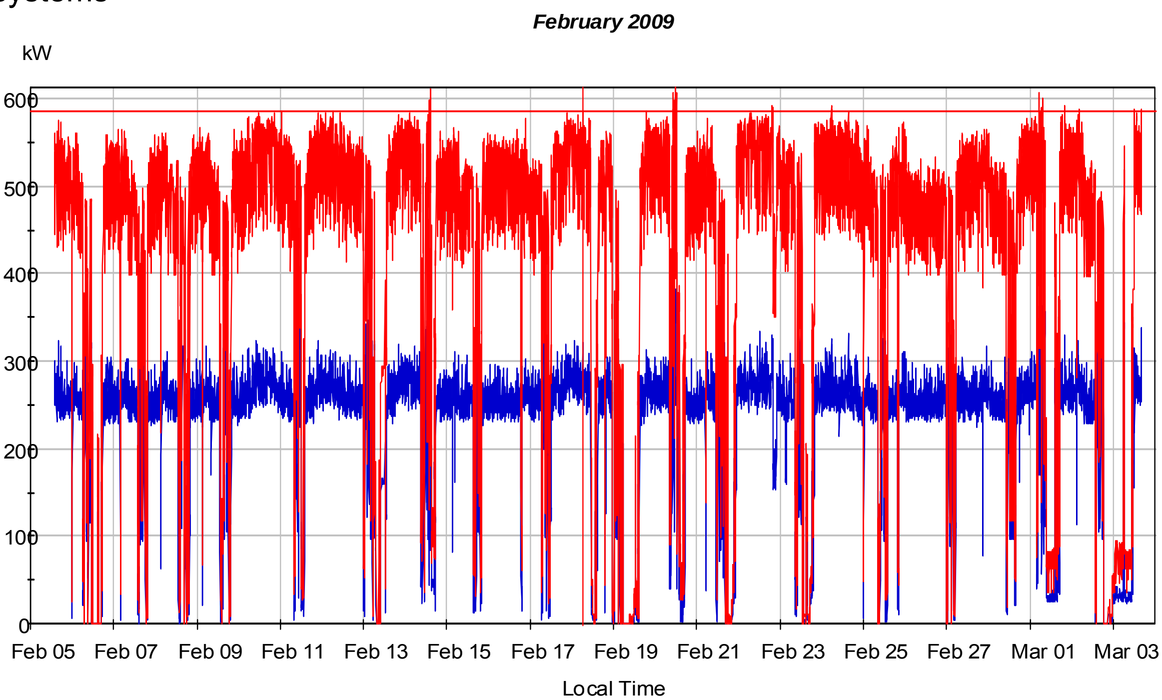
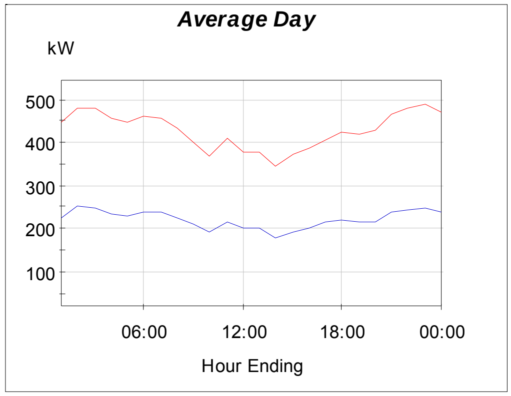


Figure YY-3: S18112 Load profiles for an average day for the actual (blue) and baseline (red) pump systems



<u>Project Impacts</u>

Analysis using the above method yielded total yearly savings of 1,815,577 kWh. The peak demand reduction was 203.5 kW.

<u>Ex-Post Net Savings</u>

A measure net-to-gross ratio of 95% was calculated from the three free ridership questions on the decision-maker survey. The survey results are shown below in Table YY-2.

Table YY-2: S18112 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Pump Motors with VFD	10 out of 10	1	Investment Criteria	2	9 of 10	2.7	5.7	95%

<u>Ex-Post Net Savings</u>

An on-site interview with the site contact indicated the SBD program was essential for implementation of the proposed measures. According to the contact, if the SBD incentive had not been involved they could not have implemented the VSD measures. Overall, his answers yielded a 5.7 of 6 score, indicating 5% free ridership. Therefore, the net savings were 95% of the yearly savings calculated based in the ex-post evaluation. Table YY-3 below summarizes the results.

Table YY-3: S18112 VSD Pump Motors Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	No calc.	203.5	N/A	0.95	193.3
kWh	1,978,538	1,815,577	92%	0.95	1,724,798

ZZ. S19021 Refrigerated Warehouse

Project S19021 is a refrigerated warehouse in which the new construction totals approximately 148,300 square feet of refrigerated space. The project received an incentive of $150,000 for adding many energy efficient measures to the facility. The measures included evaporative condensers with floating head pressure, variable set point and variable speed condenser fans, VSD fan control, product cooler VSD fan control, efficient compressor motors, increased insulation, and reduced lighting power density in the cold storage areas. The measures were verified by the evaluation team during a site visit. The facility has widely varying loads because produce arrives in from the fields at various times.

Ex-Ante Gross Savings

Ex-ante gross savings were calculated using DOE-2.2R simulation software. A variety of parameters were estimated, including the equipment schedules, cooling loads, and temperatures.

Ex-Post Gross Savings

Ex-post gross savings were calculated using the same methodology as the ex-ante gross savings. Select equipment was monitored for a three week period in December 2008. Table ZZ-1 lists both the incented equipment and the metered portion of the equipment. Metered data was used to verify modeling inputs such as the condensing temperature range and lighting schedule.

Table ZZ-1: S19021 incented Equipment

Incented Equipment
VSD Compressors
VSD Air Unit Fan Motors
VSD Condensers
Reduced LPD
Increased Insulation
Metered Equipment
VSD Compressors
VSD Air Unit Fan Motors
VSD Condenser
Reduced LPD

Figure ZZ-1 shows the VSD air unit fan power profile logged during the monitoring period. The modeled fan schedule was altered to reflect this power profile.

Figure ZZ-1: S19021 % of Power for VSD Air Unit Motors

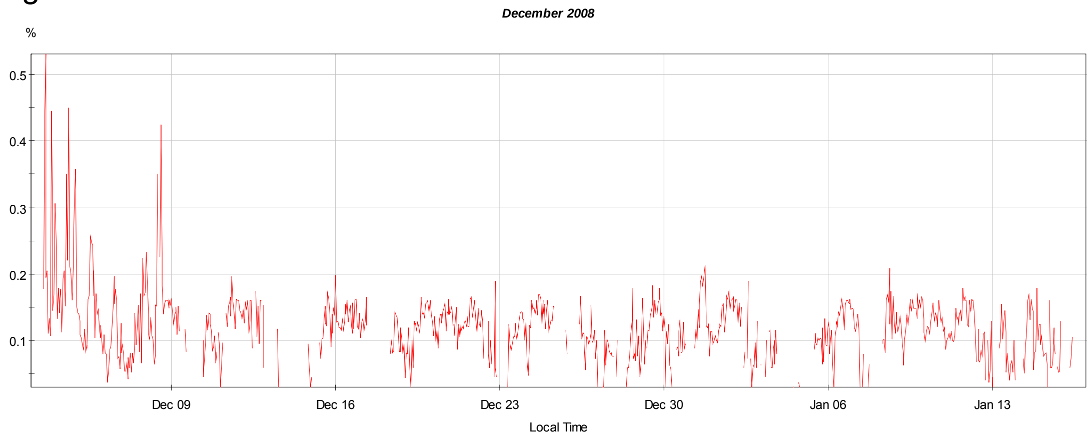
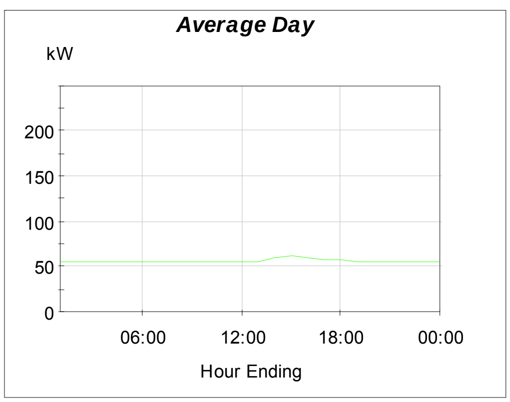


Figure ZZ-2 shows the sum of the individual condenser fans' energy usage. Clearly the fan load did not vary significantly during the metering period. As such, no changers were made in the model to account for varying condenser fan behavior.

Figure ZZ-2: S19021 Average Daily Power Consumption of the Condenser Fans



The metered lighting profile was significantly different than that contained in the Program's model. Examination of the logged data revealed that the lights were off for more hours each day than originally estimated. We incorporated the changed lighting schedule into the model to determine actual lighting savings.

<u>Ex-Post Net-to-Gross Savings</u>

Net-to-gross ratios of 65% were calculated from the three free ridership questions on the decision-maker survey for all measures at the facility. The free ridership survey results are shown in

Table **ZZ-2** below.

Table ZZ-2: S19021 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Floating Head Pressure w/ Variable Setpoint & VFD	8 of 10	0.8	Easier Sell	1	7 of 10	2.1	3.9	65%
VSD on Air Unit Fan Motors	8 of 10	0.8	Easier Sell	1	7 of 10	2.1	3.9	65%
High efficiency motors	8 of 10	0.8	Easier Sell	1	7 of 10	2.1	3.9	65%
Increased Insulation	8 of 10	0.8	Easier Sell	1	7 of 10	2.1	3.9	65%
Cool Roof	8 of 10	0.8	Easier Sell	1	7 of 10	2.1	3.9	65%
LPD reduction in with motion sensors	8 of 10	0.8	Easier Sell	1	7 of 10	2.1	3.9	65%
LPD reduction with motion sensors	8 of 10	0.8	Easier Sell	1	7 of 10	2.1	3.9	65%
Central Ammonia System	8 of 10	0.8	Easier Sell	1	7 of 10	2.1	3.9	65%

Ex-Post Net Savings

The facility representative indicated that the program was influential in the implementation of the measures. The respondent stated that the incentive made the measures an easier sale. He also stated that they typically only install high performance equipment when incentives are available to help offset the cost. This combination of answers yielded a free ridership score of 3.9 out of 6, or 35% free ridership. Therefore, the ex-post net savings were evaluated as 65% of the ex-post gross savings as summarized in Table ZZ-3.

Table ZZ-3: S19021 Savings Summary

	Ex-Ante Gross Savings	**Ex-Post Gross Savings**	**Gross Realization Rate**	**Site Net to Gross Ratio**	**Ex-Post Net Savings**
kW	336.6	368.4	109%	0.65	239.5
kWh	1,887,914	1,875,382	99%	0.65	1,226,667

AAA. S19094 Whole Building

S19094 installed multiple energy efficiency measures in the new food distribution facility. The majority of the measures pertain to the 56,700 square foot refrigerated portion of the facility. Lighting and HVAC measures do however apply to the remaining 352,900 square feet of the building, which consists of dry storage and office space. The measures installed at S19094 are as follows:

- VSD condenser fans, floating head pressure control, and wet-bulb following control strategy
- Mechanical subcooling of the low temperature circuit using the medium temperature circuit
- VSD air unit fans
- Floating suction pressure
- Efficient compressor and air unit motors
- VSD on the low temperature screw compressor
- Increased cold storage insulation
- Increased LPD *(negative savings)* and occupancy sensors throughout the refrigerated and dry warehouses
- Efficient packaged HVAC units for the office areas
- Reduced office LPD
- Skylights in the dry portion of the warehouse
- High speed freezer and cooler doors

The baselines for the proposed measures were Title 24 when applicable, and refrigerated warehouse standard practice otherwise.

<u>Ex-Ante Gross Savings</u>

Ex-Ante gross savings were calculated using DOE 2.2R hourly simulation software. Savings estimates were generated by modeling both the base case and as-built condition in the software. To accomplish this, unique load schedules, equipment schedules and equipment performance parameters were input for the as-built and baseline cases. Savings were calculated as the difference in energy use between the baseline and as-built models.

<u>Ex-Post Gross Savings</u>

The same approach was used to determine ex-post gross savings. However, based on the onsite evaluation, a number of scheduling parameters were changed to reflect the reality of the facility's usage. In particular, the following adjustments were made:

- The site visit revealed that the facility operates on a reduced operating schedule on Fridays and Saturdays, but operates on a full schedule on Sundays. Previously the facility was set to operate Monday through Saturday and then close on Sundays. All freezer and cooler schedules (load, occupancy, infiltration, and lighting) were adjusted to reflect these changes.

- The refrigeration contractor was contacted to verify the refrigeration system set points. Based on that discussion, the wet bulb following temperature differential was changed from 7 F to 9 F.

Aside from these adjustments, the model was left unchanged. The site visit revealed that all equipment was installed as proposed.

Ex-Post Net-to-Gross Savings

Measure level net-to-gross ratios varied from 22% to 98%. Net-to-gross ratios were calculated based on the three free ridership questions contained in the decision maker survey. The free ridership survey results for each of the measures are presented in Table AAA-1 below.

Table AAA-1: S19094 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Refrigeration Measures	9 of 10	0.9	Investment Criteria	2	8 of 10	2.4	5.3	88%
Proposed insulation and high speed freezer doors	9 of 10	0.9	Suggested or Introduced	2	10 of 10	3	5.9	98%
Lighting power density and control	3 of 10	0.3	No Influence	1	0 of 10	0	1.3	22%
Roof HVAC units	3 of 10	0.3	No Influence	1	0 of 10	0	1.3	22%
Skylights controlled by Photo sensors	3 of 10	0.3	No Influence	1	0 of 10	0	1.3	22%

Ex-Post Net Savings

The first site contact indicated that Savings by Design was minimally influential in the implementation of the office LPD, lighting control, day lighting and office HVAC measures. He stated that the building was designed with the potential for Savings by Design incentives in mind, but it was always the intent of the builders to make a LEED rated building.

A second site contact indicated that Savings by Design was very influential in the implementation of the various mechanical refrigeration, high speed door, and increased insulation measures. He stated that in the absence of the program, some of the measures would not have been installed. In particular, he indicated that less efficient motors would have been installed due to investment criteria. The site contact's combination of answers yielded free ridership scores of 3.4 for kWh and 3.2 for kW, which correspond to 43% kWh and 46% kW free ridership. Note that free ridership scores differ between kWh and kW because individual measure level scores were applied to the modeled savings from each measure to develop the overall kWh and kW free ridership scores. Since the relative magnitudes of the kWh and kW savings differ from measure to measure, the free ridership scores are not consistent for both parameters.

Table AAA-2: S19094 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	229.2	228.1	99.5%	0.54	123.3
kWh	1,774,739	1,759,916	99.2%	0.57	1,009,186

BBB. S19097 Whole Building

S19097 received an incentive of $63,958 for installing a number of energy efficient measures in their new refrigerated warehouse. Of the facility's 65,700 square feet, 58,400 are refrigerated. Measures installed at the facility include the following:

- VSD condenser fans, floating head pressure controls, and a wet bulb following control strategy
- VSD compressor motors
- Increased cold storage insulation
- Reduced cold storage LPD
- High efficiency HVAC units in the offices

The baselines for the proposed measures were Title 24 when applicable, and refrigerated warehouse standard practice otherwise.

<u>Ex-Ante Gross Savings</u>

Ex-Ante gross savings were calculated using DOE 2.2R hourly simulation software. Savings estimates were generated by modeling both the base case and as-built condition in the software. To accomplish this, unique load schedules, equipment schedules and equipment performance parameters were input for the as-built and baseline cases. Savings were calculated as the difference in energy use between the baseline and as-built models.

