HEEP
Healthcare Energy Efficiency Program

PG&E

[redacted] Hospital

October 8, 2014

Detailed Energy Assessment Report

Healthcare Energy Efficiency Program

Prepared for:
[redacted]

Prepared by:
Willdan Energy Solutions
6120 Stoneridge Mall Road, Suite 250
Pleasanton, CA 94588

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October 8, 2014

[redacted]

Re: Detailed Energy Assessment Report for [redacted] Hospital

Dear [redacted]

Willdan Energy Solutions presents this Detailed Energy Assessment Report to [redacted] Hospital, prepared as part of the Healthcare Energy Efficiency Program (HEEP) for customers of Pacific Gas and Electric Company (PG&E). We extend our appreciation to you and to [redacted] for supporting and participating in this energy assessment, and we also thank your PG&E account representative, Scott Warner, for ongoing project support.

Our report documents the technical analysis of energy efficiency measures (EEMs) which were selected to meet your facility's criteria. We look forward to the opportunity to assist you with your review and selection of the recommended energy efficiency measures.

Please refer to the Executive Summary on page 1 for a brief overview of the HEEP energy assessment process and for a summary of Willdan's recommendations. Tables and figures throughout the report address key equipment and usage details and provide cost-benefit analyses and summaries. The appendices describe the HEEP program and on-bill financing. The calculations were prepared by Justin Libay, EIT, and Kevin Wheatley and were reviewed by Gary McDonald, PE, and Kit Legg, PE.

To discuss any aspect of this report, or to arrange a personal meeting, please call me at 925.551.1064 or send an e-mail message to klegg@willdan.com. We appreciate the opportunity to work with [redacted] Hospital on these important projects.

Sincerely,
WILLDAN ENERGY SOLUTIONS

Kit Legg, PE
Senior Electrical Engineer
Program Manager

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1. Executive Summary

Willdan Energy Solutions (Willdan) prepared this Detailed Energy Assessment Report for [redacted] Hospital as part of the Healthcare Energy Efficiency Program (HEEP), a targeted program offered by the Pacific Gas and Electric Company (PG&E) under the auspices of the California Public Utilities Commission (CPUC). The program offers energy assessment and project identification services and assistance with obtaining cash rebates and incentives to complete energy-saving retrofits for existing equipment or systems in healthcare facilities. HEEP also supports energy-saving retrocommissioning opportunities.

1.1 Energy Savings Summary

Willdan conducted an energy assessment for [redacted] Hospital, [redacted] California, to review existing energy-consuming systems and to identify opportunities for savings. Results from the energy assessment are presented in this report. All calculations are estimates.

Based on the energy assessment and analysis, Willdan determined that implementing the energy efficiency measures (EEMs) identified in this report will significantly reduce energy usage and associated energy costs at [redacted] Hospital. The total annual savings are summarized in table 1 and the energy efficiency measures are described in detail in section 5.

Table 1. Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	1,412,796.2 kWh
Peak Electric Demand Savings	165.59 kW
Annual Natural Gas Savings	100,759.8 therms
Annual Utility Cost Savings	**$259,233**
Investment Overview (Estimated)	
Total Project Costs	$1,558,732
Total Incentive Available	$244,279
Net Cost to Customer	**$1,314,453**
Simple Payback Period With Incentive	**5.1 years**

Savings stated in this report are considered preliminary findings; realized savings and incentives will depend on the actual work performed and the measures that are implemented. The total incentive cannot exceed 50 percent of the total project cost. All estimated payback or return-on-investment (ROI) periods are based on general industry information and may not accurately represent the total implementation cost for your specific site. You are encouraged to obtain bids from qualified contractors, and Willdan is prepared to assist with quantifying potential ROI accurately.

Table 2 summarizes Willdan's recommended measures, projected energy savings, estimated costs, and calculated simple payback for implementing the measures. The simple payback period is the time it will take for annual cost savings to equal the cost of implementing the measure. Payback calculations do not take into account inflation, equipment life, or operations and maintenance savings.

Table 2. Energy Efficiency Measure Savings Summary

		Annual Savings (Estimated)				Investment (Estimated)			
EEM No.	Description of Energy Efficiency Measure	Electric Energy Savings (kWh)	Peak Electric Demand Reduction (kW)	Natural Gas Savings (therms)	Utility Cost Savings[1]	Project Costs[2]	Utility Incentive[3]	Implementation Net Cost	Payback Period (years)
EEM-01	Extend Building Management System to All Buildings and Implement a Supply Temperature Reset on the Air Handlers (All Bldgs.)	461,198.3	38.36	42,494.5	$91,827	$290,518	$85,145	$205,374	2.2
EEM-02	Implement Operating Room Temperature Setback (Bldg. 1)	5,177.9	0.22	467.0	$1,023	$6,645	$914	$5,731	5.6
EEM-03	Upgrade Chiller Control System and Implement Chilled Water Supply Temperature Reset Based on Outside Air Temperature (Bldg. 1)	15,005.7	2.27	0.0	$1,951	$100,340	$1,541	$98,799	50.6
EEM-04	Implement Chilled Water Supply Temperature Reset Based on Outside Air Temperature (Bldgs. 2 and 3)	11,416.5	(3.03)	0.0	$1,484	$7,749	$458	$7,291	4.9
EEM-05	Implement Condenser Water Supply Temperature Reset Based on Outside Air Wet-Bulb Temperature (Bldg. 1)	37,281.3	9.22	0.0	$4,847	$7,765	$4,366	$3,399	0.7
EEM-06	Implement Condenser Water Supply Temperature Reset Based on Outside Air Wet-Bulb Temperature (Bldg. 4)	11,621.1	4.37	(0.9)	$1,510	$3,882	$1,585	$2,297	1.5
EEM-07	Upgrade Fan Coil Thermostats (Bldgs. 2 and 3)	93,504.4	(0.92)	691.8	$12,674	$29,378	$8,034	$21,344	1.7

[1] The results are based on estimated savings and are considered preliminary findings; realized savings and incentives will depend on the actual work performed and the measures implemented. The savings for individual measures are based on the assumption, when applicable, that other measures will be implemented. The total savings for all measures account for interactions between individual measures. Cost savings are based on the average blended cost-of-service rate (see report section 3).

[2] Estimated project costs are based on general industry information and may not accurately represent total implementation costs for your specific facility or projects. In some cases, additional costs may be incurred to comply with the requirements of the California Office of Statewide Health Planning and Development (OSHPD).

[3] The total incentive cannot exceed 50 percent of the total project cost. Potential utility incentives are based on current utility offerings and are subject to change as mandated by the California Public Utilities Commission (CPUC).

		Annual Savings (Estimated)				*Investment (Estimated)*			
EEM No.	Description of Energy Efficiency Measure	Electric Energy Savings (kWh)	Peak Electric Demand Reduction (kW)	Natural Gas Savings (therms)	Utility Cost Savings[1]	Project Costs[2]	Utility Incentive[3]	Implementation Net Cost	Payback Period (years)
EEM-08	Install a Kitchen Ventilation Control System (Bldgs. 2 and 3)	41,970.0	5.42	1,050.0	$6,244	$19,910	$5,221	$14,689	2.4
EEM-09	Convert the Chilled Water System to Variable Flow (Bldg. 1)	81,682.8	8.82	(391.8)	$10,325	$41,448	$7,465	$33,982	3.3
EEM-10	Convert the Chilled Water System to Variable Flow (Bldgs. 2 and 3)	36,884.3	4.05	0.0	$4,795	$43,663	$3,559	$40,104	8.4
EEM-11	Convert the Chilled Water System to Variable Flow (Bldg. 4)	21,350.6	2.55	0.0	$2,776	$13,171	$2,090	$11,081	4.0
EEM-12	Upgrade Boiler #1 Burner (Bldgs. 2 and 3)	0.0	0.00	5,960.8	$4,471	$26,939	$5,961	$20,978	4.7
EEM-13	Convert Air Handlers to Variable Air Volume Operation (Bldg. 1)	55,114.0	5.95	22,135.8	$23,767	$777,859	$31,296	$746,563	31.4
EEM-14	Install Window Film (Bldgs. 2 and 3)	325,897.6	59.40	26,428.5	$62,188	$77,481	$61,410	$16,071	0.3
EEM-15	Install an Evaporative Pre-Cooler on the Condensing Unit for Air Handler S-15 (Bldgs. 2 and 3)	2,668.8	1.17	0.0	$347	$30,041	$390	$29,651	85.5
EEM-16	Install Bi-Level Lighting in Stairwells (Bldg. 1)	22,150.9	5.81	0.0	$2,880	$4,800	$2,643	$2,157	0.7
EEM-17	Install Bi-Level Lighting in Stairwells (Bldgs. 2 and 3)	8,216.9	2.25	0.0	$1,068	$3,750	$995	$2,755	2.6
EEM-18	Partially De-Lamp Fixtures and Install Lighting Controls for Library and Medical Records (Bldg. 4)	19,146.4	3.64	0.0	$2,489	$7,800	$2,078	$5,722	2.3
EEM-19	Install LED Parking Lot Lighting	17,195.6	0.00	0.0	$2,235	$16,130	$1,376	$14,754	6.6
EEM-20	Install Heat Pumps on Backup Generator Heat Pumps (Bldg. 1)	119,611.3	13.33	0.0	$15,549	$15,000	$11,569	$3,431	0.2
EEM-21	Replace Air Handler S-21 With a New Air Handler With a Variable Speed Drive on the Supply Fan (Bldg. 3)	25,702.0	2.70	1,924.0	$4,784	$34,463	$6,184	$28,279	5.9
Total		1,412,796.2	165.59	100,759.8	$259,233	$1,558,732	$244,279	$1,314,453	5.1

1.2 Energy Benchmark

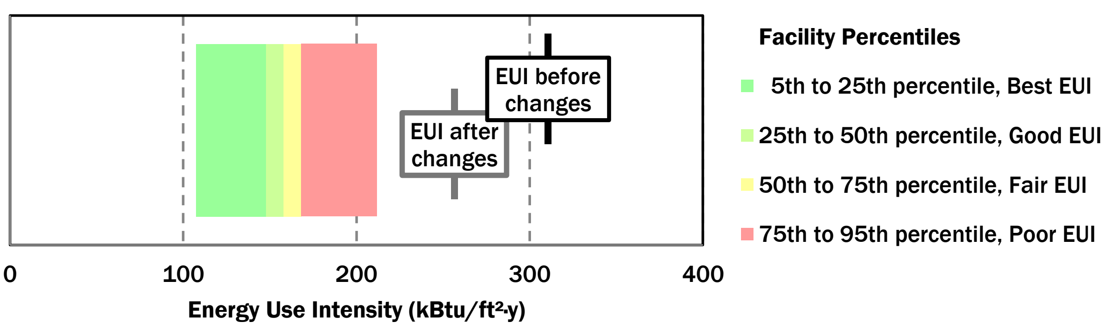
Energy benchmarking establishes a baseline of energy performance for a facility and provides information to guide energy efficiency investment decisions. Additionally, energy benchmarking allows facility operators to understand the relative energy efficiency of a facility and compare its performance to similar facilities. Comparisons between similar facilities are made by comparing the energy use intensity (EUI).

The EUI of a facility, also referred to as its energy utilization index, is the energy usage per square foot per year. EUI is calculated by totaling the annual energy usage for all utilities serving the facility, such as electric and natural gas, and dividing by the facility's gross floor area. EUI normalizes for facility size, which allows facilities of various sizes to be compared. A higher EUI indicates higher energy usage and greater opportunity for energy efficiency measures. A lower EUI indicates lower energy usage in a more energy efficient facility.

The EUI of the facility is 311 kBtu/ft²·y, which is much higher than the median EUI of 168 kBtu/ft²·y for facilities of similar size, type, and use.

By implementing the measures identified in this energy assessment report, the new EUI would be 255 kBtu/ft²·y. As a result, the facility would be closer to the median when compared to similar facilities in California.

Figure 1. Energy Use Intensity of Hospital and Similar Facilities in California



Calculation Notes. The energy usage of the facility from January 2013 to December 2013 was 9,472,897 kWh of electric energy usage and 515,667 therms of natural gas usage. For further analysis of the energy usage, see section 3.

The 35 similar facilities in California are hospitals between 150,000 ft² and 350,000 ft², built 1941-2014, and surveyed by the California Commercial End-Use Survey (CEUS) for the California Energy Commission. The similar facilities and the percentiles were identified with the EnergyIQ tool from the Lawrence Berkeley National Laboratory, http://energyiq.lbl.gov.

The American Hospital Association (AHA) encourages facilities to benchmark building performance with the Energy Star Portfolio Manager, http://portfoliomanager.energystar.gov, and to participate in the AHA's benchmarking and awards program, Energy to Care, http://www.energytocare.com.

2. Site Background Information

A detailed on-site survey of [redacted] Hospital was conducted on March 20, 2013, by Willdan. The survey team was Justin Libay and Zach Tripoli. The survey included the following steps:

- A review of the mechanical and electrical system design, installed conditions, maintenance practices, and operating methods.
- A survey of the building energy systems, including the envelope, primary HVAC systems, secondary HVAC systems, domestic hot water, building management system, lighting, backup generators, compressed air systems, sterilization system, plug loads, laundry, food preparation, refrigeration, and process loads.
- A review of building plans, operations and maintenance logs, and other documentation.

2.1 Site Description

[redacted] Hospital, [redacted], is a multi-building campus, with various additions and renovations. It is the only full-service acute care hospital in [redacted]

Figure 2. [redacted] Hospital (Google Maps)

[redacted]

Table 3. [redacted] Hospital Information

Type of Information	Facility Details
Facility name	[redacted] Hospital
Location	[redacted]
Building type	Hospital
Applicable codes	California Building Code, Office of Statewide Health Planning and Development (OSHPD)
Square footage	270,074 ft^2
Number of beds	235
Originally completed	1952
Hours of operation	24 hours per day, seven days per week, 365 days per year (24/7/365)
California climate zone	02
Equivalent full-load hours	2,185 hours for heating and 346 hours for cooling at 65°F base
ASHRAE design conditions	32.5°F heating DB 99%, 86.5°F cooling DB 1%, and 65.3°F cooling MCWB 1%

The 235 bed facility was established in 1952 and is owned by [redacted]. The facility is the only source for important services and programs, such as a designated trauma center, labor and deliver services, full-service cancer care, comprehensive heart and vascular care, accredited chest pain center, inpatient pediatrics, spine and brain institute, certified primary stroke center, and acute inpatient psychiatric services.