<u>Ex-Post Gross Savings</u>

The same approach was used to determine ex-post gross savings. However, based on the onsite evaluation, a number of scheduling parameters were changed to reflect the reality of the facility's usage. In particular, the following adjustments were made:

- The facility operating schedule was significantly changed to reflect year round operation. Previously, the schedule was set such that the facility was closed from August through October. As such, the following schedules were changed:
    - Occupancy
    - Lighting
    - Air infiltration
    - Cold storage load schedules
    - Process load schedules

Aside from these adjustments, the model was left unchanged. The site visit revealed that all equipment was installed as proposed.

<u>Ex-Post Net-to-Gross Savings</u>

Measure level net-to-gross ratios varied from 32% to 90%. Net-to-gross ratios were calculated based on the three free ridership questions contained in the decision maker survey. The free ridership survey results are presented in Table BBB-1 below.

Table BBB-1: S19097 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Refrigeration Measures	9 of 10	0.9	Design Analysis	2	5 of 10	1.5	4.4	73%
Insulation	8 of 10	0.8	Easier Sell	1	5 of 10	1.5	3.3	55%
Lighting Power Density	10 of 10	1	Design Analysis	2	8 of 10	2.4	5.4	90%
High Efficiency HVAC Units	3 of 10	0.3	Easier Sell	1	2 of 10	0.6	1.9	32%

<u>Ex-Post Net Savings</u>

The site contact indicated that Savings by Design was very influential in the implementation of the mechanical refrigeration measures. She stated that the design analysis provided by Vacom made it easier to identify savings opportunities and present them to management. Without the Savings by Design incentives, there is a roughly 50% chance that different equipment would have been installed for the refrigeration measures. The site contact also stated that Savings by Design was not very influential in their decision to install high efficiency HVAC in the office space. With regard to the LPD measure, the design analysis provided by the program convinced them to install efficient lighting as opposed to minimally compliant equipment. Lastly, with respect to the insulation measures, the presence of an incentive allowed the installation of more insulation than would have otherwise been installed. The site contact's combination of answers yielded free ridership scores of 4.42 on kWh and 4.40 on kW, indicating 26% kWh free ridership and 27% kW free ridership. Note that free ridership scores differ between kWh and kW because individual measure level scores were applied to the modeled savings from each measure to develop the overall kWh and kW free ridership scores. Since the relative magnitudes of the kWh and kW savings differ from measure to measure, the free ridership scores are not consistent for both parameters.

Table BBB-2: S19097 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	94.8	131.1	138.3%	0.73	96.2
kWh	799,472	846,924	105.9%	0.74	624,070

CCC. S19098 Whole Building

S19098 received an incentive of $125,310 for installing a series of high efficiency measures at their new distribution center. The project consisted of installing energy efficient measures in two refrigerated warehouse buildings totaling 320,000 square feet of refrigerated space as originally designed. The EEMs installed at S19098 were as follows:

- VSD controlled condenser with floating head pressure control and a wet bulb following control strategy
- VSDs on compressors attached to all three suction groups (+22, +10, -20)
- VSD blast chill air units
- Lowered LPD in the manufacturing unit
- Lowered LPD and lighting controls in the chilled warehouse
- Increased insulation and cool roof
- Improved freezer and cooler doors
- Improved dock doors
- Efficient compressor and air units motors
- VSD control of the pumps on the glycol circuit

The baselines for the proposed measures were Title 24 when applicable, and refrigerated warehouse standard practice otherwise.

Ex-Ante Gross Savings

Ex-Ante gross savings were calculated using DOE 2.2R hourly simulation software. Savings estimates were generated by modeling both the base case and as-built condition in the software. To accomplish this, unique load schedules, equipment schedules and equipment performance parameters were input for the as-built and baseline cases. Savings were calculated as the difference in energy use between the baseline and as-built models.

Ex-Post Gross Savings

The same approach was used to determine ex-post gross savings. However, based on the on-site evaluation, a number of scheduling parameters were changed to reflect the reality of the facility’s usage. In particular, the following adjustments were made:

- Adjusted the freezer and cooler load schedules to reflect the current receiving schedules
- Changed the temperature of a formerly 54 F room to reflect its current usage as a 34 F room
- Adjusted the load in the formerly 60 F room to reflect the added load; adjusted the air changes per hour requirement of the new 34 F room to be equivalent to the other 34 F room
- Created an entirely new 60 F space because the site has expanded the cold storage portion of the facility to an adjacent building. This space was added to

the model because it runs off of the same refrigeration system as the rest of the buildings. The 60 F room load schedule was created based on the facility's receiving schedule and the load previously assigned to the formerly 54 F room, which this room effectively replaced.

Aside from these adjustments, the model was left unchanged. The site visit revealed that all equipment was installed as proposed.

Ex-Post Net-to-Gross Savings

Measure level net-to-gross ratios varied from 28% to 80%. Net-to-gross ratios were calculated based on the three free ridership questions contained in the decision maker survey. The free ridership survey results are presented in Table CCC-1 below.

Table CCC-1: S19098 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Lighting Power Density	7 of 10	0.7	Design Analysis	2	7 of 10	2.1	4.8	80%
Insulation	7 of 10	0.7	Easier Sell	1	7 of 10	2.1	3.8	63%
Doors	7 of 10	0.7	Easier Sell	1	0 of 10	0	1.7	28%
VSD glycol pumps	7 of 10	0.7	Design Analysis	2	5 of 10	1.5	4.2	70%
Remaining Refrigeration Measures	7 of 10	0.7	Design Analysis	2	7 of 10	2.1	4.8	80%

Ex-Post Net Savings

The site contact indicated that Savings by Design was generally quite influential in the implementation of the measures. The design analysis provided by the program demonstrated which technologies and groupings of measures save the most energy. In the absence of the program different equipment would have likely been installed for many of the refrigeration components. Savings by Design was also influential in the implementation of the insulation and high speed door measures because the incentive made them an easier sell to management. The site contact's combination of answers yielded free ridership scores of 4.7 on kWh, 4.5 on kW and 3.4 on therms. These scores correspond to 22% kWh free ridership, 25% kW free ridership, and 43% therm free ridership. Note that free ridership scores differ between kWh, kW and therms because individual measure level scores were applied to the modeled savings from each measure to develop the overall kWh, kW, and therm free ridership scores. Since the relative magnitudes of the kWh, kW and therm savings differ from measure to measure, the free ridership scores are not consistent across all three parameters.

Table CCC-2: S19098 Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	286.8	353.3	123.2%	0.75	266.0
kWh	1,566,373	1,654,301	105.6%	0.78	1,284,910
Therms	282	282	100.0%	0.57	161.5

DDD. S19108 Variable Speed Drives on Pumps and Fans, High Efficiency Lighting

Project S19108 received an incentive of $133,323.00 for installing variable speed drives on eighteen pumps and fans in their new facility. This incentive also included installing high efficiency lights in various areas of the plant. The evaluation team visited the facility October 2009 and verified the installation of the measures. During the evaluation team's visit, data loggers were installed on the incented equipment to assess the power consumption of the affected equipment.

Ex-Ante Savings

The Program used MARS software to calculate savings from the VSD pump and fan motor savings. The algorithms or program inputs used for this analysis were not readily apparent from the project file. Constant volume pumps and fans were used as the baseline for all VSD measures.

The project file did not contain information regarding the lighting measure. It only reflected the kWh saved from installing the high efficiency lighting. The measure baseline was determined using T-24 energy standards for LPD by space type.

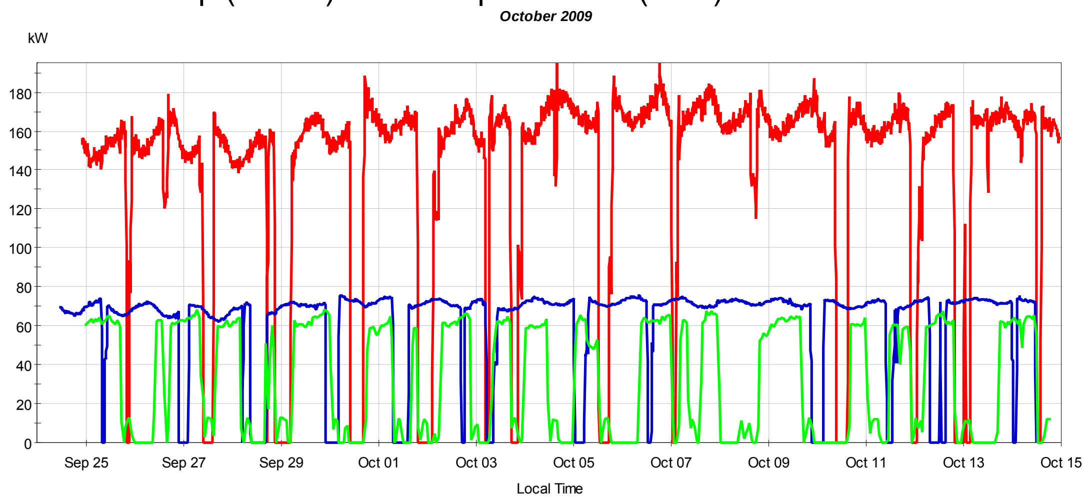
Ex-Post Savings

VSD Pumps /Fans

Data loggers were installed on ten pumps and fans for two weeks in October 2009. A detailed baseline survey with facility personnel yielded the appropriate baselines for all measures. The appropriate baseline control strategy for all fans was inlet guided vanes. The pump baselines were either throttle control or bypass depending on the application.

Figure DDD-1 shows the power profiles of a 350-hp exhaust fan, a 200-hp pressure pumps and a 250-hp inlet fan for the monitoring period.

Figure DDD-1:S19108 Power Profiles: 350 hp Exhaust Fan (Red), 200 hp Pressure Pump (Green) and 250hp Inlet Fan (Blue)



It should be noted that ex-ante savings were based on constant volume baseline conditions for all the affected equipment. Table DDD-1 below shows the incented equipment and metered equipment. It also compares the ex-ante and ex-post baselines.

Table DDD-1: S19108 Comparison of Ex-ante and Ex-post Baseline Conditions

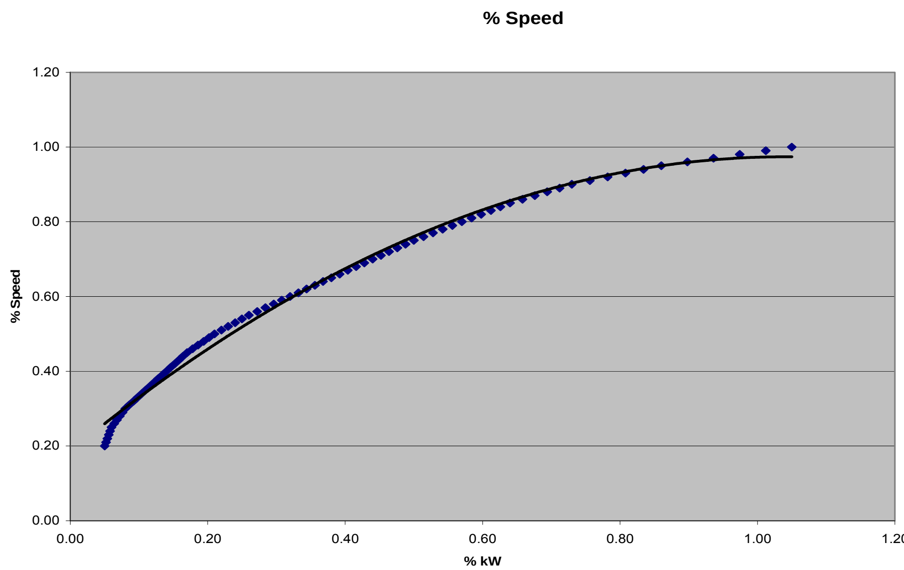
Incented Equipment	**Quantity**	**Assumed Ex-Ante Baseline Conditions**	**Ex-Post Baseline Conditions**	**Metered**
350 hp Fans	2	Constant Volume	Inlet Guided Vane	1
200 hp High Pressure Pumps	2	By-Pass Valve	By-Pass Valve	1
250 hp nlet Fan	1	Constant Volume	Inlet Guided Vane	1
75 hp Static Heater fan	1	Constant Volume	Inlet Guided Vane	1
50 hp Dehumidified Fan	1	Constant Volume	Inlet Guided Vane	1
15 hp Circulation Pumps	2	Constant Volume	Throttled Valve	1
25 hp CIP Pumps	4	Constant Volume	Throttled Valve	1
50 hp CIP Pump	1	Constant Volume	Throttled Valve	1
15 hp Recovery Pumps	2	By-Pass Valve	Throttled Valve	1
10 hp Recovery Pumps	2	By-Pass Valve	Throttled Valve	1
Total	**18**			**10**

As shown in Table DDD-1, metering was performed on each incented pump or fan type. According the facility engineer, the non-metered incented fans and pumps have similar profiles to the metered equipment. Hence the metered sample was the representation of the whole population.

Metered data were imported into data visualization software. This software was used to identify the operating schedules and poer profiles of all affected pumps and fans. The data indicated that the facility remains in constant operation. The facility engineer confirmed that the facility operates 24 hours a day, 365 days a year. He also confirmed there is not seasonality the business and production remains constant throughout the year. Key steps for determining ex-post gross savings are as follows:

1. First, a second order regression was created from EPRI's % Power vs % Speed curve for VSD pump and fan applications to determine the relationship between speed and kW for the pumps. This regression trend, which is shown in Figure DDD-2 was used to determine the % speed of the pumps and fans.

Figure DDD-2: S19108 Regression Trend of EPRI % VFD kW versus % Speed Data



2. This trend was used to determine the fan/pump speed percentage for each time stamp based on the percentage of full load power.

3. Next another regression model was built from EPRI % speed vs. % kW data for the baseline pumps and fans. Two separate regressions were performed to account for the two baseline types at the facility.

4.
5.
6.

7. Figure DDD-3 and Figure DDD-4 below show the regression trends for inlet guided vane fans and for throttled controlled pumps respectively.