The facility has four main buildings. The original hospital buildings are buildings 2 and 3, the central and east wings respectively. Building 2, the central wing, was built in the 1950s. Building 1, the west wing, is the newest building in the complex and was built in 1986. There are also small temporary buildings in the outlying areas. The Information Systems department and data center are located in a small portable building in the north parking lot.

With the exception of Building 4, the behavioral health building, the hospital operates and is occupied 24 hours per day, seven days per week, 365 days per year (24/7/365). Building 4 operates during regular weekday business hours.

Table 4. [redacted] Hospital List of Buildings

Building #	Building Name	Year Built	Floors
1	West Wing	1986	5
2	Central Wing	1950s	5
3	East Wing	1960s	5
4	Behavioral Health	1960s	2

As at many hospitals, departments move to different areas of the facility over time. The facility's emergency room is now located in building 1, along with the main operating rooms. Building 1, the west wing, also houses the trauma center, orthography, pharmacy, intensive care (ICU), and critical care (CCU). Building 2, the central wing, currently houses the kitchen, cafeteria, conference rooms, laboratory, radiology, scheduled surgery, intensive care nursery (ICN), and sterile supply. Building 3, the east wing, currently houses the administration department, patient rooms, central supply, surgery recovery rooms, and procedure rooms. Building 4, the behavioral health building, is a mixed occupancy building with the [redacted] Crisis Unit, behavioral health, medical library, and records.

Figure 3. [redacted] Hospital Site Map

[redacted]

2.2 Envelope

Building 1: West Wing

Building 1, the west wing, is a five-story steel and cement block structure with a basement. The roof is constructed with a lightweight insulating concrete roof deck. The windows consist of insulated dual-paned low-emissivity glass. The building has a triangle footprint with two of its corners pointing north and south, with corner exposures constructed completely out of glass. A majority of the windows have louvered vertical sun shades. These shades protect the glass from direct sunlight during summer but allow for some heat gain from the sun's rays during winter.

Figure 4. Building 1, the West Wing

Building 2: Central Wing

Building 2, the central wing, is a five-story steel and cement block structure. The roof is constructed with a lightweight insulating concrete roof deck. The windows have uncoated single-pane glass. The south-facing windows have awnings (overhangs) that extend along the length of the building.

Building 3: East Wing

Building 3, the east wing, is a five-story steel and cement block structure. The roof is constructed with a lightweight insulating concrete roof deck. The windows have uncoated single-pane glass. The east- and south-facing windows have awnings (overhangs) that extend along the length of the building. Awnings help to provide shade from the midday sun.

Figure 5. Building 2, the Central Wing (Left), Building 3, the East Wing (Right)

Building 4: Behavioral Health

Building 4, the behavioral health building, is a two-story steel and cement block structure. The roof is constructed with a lightweight insulating concrete roof deck. The windows have uncoated single-pane glass. Each window is recessed into the exterior wall, providing shade and preventing direct sunlight into the space during all daylight hours.

Figure 6. Building 4, the Behavioral Health Building

2.3 Primary HVAC Systems

2.3.1 Cooling

Cooling for all buildings is provided by three central chilled water systems that supply approximately 44°F chilled water to all areas and air handlers. One system serves building 1, the west wing; the second system serves buildings 2 and 3, the central and east wings; and the third system serves building 4, the behavioral health building. Each loop has its own independent set of chillers, cooling towers, and chilled water distribution pumps. Although the facility is equipped with a central Alerton building management system (BMS), it is only connected to the air handlers for building 1 and part of the chilled water systems for buildings 2 and 3.

Building 1 Chilled Water System

In building 1, the west wing, the chilled water system is located in the basement. The system is served by two Trane 200 ton centrifugal chillers, two Baltimore Aircoil 15 hp cross-flow cooling towers, two 7.5 hp condenser water pumps, two 5 hp primary chilled water pumps, and two 10 hp secondary chilled water pumps. The cooling towers are located on the roof of the building, and condenser water pumps located in the basement circulate condenser water from the chillers to the cooling towers and back.

The chillers are configured in a primary/secondary distribution system that distributes chilled water to air handlers and fan coils on demand to cool the spaces in the building. Primary/secondary systems are historically designed and installed to allow for constant water flow through chillers in the primary circuit and variable secondary flow to and from the air handlers and chilled water coils. Based on this fact, it appears that the secondary chilled water loop for building 1 may have been originally intended as variable flow.

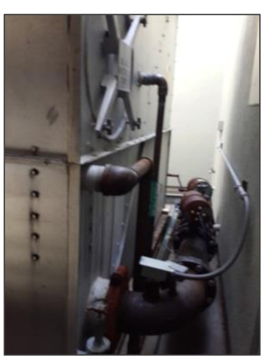
Inspection of the HVAC systems, however, indicates that most or all of the chilled-water coil control valves in building 1 are three-way, indicating that flow through the secondary loop is, in fact, constant volume. Further, it was confirmed that none of the secondary chilled water pump motors in the central plant are equipped with variable speed drives. The pump motors operate at constant speed. It seems unusual, but the chilled water system for building 1 appears to be primary constant volume/secondary constant volume in its current operation.

The chillers are relatively old, dating from 1986, and have an outdated analog control panel with limited control capabilities common in more modern units. Chilled water and condenser water pumps as well as cooling tower fans are staged on and off via the chiller control panel(s). The chilled water system for building 1 is not currently connected to the Alerton BMS, further limiting monitoring and control capabilities.

Figure 7. Building 1 Chiller (Left), Chiller Control Panel (Right)

Figure 8. Building 1 Pumps (Left), Chilled Water Pump Nameplate (Right)

Figure 9. Building 1 Cooling Tower



Building 2 and 3 Chilled Water System

Building 2 and 3, the central and east wings, share a common chilled water system, with all major components located on the roof of buildings 2 and 3. The system includes two Carrier AquaSnap 100 ton packaged air-cooled scroll chillers and one Dunham-Bush 100 ton packaged water-cooled chiller. In the current operation, cooling loads are served primarily by the Carrier chillers, with the Dunham-Bush chiller acting as a backup unit.

Figure 10. Building 3 Roof: Dunham-Bush Chiller (Left), Carrier AquaSnap Chillers (Right)

The chilled water system for buildings 2 and 3 is configured in a primary-only constant volume configuration. The Dunham-Bush and Carrier chillers use two different sets of primary distribution pumps all configured in parallel, with one set dedicated to the Dunham-Bush chiller and one set dedicated to the two Carrier chillers. The two sets of chillers and pumps can be isolated via manual isolation valves located on the roof. The Dunham-Bush chiller can be isolated from the loop to independently serve the fourth floor or, in an emergency scenario, redirected to serve the all of buildings 2 and 3 should either of the Carrier chillers fail. During wintertime, the Dunham-Bush chiller is taken off line and the Carrier chillers provide for the cooling needs of the building.

Figure 11. Dunham-Bush Chiller With Cooling Tower (Left), Dunham-Bush's Pumps (Right)

The chilled-water system for buildings 2 and 3 is primarily served by a pair of constant speed 7.5 hp pumps on the roof between the Carrier and Dunham-Bush chillers. These pumps operate continuously.

The Dunham-Bush chiller is relatively old, has limited operating hours, and limited analog control capability. The Dunham-Bush chiller is not currently connected to the BMS. The two Carrier chillers, however, are of much more recent construction and are digitally controlled through the BMS.

Figure 12. Dunham-Bush Pumps (Left), Pump Nameplate (Right)

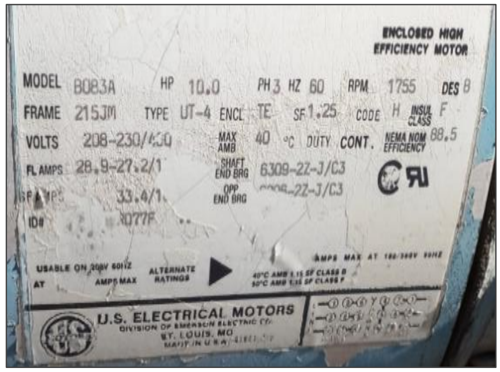
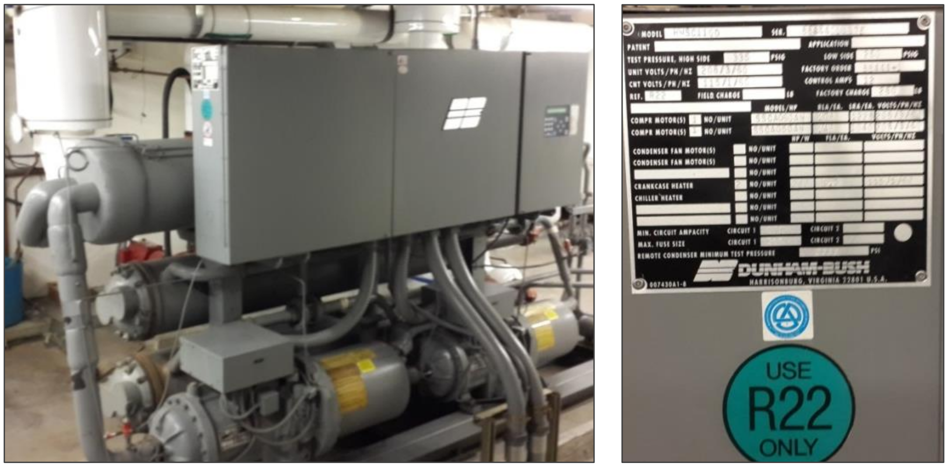


Figure 13. Primary Chilled Water Pumps for Buildings 2 and 3 (Left), Pump Nameplate (Right)

Building 4 Chilled Water System

Building 4, the behavioral health building, also has its own separate chilled water system, located on the building's lower level (first floor). The chilled water is supplied by a Dunham-Bush 100 ton water-cooled rotary screw chiller. The chilled-water system is configured in a primary only constant volume configuration and is equipped with two redundant 10 hp primary pumps. Condenser water is circulated from the chillers to a counter-flow Baltimore Aircoil cooling tower located on the roof by two redundant 10 hp condenser water pumps. The chiller is equipped with its own panel control and is not currently connected to the BMS.

Figure 14. Building 4 Chiller (Left), Chiller Nameplate (Right)



The chiller is connected to a single Baltimore Aircoil cooling tower on the roof. The tower has a 10 hp single-speed fan.

Figure 15. Building 4 Cooling Tower (Left), Cooling Tower Nameplate (Right)

Figure 16. Building 4 Condenser Water and Chilled Water Pumps

Table 5. Chiller Equipment

Tag	Manufacturer	Model #	Capacity (tons)	Equipment Location	Description
CH-1	Trane CenTraVac	CVHE-025F-AP	200	West Wing Basement	Water-Cooled Centrifugal Chiller
CH-2	Trane CenTraVac	CVHE-025F-AP	200	West Wing Basement	Water-Cooled Centrifugal Chiller
AQ-1	Carrier	30RBA10054	100	East Wing Roof	Packaged Air-Cooled Scroll Chiller
AQ-2	Carrier	30RBA10054	100	East Wing Roof	Packaged Air-Cooled Scroll Chiller
DBC #1	Dunham-Bush	EXT18122J	100	East Wing Roof	Packaged Water-Cooled Chiller
CH-4	Dunham-Bush	HWSC110D	100	Behavioral Health	Water-Cooled Rotary Screw Chiller

Table 6. Cooling Tower Equipment

Tag	Manufacturer	Model #	Fan Motor Power (hp)	Fan Drive Type	Type
CT-1 (Bldg 1)	BAC	VXT-N265-C	15	Two-speed	Horizontal
CT-2 (Bldg 1)	BAC	VXT-N265-C	15	Two-speed	Horizontal
CT-3 (Bldg 3)	BAC	VCL-234-LMP	15	Two-speed	Evaporative Condenser (Packaged with DBC #1)
CT-4 (Bldg 4)	BAC	VTO-107-KM	10	Single speed	Horizontal

Table 7. Primary HVAC Cooling System Pumps

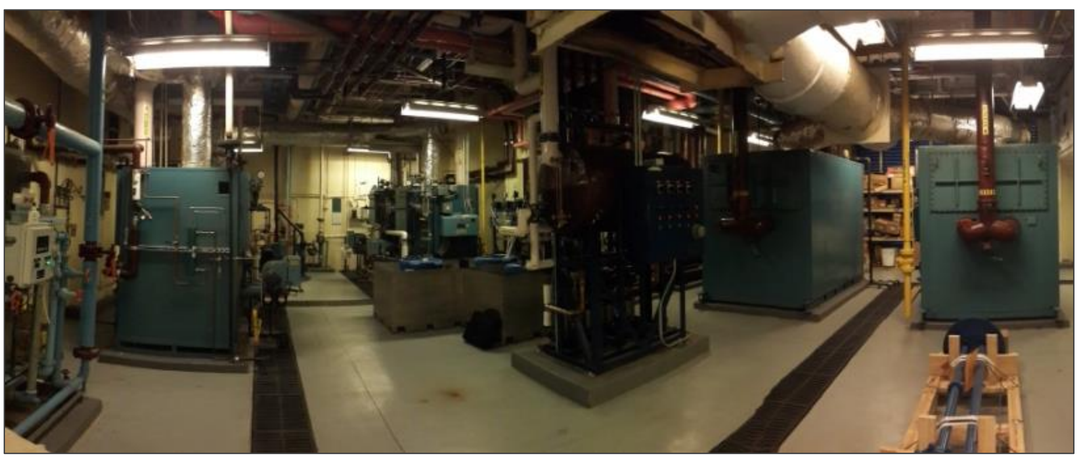
Tag	System Served	Motor Power (hp)	Capacity (gpm)	Head (feet)	VSD (Yes/No)
PCHP-1	Bldg 1 Primary Chilled Water Loop	5	457	25	N
PCHP-2	Bldg 1 Primary Chilled Water Loop	5	457	25	N
SCHP-1	Bldg 1 Secondary Chilled Water Loop	10	915	30	N
SCHP-2	Bldg 1 Secondary Chilled Water Loop	10	915	30	N
CWP-1	Bldg 1 Condenser Water Loop	7.5	572	35	N
CWP-2	Bldg 1 Condenser Water Loop	7.5	572	35	N
CHWP 1	Bldg 3 Chilled Water Loop (Carrier)	7.5	175	60	N
CHWP 2	Bldg 3 Chilled Water Loop (Carrier)	7.5	175	60	N
CHWP #1	Bldg 3 Chilled Water Loop (Dunham-Bush)	10	300	75	N

Tag	System Served	Motor Power (hp)	Capacity (gpm)	Head (feet)	VSD (Yes/No)
CHWP #2	Bldg 3 Chilled Water Loop (Dunham-Bush)	10	300	75	N
CWP #1	Bldg 4 Condenser Water Loop	10	300	75	N
CWP #2	Bldg 4 Condenser Water Loop	10	300	75	N
CHWP#1	Bldg 4 Chilled Water Loop	10	230	50	N
CHWP#2	Bldg 4 Chilled Water Loop	10	230	50	N

2.3.2 Heating

The heating systems are separate, independent systems serving areas similar to the three chilled water systems described above. Each building has a unique combination of steam and heating hot water systems to provide heating for spaces, domestic water, and sterilization. For example, buildings 1, 2, and 3 have their own high pressure steam systems; however, only buildings 2 and 3 have a low pressure steam system. Building 4 uses heating hot water produced by hot water boilers directly, instead of steam boilers, for space heating. Only parts of the heating systems in the facility are connected to the Alerton BMS.

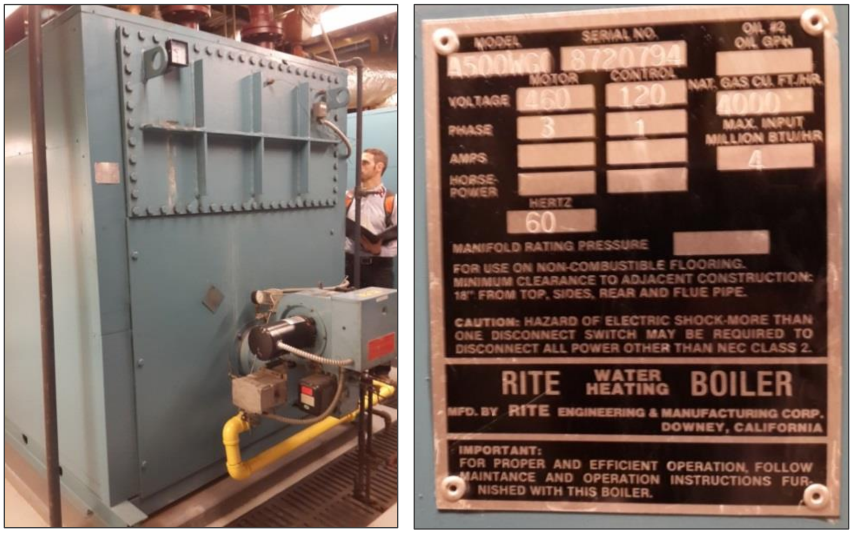
Figure 17. Building 1 Boiler Room: High Pressure Steam Boilers (Left), Heating Hot Water Boilers (Right)



Building 1 Heating System

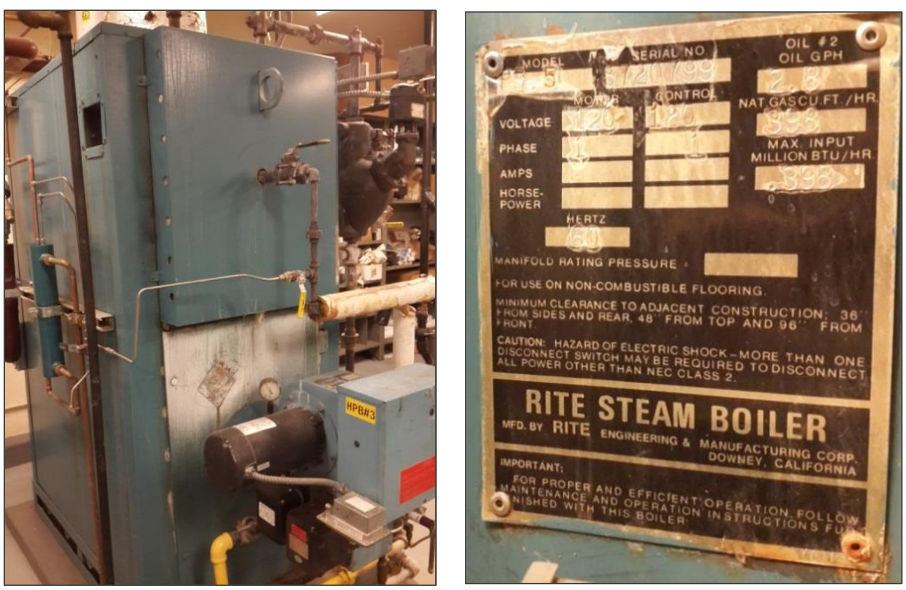
In building 1, the west wing, two Rite 4,000 MBH heating hot water boilers serve the air handlers. During the audit, a constant 180°F supply temperature was observed. The heating hot water is pumped through a primary only constant volume distribution system with two 2 hp 200 gpm pumps. These pumps operate continuously.

Figure 18. Building 1 Heating Hot Water Boilers (Left), Boiler Nameplate (Left)



Also in building 1, four Rite 398 MBH output high pressure steam boilers serve the hospital sterilizers in the Sterile Processing Department (SPD) and humidifiers in the air handlers.

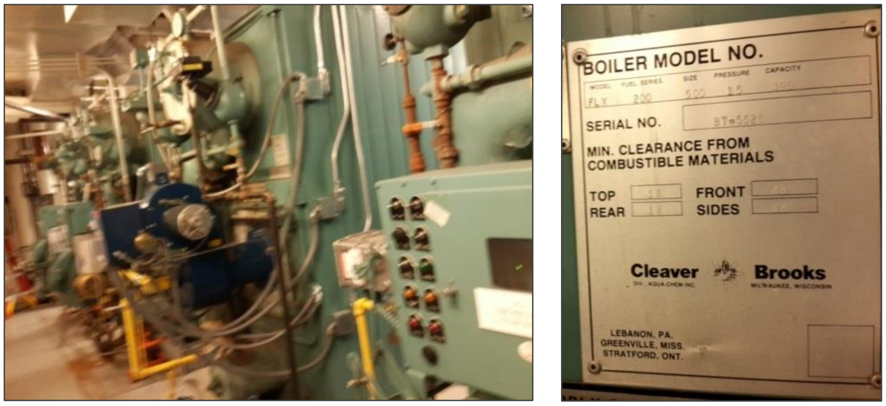
Figure 19. Building 1 High Pressure Steam Boiler (Left), Boiler Namplate (Right)



Building 2 and 3 Heating System

For building 2, the central wing, four Cleaver-Brooks 2,000 MBH low pressure steam boilers provide steam directly to the baseboard heaters and air handler heating coils. Steam condensate from the low pressure steam system is collected in steam traps located around building 2 and forced under pressure back to the central condensate collection system. Several steam trap leaks were noticed and discussed during the audit.

Figure 20. Cleaver-Brooks Low Pressure Steam Boilers (Left), Boiler Nameplate (Right)

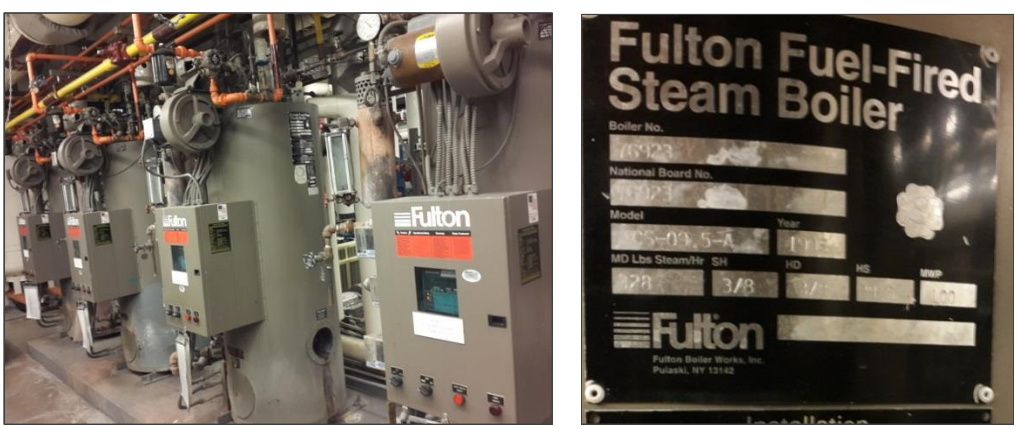


For building 3, the low pressure steam system directly serves the steam radiators, and a heat exchanger provides heating hot water to the heating hot water radiators. Heating hot water is currently supplied at a constant 180°F to building 3 by two redundant 5 hp constant speed pumps.

Figure 21. Low Pressure Steam Heat Exchangers

Buildings 2 and 3 are also served by four Fulton 398 MBH high pressure steam boilers for sterilization and to provide domestic hot water to the kitchen via a heat exchanger.

Figure 22. Building 2 and 3 High Pressure Steam Boilers (Left), Boiler Nameplate (Right)



It should be noted that during the audit of the boiler room for buildings 2 and 3, temperatures inside the boiler room were observed to be very high, sometimes exceeding 125°F. The high temperatures indicate insufficient ventilation.

Building 4 Heating System

Building 4 is served by two Parker 490 MBH hot water boilers that provide 180°F heating hot hater in a primary only constant volume distribution system. The heating hot water is circulated throughout the building by two redundant 5 hp constant speed pumps.

Figure 23. Building 4 Hot Water Boiler (Left), Boiler Nameplate (Right)

Table 8. Hot Water Boilers

Tag	Manufacturer	Area Served	Model #	Thermal Efficiency	Maximum Input Capacity (MBH)
B-1	Rite	Building 1	A500WGO	80%	4,000
B-2	Rite	Building 1	A500WGO	80%	4,000
HPB#1	Rite	Building 1	P9.5	80%	398
HPB#2	Rite	Building 1	P9.5	80%	398
HPB#3	Rite	Building 1	P9.5	80%	398
HPB#4	Rite	Building 1	P9.5	80%	398
HPB-1	Fulton	Building 2	ICS-0.95-A	80%	398
HPB-2	Fulton	Building 2	ICS-0.95-A	80%	398
HPB-3	Fulton	Building 2	ICS-0.95-A	80%	398
HPB-4	Fulton	Building 2	ICS-0.95-A	80%	398
LPB-1	Cleaver-Brooks	Building 2	FLX-200	80%	2,000
LPB-2	Cleaver-Brooks	Building 2	FLX-200	80%	2,000
LPB-3	Cleaver-Brooks	Building 2	FLX-200	80%	2,000
LPB-4	Cleaver-Brooks	Building 2	FLX-200	80%	2,000
B1	Parker Boiler	Building 4	T1458	80%	490
B2	Parker Boiler	Building 4	T1458	80%	490

Table 9. Primary HVAC Heating System Pumps

Tag	System Served	Motor Power (hp)	Capacity (gpm)	Head (feet)	VSD (Yes/No)
HWP#1	Bldg 1 Hot Water Loop	2	200	20	N
HWP #2	Bldg 1 Hot Water Loop	2	200	20	N
P5	Bldg 4 Hot Water Loop	5	110	65	N
P6	Bldg 4 Hot Water Loop	5	110	65	N
P8	Bldg 4 Hot Water Loop	1.5	–	–	N

2.4 Secondary HVAC Systems

Building 1 Air Handlers

In building 1, the west wing, air handling units are served by 100 percent outside air (OSA) constant-air-volume (CAV) systems with chilled water cooling coils. The zone terminal units have hot water reheat with humidifiers. Most zone level heating coils have 2-way hot-water flow control valves, with exception of the third floor which has 3-way valves. Each air handling unit serves a separate floor, with the exception of the first floor.

The first floor houses the emergency department, main lobby, and shops. Air handler AHU-4 serves the main surgery center and has the added capability of HEPA filtration with ultra-violet (UV) sterilization using 300 W UV lamps to minimize the risk of biological growth on surfaces and contact with the incoming air. Air handler AHU-5 serves the emergency rooms, including operating rooms. AHU-5 operates all hours to maintain a 65°F space temperature set point for the emergency room (ER) trauma rooms. Air handler AHU-6 serves the shops and main lobby.

Figure 24. AHU-4 Filter Panel (Left), UV Panels (Right)

Building 2 and 3 Air Handlers

In buildings 2 and 3, the central and east wings, the air systems are the most complex of the facility. All air handlers are 100% outside air; however, the air handlers are a mix of constant-volume dual-duct and packaged constant-volume air handlers. For the packaged air handlers, zone-level heating is provided by a mix of terminal reheat boxes and baseboard heating systems. In addition to spaces served by air handlers, certain spaces are served by unitary fan coils, without outside air. The fan coils are two-pipe units with cooling capability only, with heating provided by baseboard heating.

Buildings 2 and 3 house a scheduled surgery area that operates from 8 a.m. to 5 p.m., Monday to Friday. The space temperature set point for operating rooms is typically 65°F. This temperature is maintained at all times in the surgery suites, during occupied and unoccupied hours.