Figure DDD-3: S19108 Regression Trend for Inlet Guided Vane % Speed versus % kW

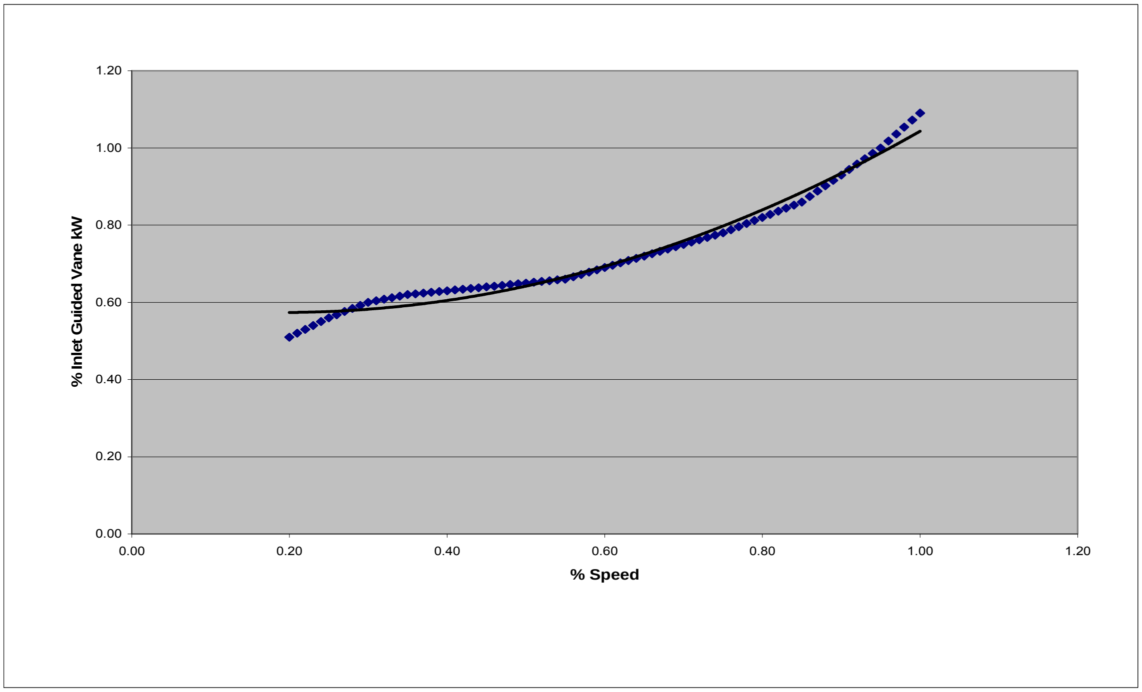
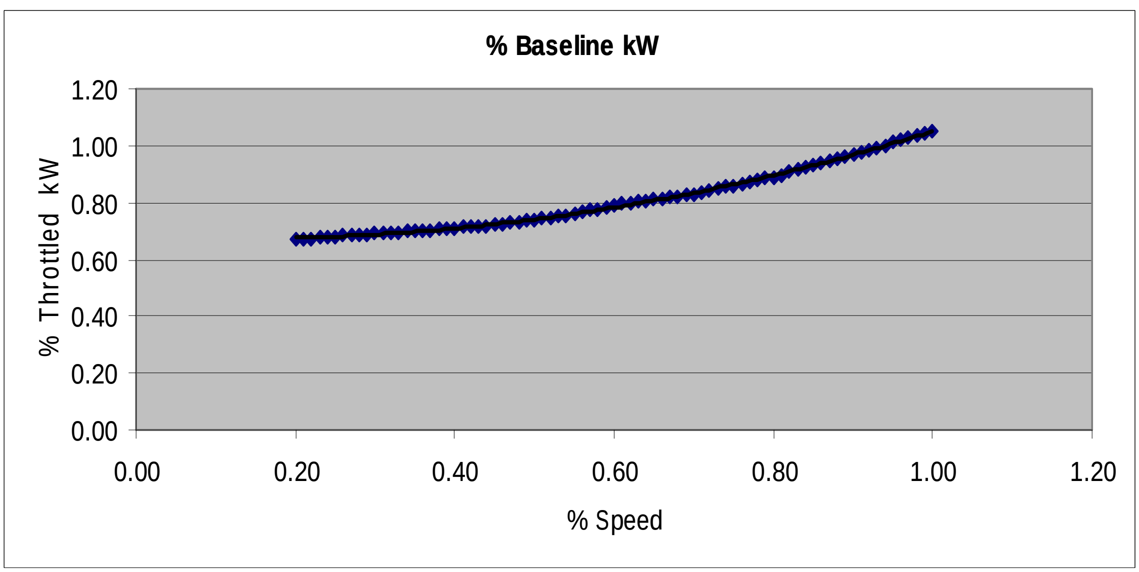


Figure DDD-4: S19108 Regression Trend for Throttled % Speed versus % kW



8. Using the speed percentage determined using the VSD curve in the appropriate baseline regression yielded percent power for the baseline condition. This value was then multiplied by the full load power the pump or fan to determine the power draw at a given operating conditions.

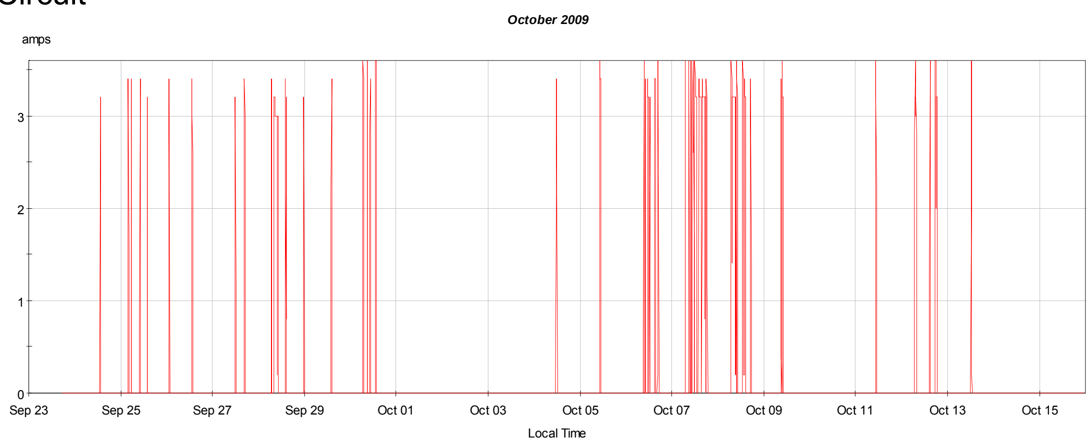
9. Finally, ex-post demand savings were calculated by subtracting ex-post power from baseline power during the CPUC define Peak hours.

10. Energy savings were estimated by integrating the demand savings over the monitoring period and scaling the result to an annual profile.

High Efficiency Lighting

The evaluation team counted lighting fixtures in the affected areas, verified the installed fixture types, and installed data loggers on the lighting panel. The building's lighting controls were divided into two categories. Some of the lights were on simple On/Off switches while the rest had occupancy sensor controls. We monitored two lighting circuits: one with simple on/off control and the other one with occupancy sensor control. Figure DDD-5 shows the logger data recorded from the occupancy sensor controlled circuit.

Figure DDD-5: S19108 Amp Profile of Occupancy Sensor Controlled Lighting Circuit



From the lighting plan we determined the numbers of lights with on/off control and the number of lights under occupancy sensor control. From review of our metered data we determined the operating hours of lights under both control types. The following equation was used to calculate the energy usage and demand of the evaluated lighting:

$kWh_{Evaluated}$ = (((W/Fix) x # Fixtures)/1000) x hrs/yr

where,

$kWh_{Evaluated}$ = ex-post annual lighting energy consumption kWh/yr

W/Fix = Watts per fixture

Fixtures = numbers of fixtures

hrs/yr = annual operating hours of the lights

Annual operating hours for occupancy sensor controlled lights were lower than the on/off controlled lights. The baseline power draw was calculated using Title 24 LPD requirement of 0.7 watt/ ft^2 for industrial storage. The following equation was used to calculate baseline lighting energy usage:

$kWh_{Baseline}$ = ((0.7 watt/ft2) x total square feet)/1000 x hrs/yr

Ex-post lighting savings were calculated by subtracting evaluated energy usage from baseline energy usage.

<u>Project Impact</u>

Our evaluation team determined that the variable speed drive measures saved less energy than projected. The main reason for this discrepancy was a change in the baseline. The ex-ante savings estimate was calculated based on a constant volume fan/ pump baseline whereas our ex-post savings were based on with an inlet guided vane baseline for fans and a throttled valve controlled baseline for pumps. The lighting measures saved considerably more than expected. Since it was not clear how ex-ante savings were determined, it was difficult to assess this discrepancy. The evaluation team believes that the operating hours used in the ex-ante estimate were likely less than what was found in our evaluation.

<u>Ex-Post Net-to-Gross Savings</u>

A net-to-gross ratio of 35% was calculated for both measures from the three free ridership questions on the decision-maker survey. The free ridership survey results are shown in Table DDD-2.

Table DDD-2: S19108 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
VSD Pumps	6 of 10	0.6	Easier Sell	1	5 of 10	1.5	3.1	52%
LPD	6 of 10	0.6	Easier Sell	1	5 of 10	1.5	3.1	52%

EX-Post Net Savings

The facility representative indicated that Savings by Design was influential in implementing both measures The Program made the implementation of both measures and easier sell. He also indicated that they may have installed the energy efficient measure without the incentive. This combination of answers yielded free riderships scores of 3.1 for both measures. Hence, ex-post net savings for both measures were calculated as 52% of the ex-post gross savings.

Table DDD-3 and Table **DDD-4** summarize the results for the VSD and lighting measures respectively.

Table DDD-3: S19108 Variable Speed Drive Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	0.0	369.6	0%	0.52	191.0
kWh	3,466,711	2,136,956	62%	0.52	1,104,094

Table DDD-4: S19108 Lighting Savings Summary

	Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate	Site Net-to-Gross Ratio	Ex-Post Net Savings
peak kW	10.6	30.0	283%	0.52	15.5
kWh	30,842	110,212	357%	0.52	56,943

EEE. S19151 Whole Building

S19151 received an incentive of $38,480 for installing energy efficient measures in their new grape cold storage facility expansion. The expansion consists of 42,000 square feet of new conditioned space. As part of the expansion, one new blast chiller was added to the facility. The rest of the conditioned space is cold storage. S19151 implemented the following EEMs in their expansion:

- Condenser fan cycling, floating head pressure controls and a wet-bulb following control strategy
- VSD controls of blast chiller room fans and cold storage room fans
- Increased wall and ceiling insulation
- Reduced LPD throughout the facility

The baselines for the proposed measures were Title 24 when applicable, and refrigerated warehouse standard practice otherwise.

<u>Ex-Ante Gross Savings</u>

Ex-Ante gross savings were calculated using DOE 2.2R hourly simulation software. Savings estimates were generated by modeling both the base case and as-built conditions in the software. To accomplish this, unique load schedules, equipment schedules and equipment performance parameters were input for the as-built and baseline cases. Savings were calculated as the difference in energy use between the baseline and as-built models.

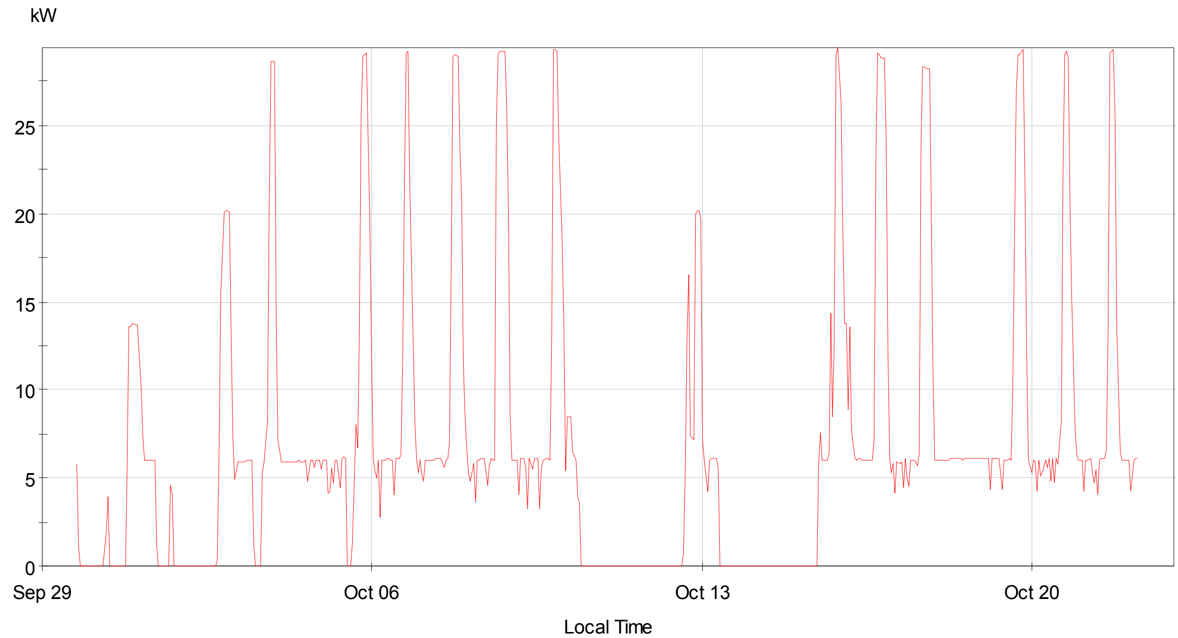
<u>Ex-Post Gross Savings</u>

The same approach was used to determine ex-post gross savings. However, based on the onsite evaluation and metering performed at the facility, a number of scheduling parameters were changed to reflect the reality of the facility's usage. In particular, the following adjustments were made:

- The site visit revealed that the usage of the three new cold storage rooms is staggered based on load, with one of the three rooms always put into operation last and taken out of operation first. As such, the operating schedule of the third room was reduced to reflect the facility's actual usage.
- Adjusted the facility schedule to begin receiving product in August as opposed to July as originally scheduled. This consisted of adjusted load, lighting, equipment, infiltration and occupancy schedules for July and August.
- Adjusted the pre-cooler monthly schedule to reflect the reduced schedule discussed with the pre-cooler operator
- Used metered data collected during three weeks in September and October 2009 from the room fans in the pre-cooler to adjust the hourly precooling load schedule. Pre-cool cycling lengths and daily start times were changed as part of this process. Figure EEE-1 below illustrates the metered precooler room fan schedule used for developing the pre-cooler load schedule.

Figure EEE-1: S19151 Metered Precooler Room Fan Load Profile

October 2009



Aside from the above adjustments, the model was left unchanged. The site visit revealed that all equipment was installed as proposed. It should be noted that gross peak demand savings were only 2% of the ex-ante estimate. This drastic change occurred because the facility was found to be almost completely closed during July—the month in which the DEER defined peak occurs. Accordingly, there are little to no peak demand savings as defined by DEER.

Ex-Post Net-to-Gross Savings

Measure level net-to-gross ratios varied from 0% to 90%. Net-to-gross ratios were calculated based on the three free ridership questions contained in the decision maker survey. The free ridership survey results are presented in Table EEE-1 below.

Table EEE-1: S19151 Net-to-Gross Summary

Measure	Perceived influence of Program Response	Perceived influence of Program Score (Max 1)	Source of Influence Score - Comments	Source of Influence Score (Max 2)	"In the Absence of the Program" Response	"In the Absence of the Program" Score (Max 3)	Net Savings Score (Max 6)	Measure Net-To-Gross Ratio
Refrigeration Measures	3 of 10	0.3	Easier Sell	1	3 of 10	0.9	2.2	37%
Insulation	0 of 10	0	No Influence	0	0 of 10	0	0	0%
Reduced LPD	7 of 10	0.7	Design Analysis	2	9 of 10	2.7	5.4	90%

Ex-Post Net Savings

The site contact indicated that the program did not heavily influence their decision to implement most of the refrigeration measures and had no influence on their decision to increase the building insulation above baseline. He stated that while the incentive was a small factor, previous program applications had shown the benefit of installing the proposed refrigeration measures. As such, the installed mechanical equipment would have likely been implemented regardless of the program. The site contact did however indicate that the program provided important design assistance for the lighting measure. The as-built lighting almost definitely would have been installed differently in the absence of the program. The site contact's combination of answers yielded free ridership scores of 2.3 for kWh and 1.24 for kW, indicating 64% and 79% free ridership for kWh and kW respectively. Note that free ridership scores differ between kWh and kW because individual measure level scores were applied to the modeled savings from each measure to develop the overall kWh and kW free ridership scores. Since the relative magnitudes of the kWh and kW savings differ from measure to measure, the free ridership scores are not consistent for both parameters.

Table EEE-2: S19151 Savings Summary

	Ex-Ante Gross Savings	**Ex-Post Gross Savings**	**Gross Realization Rate**	**Site Net-to-Gross Ratio**	**Ex-Post Net Savings**
peak kW	132.1	2.7	2%	0.21	0.56
kWh	484,353	317,827	66%	0.38	121,601

FFF. SCE Smart Well Completion

S18079, S18080, S18081, S18082, S18084, S18086, S18103, S18109, S18088, S18089, S18093, S18101 and S18077

Thirteen sites in the SCE sample received incentives for installing new, more energy-efficient oil wells. Energy savings were claimed from selective completion processes known as smart well completion as compared to slotted completion processes. All thirteen sites are owned by one oil production company. The energy savings, demand savings, and the incentive amounts claimed for each site are presented in Table FFF-1.

Table FFF-1: Ex-Ante Savings Summary

Project ID	Well ID	Ex-Ante kWh Savings	Ex-Ante kW Savings	Incentive Received($)
S18079	1	405,062	46.2	30,961
S18080	2	387,017	44.2	27,710
S18081	3	346,370	39.5	31,985
S18082	4	399,806	45.6	32,027
S18084	5	400,332	45.7	30,471
S18086	6	380,885	43.5	32,139
S18103	7	401,734	45.9	32,405
S18109	8	388,506	44.3	25,040
S18088	9	390,871	44.6	31,080
S18089	10	381,936	43.6	31,270
S18093	11	315,185	36.0	30,555
S18101	12	405,062	46.2	25,215
S18077	13	312,995	35.7	32,405

Measure Description

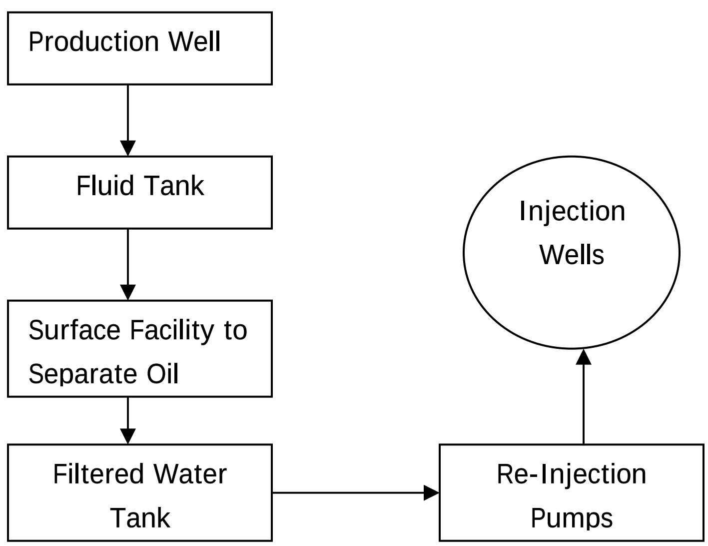
There are various completion techniques that can be implemented by oil producers to extract oil from ground. The "smart well" completion is a relatively new technique that is expected to produce higher oil to water ratio than a conventional well completion. Smart well completion is a two-part process of enhanced logging and selective perforation of the well sleeve. Enhanced logging is a data collection technique whereby a bundle of sophisticated instrumentation is sent down a drilled well hole to sense geological conditions at different levels[2]. The data collected in the logging step directs where perforations of the well sleeve should be placed in order to produce an optimal (higher) oil to water ratio. In essence, smart well logging provides a better "map" of oil to water

[2] In today's market, there are many enhanced operations that are under the umbrella of "smart well" technologies. However, the enhanced logging and selective perforation are realizing the savings in these projects, so the evalution of these projects will focus soley on these aspects of the smart wells.

ratios along the depth of the well and, consequently, the fluid extracted from the well has higher oil content than it would have with standard well completion. Energy savings are realized since less fluid needs to be pumped through the system per unit of oil produced.

The oil field cycle has several steps. The extracted fluid from the production well is transferred into a separation tank where oil is separated from water by gravity. The water goes through a filtration process to remove impurities and the clarified water is then pumped into a storage tank. The water from the storage tank is then injected back into the subsurface strata through separate injection wells using a re-injection pump. Figure FFF-1 below shows the oil extraction process.

Figure FFF-1: Oil Extraction Process Flowchart



Since less water is extracted from the oil wells, less water goes through the filtration system and less water needs to be re-injected back into the subsurface strata. Consequently, smart well completion not only saves electricity from pumping less fluid from the production well but also saves energy in the surface operations and re-injection processes.

<u>Ex-Ante Gross Savings</u>

Ex-Ante energy savings for the smart well completion technique was carried out in three basic calculation steps.

1. Energy required to lift the fluid from the well depth (including piping friction losses)

2. Energy required to operate the ground facility to separate oil from water (including piping friction losses)
3. Energy required to re-inject water back into the well depth

The following equations were used to estimate the energy savings for the above three steps

Energy Lift

Energy required (ft-lb per hour) = (Production x Well Depth x 62.4 lb/ft^3 x 5.61 ft^3/bbl x 1day/24 hrs)---(1)

Lift Power (kW) = (Energy Required x 3.8 x 10^{-7} kW/ft-lb)/ (Pump Efficiency x Motor Efficiency) ---(2)

Facility Power

Facility Power = Lift power x 40% --------(3)

Energy Re-inject

Same as Energy lift

Friction Loss:

Flow Rate = (Production Flow Rate x 42 gallons/bbl)/ (24 hrs x 60 secs)
Head Loss = Friction of Water x Well Depth/ 100 ft
Friction Power = Flow rate x head loss specific gravity/ (3960 x pump efficiency)
KW = (Friction power x 0.7457/ motor efficiency)----------------------------(4)

Total Power (kW) = Facility Power + Re-inject Power + Lift-Power + (2x Friction Loss)-------------------(5)

Total power for both conventional wells (baseline) and smart wells (Ex-Ante) were determined from equation (5). Pump efficiency and fluid production rate were adjusted to generate the as-built condition from the baseline condition. For all thirteen sites, the baseline fluid flow was 1,700 BFPD, where as the proposed flow was 1,000 BFPD. The pump efficiency decreased from 67.5% in the baseline condition to 61 % in the proposed condition. The rest of the parameters in these equations remained unchanged from baseline to proposed conditions.

The kW savings were simply the difference between baseline power and proposed power. Annual energy savings were calculated by multiplying the kW savings by the annual operating hours of the wells. The project file indicated that all the thirteen wells operate 8,760 hours a year.

A review of the project files and reconnaissance audits of the wells revealed that the thirteen oil production wells have varying fluid production rates, not equal 1,000 BFPD flows as assumed in the ex-ante calculation. A discussion with the facility head engineer also revealed that all the wells do not operate 8,760 hours a year. He also stated that the facility runs the wells based on customer oil demand. Table FFF-2 shows the relevant parameters used in the ex-ante savings calculation.

Table FFF-2: Ex-Ante Operational Summary

Project ID	Well ID	Well Depth (ft)	Baseline Fluid Production (bbl/D)	Proposed Fluid Production(bbl/D)	Operating Hours (hrs/yr)	Ex-Ante kWh Savings
S18079	1	3,477	1,700	1,000	8,760	405,062
S18080	2	3,112	1,700	1,000	8,760	387,017
S18081	3	3,592	1,700	1,000	8,760	346,370
S18082	4	3,597	1,700	1,000	8,760	399,806
S18084	5	3,422	1,700	1,000	8,760	400,332
S18086	6	3,609	1,700	1,000	8,760	380,885
S18103	7	3,639	1,700	1,000	8,760	401,734
S18109	8	2,812	1,700	1,000	8,760	388,506
S18088	9	3,490	1,700	1,000	8,760	390,871
S18089	10	3,512	1,700	1,000	8,760	381,936
S18093	11	3,432	1,700	1,000	8,760	315,185
S18101	12	2,832	1,700	1,000	8,760	405,062
S18077	13	3,639	1,700	1,000	8,760	312,995

The above discrepancies were noted and the changes were incorporated in our ex-post savings calculation.

<u>Ex-Post Gross Savings</u>
A detailed discussion with a facility engineer and observation of site production logs showed that all thirteen incented oil wells have different flow rates and unique production schedules. Hence each oil well has its own baseline energy profile. The only way to evaluate the savings of these wells was to establish a baseline energy profile for each well.

According to the facility's geologist, in order for a conventional well to serve as a baseline for a corresponding smart well, the following criteria need to be met:

1. The conventional well should have the same depth as the smart well

2. Both the wells should fall within the same geological zone because geological zones indicate production capacity

3. Both wells should have equal sleeve diameters

It is difficult to find conventional wells that have exactly the same specifications as the corresponding smart wells. Working with the facility engineer we identified conventional oil wells that closely match the specifications of the incented smart wells. We selected corresponding baseline wells which have similar subsurface geology to the corresponding smart wells. The baseline well criteria were relaxed to allow for wells of approximately equal depth. The requirements on equivalent sleeve diameter and "geological zone" were however left in place.

With the above information, we determined the evaluation approach to estimate the savings for the smart well completion technique. Our ex-post savings calculations were implemented in three basic steps.

1. **Lift Energy:** A kWh/bbl savings was established (where bbl is a 42-gallon barrel of oil) for both standard and smart wells, representing the efficiency of oil extraction. Only the production that actually occurred was credited with the efficiency increase. Then the kWh/bbl was multiplied with annual oil production of the smart well to get the annual energy savings of the well.
2. **Ground Facility Energy:** A kWh/bbl was established for the ground facility. The difference in fluid flow (bbl) between a smart and conventional well going through the facility to produce an equal quantity of oil was then multiplied with kWh/bbl to determine savings.
3. **Re-injection Energy:** A kWh/bbl was established for the re-injection system. The difference in re-injected fluid flow (bbl) between the smart and conventional wells was then multiplied with kWh/bbl to determine savings.

Lift Power

Seven smart wells and seven corresponding dumb (conventional) wells were selected and time series kW data loggers were installed at a sampling interval of 5 minutes for a period of four weeks. The evaluation team also collected well depth, sleeve diameter, daily flow rate, and oil to water ratio data for the above seven pair of wells during this monitoring period. We also collected annual oil production data for each of these seven wells from the Division of Oil, Gas, and Geothermal Resources (DOGGR) Database.

Although the seven smart wells and their seven corresponding dumb (conventional) wells were selected based on approximately equal well depth and sleeve diameter, our collected data showed variations in both well depth and sleeve diameter between the smart wells and their corresponding conventional wells. Table FFF-3 shows the well depths and sleeve diameters for the seven monitored pairs of wells.

Table FFF-3: Comparison of Well Depths and Sleeve Diameters of the Monitored Wells

Smart Wells				Conventional Wells			
Project ID	Well ID	Well Depth (ft)	Sleeve Diameter (inch)	Project ID	Well ID	Well Depth (ft)	Sleeve Diameter (inch)
S18077	13	3,652	3.50	S18077D	13D	3,267	3.50
S18079	1	5,447	2.87	S18079D	1D	5,587	2.87
S18080	2	5,746	2.87	S18080D	2D	5,350	2.87
S18081	3	5,561	2.87	S18081D	3D	5,520	2.87
S18089	10	3,550	3.5	S18089D	10D	3,115	2.87
S18101	12	6,709	2.78	S18101D	12D	6,790	2.87
S18109	8	3,200	3.50	S18109D	8D	2,904	2.87

Well depth and sleeve diameter dictate friction loss in the pipe, which in turn affects the power draw of the well pump. Hence, variations in the above parameters from the as-built to baseline conditions may generate inaccurate baseline power profiles. To estimate the actual baseline power, we established a regression trend among baseline well depths, baseline sleeve diameters and their corresponding kW. Basically, our regression model normalized the kW profile based on well depth and sleeve diameter. This relationship was then used to determine the normalized baseline power draw of each well pump. The following regression based equation was used to calculate the actual baseline kW of each affected pump.

Y_{NBL}= (-0.0136478 x WD_{SMT}) + (-43.5721 x SS_{SMT}) + 223.3478-------------------------------(1)

where,

Y_{NBL} = normalized baseline power, kW

WD_{SMT} = well depth of the smart well, ft

SS_{SMT} = sleeve diameter of the smart well, inches

Normalized baseline time series kW data and as-built time series kW data were used to calculate the average kWh per day of each production well. Using the average kWh/d data along with the oil and water quantity, we determined the kWh/ bbl oil and kWh/bbl fluid.

Table FFF-4 compares the monitored production wells in terms of daily oil and water production and daily kWh consumption. Table FFF-5 shows the kWh savings per barrel of oil due to installation of smart well technology.

Table FFF-4: Oil and Water Production Data for the Monitored Wells

	Smart Well						Conventional Well					
Project ID	Well ID	Oil (bbl/day)	Water (bbl/day)	Oil to water ratio	Total fluid (bbl/day)	Average kWh/day	Oil (bbl/day)	Water (bbl/day)	Oil to water ratio	Total fluid (bbl/day)	Average kWh/day	kWh/day Savings
S18077	13	42	1,851	2.3%	1,893	801	30	1,215	2.5%	1,245	504	(297)
S18079	1	15	178	8.4%	193	262	5	561	0.9%	566	575	313
S18080	2	32	122	26.2%	154	398	6	424	1.4%	430	477	79
S18081	3	18	103	17.5%	121	316	5	266	1.9%	271	538	221
S18089	10	44	1,299	3.4%	1,343	1,709	24	2,761	0.9%	2,785	538	(1,171)
S18101	12	14	50	28.0%	64	269	10	168	6.0%	178	256	(13)
S18109	8	17	1,830	0.9%	1,847	1,265	33	2,590	1.3%	2,623	652	(613)

Table FFF-5 : Energy Savings per Barrel of Oil Produced

	Smart Well				Conventional Well			
Project ID	Well ID	Average kWh/day	kWh/bbl-Oil	kWh/bbl-fluid	Average kWh/day	kWh/bbl-Oil	kWh/bbl-fluid	kWh/bbl-oil Savings
S18077	13	801	19.1	0.42	504	21.0	0.40	1.94
S18079	1	262	17.5	1.36	575	113.1	1.02	95.67
S18080	2	398	12.4	2.59	477	66.4	1.11	53.91
S18081	3	316	17.6	2.61	538	95.1	1.98	77.49
S18089	10	1,709	38.8	1.27	538	53.0	0.19	14.19
S18101	12	269	19.2	4.20	256	29.6	1.44	10.36
S18109	8	1,265	74.4	0.69	652	47.3	0.25	(27.12)

$$kWh/bbl_{\text{-oil smart}} = (kWh/day_{\text{-smart}}) / (bbl/day_{\text{-oil-smart}})$$

$$kWh/bbl_{\text{-oil-Con}} = (kWh/day_{\text{-Con}}) / (bbl/day_{\text{-oil-Con}})$$

$$kWh/bbl_{\text{-Svg}} = (kWh/bbl_{\text{-oil-Con}} - kWh/bbl_{\text{-oil-smart}})$$

$kWh/yr_{\text{-Svg-L}} = (kWh/bbl_{\text{-Svg}}) \times$ (number of barrels of oil per year from the smart well)------- (2)

where,

$kWh/bbl_{-oil\ smart}$/ $kWh/bbl_{-oil-Con}$ = energy consumption per barrel of oil (kWh)

kWh/day = average energy consumption per day (kWh/Day)

bbl/day_{-oil} = barrel of oil produced per day (bbl)

kWh/bbl_{-Svg} = energy savings per barrel (kWh/bbl)

kWh/yr_{-Svg-L} = annual oil lifting energy savings (kWh/yr)

Ground Facility Power

The evaluation team collected name plate information from all ground facility equipment to assess the energy consumption required to separate oil from water. Table FFF-6 below shows equipment details and power draw estimates for each piece of equipment in the facility. The facility engineer indicated that all pumping systems operate at a 65% load factor for 8,760 hours a year.