Buildings 2 and 3 also house the kitchen and cafeteria. Air handler S-15 serves the kitchen and maintains a fixed space temperature set point of 70°F during occupied and unoccupied hours. Also, the kitchen hood in the kitchen runs continuously.

Figure 25. Kitchen Air Handler (Left), Kitchen Ventilation Hood (Right)

The most notable characteristic of buildings 2 and 3 is the configuration of the patient rooms around the perimeter of the building. Each room has baseboard heating. In building 2, baseboard units are supplied with steam. In building 3, baseboard units are supplied with heating hot water. The heating control is performed manually, without a thermostat, by a hand valve at the bottom at each baseboard unit. Cooling is provided by a chilled water coil located within the room fan coil unit that recirculates room air. Cooling is controlled by a mercury-switch-style dial thermostat located by the door of each room. The heating and cooling controls are independent of each other. This creates a situation where heating and cooling are being provided to the space at the same time, wasting energy. Also, the configuration of the fan coil fan indicates that the fan runs continuously, whether or not room temperature is satisfied.

Figure 26. Standard Baseboard Heater (Left), Dial Thermostat (Right)

Building 4 Air Handlers

Building 4, the behavioral health building, is served by four 100 percent outside air constant-volume systems with heating and cooling capability. Both heating and cooling coils have 3-way fluid flow control. In addition to the system-level heating capability of the air handlers, all of the building 4 spaces also have baseboard heating at the zone level. Zone level heating control appears to be independent of the air systems using analog thermostats. As in buildings 2 and 3, zone heating and cooling controls are independent of each other. This creates a situation where heating and cooling are being provided to the space at the same time, wasting energy.

Figure 27. Building 4 Air Handler

Figure 28. Building 1 Baseboard Unit (Left), Thermostat (Right)

Table 10. Air Handlers

Tag	System Type	Equipment Location	Area Served	100% OSA? (Yes/No)	VSD (Yes/No)
AHU-1	Constant Volume w/ Humidifier & Reheat	Bldg 1 5th Floor Mech Room	Bldg 1 Level 2	Y	N
AHU-2	Constant Volume w/ Reheat	Bldg 1 5th Floor Mech Room	Bldg 1 Level 3	Y	N
AHU-3	Constant Volume w/ Reheat	Bldg 1 5th Floor Mech Room	Bldg 1 Level 4	Y	N
AHU-4	Constant Volume w/ Humidifier & Reheat	Bldg 1 Level L Mech Room	Bldg 1 Level 1	Y	N
AHU-5	Constant Volume w/ Reheat	Bldg 1 Level L Mech Room	Bldg 1 Level L	Y	N
AHU-6	Constant Volume w/ Reheat	Bldg 1 Level L Mech Room	Bldg 1 Level L	Y	N
AHU-7	Constant Volume w/ Reheat	Bldg 1 Level L Mech Room	Bldg 1	Y	N
AHU-8	Constant Volume w/ Reheat	Bldg 1 Basement	Bldg 1 Basement	Y	N
AHU-10	Constant Volume w/ Reheat	Bldg 1 ED Lobby	Bldg 1 ED Lobby	N	N
ACU-1	Constant Volume w/ Cooling Coils Only	Bldg 1 Elevator Machine Room	Bldg 1 Elevator Machine Room	Y	N

Tag	System Type	Equipment Location	Area Served	100% OSA? (Yes/No)	VSD (Yes/No)
S-1	Constant Volume w/ Heating Coils	Bldg 2 Mech Room	Bldg 2	Y	N
S-2	Dual Duct w/ Humidifier	Bldg 2 Mech Room	Bldg 2 Operating Rooms	Y	N
S-3	Dual Duct w/ Humidifier & Baseboards	Bldg 2 Penthouse	Bldg 2 5th Floor	Y	N
S-10	Packaged Constant Volume w/ Cooling Coils, Reheat & Baseboards	Bldg 2 3rd Floor Rooftop	Bldg 2 3rd Floor EP Lab	Y	N
S-11	Constant Volume w/ Heating Coils	Bldg 3 Rooftop	Bldg 3 2nd–5th Floors	Y	N
S-12	Constant Volume w/ Cooling Coils, Reheat & Baseboards	Bldg 2 Rooftop	Bldg 2 2nd Floor Lab, 3rd and 4th Floor	Y	N
S-13	Constant Volume w/ Reheat & Baseboards	Bldg 3 Mech Room	Bldg 3 3rd and 4th Floor	Y	N
S-14	Constant Volume w/ Reheat & Baseboards	Bldg 3 Mech Room	Bldg 3 1st Floor	Y	N
S-15	Packaged Constant Volume w/ Reheat	Outside Bldg 2 Dining Area	Bldg 2 Kitchen and Dining Area	Y	N
S-17	Packaged Constant Volume w/ Cooling & Heating Coils	Bldg 2 2nd Floor Rooftop	Bldg 2 2nd Floor Lab Offices	Y	N
S-18	Packaged Constant Volume w/ Cooling & Heating Coils	Bldg 2 Rooftop	Bldg 2 2nd Floor Radiology	Y	N
S-19	Packaged Constant Volume w/ Cooling & Heating Coils	Bldg 2 2nd Floor Rooftop	Bldg 2 2nd Floor Radiology	Y	N
S-20	Dual Duct	Bldg 3 Rooftop	Bldg 2 4th and 5th Floor	Y	N
S-21	Variable Air Volume w/ Cooling & Heating Coils	Bldg 3 Rooftop	Bldg 3 5th Floor	Y	Y
S-25	Packaged Constant Volume w/ Cooling & Heating Coils	Outside Bldg 3 Office Area	Bldg 3 2nd Floor Office Area	Y	N
OAF-1	Constant Volume Supply Fan	Bldg 2 4th Floor	Bldg 2 4th Floor Bedrooms	Y	N
UV-1	Unit Ventilator	Bldg 2 1st Floor	Bldg 2 1st Floor Machine Shop Area	Y	N
B4 S-1	Constant Volume w/ Reheat	Bldg 4 North Penthouse	Bldg 4 North Wing	Y	N
B4 S-2	Constant Volume w/ Reheat	Bldg 4 East Penthouse	Bldg 4 East Wing	Y	N
B4 S-3	Constant Volume w/ Reheat	Bldg 4 Upper Fan Room	Bldg 4 Central Air	Y	N
B4 S-6	Constant Volume w/ Reheat	Bldg 4 Lower Fan Room	Bldg 4 Lower Level	Y	N

2.5 Domestic Hot Water Systems

In building 1, a heat exchanger is connected to the heating hot water loop and used to heat domestic hot water. The domestic hot water supply temperature was observed to be 135°F at the heat exchanger during the audit.

In buildings 2 and 3, for the kitchen, high pressure steam is used to heat domestic hot water using a steam heat exchanger. Low pressure steam is also used to heat domestic hot water using a steam heat exchanger. Domestic hot water is currently supplied at 120°F.

In building 4, domestic hot water is heated by two Parker 550 MBH hot water heaters that supply 115°F water. The Parker hot water heaters use atmospheric burners with limited turndown capability. Domestic hot water is pushed through the boilers under City water pressure, but recirculated using a dedicated 0.5 hp pump.

The variation of the supplied domestic hot water temperatures throughout the campus is cause for further investigation. Domestic hot water should be stored at a minimum of 140°F to prevent legionella; however, the water delivered at the faucet should be at a maximum of 120°F to prevent scalding. Willdan did not discuss the difference in temperatures with the customer, but the differences in building use types may explain the different temperatures.

Figure 29. Building 1 Heat Exchanger for Domestic Hot Water (Left), Building 4 Boiler for Domestic Hot Water (Center), Boiler Nameplate (Right)

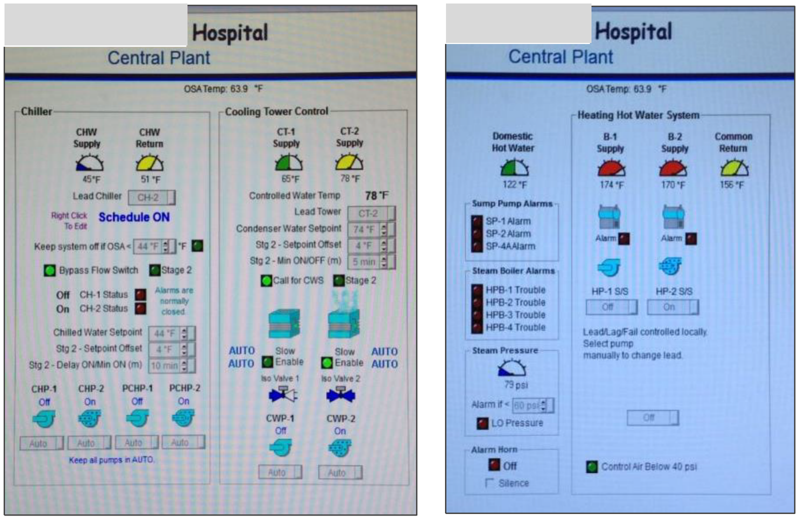
Table 11. Building 4 Domestic Hot Water Boiler Equipment

Tag	Area Served	Manufacturer	Model #	Maximum Input Capacity (MBH)	Thermal Efficiency
B3	Bldg. 4	Parker Boiler	WH490L	550	80%
B4	Bldg. 4	Parker Boiler	IH-490	550	80%

2.6 Building Management System

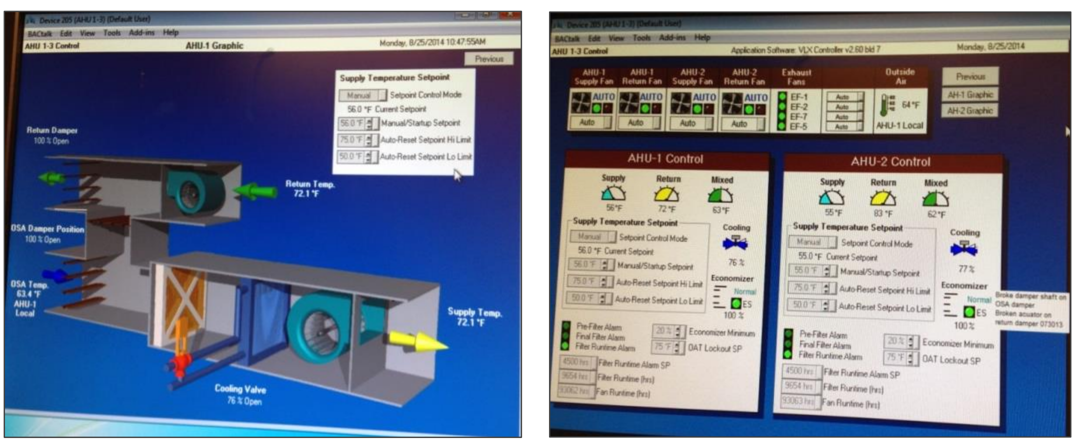
The building management system (BMS) is an Alerton System provided by Syserco. The BMS does not extend to the entire facility. It is mostly limited to the air and water systems for building 1 and the Carrier chillers for buildings 2 and 3. No other supervisory control, monitoring, or data collection is performed for the remainder of the facility's central plant and air handler systems. The Alerton BMS is functional, effective, and expandable.

Figure 30. Building 1 (West Wing) Central Plant Screen Captures



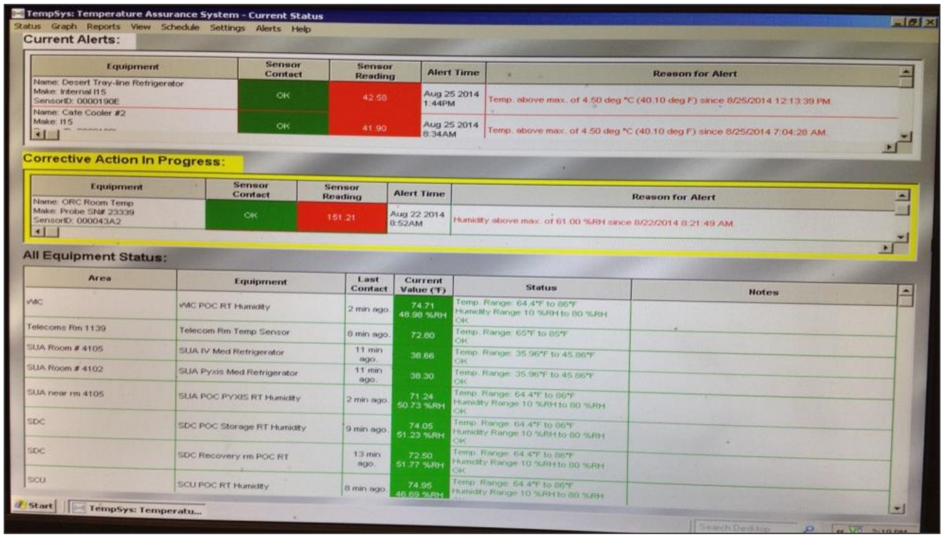
The BMS performs basic monitoring, temperature limits, and set point control. In the case of the building 1 chillers and cooling towers, equipment staging can be enabled. The system does not have any advance reset function currently programmed.

Figure 31. Typical Building 1 Air Handler Screen Capture (Left) and Detail Screen (Right)



The facility also has a TempSys wireless temperature monitoring system installed that is independent of the BMS. A limited number of key temperature and humidity sensors report to a frontend that warns facility personnel when a temperature sensor has fallen out of a preset range. The hospital uses this system to monitor refrigerators, room temperatures, and humidity.

Figure 32. Temperature Monitoring System Screen Capture



2.7 Lighting

Interior

Interior lighting consists primarily of recessed linear fluorescent fixtures featuring F32T8 and F17T8 lamps with electronic ballasts. Willdan also observed high intensity discharge fixtures in the central plant building, mechanical rooms, and storage rooms. There are no advanced occupancy controls for lighting; most lighting controls are manual via light switch.

Figure 33. Medical Records Office

Figure 34. Kitchen Lighting (Left), Typical Hallway Lighting (Right)

Exterior

Building exterior lighting consists of wall pack fixtures featuring 70 W HPS lamps and ballasts. Lights are controlled via time clock, according to facility staff.