Table FFF-6: Ground Facility Equipment Schedule

Name	hp	#	Efficiency	Assumed Load Factor	Total kW
Filter Charge Pump	100	3	94%	0.65	154.5
Filter Charge Pump	75	2	93.6%	0.65	77.7
Filter Charge Pump	125	1	94.1%	0.65	64.4
Packard Shipping Pump	100	2	94.1%	0.65	103.0
Air Compressor	20	2	91.0%	0.65	21.3
Mixer	20	4	91.0%	0.65	42.6
Skimming paddle	0.3	2	82.2%	0.65	0.4
Pumps	100	2	94.1%	0.65	103.0
Total					**566.9**

The facility log indicated that the fluid flows through the ground facility are 315,000 bbl/day. With the above information we determined the kWh/bbl going through the ground facility.

kWh/bbl_{-GF} =((kW_{-T-GF}) x 24)/ 315,000 bbl/day---------------------(3)

where,

kWh/bbl_{-GF} = energy consumption per barrel of fluid going through ground facility

kW_{-T-GF} = total power draw of the ground facility (kW)

$kWh_{-Svg-GF}$ = kWh/bbl_{-GF} x [(total bbl of fluid per year to generate a specific amount of oil in a conventional completion) – (total bbl of fluid per year to generate a specific amount of oil in a smart well completion)]----------------------------(4)

where,

$kWh_{-Svg-GF}$ = annual energy savings due to reduction of fluid flow through ground facility

Re-injection Power

To estimate the re-injection power, we collected the name plate information of the re-injection pumps. There were 4 injection pumps operating 8,760 hours a year. During the on-site visit, we also took spot watt measurement to assess the power draw of the pumps.

Table **FFF-7** shows the pumping power used for injecting fluid into the injection wells.

Table FFF-7: Re-injection Pumping Power

Name	hp	#	Assumed Load Factor	Efficiency	Total kW
Re-injection Pump-1	3000	1	0.63	0.95	1989
Re-injection Pump-2	1750	1	0.65	0.95	1197
Re-injection Pump-3	900	1	0.65	0.95	616
Re-injection Pump-4	1750	1	0.69	0.95	1271
Total					**5074**

A facility engineer indicated that they recycle 100% of the water from the ground facility and inject 315,000 bbl into the injection wells everyday. The re-injection process energy consumption was calculated as follows:

kWh/bbl_{-RJ} =((kW_{-T-RJ}) x 24)/ 315,000 bbl/day---------------------(5)

where,

kWh/bbl_{-RJ} = energy consumption per barrel of water re-injected to ground

kW_{-T-RJ} = total power draw of the re-injection pumps (kW)

$kWh_{-Svg-RJ}$ = kWh/bbl-$_{RJ}$ x [(total bbl of fluid per year to generate a specific amount of oil in a conventional completion) – (total bbl of fluid per year to generate a specific amount of oil in a smart well completion)]-----------------------------(6)
where,

$kWh_{-Svg-RJ}$ = annual energy savings due to reduction of fluid flow to the injection wells

Total Savings

Total savings were calculated by adding the savings generated from lifting, surface facility and re-injection.

Total Energy Savings (kWh/yr) = annual oil lifting energy savings (kWh/yr) + annual energy savings due to reduction of fluid flow through ground facility (kWh/yr) + annual energy savings due to reduction of fluid flow to the injection wells (kWh/yr)

Energy Savings of Each Well

Our evaluation determined that not necessarily all smart wells save energy relative to their equivalent conventional wells. In some cases, a smart well may consume more energy than conventional wells. In our analysis, we found that some conventional wells performed better than their corresponding smart wells. In other words, some conventional oil wells produce fluid with higher oil to water concentrations than the corresponding smart wells. A detailed discussion with the facility's geologist revealed that they log the wells to measure the resistivity of the reservoir sand. The higher the resistivity, the higher the concentration of oil and vice versa. He also stated that even with all the improved geologic characterization obtained through logging, they still sometimes ended up getting higher water concentrations in the smart wells than expected. He said no matter what they predict about the geological zones, there are always unknown variables underground.

With all the above findings, the evaluation team decided to average the findings from the measured wells and apply them to determine kWh per barrel results.

First, the total annual energy savings for all seven metered wells were calculated and summed. Then the annual oil productions in bbl for the above wells were summed. The oil production data used was obtained from the Division of Oil, Gas, and Geothermal Resources (DOGGR) Database.

The seven metered wells saved 3,199,441 kWh while producing 63,974 barrels per year. The total annual kWh was divided by total oil produced to determine the kWh savings per barrel of oil produced. The energy (kWh) required to produce a barrel of oil was 50 kWh/ barrel. Table FFF-8 shows the thirteen incented oil wells and their annual oil production.

Table FFF-8: Incented Smart Wells and their Oil Production

Site ID	Oil Production(BBL/yr)
S18077	8,092
S18079	6,532
S18080	15,182
S18081	7,232
S18082	12,711
S18084	11,942
S18086	13,656
S18088	9,737
S18089	16,168
S18093	17,935
S18101	3,727
S18103	11,812
S18109	7,041

The kWh per barrel of oil produced was then multiplied by oil production per year (bbl/yr) of each well to determine the annual energy savings for the wells. Demand savings for each well were simply calculated by dividing annual kWh savings by annual well operating hours. Table FFF-9 shows the energy and demand savings for the thirteen incented wells.

Table FFF-9 Gross Savings Comparison

Site ID	Well ID	Ex-Ante Gross kWh Savings	Ex-Ante Gross kW Savings	Ex-Post Gross Savings kWh	Ex-Post Gross Savings kW	Gross kWh Realization Rate	Gross kW Realization Rate
S18077	1	405,062	46.2	404,694	46.2	100%	100%
S18079	2	387,017	44.2	326,676	37.3	84%	84%
S18080	3	346,370	39.5	759,276	86.7	219%	219%
S18081	4	399,806	45.6	361,684	41.3	90%	91%
S18082	5	400,332	45.7	635,697	72.6	159%	159%
S18084	6	380,885	43.5	597,238	68.2	157%	157%
S18086	7	401,734	45.9	682,958	78.0	170%	170%
S18088	8	388,506	44.3	486,963	55.6	125%	125%
S18089	9	390,871	44.6	808,587	92.3	207%	207%
S18093	10	381,936	43.6	896,958	102.4	235%	235%
S18101	11	315,185	36.0	186,393	21.3	59%	59%
S18103	12	405,062	46.2	590,737	67.4	146%	146%
S18109	13	312,995	35.7	352,132	40.2	113%	113%

Ex-Post Net Savings

The facility representative stated that Savings by Design had no influence in implementing smart well completion. He indicated that the installation of each smart well completion costs an additional $250,000 more than conventional well completion. The decision to implement smart wells is therefore dictated by oil prices. When oil is $80 to $90 a barrel, it makes it easier to justify implementing smart well technology. But if oil is $50 a barrel, it is impossible to consider this technology.

He also stated that they may not have installed as many wells had their not been an incentive. It allowed them to do several more; possibly two or three wells were sponsored as a result of the program since they put the money from the incentives back into the projects. In the current economic conditions they would not even apply for Smart Wells. Furthermore, the site contact stated that participating in the project evaluation work is a time consuming process. He found it hard to justify participating in the evaluation from the company's perspective because of the amount of incentive received.

The above detailed discussion with facility representative revealed that the economy and oil prices drive the installation of smart wells, not the presence of Savings by Design or the incentive amount.

The above responses yielded a free ridership score of 0 out of 6, indicating 100% free ridership. Hence, ex-post net savings for all the thirteen smart wells were calculated as 0 as shown in Table FFF-10.

Table FFF-10 Savings Summary

Site ID	Well ID	Ex-Post Gross Savings kWh	Ex-Post Gross Savings kW	Ex-Post Net Savings kWh	Ex-Post Net Savings kW	Site Net to Gross Ratio kWh	Site Net to Gross Ratio kW
S18077	1	404,694	46.2	0	0	0.0	0.0
S18079	2	326,676	37.3	0	0	0.0	0.0
S18080	3	759,276	86.7	0	0	0.0	0.0
S18081	4	361,684	41.3	0	0	0.0	0.0
S18082	5	635,697	72.6	0	0	0.0	0.0
S18084	6	597,238	68.2	0	0	0.0	0.0
S18086	7	682,958	78.0	0	0	0.0	0.0
S18088	8	486,963	55.6	0	0	0.0	0.0
S18089	9	808,587	92.3	0	0	0.0	0.0
S18093	10	896,958	102.4	0	0	0.0	0.0
S18101	11	186,393	21.3	0	0	0.0	0.0
S18103	12	590,737	67.4	0	0	0.0	0.0
S18109	13	352,132	40.2	0	0	0.0	0.0

Appendix D. Theoretical Foundation of Model-Based Statistical Sampling Plan (MBSS™)

A model-based statistical sampling plan (MBSS™) methodology was used to develop an efficient sample design and to assess the likely statistical precision. Model-based sampling methods were also used to analyze the data, i.e., to extrapolate the findings from the sample sites to the target population of all program participants and to evaluate the statistical precision of the results. This section explains the theoretical foundation behind the sampling plan.

Theoretical Foundation of Model-Based Statistical Sampling Plan (MBSS™)

The selection of the sites was guided by a model-based statistical sampling plan (MBSS™). Model-based sampling methods were also used to analyze the data, i.e., to extrapolate the findings from the sample sites to the target population of all program participants and to evaluate the statistical precision of the results.

Given that MBSS™ was used in the previous studies (1994-96 evaluation studies, the 1998 baseline study, and the 1999-2001, 2002, 2003, and 2004-05 SBD studies), it was possible to use the statistical parameters from these studies to establish the expected precision parameters for the current evaluation. Information from the program tracking data was combined with findings from prior studies – the error ratio and gamma parameter[3]. Using these data, the expected statistical precision for gross annual energy savings was calculated from the planned sample size for the participant sample. Once the sample size had been determined, a sample design was selected that was efficiently stratified by the tracking estimate of annual energy savings, with a proportional representation of each utility in the combined participant population.

1.1 Theoretical Foundation

MBSS™ methodology was used to develop efficient sample designs and to assess the likely statistical precision. The target variable of analysis, denoted *y*, is the energy savings of the project. The primary stratification variable, the estimated energy savings of the project, is denoted *x*. A ratio model was formulated to describe the relationship between *y* and *x* for all units in the population, e.g., all program participants.

The MBSS™ ratio model consists of two equations called the primary and secondary equations:

$$\begin{aligned} y_k &= \beta x_k + \varepsilon_k \\ \sigma_k &= sd(y_k) = \sigma_0 x_k^{\gamma} \end{aligned}$$

Here $x_k > 0$ is known throughout the population.

K denotes the sampling unit, i.e., the project.

$\{\varepsilon_1, \ldots, \varepsilon_N\}$ are independent random variables with *an* expected value of zero, and

[3] Error ratio and gamma parameter describe the relationship between the x and y variables of the MBSS model. These parameters are used in conjunction to inform the sample design. Both of these parameters are explained in detail in the Theoretical Foundation section below.

β, σ_0, and γ (gamma) are parameters of the model.

The primary equation can also be written as

$$\mu_k = \beta x_k$$

Under the MBSS ratio model, it is assumed that the expected value of *y* is a simple ratio or multiple of *x.* Here, y_k is a random variable with expected value μ_k and standard deviation σ_k.

Both the expected value and standard deviation generally vary from one unit to another depending on x_k, following the primary and secondary equations of the model. In statistical jargon, the ratio model is (usually) a heteroscedastic regression model with zero intercept.

One of the key parameters of the ratio model is the error ratio, denoted *er*. The error ratio is a measure of the strength of the association between *y* and *x*. The error ratio is suitable for measuring the strength of a heteroscedastic relationship and for choosing sample sizes. It is *not* equal to the correlation coefficient. It *is* somewhat analogous to a coefficient of variation except that it describes the association between two or more variables rather than the variation in a single variable.

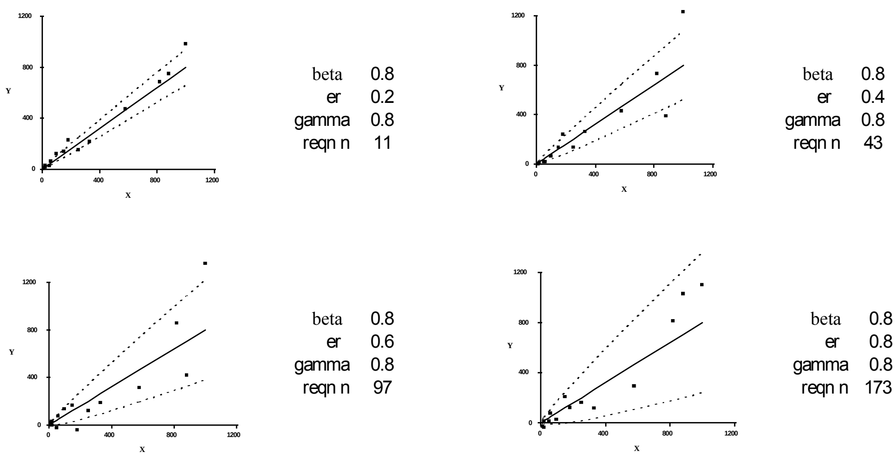
Using the model discussed above, the error ratio, *er*, is defined to be:

$$er = \frac{\sum_{k=1}^{N} \sigma_k}{\sum_{k=1}^{N} \mu_k} = \frac{\frac{1}{N}\sum_{k=1}^{N} \sigma_k}{\frac{1}{N}\sum_{k=1}^{N} \mu_k}$$

Figure 1 gives some typical examples of ratio models with different error ratios. An error ratio of 0.2 represents a very strong association between *y* and *x*, whereas an error ratio of 0.8 represents a weak association. Loosely speaking, an error ratio of .75 implies that the measured savings is typically within ±75% of the tracking estimate of savings adjusted for the realization rate. The smaller the error ratio, the stronger the association between tracking and measured savings, and the smaller the sample size needed to estimate the program realization rate with a fixed precision.

As Figure 1 indicates, the error ratio is the principle determinant of the sample size required to satisfy the 90/10 criteria for estimating *y*. If the error ratio is small, then the required sample is correspondingly small.

Figure 1: Examples of MBSS Ratio Models



The model parameters – b, g, and the error ratio -- were calculated from the 2003 SBD study. The model parameters are shown in Table 1. Based on the 2003 SBD sample projects, the error ratio is 0.69. *Using this value, our analysis indicated that a sample of 180 2004-05 SBD program participants would provide a relative precision of about ±7.8% at the 90% level of confidence*.

Table 1: Sample Design Model Parameters

Parameter	Value
b	1.129
g	0.78
Error ratio	0.69

In order to inform future sample designs, the model parameters b and g were calculated, along with the error ratio, using the actual participant population and sample. Table 2 shows the results.

Table 2: Actual Model Parameters

Parameter	Value
b	1.023
g	0.80
Error ratio	0.75

The evaluation methodology is based on engineering models of participant projects that are statistically projected to the SBD program populations.

Appendix E. Net Savings Assessment Methodology

This section explains free-ridership and its role in calculating net savings in the Savings By Design project. Included are the Free-ridership Decision Maker Survey and the scoring methodology used to determine free-ridership.

1. Net Savings Assessment Methodology

For a new construction program, free-ridership mostly comes into play at the measure level. When a project receives an incentive for a measure that would have been installed without the program, this constitutes free-ridership in its classic form. Conversely, if a baseline or minimally code compliant measure would have been installed in the absence of program influence, there is no free-ridership associated with that measure. However, free-ridership is not always an all or nothing proposition, partial free-ridership indicates that the program influence was responsible for the installation of the measure to some degree, but not completely. The first goal of the methodology explained below is to determine the degree of free-ridership for each individual measure.

For complicated projects that were incented for numerous measures, the levels of free-ridership often vary widely across the measures. For instance, a project could be a complete free-rider on one set of measures, have partial free-ridership on another and have no free-ridership on others. Since most SBD projects have multiple measures and frequently have interactive effects, simple multiplication of measure net-to-gross ratios to site parametric results do not yield accurate site level net savings. Instead, the free-ridership of the SBD Program was estimated via a "bottom-up approach," by making measure adjustments to the as-built simulation model in order to create a "net savings model". The goal of net savings model is to contain only those measure that were influenced by the program, and to reflect the degree of influence. That is, all measures determined to be free-riders "set back" toward baseline values such that a comparison with baseline model outputs show only net savings effects.

The individual measure free-ridership was estimated through participant decision-maker surveys and reviewing associated program file documentation. All available information was used to best determine what the customer would have done in the absence of the program. The net savings scoring questions are provided below along with their associated scoring. These questions were asked for each incented measure documented in the tracking database (systems approach) or identified in the project file (whole building approach). The cumulative score for each measure was compared to the maximum value of 6 to determine the degree of free-ridership. The scoring methodology is presented in more detail within the Scoring Methodology section below. It is important to note that the final measure score relies on multiple responses in the score determination. Furthermore, several key responses are followed by an open ended question requesting an explanation for the response. If there is any inconsistency between answers regarding a particular measure, the trained surveyor brings this to the attention of the respondent, to either explain away the apparent inconsistency or revise the responses to better reflect the reality of the measure decision.

Finally, the results of each interview were reviewed by the evaluation project manager, along with the project file, to confirm the outcome. The final score was modified, if necessary, to reflect additional information identified in the review. The complete interview document is available for review in these appendices.

1.1.1 Free-ridership Net Savings Results

To calculate free-ridership KEMA surveyed decision-makers (included in appendix) on their efficiency choices for incented measures. Based on the survey responses the engineering simulation models were adjusted to reflect these efficiency choices absent the Savings By Design program. The engineering models were then re-simulated. The results of these simulations were analyzed to obtain the net savings for participants.

2. Free-ridership Decision Maker Survey

2.1 Free-ridership Scoring Questions

Q22.

On a scale from 0 to 10, where 0 means not influential whatsoever, and 10 means extremely influential, how influential was Savings By Design, including the incentives, design assistance, design analysis and interactions with SBD representatives and consultants in the implementation of <<the measure>>?

__________ (points = answer *0.1)

Q22_a

Why?____

____

Q23.

How did Savings By Design influence the implementation of (maximum of 2 points) Open ended Question that is coded:

1 = SBD had no influence on this measure 0 points

2 = SBD representative first suggested/introduced measure 2 points

3 = SBD performed simulations and/or design analysis 2 points

4 = SBD incentive made this measure an “easier sell” 1 points
5 = SBD incentive helped the measure meet investment criteria 2 points
6 = Prior SBD projects have had success with this measure 1 points
7 = DK, Not Certain, Can’t Remember 0 points
50= other individually assessed

Q24.

On a scale of 0 to 10 where 0 means would have been installed exactly the same and 10 means the <<the measure>> definitely would not have been installed. How likely is it that you would have installed this <<the measure>> without the program recommendations, consultation on enhanced design strategies, analysis and/or incentives?

__________ (points = answer *0.3)

Q24_1a Why? (Ask for each Measure)

DO NOT PROMPT Pre-coded Anticipated responses of Why’s include:

1 = As a result of what was learned through previous SBD program Participation
2 = As a result of what was learned in past utility efficiency programs
3 = Because it is our standard practice
4 = Because we have had positive prior experience with the same measure
5 = Because we would have funded design analysis through the project budget
6 = Measure already met financial criteria without the program incentive
7 = Other

2.2 Scoring Methodology

The scoring methodology to determine net savings is based on the answers to questions Q22 through Q24. The score for each measure ranges from 0 to 6, where 6 represents a measure that was completely influenced by the program, and a score of zero, for a measure that would have been installed without the program influence.

Energy efficiency measures can be classified into two distinct types, dichotomous measures, those measures that are either implemented or not, such as VFDs and lighting controls, and measures with continuous or incremental efficiency ratings such as motor efficiency and glazing performance.

A copy of the database containing all of the “as surveyed” models was made after final calibrations and implementing several quality control step to reduce data entry errors and omissions. This copy was converted into a “modified” or net savings database. The net savings database consisted of models with adjustments of efficiency levels and removals of some dichotomous measures from the “as-surveyed” database, according to the free-ridership assessment.

For both dichotomous measures and measures with continuous or incremental energy efficiency ratings, an energy rating net value to use in the simulation was calculated using the following formula.

$$\frac{[(6-Score)(BaselineRating)]+[(Score)(AsBuiltRating)]}{6}=NetValue$$

Dichotomous measures were left in the models when measures had scores of 3.0 or more. The dichotomous measure was removed from the net savings model if the score was less than 3.0, i.e. if free-ridership for the measure was equal to or greater than 50%.

A net savings rating was calculated for all continuous energy ratings to be modified, including motor efficiency, cooling EER, LPD, glazing U-value and shading coefficient. These were calculated on a per item basis and adjusted individually to create the net savings models.

For example, the lighting power density (LPD) measure of one site had a score of 3.6. When asked Q22, the responded provides a response as a numeric value between 0-10 where 0 represents not at all influential and 10 represents extremely influential. The responded gives a response of 8, which counts as 0.8 points toward the total free-rider score (score of 8 *0.1). When asked question Q23, the responded stated the incentive made the measure an “easier sell”, counting one point in the freerider scoring. And for the final questions Q24 the responded is again asked to provide a numerical value between 0-10 (where 10 represents defiantly would not have been installed and 0 represents would have been installed exactly the same), he respondents with an answer of 6 indicating the measure was influenced by the program but may have been installed without the incentive, resulting in 1.8 points (score of 6*0.3) for Q24. This site had an as-built LPD of 0.94 watts per square foot. The space, which is an office, had a baseline LPD of 1.6 Watts per square foot. These values and the score were plugged into the above equation.

$$\frac{[(6-3.6)(1.6)]+[(3.6)(0.94)]}{6}=1.20$$

Therefore the net LPD for this space was 1.20 watts per square foot. In the net savings simulation model, lighting fixtures were added until the LPD was brought up to 1.20 watts per square foot. For sites with multiple space types, the same adjustment approach was applied to every space type.

For a more complex example, assume the site in the previous LPD example also was incented for VFDs on secondary chilled water pumps. When asked Q22 for the VFDs, the site contact responds with a zero indicating they were not influenced by the program. When asked question Q23, the respondent claimed zero again indicating SBD had no influence on this measure resulting in a score of zero points. The respondent answered again with a zero indicating the measure would have been installed exactly the same in response to Q24. Therefore, the total score for the VFDs would be 0, indicating no influence by the program. In this case, the VFD controls would be changed to constant volume in the net savings model.

Having an analogous net savings model for every "as-surveyed" model provided a simple approach to the calculation of net program savings. The ex-post net savings were calculated using the same methodology as whole building savings for the original "as-surveyed models." The modified net savings "as-built" run for both energy and demand was deducted from the baseline run yielding the ex-post net savings.

Once the final net savings database, a database of net savings models, was complete, then:

1. The *ex-post net savings* are determined for each participant at the end-use level via a series of parametric model runs of the entire database,
2. The program ex-post net savings estimate is calculated by using the same MBSS methods described for the ex-post gross savings, but using the ex-post net savings estimates for each sample point.

The Free-ridership rate is calculated as the proportion between the program ex-post gross savings less the program ex-post net savings divided by the program ex-post gross savings. The net-to-gross ratio is simply 1 – Free-ridership rate or the program ex-post net savings divided by the program ex-post gross savings.

Appendix F. Savings By Design Program Process Findings

The process findings section elaborates on the free-ridership survey results. This section addresses the following areas of interest:

- ♦ Respondent information,
- ♦ Building descriptive statistics,
- ♦ Savings By Design program attitudes and awareness,
- ♦ Importance of Dollar Incentives, Design Assistance and Design Analysis

Participant responses are quantified; open-ended responses are also recorded here.

1. Savings By Design Program Process Findings

KEMA designed decision-maker (DM) surveys to help determine the net savings attributable to the program. The questions were designed to learn more about program awareness and attitudes, specific building characteristics, and design and construction practices. The following sections report these results and correlate directly with the flow of the decision-maker survey. This section addresses the following areas of interest:

- Respondent information,
- Building descriptive statistics,
- Savings By Design program attitudes and awareness,
- Importance of Dollar Incentives, Design Assistance and Design Analysis

1.1 Survey Respondents

The target number of total interviews was approximately 190. The final dataset, however, contained survey responses from 179 participants. Out of the 179, 11 surveys were incomplete due to the respondent not answering all the questions or the respondent was not the primary decision-maker for the project and the primary decision-maker was not available. In some cases the respondent was non-responsive; or they did not complete the survey [left the interview midway] and later was not available to answer questions despite repeated attempts to reach them. Out of the 190, 33 or 17.3% of the primary decision-makers were no longer with their company; requiring survey staff to obtain an alternate owner-level respondent or a design team respondent. We also surveyed industrial participants using the standard decision-maker survey; omitting questions that were not applicable.

We weighted all decision-maker responses to the population Using case weights developed per the gross savings analysis so that the 191 survey participants were representative of the entire SBD population. The sample design targeted decision-makers, that included building owners and, in many cases, members of the design team for the buildings in the sample. Frequently, we interviewed multiple people in order to complete a single survey. For example, numerous interviews included the mechanical engineer responsible for designing the HVAC system in addition to the building owner or facilities manager who answered the less technical questions.

Many of the SBD program participants were responsible for multiple buildings within our sample, a total of 53 projects are represented by only 13 unique respondents. Of the 13 unique respondents, 4 of them were responsible for a total of 30 projects. In some cases, one person answered several surveys, one survey for each of the sampled projects under their control. In fact, we asked the same questions multiple times in order to get project specific information since different projects may have required different responses.

1.2 Methodology

1.2.1 Weighted Responses

We weighted all responses to the population in order to produce an unbiased extrapolation to the population.. Each survey (sample element) has a weight, calculated using MBSS techniques, and is associated with the responses that tell how many individuals a single sample element represents. Qualitatively, the weights indicate how much each survey "counts" toward representing the population.
We calculate the weights using the below equation. The results are reported as percent of respondents:

(Weighted number of respondents) ÷ (Total weighted sample)

1.2.2 Percentage of Respondents

Due to the design of the survey and response categories, all column totals equal 100%, except where noted otherwise.

1.2.3 Sample Size

"Sample size", as reported in all tables in this section, represents the actual un-weighted number of respondents who answered the question, and is reported separately for each question. This is necessary since not every question was answered by every person, due to refusal or inapplicability.

1.2.4 Survey Responses

Respondents do not always answer every question with a specific response and will often refuse to answer questions due to non-applicability, skip patterns, or other reasons. "Don't know" answers are included in the sample for each question and are considered a legitimate category of response. Variations in sample size for certain questions are due to the elimination of non-responses (missing values) where appropriate.

Within the Process Findings chapter we provide a sample of verbatim responses for the three open-ended questions while the freeridership survey questions and open-ended comments are not contained within this chapter. In some cases, sample responses were selected for their content and may not be representative of all the responses for that question. A complete list of responses for each question can be made available upon request.

1.3 Survey Results

1.3.1 Respondent Information

This subsection provides information on the respondent. Table 1 indicates that 98.2% of the people who were interviewed were either the owner of the building or the owner's representative. The last line of Table 1 shows that responses for this question were recorded from a total of 179 people.

Table 1 : Respondent Information (q1)

Interviewee	% of Respondents
Owner or Owner's Representative	98.2%
Others	1.8%
Don't Know	-
Refused	-
Sample Size	179

We also asked the respondents if they recalled participation in the SBD program. As Table 2 shows, 96.3% of all respondents recalled participating in the program.

Table 2 : If Respondent Recalled Participation in SBD Program (q2)

Interviewee	% of Respondents
Recalled Participation in SBD Program	96.3%
Didn't Recall Participation in SBD Program	3.7%
Don't Know	-
Refused	-
Sample Size	179

1.3.2 Building Descriptive Statistics

This subsection focuses on descriptive statistics of the surveyed buildings, including building construction type, and occupancy.

Table 3 presents a list of the building types included in the sample that is representative of the program participant population. Industrial projects, single-story large retail, and parking garages collectively represent 36% of all projects. In the previous program cycle 2004-2005, retail and wholesale was 21.2% of the sample, however, for this period, retail buildings represent 16.5%. Educational facilities at were at 14.3% compared to this program cycle at 18.5%. There were no hotels and only 1.3% of the projects were hotels in 2004-2005.

Table 3 : Building Description (q3)

Type of Building	% of Respondents
Industrial Equipment	13.5%
Single-Story Large Retail	11.5%
Parking Garage	10.9%
Lt.Manufacturing	7.6%
Small Office	7.2%
Small School	7.3%
Large School	7.1%
Grocery	5.2%
Small Retail	5.0%
Assembly	5.0%
Bio/Tec Manufacturing	4.0%
Large Office	3.6%
Large University	3.3%
Full-Service Restaurant	2.7%
Conditioned Warehouse	1.9%
Unconditioned Warehouse	1.9%
Quick Service Restaurant	1.2%
Community College	0.8%
Hospital	0.3%
Hotel	-
Multi-Story Large Retail	-
Sample Size	179

Table 4 classifies the buildings by project type. New Construction is the primary building type with 65% of all SBD projects as new buildings. While slightly less than 10% are industrial projects and may not necessarily be contained inside a building hence indicating not applicable. First tenant improvements and renovations are the least common building types within the program; this maybe due to the quick time line on those types of projects along fewer qualified energy efficiency measures.

Table 4 : Type of Project (q4)

Type of Project	% of Respondents
New Building (Brand New Construction)	65.8%
Industrial Projects and/or Not Applicable	9.4%
Gut rehabilation of existing building	7.5%
Addition to an existing building	6.1%
Renovation or remodel of an existing building	5.1%
First Tenant improvement or newly conditioned space in an existing shell building	4.3%
Renovation and addition	1.8%
Sample Size	179

Table 5 shows that construction was complete for 90% of all buildings were completely built out. Construction was not complete for 2% and the remaining 7.8% are not applicable as these are industrial projects.

Table 5 : Building Completed (q6)

Building Completely Built Out	% of Respondents
Yes	89.8%
No	2.4%
Not Applicable	7.8%
Sample Size	179

Table 6 shows that 88% of all buildings were fully occupied at the time of the survey. However, not reflected among those who stated "Not Completely Occupied", are two projects they were shut down due to the decline in the economy. A third industrial project, which is reflected in the responses, has been temporarily shut down and it's unknown as to when it will be in use.