The parking area was inspected around the medical office building at . The lower floor of the parking structure is illuminated by 61 ceiling-mounted first-generation 700 series T8 linear fluorescent fixtures. The top level of the parking structure is illuminated by 5 pole-mounted 175 watt (W) metal halide fixtures. The surrounding parking lot is illuminated by 8 pole-mounted 150 W high pressure sodium (HPS) lamps and ballasts.

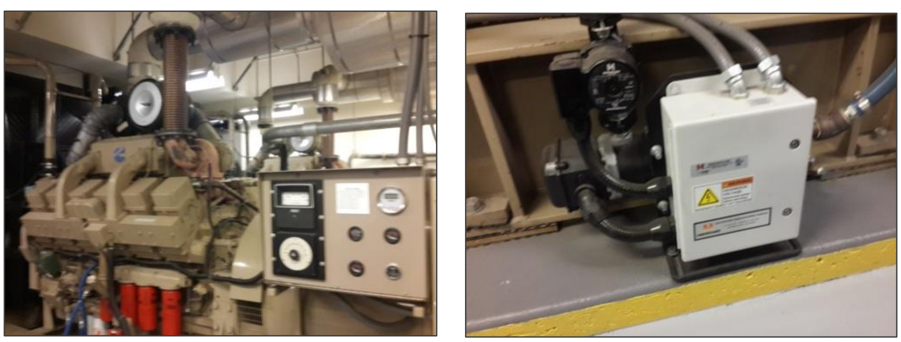
Figure 35. Parking Area

2.8 Miscellaneous Equipment

Backup Generators

The facility includes two 1,800 kW backup generators with 9,000 W electric resistance block heaters. Block heaters, also known as water jacket heaters or engine preheaters, are essential for the instant-on use of diesel-fueled emergency generators. To meet the 10 second start window specified in National Fire Protection Association (NFPA) Standard 110, generators require an engine temperature maintained between 100°F and 120°F.

Figure 36. Backup Generator (Left), Block Heater (Right)



3. Historical Energy Usage

PG&E delivers the facility's electric utility service under the A10S and E20S rate schedules (Service Account IDs [redacted]) and delivers natural gas utility service under the GNR1 rate schedule (Service Accounts ID [redacted]). The facility's Energy Insight account number is [redacted]. Willdan obtained monthly usage data for a five year period, 2009 through 2013. The usage data is presented in the table and figures in this section.

Table 12. Historical Electric and Natural Gas Usage and Cost

Month	Electric Energy Usage (kWh)	Electric Demand (kW)	Total Electric Cost	Natural Gas Usage (therms)	Natural Gas Cost
January 2013	736,608	1,196	$90,599	65,612	$48,873
February 2013	709,966	1,316	$87,837	55,868	$40,950
March 2013	704,700	1,267	$86,666	46,316	$36,021
April 2013	797,369	1,435	$98,031	43,076	$32,106
May 2013	774,579	1,475	$103,178	35,746	$26,391
June 2013	804,933	1,434	$108,348	33,648	$24,957
July 2013	899,574	1,529	$119,834	33,226	$24,612
August 2013	822,442	1,612	$113,256	30,706	$22,876
September 2013	878,104	1,564	$118,158	30,600	$22,753
October 2013	837,522	1,435	$111,297	37,767	$27,788
November 2013	765,395	1,668	$100,478	44,609	$33,995
December 2013	722,067	1,301	$90,523	60,158	$46,180
Total	**9,453,259**		**$1,228,205**	**517,332**	**$387,502**

The facility's average electric blended cost-of-service rate (electric costs divided by electric usage) is $0.130 per kilowatt-hour. The natural gas utility data provided was limited to PG&E transmission and service costs, but the commodity component of the charge is paid to a third party provider. Current net natural gas costs are approximately $0.75 per therm. This rate was applied to natural gas usage to calculate the approximate cost of natural gas.

Figure 37. Electric Energy Usage and Total Electric Cost

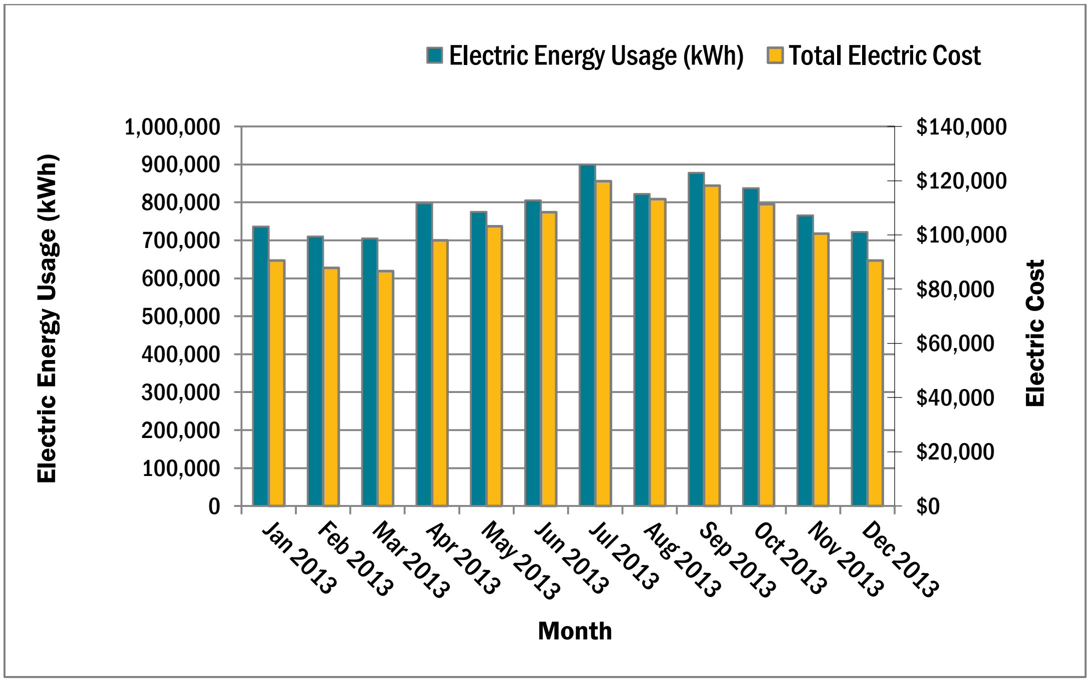


Figure 38. Electric Demand

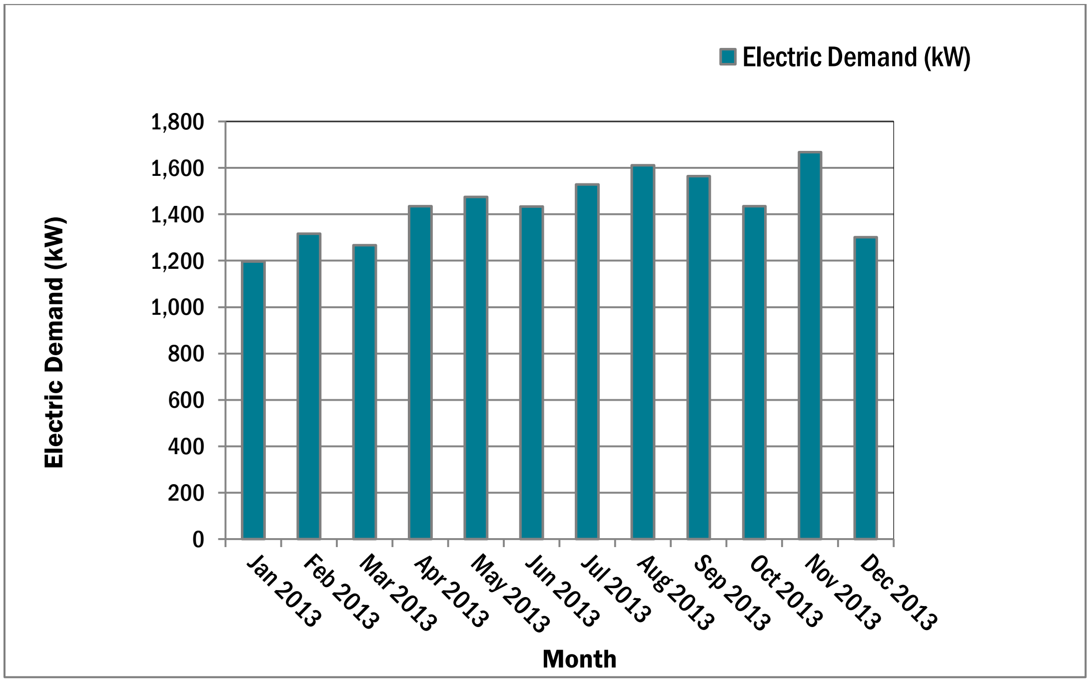
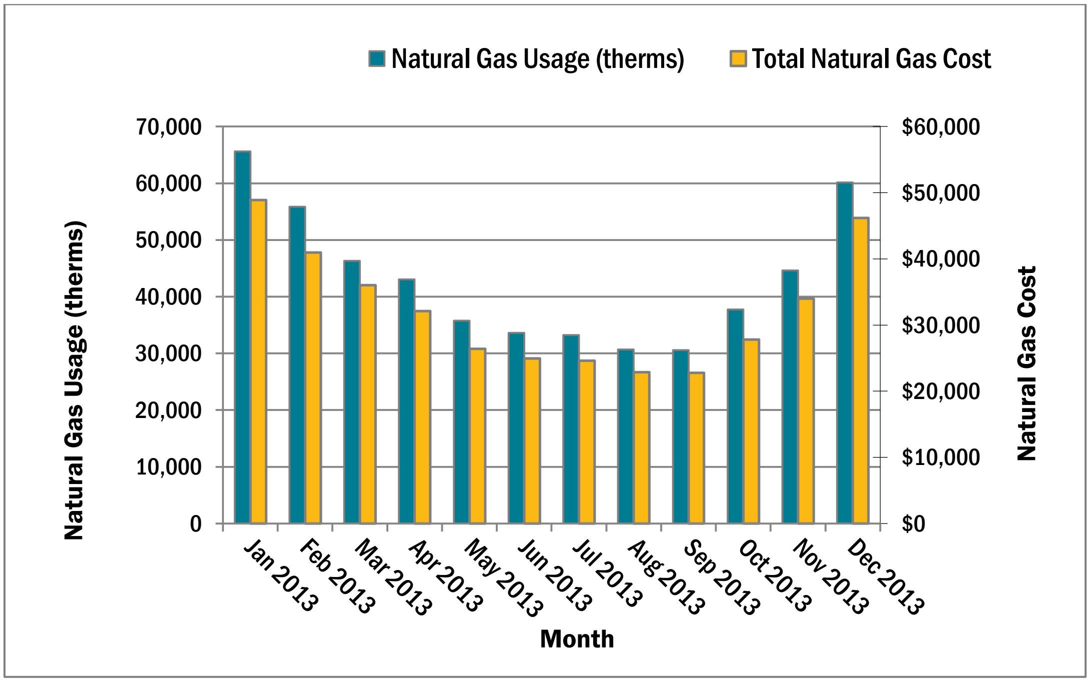


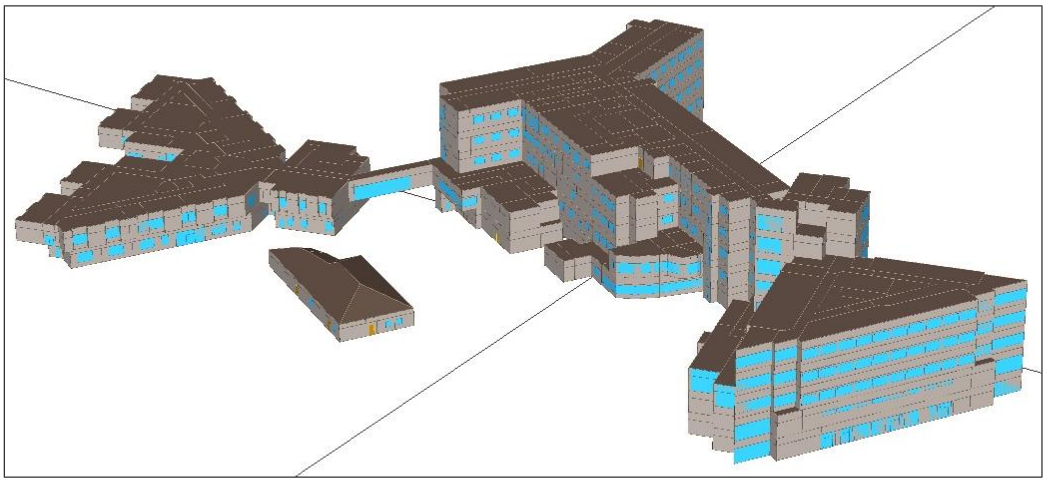
Figure 39. Natural Gas Usage and Cost



4. Whole-Building Energy Simulation

A building energy model was used to analyze energy usage and calculate the savings of the recommended energy efficiency measures. Willdan used eQUEST to create the building energy model (see figure 40). Funded by the U.S. Department of Energy, eQUEST is a sophisticated tool that allows detailed comparative analysis of building designs and technologies by simulating energy usage.

Figure 40. eQUEST Building Energy Model



4.1 Calibrated Simulation Approach

Calibration of a building energy model is the process of making consecutive changes to the inputs and parameters of a model with a goal of matching the actual operating conditions. The simulation results are compared to the annual and monthly energy usage, normalized from the utility billing data. A successfully calibrated model gives confidence in the energy savings simulated for the recommended energy efficiency measures.

A model is considered calibrated when acceptable calibration tolerances have been met. Guidelines for acceptable tolerances are provided in *Guideline 14-2002: Measurement of Energy and Demand Savings* from the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), in the *International Performance Measurement and Verification Protocol* (IPMVP), and in *M&V Guidelines: Measurement and Verification for Federal Energy Projects* from the Federal Energy Management Program (FEMP). The calibration goal is expressed as a Coefficient of Variation of the Root Mean Squared Error, CV(RMSE). Based on these guidelines, Willdan's calibration goals are shown in the table below.