Table 6 : Building Occupancy (q7)

Building Completely Occupied	% of Respondents
Yes	88.3%
No	3.9%
Not Applicable	8%
Sample Size	179

Table 7 shows that as-built building plans were available for 62% of the projects. The plans were not available for the 19% of the respondents. In some case, we were able to later borrow and/or pick up plans at an alternate location.

Table 7 : Availability of Building plans (q8)

Availability of Building Plans	
Yes	61.9%
No	18.8%
Don't Know	10.2%
Not Applicable	9.1%
Sample Size	179

Table 8 provides information on building ownership. Approximately 83% of all projects were owned by private companies, whereas the remainders were owned by public agencies.

Table 8 : Ownership Intent (q9)

Ownership of Building	% of Respondents
Private	82.9%
Public	17.1%
Sample Size	179

Table 9 summaries the purpose for the construction or renovation of the buildings. As indicated in the table, 71.7% were built for owner occupation. Approximately 24% of the buildings were built by a developer with the intent to lease the space. Findings from previous SBD studies have shown that decision-makers for owner occupied buildings tend to rely on more sophisticated investment decision making procedures, such as return on investment (ROI) or lowest lifecycle cost; whereas decision-makers for speculative buildings more frequently used lowest first cost decision making.

For this program cycle we also interviewed tenants as well as the developers of some properties for the “Built by a Developer with Intent to Lease” category. We interviewed the tenants when they decided to participate in the survey rather than the developer. However, in some cases where we interviewed both the tenant and the developer we learned the developer was unwilling to apply for the SBD program on behalf of their tenant because they were reluctant to guarantee that they would install the energy efficient equipment proposed on the SBD contract. They were concerned that if they did not achieve the proposed efficiency levels in the contract, they would incur a financial loss if incentives are adjusted downward.

Table 9 : Occupancy Intent during Construction (q10)

Occupancy Intent	% of Respondents
Built to be Owner occupied	71.7%
Built by a developer with the intent to lease space	23.8%
Built and Occupied by Developer with Intent not to lease remaining space	1.4%
Don't Know	3.1%
Sample Size	179

1.3.3 Savings by Design Program Attitudes and Awareness

We asked all SBD program participants how they first became aware of the SBD program, services, and owner incentives that were available. As shown in Table 10, approximately 68% of the respondents heard of the program through utility representatives or previous utility program participation. This percentage is similar to the 2004-2005 program cycle findings at 77%.

Previous participation in the SBD program continues to be the most common source of program awareness. Reoccurring participants are often corporations with prototypical buildings. Previous participation remains the same from 2004 through 2008 at 45% the difference among the two program cycles in only a factor of (0.4%). This finding suggests that the program needs to change its marketing strategy to attract a broader audience and get more customers that have not previously participated or consider imposing limits on reoccurring participants.

Participants who "learn from utility representatives" is at its lowest level at 22% compared to previous program years. The 2002 results reflected 26%, 2003 results 35% and 2004-05 32%. The lack of responses in support of websites or marketing materials (i.e., 2004-2005 website results 0.4% and marketing material 2.2%) suggest that the utilities may want to revisit the purpose and content of these sources. It may be a case where these sources are not as critical in the decision making process and the final decision to participate in a program of this type likely requires the advice of a professional consultant or someone who is knowledgeable of the program services. Alternate sources in which participants learned about the program that are notated as "Other" include Third-Party Consultants, Energy Service's Company (ESCO), LEED Consultants, and/or City Agencies.

Table 10 : Source of Awareness of Savings by Design (q11)

First Became aware of SBD from	% of Respondents
Utility Representative	22.9%
Previous Participation	45.0%
Marketing Material	1.3%
Architect	12.5%
Engineer	4.8%
Website	-
Manufacturer Rep.	2.7%
Construction Manager	0.8%
Energy Manager	0.7%
Previous Tenant	0.3%
Utility Seminar or PEC Center or SCE	1.9%
Don't know	0.3%
Other	6.8%
Sample Size	179

As shown in Table 11 when asked whether the respondent worked directly with SBD representative, 83% said yes. The remaining 15.8% did not work directly with SBD representatives and 1.3 % did not know. These results again mimic the previous program cycle with 83% working with their SBD representative and 17% did not work with them in 2004-2005.

Table 11 : If Worked Directly With SBD Representative (q12)

Worked Directly With SBD Representative	% of Respondents
Yes	82.9%
No	15.8%
Don't Know	1.3%
Refused	-
Sample Size	179

We asked all SBD participants at what stage of the design and construction process they became actively involved with the SBD representatives. Respondents were read the list of options in Table 12. The results indicate that 80 % became involved with the program early in the design process (28% during project conception, 22% during project development, 9% during schematic design, and 14% during the design development phase. SBD involvement began during the construction documents phase for 7% of respondents. And only 4% quoted “during construction phase” which is an improvement from the previous cycle at 10%. No one stated, following completion or following facility occupancy. Although the majority of participants state they are involved early in the phase a common recommendation is utilities should get involved earlier and improve their services on “fast track” projects.

Table 12 : Stage of Involvement with SBD representatives (q13)

Stage	% of Respondents
Project Conception	28.1%
Project Development	21.6%
Schematic Design	13.9%
Design Development	17.4%
Construction Document	7.4%
During Construction	4.1%
Completion of Construction	0
Facility Occupancy	0
Don't Know	4.3%
Sample Size	179

Table 13 summarizes the responses given when we asked SBD participants (unprompted) which member of their project team was the single biggest advocate for participating in the program. Nearly 71% of the participants said that the owners or the developers were the biggest advocates for SBD participation. This continues to supports the finding of the NRNC baseline study[4] that asserts that architects and engineers feel that the owners are the key decision-makers. When we prompted the respondents who chose the option "other" notable advocates were included Civil Engineer, Refrigeration Contractor, Building Tenant, and some other specific designations or names.

Table 13 : Single Biggest Advocate for Participating in SBD (q14)

Single Biggest Advocate	% of Respondents
Owner Developer	70.8%
Architect	11.4%
Lighting Designer	0.7%
Electrical Engineer	0.8%
Mechanical Engineer	6.1%
Energy Manager	1.9%
Manufacturer Rep.	1.3%
Other	6.9%
Sample Size	179

1.3.4 Importance of Dollar Incentives, Design Assistance, and Design Analysis

We asked SBD participants to rate the level of importance of the incentives paid to the owner in motivating their organization to participate. As shown in Table 14, approximately 90% said the incentive was either "very important" or "somewhat important", while only 3% rated the incentive very unimportant or somewhat unimportant. These responses are similar to the prior program results with 87% indicating important and 5% indicating unimportant. These responses continue to suggest incentives are a critical tool for engaging program participation of building owners.

[4] 1999 Non-Residential New Construction Baseline Study.

Table 14 : Importance of Owner Incentive in Participation (q15)

Importance of Dollar Incentive	% of Respondent
Very Important	59.3%
Somwhat Important	30.2%
Neither Important nor Unimportant	7.0%
Somewhat Unimportant	1.9%
Very Unimportant	1.4%
Don't Know	0.3%
Sample Size	179

We asked all SBD participants to rate the level of importance of the design assistance provided by SBD in motivating their participation in the program. Table 15 shows that 73% of respondents rated the assistance as very or somewhat important, while 16% rated the assistance as very or somewhat unimportant. The value of these services has diminished from the prior program cycle (2004-05) with 76% indicating important and 5% as unimportant. The level of unimportance has increase by nearly two-thirds. This maybe attributed to the fact that many of the program participants are repeated customers who do not utilize these services and/or the projects they submitted already meet the program criterion and therefore do not require extensive review. Comments received from the freeridership open-ended survey questions further support these conclusions. Two examples are displayed below.

"We didn't have to change our prototype to qualify for the program but do recognize the program validates we are making the right decision".

"Didn't further the implementation just reinforces they are a good idea."

Table 15 : Importance of Design Assistance for Participation (q16)

Importance of Design Assistance and Analysis	% of Respondent
Very Important	42.7%
Somwhat Important	37.4%
Neither Important nor Unimportant	8.0%
Somewhat Unimportant	6.8%
Very Unimportant	4.8%
Don't Know	0.3%
Sample Size	179

As shown in Table 16, 62% of the participants stated that SBD participation influenced them to change their standard building practices to construct more efficient buildings in the future. 28% of the respondents answered that SBD participation did not influence changes in their standard practice. Almost 8% stated they had no plans to build any more buildings in the future.

Table 16 : Changed Standard Practice to Higher Energy Efficiency due to SBD Participation (q17)

If Participation Changed Standard Building Practice?	% of Respondents
Yes	61.9%
No	27.8%
No plans to build anymore buildings	8.1%
Don't Know	2.2%
Sample Size	179

Participants who answered "yes" in Table 16 were asked about the changes they have made to the standard practice that would lead to a more energy efficient building design. Verbatim comments are shown below.

All Participant Responses (q18)

SBD combined with LEED, we would look at all the same measures again on a future building. (Common Response)

I see us staying on this path. On our next bldg we would like to be aware of the most efficient systems. But there is always a balance of capital vs. first cost trade off. (Common Response)

We tend to go the most efficient system possible. But the program keeps us exploring the latest technology for energy efficient building design. (Common Response)

Saving energy as a way for cost control, incentive was a catalyst. Review concepts earlier in the design phase to capture more incentives.

SBD helps to reiterate that making an investment and the upfront is worth it in the long-term. Since our funding is limited it helps to take the "sting" out of it. And implies we are building green which is a growing concern.

From day one we have always incorporated SBD input. On some recent projects we incorporated a different control system as a result of their input.

Put forth a greater consideration for the lifecycle cost and the savings associated with higher performance systems.

On going process, we're changing designs all the time. It certainly helps to push us to install the most efficient products we can get our hands on.

Our prototype is constantly evolving; skylights are now installed throughout the country SBD was the catalyst for the change. We are also installing more white roofs, higher efficiency HVAC and improved thermal efficiency.

Changes, just that we incorporate SBD on every project that we build. SBD helps build state-of-the-art buildings and aids us in equipment selection and design strategies; they are a significant part of our planning process.

SBD helped us change our standard; California projects lead the nation in energy requirements. We have 2-3 prototypes and apply those nationwide. We've made improvements on watts per SQFT, Occupancy Sensors, EMS, demand response and outdoor lighting along with sign lighting. Each year we meet with SBB to review our prototype.

Would prefer SBD get involved earlier in the process. On our next project we would like to get a cool (white reflective) roof that would make the building more energy efficient and we would take advantage of the linear fluorescent lighting.

Yes and no, the reason why I hesitant we are very energy conscious. Run our operating budget as tight as possible so when we add new load were adding a line item to our utility *bill. Energy efficiency is always as priority but the incentives help the design community to make sure energy efficiency is enforced.*

Similarly, the participants who answered “No” in Table 16 were asked to give reasons in support of their response. Some of their comments are below.

Selected Participant Responses (q17 why)

Because we are a very green company, it's our standard practice. (Common Response)

The college program has an environmental policy that comes from the chancellor’s office to do better that Title-24 by 20%. (Common Response among Higher Education Participants)

Already ahead of the curve, SBD didn’t provide me with anything I don't already know. The problem with the design services is they take too long they need to be more nibble. We are green builders and want to build green because it’s the right thing to do.

Our buildings already meet all the SBD recommendations. We find they are unable to provide useful suggestions, they know less than we do.

We’re a forward thinking company; already adopted energy efficiency practices as a standard protocol. We always plan to exceed Title-24 regardless of program participation status.

We use the California prototypes as a baseline design in all our buildings. It’s a benchmark that is constantly evolving. Our buildings have a 120 day construction start to finish cycle so SBD suggestions get implemented on future projects.

We put energy efficiency measures in our buildings because it’s our company practice. It has nothing to do with SBD.

We are concerned about energy costs but we’re cheap and always concerned with the bottom line. In the last 2 years the program has helped us validate the savings but and we want them to be proven. Ultimately we're looking for the free money.

This project didn't have any bearing on future design practices.

We asked participants to rate the value of SBD “Incentives”, “Design Assistance”, and “Design Analysis”. The weighted results, shown in Table 17, indicate high satisfaction with all three components. Two-thirds of respondents gave a rating of 1 or 2 where a rating of 1 is “very valuable” for the incentive and a “2” is somewhat valuable. While an equal number of the respondents indicated the program services “design assistance” was only somewhat valuable or neutral. The ratings in 2004-05 are the highest for

“Incentives” where over 83% rated this service 1 or 2 the ratings for this program cycle have decrease by 14% to 69%. The average and standard deviation scores for “Incentives”, “Design Assistance” and “Design Analysis” in the 2004-05 study we’re un-weighted while the averages and standard deviation as shown in this report are weighted. To compare the two studies one must look at the percentages. All program services have slightly depreciated with more respondents rating the services with a “5” or “not at all valuable”. Results for the “incentive was not at all valuable” are 4% compared to 2004-05 at 3%, “Design Assistance” is rated at 4% as compared to 2% and “Design Analysis” has significantly increased in terms of being un-valued service from 7% compared to 2%. There are fewer respondents (104) in “Design Analysis” as those who did not apply for the “Whole-Building Approach” were not asked to rate the value of this service.

Table 17 : Value of Incentives, Design Assistance, and Design Analysis (q19)

% of Participants 1=Very Valuable 5=Not at all Valuable	Incentives	Design Assistance	Design Analysis
1	43.2%	22.7%	32.0%
2	25.4%	28.2%	34.9%
3	14.6%	28.2%	20.0%
4	11.9%	9.7%	1.7%
5	4.3%	4.1%	7.3%
Don't Know	0.7%	6.8%	4.1%
NA		0.3%	
Sample Size	179	179	104
Mean	2.08	2.40	2.14
Standard Deviation	2.19	1.99	1.90

We asked participants were asked to provide recommendations for changes to the SBD program in order to improve its delivery to customers. The given answers were unprompted, and multiple responses were accepted. We categorized based on common responses. We calculated the percentages using the following equation:

(Weighted number of respondents with a particular answer) ÷
(Total weighted number of respondents who answered the question)

All survey respondents gave responses to the question seeking recommendations to improve the program. Table 18 shows that 51% of the participants felt that no changes were needed which is the exact same percentage from the prior program cycle 2004-2005. Other suggestions for improving the program included “utilities should try to get involved earlier in projects” 16% and “increase (in) incentives” 13%, and “other” 11%. In the prior program cycle (2004-05) only 10% of the respondents recommended an “increase (in) incentives,” however in 2002 this response was at a historical high with 27.5% recommending an increase in incentives. As multiple answers were accepted on this question, the percentages in Table 18 do not add up to 100%.

Table 18 : Recommended Changes to Savings by Design (q20)

Recommendations	% of Respondents
No Changes Needed	51.2%
Utilities should try to get involved earlier in projects	16.0%
Increase Incentives	13.0%
Other	11.1%
Review and response from utility needs to be more timely	6.2%
Less paperwork and red tape	5.0%
More marketing to increase awareness of program	4.5%
More interaction with design team	3.4%
Don't Know	1.8%
Increase post project feedback, better "closure"	1.3%
Utility Reps need to present benefits more clearly	0.8%
Refused	-
Sample Size	179

Respondents who chose “Other” in Table 18 were asked to state their specific recommendation(s). Selected “Other” comments and recommendations are listed below.

Other Selected Recommendations (q20 Other)

Provide some comparables (or case studies) so the customers have an idea of what their incentives might be and what measures to pursue. (Common Response)

More Public Awareness of the Program (Common Response)

We should have got involved earlier but this was a fast track project. (Common Response)

During the design development phase, utility contractors for SBD need to do a more careful review of what's already been submitted and get involved with the projects during design development phase to have to most productive conversation.