Table 13. Calibration Goals Used by Willdan for Whole-Building Energy Simulation

Measure of Accuracy	Tolerance
Annual Error	±10 percent
Maximum Monthly Error	±20 percent
CV(RMSE)	10 percent

Note: CV(RMSE) is the coefficient of variation of the root mean squared error.

Willdan's energy model calibration process includes the following steps:

- Normalize the utility billing data to account for billing months that do not align with calendar months.
- Use location specific actual meteorological year (AMY) weather data that corresponds to the year of the utility billing data.
- Simulate the initial baseline model and compare to the utility billing data.
- Refine the model by making adjustments to model inputs such as internal loads, HVAC system, operational schedules, occupancy, and non-HVAC systems.
- Once calibrated, use typical meteorological year (TMY) weather data to simulate the energy savings for the recommended EEMs.

For charts of actual usage and modeled usage, see appendix C, eQUEST Calibration Summary.

4.2 Calibration Results

Willdan compared the facility's normalized utility billing data for 2013 to the energy model for the purpose of calibration.

- The utility data has 9,472,897 kWh per year as the normalized electric energy usage. The model predicts 8,790,330 kWh per year, with a CV(RMSE) of 8 percent.
- The model predicts the electric demand with a maximum monthly error of 19 percent and a CV(RMSE) of 9 percent.
- The utility data has 515,667 therms per year as the normalized natural gas energy usage. The model predicts 471,586 therms per year, with a CV(RMSE) of 10 percent.

Standard guidelines allow a 10 percent range for calibration; Willdan therefore considers this a successfully calibrated energy model.

4.3 Energy End-Use Allocation

Whole-building energy simulation provides a breakout of the electric energy and natural gas usage by end use. This level of detail is helpful in understanding the relative uses of electricity and natural gas within the building energy model. The charts show the estimated energy usage before project completion.

Figure 41. Annual Electric Energy Usage (kWh) by End Use

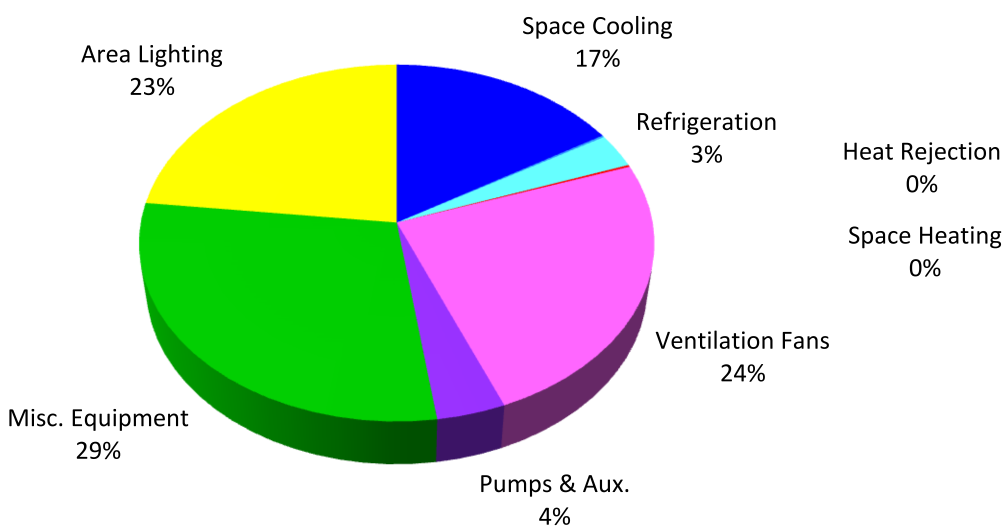
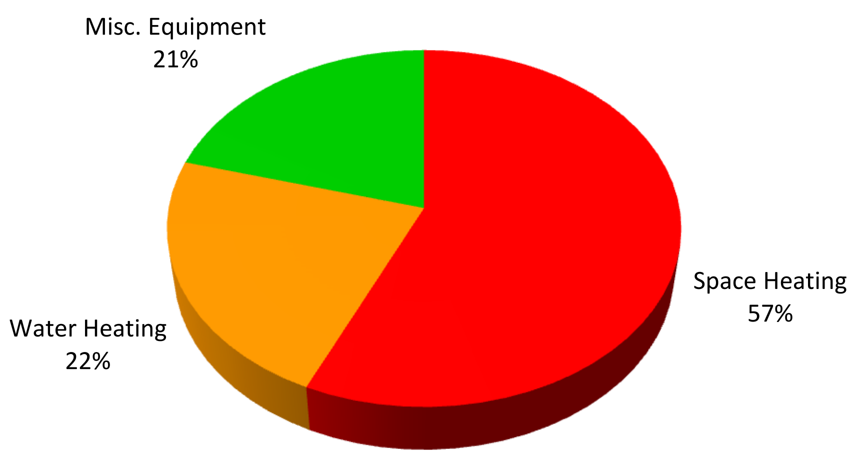


Figure 42. Annual Natural Gas Energy Usage (therms) by End Use



5. Energy Efficiency Measures

Willdan identified a number of opportunities for improving the overall energy efficiency of the facility, based on discussions with facility engineers, observations during the site survey, and whole-building energy simulation. Willdan's recommended energy efficiency measures are described in this section, followed by measures for future consideration and measures not recommended.

5.1 Measures Recommended for Implementation

The description of each energy efficiency measure includes the existing conditions, proposed conditions, brief scope of work, and simple economics. The projected energy savings, estimated costs, and calculated simple payback periods for implementing the measures are described. The simple payback period is the number of years it will take for the annual cost savings to equal the cost of implementing the measure. Payback calculations do not take into account inflation, equipment life, or operations and maintenance costs. Amounts are estimates.

EEM-01: Extend Building Management System to All Buildings and Implement a Supply Temperature Reset on the Air Handlers (All Bldgs.)

Existing Condition

The installed building management system (BMS) controls only equipment in building 1 (west wing), and part of the central plant for buildings 2 and 3 (central and east wings). In some cases, the equipment can only be monitored and not controlled. In the cases where equipment can be monitored and controlled, the options for control are limited to turning equipment on and off. The system does not offer more modern control functions, such as modulation in response to varying weather and load conditions.

In many California healthcare facilities, building controls and automation date from an earlier era and lack the functionality of current and more modern systems. Older systems often include pneumatic components and lack more complex digital control logic that uses more of the available operating data. In other cases, an older BMS may simply be unsupported by the original manufacturer and lack spare parts. Very often in-house maintenance personnel lack expertise for maintaining older pneumatic systems or may no longer be able to make programming changes using old, unsupported code. As a result, many older control systems degrade into crude monitoring tools that only perform on and off operation of equipment.

Newer systems with more complex algorithms allow building operators to implement control strategies that lead to more efficient equipment operation. Modern direct-digital control systems provide smarter control.

HVAC equipment is typically sized to handle building heating and cooling loads under worst case conditions (when load is highest). Modern BMS systems are designed to adjust operation of many individual components simultaneously to efficiently meet operating requirements at any time and any load. With modern BMS, control set points and strategies can be adjusted to meet only the actual load, eliminating unnecessary waste of energy.

A modern BMS can provide tighter and more flexible scheduling of equipment, provide optimal coordination of multiple system components, predict the optimum time to start and stop equipment eliminating excessive runtime, improved economizer control, and dramatically improve energy efficiency,

Proposed Condition

This measure recommends extending the BMS throughout all four buildings, upgrading systems as needed to direct digital controls (DDC), extending the BMS to the new DDC components, and tying all HVAC controllers to the BMS. These new controllers, which come standard on most new mechanical equipment, are more reliable, require less maintenance, and provide more sophisticated control. Full DDC BMS control will enable the facility to schedule and implement advanced control strategies.

A DDC control upgrade will make it possible to dynamically reset the fan discharge pressure based on the zone demands. Fan pressure reset relies on zone level DDC control and feedback from individual variable-air-volume controllers indicating damper position. This control strategy increases variable-air-volume air handler efficiency by reducing duct pressure at part-load conditions, leading to substantial fan energy savings.

Supply air temperature control is one of the most important operation and control parameters for air handlers. Most of the HVAC systems require cooling at the main air handler with downstream heating (reheat). If the main cold air supply temperature is adjusted too low, unnecessary cooling and dehumidification occurs upstream, requiring greater energy use. Downstream, however, the same air requires more reheat, also requiring greater energy use. The combined impact of greater cooling and heating energy use from a misadjusted supply air temperature set point can be high. The fan will supply more air to the building during the cooling season, and fan energy consumption will be higher than necessary.

The energy savings are from the reduced energy usage (and cost) of the fan power for cooling and heating. Other benefits of a BMS include faster response to comfort problems, mitigation of comfort problems in critical areas before they become issues by using alarm settings, scheduling, customized set points, temperature setbacks, documentation of performance for quality control purposes, and ongoing commissioning.

Scope of Work

This project entails the following work:

- Install new DDC control panels, install communications components, and extend BMS to the new panels.
- From new DDC panels, extend digital communication to individual controlled components.
- Gradually and unit-by-unit, replace all analog pneumatic with digital electric control components.
- Provide new sensors and control logic as necessary for full DDC control.
- Start up and recommission each device as components are installed, providing trend reports as confirmation of proper unit control.

Economics

Implementation of this measure will reduce electric energy usage by 461,198.3 kilowatt-hours and reduce natural gas usage by 42,494.5 therms each year. The measure will reduce energy costs by $91,827 each year. The incentive is calculated as $150/kW for peak demand reduction and as $0.08/kWh and $1/therm for annual savings. The implementation costs are $205,374 after incentive, with a simple payback period of 2.2 years. Savings, costs, and incentives are estimates.

Table 14. EEM-1: Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	461,198.3 kWh
Peak Electric Demand Savings	38.36 kW
Annual Natural Gas Savings	42,494.5 therms
Annual Utility Cost Savings	$91,827
Investment Overview (Estimated)	
Project Costs	$290,518
Incentive Available	$85,145
Net Cost to Customer	$205,374
Simple Payback Period With Incentive	2.2 years

Calculation Methodology

Energy savings were estimated using parametric runs in eQUEST. This feature allows comparisons of scenarios by changing only specific parameters for each run (scenario) within the same model. Each run is based on the previous run, in a cascading manner, to account for the interactive effects of the measures. Specifically, these parameters were changed in the parametric run to estimate the savings:

- Change cooling control for all system level air handlers from constant to warmest, which sets the cooling coil temperature each hour to adequately cool the zone with the highest temperature. Set the maximum cooling reset temperature to 60°F.
- Change heating control for all system level air handlers from constant to coldest, which sets the heating coil temperature each hour to adequately heat the zone with the lowest temperature. Set the minimum heating reset temperature to 70°F.

Measurement & Verification

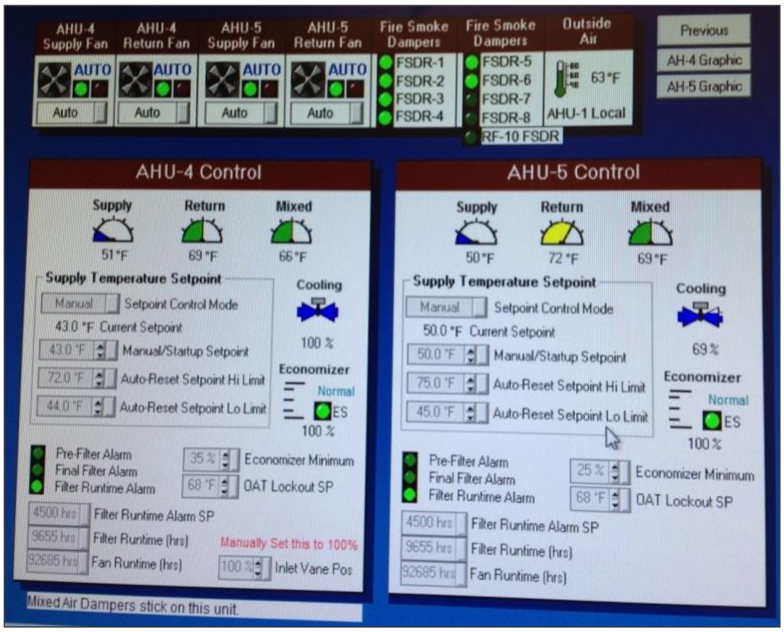
The proposed measurement and verification method for this measure is to obtain screen captures of the BMS, verify that the appropriate programing has been enabled, and obtain invoices for the implemented measure.

EEM-02: Implement Operating Room Temperature Setback (Bldg. 1)

Existing Condition

Building 1 (west wing) operating rooms are currently conditioned to a supply temperature set point of 43°F. The relatively low temperature and humidity requirements of operating rooms require the availability of low temperature chilled water, causing chillers to operate less efficiently, and the HVAC systems to work harder. Currently, the operating rooms are maintained at low temperature and humidity during all hours, 24/7, whereas the operating rooms are only active during part of the day.

Figure 43. BMS Screen Capture of Operating Room AHU-4



Proposed Condition

This measure recommends changing the operating rooms' temperature set points to 75°F during inactive hours. An operating room temperature setback, also known as a night setback or unoccupied setback, reduces the amount of air supplied when the operating room is not in use. The setback strategy may also allow temperature or humidity settings (or both) to drift during times the room is not in use.

Less energy is needed to maintain room temperature in operating rooms during unoccupied periods because equipment loads are low to nonexistent when the room is not in use. Also, because operating rooms are typically located within the building core, they are not affected by temperature gains and losses that result from the building envelope. For further information, see the paper "Operating Room HVAC Setback Strategies," published by the American Society for Healthcare Engineering (ASHE), http://www.ashe.org/resources/management_monographs/pdfs/mg2011love.pdf.

ANSI/ASHRAE/ASHE Standard 170-2013, *Ventilation of Health Care Facilities*, for Class B and C operating rooms (for major surgical procedures) allows a design temperature between 68°F and 75°F with a relative humidity between 20 percent and 60 percent.