Provide a dedicated single point of contact for each project. Respondent spoke with 8 or 9 SBD representatives over the course of project.

Include a clear description of the various rate structures and as part of the customers building retrofit or new construction project. For retrofits bring in customers existing load profile and for new projects provide comparable projects and break down how the rate works. They (utilities) don't do enough rate structure analysis and they focus too much on the incentives. Show customers how cut their bill by adjusting their usage patterns and rate structure.

On tenant-improvement (TI) projects we really need a rapid response. And for the little amount of incentives we gain on these types of projects (TI) it doesn't justify the cost we pay to our consultants to follow up with (utility).

Program needs to be more customized for our business type (car dealership).

Uniformity of program delivery among utilities; SCE does a better job than PG&E and in some cases PG&E has rejected our design while SCE has approved it.

We get a good turn around but I've talked with a few of my colleagues and found they have trouble with SBD response time.

We've found we need to start the application process later in the project because schools have a long (3-5 year process to develop). The program has changes and it makes it difficult to adhere to them with the long development cycle.

When we contacted the (utility) to let them know we would be needing power at this site I think they should have informed us about the program then. The architect should have marketed it to us as well. SBD could have been involved earlier on in the project had someone brought it to our attention sooner.

Reached a point of diminishing returns, incentives stop even though we’re saving energy.

It wasn't as flexible as we would have liked it to be.

1.4 Prototype Projects

Prototype plans refer to a master set of plans used for the construction of multiple buildings. This is common practice among large retail and restaurant chains, many of which participated in the SBD program.

We asked participants if they used a set of prototype plans or master specifications in the design and construction of their building 32% responded yes as shown in Table 19.

Table 19 : Used a set of Prototype Plans (q21)

Prototype Plans Used	% of Respondents
Yes	25.9%
No	72.2%
Don't Know	1.9%
Refused	-
Sample Size	179

1.5 Conclusions

Utility representatives remain the primary vehicle for marketing the program. A majority of the respondents heard of the program through utility representatives or previous utility program participation.

The program participants were generally satisfied with the program. This is indicated by the frequent "no changes needed" responses 51% when asked what the program should improve. For the approximate 49% of customers who suggested a program improvement, many of them indicated the utilities need to get involved earlier.

The interest to have utilities involved earlier in the projects is due to the timeliness of their recommendations. Large corporations with prototypical buildings often stated they use the recommendations provided on future projects while non-prototypical projects are subject to wait for utility feedback, make a change order depending on how far along they are in the process, or not include the recommendations.

Develop case studies as a way to help potential participants identify common measures and incentive levels. The request for case studies was suggested by several design team consultants as a way to help both the end user i.e. participant and their design team. These studies would highlight common measures applied to various building types and provide estimates on incentive levels. With this information potential participants and their consultants can make an informed decision on whether or not applying for the program incentives and services worth the time and effort required.

The necessity for incentives are not clear for all measure adoptions. While incentives may be necessary for enlisting program participation an incentive is not necessary when standard practice exceeds the minimum code compliance. This may explain situations where the respondent expressed the importance of incentives while stating that their measure choices were standard practice. Sixty-one percent of respondents have indicated the program has influenced them to change their standard building practice. While this does represent a significant proportion of the respondents this number has decreased by 16% from the 2004-05 program. The decrease in influence suggests that the measures the program is recommending are becoming a standard course of practice for a significant portion of the reoccurring or first time participants. These participants tend to implement energy efficient measures for reasons outside of the program, such as to gain insight on new products available in the market, validate and obtain direction on design concepts, off set their first costs, and ultimately to save energy. The incentives still play an important part but it is not always the determining factor.

Appendix G. Recruiting and Decision Maker Survey

This survey instrument is a phone script used for recruiting Savings by Design participants to take part in this NCCS NRNC M&V study. The survey includes screening questions used to inform basic site characteristics as well as the influence and effectiveness of the Savings by Design program overall.

2006-08 NRNC Evaluation Recruiting & Decision Maker Survey

Contact and Project Info	Owner Info
Site ID: «RLW_ID»	Owner Company: «Owner_Company»
Contact Person: «Owner_contact»	Owner Address: «Owner_Address», «Owner_City»
Business Name: «PROJECT_NAME»	Contact Email: «Contact_email»
Address: «ADDRESS», «CITY»	Contact Fax: «Contact_Fax»
Phone: «Phone»	Bldg Type: «Bldg_Type»
Program Delivery Type: «Approach»	Sample: «Sample»
Square Footage: «SQFT_Orig» **(VERIFY)**	

Contact Log

	Date	Time	Contacted			Comments
1						
2						
3						
4						
5						
6						
7						

Num of Calls _____________**Num of Contacts:** _____________

Hello, my name is <<surveyor>> and I am calling on behalf of the California Public Utilities Commission I would like to speak with **«Owner_contact»** regarding participation in <<utility>>'s New Construction Program, Savings by Design.

Are you the owner or the owner's representative for the building at **«ADDRESS»**?

01 Yes
02 No (Get contact info) Name:_____________________
98 DK (Get contact info) Phone:_____________________
Refused (Thank and terminate)

Hello «Owner_contact», this is «Surveyor» calling on behalf of the California Public Utilities Commission with regard to **«PROJECT_NAME»** located at **«ADDRESS»**. I am contacting you today regarding your past participation in **<<UTILITY>>'S** Non-residential New Construction program, Savings by Design. Our records show that your project received financial incentives for installing high performance energy efficiency features in the building. We are working with **CPUC** to verify the installed energy efficiency measures and the energy savings resulting from them.

Do you recall participating in **«utility»'s** Savings By Design program?

01 Yes

02 No (Confirm Building Address, ask for someone else, Thank and Terminate)
98 DK (Get contact info)
99 Refused (Thank and Terminate)

Name: ______________________

Phone: ______________________

As you may be aware through Savings By Design program materials, **<<UTILITY>>** is required to have an independent evaluation of the Savings By Design program to ensure the anticipated energy savings are actually being realized. Participants in the program are asked to participate in the evaluation so that program design can be improved and program energy savings results can be documented. In order to complete the evaluation we have been asked to conduct site surveys at a sample of participant sites to independently measure and verify the energy savings **<<UTILITY>>** reported. Our independent evaluation is strictly confidential and can in no way effect the incentive you were already paid.

The purpose of the on-site visit is to collect information and data that is required to build an engineering model of your project, which in turn allows us to estimate the energy savings for each building or site as it was actually built and used.

The on-site survey usually begins with a 30 minute meeting between our engineer/surveyor and your facility manager. During this meeting information such as building schedules and control schemes will be discussed and documented. The engineer/surveyor will then ask to review building plans, if available, and conduct a walk through of the facility to obtain specific measurements and equipment inventories needed for the model. The on-site visit is non-intrusive and normally takes between 3 and 8 hours, depending upon the size and complexity of the building and availability of building plans. Other than the introductory meeting, our engineer does should not need any further assistance, other than access to the building systems.

The on-site can be scheduled at your convenience, when would be a good time for you? *(Continue with Pg 3 "Scope of Work" if needed)*

1. Appointment Date and Time____
2. Refused

Screener

Before we finish I would like to ask you some questions about the building. We understand that designing and building new commercial properties is a long and difficult process that includes the decisions and input of many different decision makers, such as architects, engineers and building owners. If at anytime you feel someone else is more qualified to answer the following questions, please notify me and we will skip the question.

Our information shows that this building is a **«Bldg_Type»** , is this correct?

01 Yes
02 No

(If no, Ask what type of building and primary occupancy type)

If mixed Occupancy please describe:

____
____
____
____

How would you describe the project (at **«ADDRESS»**), is it a…….

01 New building (brand new construction)
02 First Tenant improvement or newly conditioned space in an existing shell building
03 Renovation or remodel of an existing building
04 Addition to an existing building (Go to Q4a)
05 Renovation and addition (Go to Q4a)
06 Gut Rehabilitation of existing building
98 DK (Get contact info) Name: _____________________
99 Refused (Get contact info) Phone: _____________________

Q4a. Where in the building was the addition built? (Describe)

____
____
____
____

When was the building completed and opened for occupancy? (Month and Year)

Completed: _____________

Opened for Occupancy: ______________ (If different from completed date)

Is the building completely built out?

01 Yes (Skip to 0)
02 If No, **% Complete**________ **Expected Completion Date**_________

Is the building completely occupied?

01 Yes
02 If No, **% Occupied**________

Q7a. If no, what work remains?

____
____
____
____
____

Building Classification

Was this building constructed and is it owned by a private company or a public agency?

01 Private company
02 Public agency
98 DK
99 Refused

Was this building constructed to be occupied by the owner of the building, or built by a developer with the intent to lease space?

01 Built to be Owner Occupied
02 Built by a developer with the intent to lease space
03 Built and occupied by developer with intent to lease remaining space
98 DK
99 Refused

Building Owner Questions

How did you first become aware of the SBD program, services, and owner incentives that were available to you?

Utility Representative
Previous Utility Program Participation
Marketing Material
Architect
Engineer
Web Site
Manufacturer Rep.
Construction Manager
Energy Manager
Previous Tenant
Utility Seminar PEC Center or SCE
50 Other: ___________
98 DK
99 Refused

Did you work directly with the Savings By Design representative or consultant on this project?

01 Yes
02 No **(**Get name and contact info of person that did)
98 DK
99 Refused (Thank and Terminate)

Name: _____________________

Phone: ___________________

At which stage of the design and construction process did you first become actively involved with the Savings By Design Representative? **(READ LIST)**

01 Project Conception
02 Project Development Phase
03 Schematic Design Phase
04 Design Development Phase
05 Construction Documents Phase
06 During Construction
07 Following Completion of Construction
08 Following Facility Occupancy
50 Other: ___________
98 DK
99 Refused

Which member of your project team, including yourself, was the single biggest advocate for participating in the program? **DO NOT PROMPT, ACCEPT ONLY ONE RESPONSE**

01 Owner/Developer

02 Architect
03 Lighting Designer
04 Electrical Engineer
05 Mechanical Engineer
06 Energy Manager
07 Manufacturer Rep.
06 Construction Manager
50 Other: ___________
98 DK
99 Refused

How important was the dollar incentive for the measures paid to the owner, in motivating the organization to participate in the SBD program?

01 Very important
02 Somewhat important
03 Neither important nor unimportant
04 Somewhat unimportant
05 Very unimportant
98 DK
99 Refused

Project Approach: <<implementation approach>>

Design Assistance: Yes or No

If no design assistance or analysis, skip 0.

READ:

Design assistance is available to building owners and their design teams and typically includes recommendations for efficient equipment and consultation on enhanced design strategies. Design analysis is typically computer simulations to estimate building energy savings for energy conservation measures being considered. A goal of design assistance is to provide building owners with the tools and skills to apply on future projects

How important was the design assistance and design analysis provided by SBD in motivating your organization to participate in the SBD program?

01 Very important
02 Somewhat important
03 Neither important nor unimportant
04 Somewhat Unimportant
05 Very Unimportant
98 DK
99 Refused

Has participation in any component of SBD influenced you to change your standard building practice that would lead to more energy efficient buildings in the future?

01 Yes
02 No, Why? (Skip to 0)
03 No Plans to build any more buildings.
98 DK (Skip to 0 and ask who would know and get their name and phone)
Name:______________________
99 Refused (Skip to 0) **Phone:**______________________

Why:____

What changes have you made, or do you foresee making, to your standard practice that would lead to a more energy efficient building design?

Record Answer Verbatim:____

On a scale of 1 to 5, with 1 being very valuable and 5 being not at all valuable, how would you rate the value of the following SBD components for this project?

	Rating	DK	NA (Not Provided)	
a. Incentive	1 2 3 4 5	98	99	100
b. Design Assistance	1 2 3 4 5	98	99	100
c. Design Analysis	1 2 3 4 5	98	99	100

If any, what recommendations would you have to change the SBD program to improve its delivery to customers such as yourself? **(DO NOT READ)**

No changes needed
Utility reps need to present benefits more clearly
Increase incentives
More marketing to increase awareness of program
Review and response from utility needs to be more timely
More interaction with design team
Utilities should try to get involved earlier in projects
Less paperwork and red tape
Increase post project feedback, better "closure"
Other: ____
98 DK
99 Refused

Read:

"Either you or another member of the design team can answer the next questions. As I read through these questions, If you feel someone else is more qualified to respond please specify whom that person is."

Read:

The following questions address the influence of the Savings By Design program on specific measures. <u>Please bear in mind that when we refer to Savings By Design, we mean all aspects of the</u>

program; financial incentives, design assistance, design analysis or any other interaction with SBD representatives or consultants.

ASK THE FOLLOWING 3 QUESTIONS FOR EACH MEASURE LISTED, RECORD RESPONSES ON THE MATRIX BELOW

On a scale from 0 to 10, where 0 means not influential whatsoever, and 10 means extremely influential, how influential was Savings By Design, including the incentives, design assistance, design analysis and interactions with SBD representatives and consultants in the implementation of «MeasDesc1»?

_________ (points = answer *0.1)

How did Savings By Design influence the implementation of ***<<the measure>>*** (choose all that apply) (**maximum of 2 points**)

DO NOT PROMPT

1 = SBD had no influence on this measure **0 point**
2 = SBD representative first suggested/introduced measure **2 points**
3 = SBD performed simulations and/or design analysis **2 points**
4 = SBD incentive made this measure an "easier sell" **1 point**
5 = SBD incentive helped the measure meet investment criteria **2 points**
6 = Prior SBD projects have had success with this measure **1 points**
7 = DK, Not Certain, Can't Remember **0 points**
50= other **individually assessed**

On a scale of 0 to 10 where 0 means that this measure would have been installed exactly the same regardless of interaction with Savings By Design regarding this project and 10 means that the measure would definitely not have been installed without Savings By Design influence and interaction, what is the likelihood that this measure would not have been installed with SBD interaction? Why?

_________ (points = answer *0.3)

#	Measure	Q20	Q21	0	0	0
1	«MeasDesc1» ---- «MeasDetail1»					
2	«MeasDesc2» ---- «MeasDetail2»					
3	«MeasDesc3» ---- «MeasDetail3»					

4	«MeasDesc4» ---- «MeasDetail4»					
5	«MeasDesc5» ---- «MeasDetail5»					
6	«MeasDesc6» ---- «MeasDesc6»					
7	«MeasDesc7» ---- «MeasDetail7»					
8	«MeasDesc8» ---- «MeasDetail8»					
9	«MeasDesc9» ---- «MeasDetail9»					
10	«MeasDesc10» ---- «MeasDetail10»					

Why? (Ask for each Measure)

Measure#(__)____
_____________Measure#(__)____
____

Measure#(__)____
_____________Measure#(__)____
____

Measure#(__)____
_____________Measure#(__)____
____

Mitigating factors scoring documented by surveyor, or project file reviewer.

Measure#(__) FR Score ____; Surveyor or Project file reviewer ______; Project Manager _______; Date _____
Explanation:
____
____
____

Measure#(__) FR Score ____; Surveyor or Project file reviewer ______; Project Manager _______; Date _____
Explanation:
____
____
____

Measure#(__) FR Score ____; Surveyor or Project file reviewer ______; Project Manager
_______; Date _____ ....
Explanation:
____
____
____

Measure#(__) FR Score ____; Surveyor or Project file reviewer ______; Project Manager _______; Date _____
Explanation:
____

Thank you, this concludes our interview. Do you have any questions before we finish?