Scope of Work

This project involves the following work:

- Verify that the control system for the operating room HVAC equipment is installed and working correctly.
- Identify each operating room's schedule and typical occupancy hours.
- Program the unoccupied set point to be 75°F, leaving adequate ramp up time and cooling before occupied periods.
- Verify the program's functional operation.

Economics

Implementation of this measure will reduce electric energy usage by 5,177.9 kilowatt-hours and reduce natural gas usage by 467.0 therms each year. The measure will reduce energy costs by $1,023 each year. The incentive is calculated as $150/kW for peak demand reduction and as $0.08/kWh and $1/therm for annual savings. The implementation costs are $5,731 after incentive, with a simple payback period of 5.6 years. Savings, costs, and incentives are estimates.

Table 15. EEM-2: Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	5,177.9 kWh
Peak Electric Demand Savings	0.22 kW
Annual Natural Gas Savings	467.0 therms
Annual Utility Cost Savings	$1,023
Investment Overview (Estimated)	
Project Costs	$6,645
Incentive Available	$914
Net Cost to Customer	$5,731
Simple Payback Period With Incentive	5.6 years

Calculation Methodology

Energy savings were estimated using parametric runs in eQUEST. This feature allows comparisons of scenarios by changing only specific parameters for each run (scenario) within the same model. Each run is based on the previous run, in a cascading manner, to account for the interactive effects of the measures. Specifically, these parameters were changed in the parametric run to estimate the savings:

- Change thermostat set point schedule in the space to the proposed operating room setback schedule.
  - Operating room setback schedule increases the cooling thermostat set point from 68°F to the maximum allowable thermostat set point of 75°F between 6 p.m. and 6 a.m.

Measurement & Verification

The proposed measurement and verification method for this measure is to obtain screen captures of the BMS with the set point reset parameters, verify that the reset program has been enabled, and obtain invoices for the implemented measure.

EEM-03: Upgrade Chiller Control System and Implement Chilled Water Supply Temperature Reset Based on Outside Air Temperature (Bldg. 1)

Existing Condition

As described previously, primary cooling for building 1 (west wing) is provided by a central chilled water system. The chilled water system includes two water-cooled 200 ton centrifugal chillers by Trane (CH-1 and CH-2). The chillers are configured in a primary/secondary distribution system that distributes chilled water to air handlers and fan coils on demand to cool the spaces in the building. The chillers are relatively old, dating from the mid 1980s, and have limited control capabilities. Currently, chilled water is supplied by the chillers at a constant and fixed 44°F.

Figure 44. Building 1 (West Wing) Chiller's Outdated Control Panel

Proposed Condition

This measure recommends upgrading the control capabilities of the chillers to include a chilled water temperature reset strategy.

A chilled water supply temperature reset strategy will allow the temperature of chilled water to vary up and down within a fixed range as cooling requirements vary. When outside temperatures rise and more building cooling is required, chilled water will automatically be supplied at a lower temperature. When outside temperatures drop and less building cooling is required, chilled water will automatically be supplied at a higher temperature. In other words, on hot days the chilled water temperature will be lower, 44°F, while on mild days the chilled water temperature will be higher, 48°F.

Varying the supply temperature on the chilled water loop to more accurately meet the cooling load of the building will save energy. The chillers will operate more efficiently at higher chilled water temperatures. The measure provides energy savings by reducing the compressor energy of the chillers during part-load conditions (night time, winter months, and milder temperatures).

Scope of Work

This project includes the following work:

- Procure and install new outside air temperature sensor, if necessary, and connect new signal input to the existing chiller control panel.

- Install new electronic control components into existing control panel to allow chilled water reset and other control features.
- Program the chiller control algorithm so that an increase in outside air temperature will decrease the chilled water supply temperature, and vice versa.
- Establish proper controls and upper and lower temperature set points per design documents and specifications.
- Verify new control sequence by trending chilled water supply temperature and outside air temperature. Confirm control of air handler discharge air temperature at the air handler level for each unit served under the new reset strategy.
- Verify proper humidity control and confirm that the new reset strategy does not adversely impact any zone requirements for humidity control.

Economics

Implementation of this measure will reduce electric energy usage by 15,005.7 kilowatt-hours each year. The measure will reduce energy costs by $1,951 each year. The incentive is calculated as $150/kW for peak demand reduction and as $0.08/kWh and $1/therm for annual savings. The implementation costs are $98,799 after incentive, with a simple payback period of 50.6 years. Savings, costs, and incentives are estimates.

Table 16. EEM-3: Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	15,005.7 kWh
Peak Electric Demand Savings	2.27 kW
Annual Natural Gas Savings	0.0 therms
Annual Utility Cost Savings	$1,951
Investment Overview (Estimated)	
Project Costs	$100,340
Incentive Available	$1,541
Net Cost to Customer	$98,799
Simple Payback Period With Incentive	50.6 years

Calculation Methodology

Energy savings were estimated using parametric runs in eQUEST. This feature allows comparisons of scenarios by changing only specific parameters for each run (scenario) within the same model. Each run is based on the previous run, in a cascading manner, to account for the interactive effects of the measures. Specifically, these parameters were changed in the parametric run to estimate the savings:

- Change cooling set point control for building 1 chilled water loop from fixed to outside air reset.
- Change chilled water supply reset schedule to proposed reset schedule.

  Outdoor Air Temperature Chilled Water Supply Reset Schedule:

  - At <60°F outside air temperature, use a set point of 48°F.
  - At ≥80°F outside air temperature, use a set point of 44°F.

Measurement & Verification

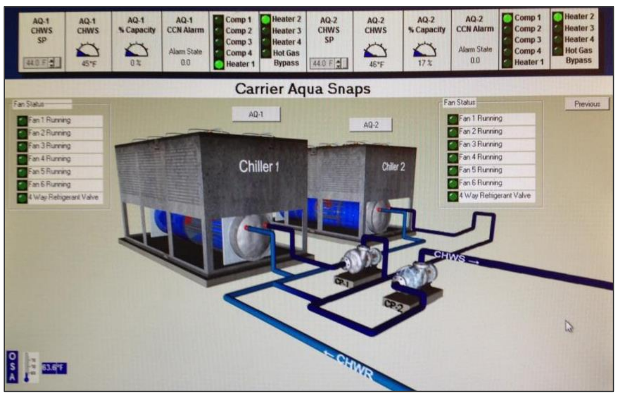
The proposed measurement and verification method for this measure is to inspect the installed equipment, verify that the equipment is connected to the BMS, obtain screen captures to verify the outside air reset programming for the chillers in the BMS, and obtain invoices for the work and installed equipment.

EEM-04: Implement Chilled Water Supply Temperature Reset Based on Outside Air Temperature (Bldgs. 2 and 3)

Existing Condition

Primary cooling for buildings 2 and 3 (central and east wings) is provided by a chilled water system. The chilled water system includes two 100 ton Carrier AquaSnap air-cooled chillers that currently operate with a constant chilled water supply temperature of 44°F. Both chillers are currently connected to the facility's BMS; however, the BMS does not currently employ a temperature reset control strategy.

Figure 45. Carrier AquaSnap Chillers (BMS Screen Capture)



Proposed Condition

This measure recommends modifying the BMS programming to employ a chilled water supply temperature reset strategy.

A chilled water supply temperature reset strategy will allow the temperature of chilled water to vary up and down within a fixed range as cooling requirements vary. When outside temperatures rise and more building cooling is required, chilled water will automatically be supplied at a lower temperature. When outside temperatures drop and less building cooling is required, chilled water temperature will automatically be supplied at a higher temperature. In other words, on hot days the chilled water temperature will be lower, 44°F, while on mild days the chilled water temperature will be higher, 48°F.

Varying the supply temperature on the chilled water loop to more accurately meet the cooling load of the building will save energy. The chillers will operate more efficiently at higher chilled water temperatures. The measure provides energy savings by reducing the compressor energy of the chillers during part-load conditions (night time, winter months, and milder temperatures).

Scope of Work

This project involves the following work:

- Procure and install new outside air temperature sensor, if necessary, and connect new signal input to the existing chiller control panel and BMS.

- Reprogram the BMS to adjust the chiller temperature set point so that an increase in outside air temperature will decrease the chilled water supply temperature, and vice versa.
- Establish proper controls and upper and lower temperature set points per design approach.
- Verify new control sequence by trending chilled water supply temperature and outside air temperature. Confirm control of air handler discharge air temperature at the air handler level for each unit served under the new chilled water supply temperature reset strategy.
- Verify proper humidity control and confirm that the new chilled water supply temperature reset strategy does not adversely impact any zone requirements for humidity control.

Economics

Implementation of this measure will reduce electric energy usage by 11,416.5 kilowatt-hours each year. The measure will reduce energy costs by $1,484 each year. The incentive is calculated as $150/kW for peak demand reduction and as $0.08/kWh and $1/therm for annual savings. The implementation costs are $7,291 after incentive, with a simple payback period of 4.9 years. Savings, costs, and incentives are estimates.

Table 17. EEM-4: Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	11,416.5 kWh
Peak Electric Demand Savings	(3.03) kW
Annual Natural Gas Savings	0.0 therms
Annual Utility Cost Savings	**$1,484**
Investment Overview (Estimated)	
Project Costs	$7,749
Incentive Available	$458
Net Cost to Customer	**$7,291**
Simple Payback Period With Incentive	4.9 years

Calculation Methodology

Energy savings were estimated using parametric runs in eQUEST. This feature allows comparisons of scenarios by changing only specific parameters for each run (scenario) within the same model. Each run is based on the previous run, in a cascading manner, to account for the interactive effects of the measures. Specifically, these parameters were changed in the parametric run to estimate the savings:

- Change cooling set point control for building 2 and 3 chilled water loop from fixed to outside air reset.
- Change chilled water supply reset schedule to proposed reset schedule.

  Outdoor Air Temperature Chilled Water Supply Reset Schedule:

  - At <60°F outside air temperature, use a set point of 48°F.
  - At ≥80°F outside air temperature, use a set point of 44°F.

Measurement & Verification

The proposed measurement and verification method for this measure is to inspect the installed equipment, verify that the equipment is connected to the BMS, obtain screen captures to verify the outside air reset programming for the chillers in the BMS, and obtain invoices for the work and installed equipment.

EEM-05: Implement Condenser Water Supply Temperature Reset Based on Outside Air Wet-Bulb Temperature (Bldg. 1)

Existing Condition

The building 1 (west wing) central chilled water system is water cooled and includes a condenser water loop serving chillers CH-1 and CH-2. Hot condenser water circulates through two cross-flow cooling towers to cool the condenser water down to a controlled temperature. At the building 1 central plant, the condenser water temperature is controlled to a constant 74°F per the BMS.

Proposed Condition

This measure recommends varying the condenser water temperature according to ambient temperature and humidity conditions. When outside air conditions are cooler and less humid, the cooling towers are directed to produce lower temperature condenser water, without over-working the cooling tower fans. When lower temperature condenser water is supplied, the chillers operate more efficiently. Lower temperature condenser water results in lower compressor discharge pressure, lower overall compressor "lift," and better cooling efficiency in the chillers. The existing chillers can operate with condenser water as low as 65°F, as long as cooling requirements are high.

Scope of Work

This project involves the following work:

- Procure and install new outside air temperature and humidity sensors, if necessary, and connect new signal input to the existing chiller control panel.
- Install new electronic control components into existing control panel to allow condenser water reset and other control features.
- Program the chiller control algorithm to accommodate a wet-bulb reset condenser water reset strategy.
- Establish proper controls and upper and lower temperature set points per design documents and specifications.
- Verify new control sequence by trending condenser water temperature and ambient temperature and humidity.
- Verify proper chiller operation and control.

Economics

Implementation of this measure will reduce electric energy usage by 37,281.3 kilowatt-hours each year. The measure will reduce energy costs by $4,847 each year. The incentive is calculated as $150/kW for peak demand reduction and as $0.08/kWh and $1/therm for annual savings. The implementation costs are $3,399 after incentive, with a simple payback period of 0.7 years. Savings, costs, and incentives are estimates.

Table 18. EEM-5: Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	37,281.3 kWh
Peak Electric Demand Savings	9.22 kW
Annual Natural Gas Savings	0.0 therms
Annual Utility Cost Savings	$4,847
Investment Overview (Estimated)	
Project Costs	$7,765
Incentive Available	$4,366
Net Cost to Customer	$3,399
Simple Payback Period With Incentive	0.7 years

Calculation Methodology

Energy savings were estimated using parametric runs in eQUEST. This feature allows comparisons of scenarios by changing only specific parameters for each run (scenario) within the same model. Each run is based on the previous run, in a cascading manner, to account for the interactive effects of the measures. Specifically, these parameters were changed in the parametric run to estimate the savings:

- Change condenser water supply set point control from fixed to outside air reset.
- Change condenser water supply reset schedule to proposed reset schedule.

  Outdoor Air Temperature Condenser Water Supply Reset Schedule:

  - At <50°F outside air temperature, use a set point of 80°F.
  - At ≥80°F outside air temperature, use a set point of 65°F.

Measurement & Verification

The proposed measurement and verification method for this measure is to obtain screen captures of the BMS with the condenser water temperature reset parameters, verify that the reset program has been enabled, and obtain invoices for the implemented measure.

EEM-06: Implement Condenser Water Supply Temperature Reset Based on Outside Air Wet-Bulb Temperature (Bldg. 4)

Existing Condition

Building 4 (behavioral health) has a condenser water loop serving the Dunham-Bush chiller. The condenser water supply temperature has a set point of a constant 80°F per the site audit.

Proposed Condition

This measure recommends varying the condenser water temperature according to ambient temperature and humidity conditions. When outside air conditions are cooler and less humid, the cooling towers are directed to produce lower temperature condenser water, without over-working the cooling tower fans. When lower temperature condenser water is supplied, the chillers operate more efficiently. Lower temperature condenser water results in lower compressor discharge pressure, lower overall compressor "lift," and better cooling efficiency in the chillers. The existing chillers can operate with condenser water as low as 65°F, as long as cooling requirements are high.

Scope of Work

This project involves the following work:

- Procure and install the necessary controls and sensors.
- Verify installation and intended performance as designed.
- Program the control algorithm to increase the condenser water supply temperature when outside air temperature is high and to decrease the condenser water supply temperature when lower load and web bulb depression conditions are present.
- Design the system to provide and establish proper controls and prevent chiller surge at low condenser water supply temperatures.
- Verify valve positions, wet bulb, and damper position as related to the design operations manual. Provide for head pressure control on chillers, if necessary and per design requirements.

Economics

Implementation of this measure will reduce electric energy usage by 11,621.1 kilowatt-hours and increase natural gas usage by 0.9 therms each year. The measure will reduce energy costs by $1,510 each year. The incentive is calculated as $150/kW for peak demand reduction and as $0.08/kWh and $1/therm for annual savings. The implementation costs are $2,297 after incentive, with a simple payback period of 1.5 years. Savings, costs, and incentives are estimates.

Table 19. EEM-6: Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	11,621.1 kWh
Peak Electric Demand Savings	4.37 kW
Annual Natural Gas Savings	(0.9) therms
Annual Utility Cost Savings	$1,510
Investment Overview (Estimated)	
Project Costs	$3,882
Incentive Available	$1,585
Net Cost to Customer	$2,297
Simple Payback Period With Incentive	1.5 years

Calculation Methodology

Energy savings were estimated using parametric runs in eQUEST. This feature allows comparisons of scenarios by changing only specific parameters for each run (scenario) within the same model. Each run is based on the previous run, in a cascading manner, to account for the interactive effects of the measures. Specifically, these parameters were changed in the parametric run to estimate the savings:

- Change condenser water supply set point control from fixed to outside air reset.
- Change condenser water supply reset schedule to proposed reset schedule.

  Outdoor Air Temperature Condenser Water Supply Reset Schedule:

  - At <50°F outside air temperature, use a set point to 80°F.
  - At ≥80°F outside air temperature, use a set point to 65°F.

Measurement & Verification

The proposed measurement and verification method for this measure is to obtain screen captures of the BMS with the condenser water temperature reset parameters, verify that the reset program has been enabled, and obtain invoices for the implemented measure.

EEM-07: Upgrade Fan Coil Thermostats (Bldgs. 2 and 3)

Existing Condition

Many of the conditioned spaces in building 2 and 3 (central and east wings) are heated and cooled by fan coil units. Fan coil units normally contain a small room circulation fan and relatively small heating and cooling coils that carry hot and chilled water. Fan coil units are sometimes supplied with a small volume of outside air for space ventilation, but often are not. Normally fan coil units are controlled by an independent room thermostat that opens and closes the control valves on the heating and cooling coils to provide heating and cooling to the space and, for newer systems, cycle the circulating fan on and off.

Older fan coil units, which have pneumatic control systems, commonly have very basic control systems. Very often, the recirculation fan on the unit runs continuously, even when the space is at the controlled temperature and neither heating nor cooling is required. Circulation fans on older fan coil units are typically very inefficient split capacitor motors that consume a surprising amount of energy and add considerable heat to the space.

Proposed Condition

This measure recommends replacing the existing pneumatic fan coil thermostats in buildings 2 and 3 (central and east wings) with electronic thermostats that cycle the circulation fan off when zone temperature conditions are met (that is, “auto” fan operation) and automatically revert to a setback temperature during periods of no occupancy.

This measure will dramatically reduce unnecessary fan operation in fan coils and substantially reduce cooling requirements in these spaces. In addition, if the spaces are not occupied continuously, the setback feature incorporated in the new thermostat will reduce heating and cooling requirements. There is also the added benefit of the ability to connect the thermostats to the BMS when possible.

Scope of Work

This project involves the following work:

- Isolate areas served by fan coils, one-by-one, and disable the fan coils.
- For each fan coil, disable and remove the existing pneumatic thermostat and related control components.
- Install new fan coil controller, including small horsepower fan starter (if necessary) and new electronic thermostat.
- Restart fan coil and confirm proper temperature control and fan cycling capability.

Economics

Implementation of this measure will reduce electric energy usage by 93,504.4 kilowatt-hours and reduce natural gas usage by 691.8 therms each year. The measure will reduce energy costs by $12,674 each year. The incentive is calculated as $150/kW for peak demand reduction and as $0.08/kWh and $1/therm for annual savings. The implementation costs are $21,344 after incentive, with a simple payback period of 1.7 years. Savings, costs, and incentives are estimates.

Table 20. EEM-7: Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	93,504.4 kWh
Peak Electric Demand Savings	(0.92) kW
Annual Natural Gas Savings	691.8 therms
Annual Utility Cost Savings	$12,674
Investment Overview (Estimated)	
Project Costs	$29,378
Incentive Available	$8,034
Net Cost to Customer	$21,344
Simple Payback Period With Incentive	1.7 years

Calculation Methodology

Energy savings were estimated using parametric runs in eQUEST. This feature allows comparisons of scenarios by changing only specific parameters for each run (scenario) within the same model. Each run is based on the previous run, in a cascading manner, to account for the interactive effects of the measures. Specifically, these parameters were changed in the parametric run to estimate the savings:

- Apply patient room fan schedule to all zone level air handlers.
  - The cooling fan schedule shuts off the room circulation fans between the hours of 10 p.m. and 5 a.m.

Measurement & Verification

The proposed measurement and verification method for this measure is to obtain equipment nameplate information, verify fan coil settings, and obtain invoices for the implemented measure.

EEM-08: Install a Kitchen Ventilation Control System (Bldgs. 2 and 3)

Existing Condition

The kitchen in building 2 (central wing) is currently equipped with two kitchen fume hoods. The existing kitchen fume hood fans are operated manually and usually operate continuously. At the time of the site visit, access to the exhaust fan motors was not available. However, typical exhaust fan motor horsepower for similarly sized fume hoods is usually between 5 and 10 horsepower. In the kitchen, the fume hood fans were estimated to be 5 horsepower each. Upon implementation of this measure, the installer will verify the existing motor horsepower.

Proposed Condition

This measure recommends installing an integrated fume hood volume control system by MeLink, Siemens, or an equivalent system. The system will be variable flow, requiring variable speed drives (VSDs) on both fume hood fans. The system will be designed to monitor activity below the hood and dynamically control the rate of ventilation to adequately clear the cooking surfaces and surrounding areas of smoke and heat. During periods when the kitchen is not in service, the fume hood fans will be shut off completely.

Better management of the fume hood fans via the new volume control system will minimize kitchen ventilation air. Minimizing kitchen ventilation air will reduce fan energy use as well as heating and cooling in the main air systems serving the kitchen and dining area.

Scope of Work

This project involves the following work:

- Inspect the existing kitchen hood controls. Verify fan horsepower and the operating condition of the existing system.
- Specify and procure the new fan variable speed drives.
- Procure and install the new variable flow exhaust system controls as specified by the manufacturer.
- Verify proper operation of the system and proper removal of smoke, heat, and kitchen air contaminants.
- Verify that kitchen fume hood controls operate in unison with building HVAC systems.
- Connect the new controls system to the existing BMS for ongoing monitoring and alarm function capabilities.

Economics

Implementation of this measure will reduce electric energy usage by 41,970.0 kilowatt-hours and reduce natural gas usage by 1,050.0 therms each year. The measure will reduce energy costs by $6,244 each year. The incentive is calculated as $150/kW for peak demand reduction and as $0.08/kWh and $1/therm for annual savings. The implementation costs are $14,689 after incentive, with a simple payback period of 2.4 years. Savings, costs, and incentives are estimates.

Table 21. EEM-8: Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	41,970.0 kWh
Peak Electric Demand Savings	5.42 kW
Annual Natural Gas Savings	1,050.0 therms
Annual Utility Cost Savings	$6,244
Investment Overview (Estimated)	
Project Costs	$19,910
Incentive Available	$5,221
Net Cost to Customer	$14,689
Simple Payback Period With Incentive	2.4 years

Calculation Methodology

For this measure, Willdan used the deemed measure calculation methodology to estimate the energy savings. Work Paper PGECOFST116, "Commercial Kitchen Demand Ventilation Controls," Revision 3, specifies the following savings and measure cost values per nameplate rated exhaust fan horsepower:

- 0.542 kW peak electric demand reduction
- 4,197 kWh/yr electric energy savings
- 105 therm/yr natural gas savings
- $1,991 measure cost

Measurement & Verification

The proposed measurement and verification method for this measure is to obtain equipment nameplate information, verify controls are enabled, and obtain invoices for the implemented measure.

EEM-09: Convert the Chilled Water System to Variable Flow (Bldg. 1)

Existing Condition

The building 1 (west wing) chilled water system is configured as a primary/secondary distribution system. Primary/secondary systems were historically designed and installed to allow for constant water flow through chillers in the primary circuit, and variable secondary flow to and from air handlers and building chilled water coils. Based on this fact, it appears that the building 1 secondary chilled water loop was originally intended as variable flow.

Inspection of the building 1 HVAC systems, however, confirmed that none of the secondary chilled water pump motors are equipped with variable speed drives. The pump motors operate at constant speed. Further, most or all of the control valves are three-way, indicating that flow through the secondary loop is, in fact, constant volume. It seems unusual, but the building 1 chilled water system appears to be primary constant volume/secondary constant volume in its current operation.

Proposed Condition

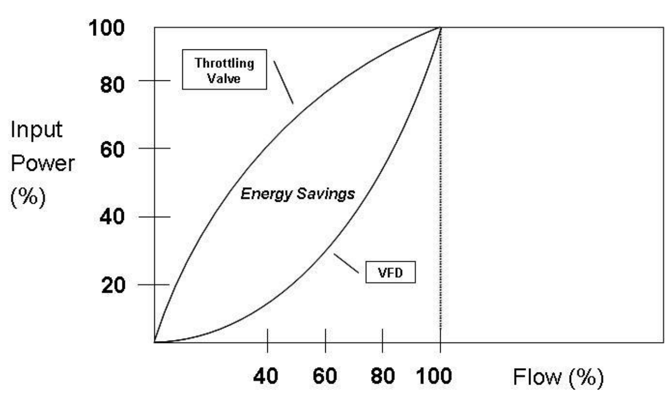
This measure recommends converting the building 1 secondary chilled water loop to variable flow. Variable flow reduces the pumping energy that is wasted when the system operates at constant volume.

The conversion requires two basic system changes: the conversion of chilled water control valves (at air handlers) from three-way to two-way control and the installation of variable speed drives (VSDs) on secondary pumps to control system differential pressure.

Instead of three-way control valves with bypasses, two-way control valves should be used at air handlers to vary flow through the cooling coils without bypassing chilled water around the coil. This can be achieved either by replacing the existing three-way valve with a two-way control valve or by simply closing the bypass on existing three-way valves so they operate as two-way control valves.

With two-way control valves in place on air handlers and cooling coils, the secondary loop becomes a variable flow loop. It is important to then equip the secondary chilled water pumps with VSDs. The VSDs are then modulated to control the pressure differential across the secondary distribution system, allowing the pumps to operate efficiently. By converting the system to variable flow and modulating pumps speed, substantial pumping energy is saved.

Figure 46. Example of Pump VSD Energy Savings (eng-tips.com)



Scope of Work

This project involves the following work:

- Convert or replace existing 3-way chilled water control valves at air handlers with 2-way.
- Install suitable variable speed drives on existing pump motors. Verify that the current installed motor is compatible with the VSD.
- Install new pressure sensor at a suitable location on the chilled water distribution header. Using existing or new controller, program and setup logic to allow the pump VSDs to modulate to control pressure in the chilled water distribution header.
- Confirm proper temperature control at all air handler and chilled water coils.
- Confirm proper pump and VSD operation by monitoring system pressure and pump speed.

Economics

Implementation of this measure will reduce electric energy usage by 81,682.8 kilowatt-hours and increase natural gas usage by 391.8 therms each year. The measure will reduce energy costs by $10,325 each year. The incentive is calculated as $150/kW for peak demand reduction and as $0.08/kWh and $1/therm for annual savings. The implementation costs are $33,982 after incentive, with a simple payback period of 3.3 years. Savings, costs, and incentives are estimates.

Table 22. EEM-9: Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	81,682.8 kWh
Peak Electric Demand Savings	8.82 kW
Annual Natural Gas Savings	(391.8) therms
Annual Utility Cost Savings	$10,325
Investment Overview (Estimated)	
Project Costs	$41,448
Incentive Available	$7,465
Net Cost to Customer	$33,982
Simple Payback Period With Incentive	3.3 years

Calculation Methodology

Energy savings were estimated using parametric runs in eQUEST. This feature allows comparisons of scenarios by changing only specific parameters for each run (scenario) within the same model. Each run is based on the previous run, in a cascading manner, to account for the interactive effects of the measures. Specifically, these parameters were changed in the parametric run to estimate the savings:

- Change chilled water valve type from 3-way to 2-way valves for all building 1 air handlers.
- Change secondary pump capacity control from “one speed pump” to “variable speed pump.”
- Secondary pump minimum speed to 0.3 flow ratio.

Measurement & Verification

The proposed measurement and verification method for this measure is to obtain equipment name plate information, verify that the VSD is enabled, and obtain invoices for the implemented measure.

EEM-10: Convert the Chilled Water System to Variable Flow (Bldgs. 2 and 3)

Existing Condition

The building 2 and 3 (central and east wing) chilled water system is configured as a primary constant-volume distribution system. All of the control valves in buildings 2 and 3 (central and east wings) are three-way, and chilled water is circulated at a constant and fixed volume regardless of the cooling load.

Proposed Condition

This measure recommends converting the building 2 and 3 chilled water loop to variable flow. Variable flow reduces the pumping energy that is wasted when the system operates at constant volume.

The conversion requires two basic system changes: the conversion of chilled water control valves (at air handlers) from three-way to two-way control and the installation of variable speed drives (VSDs) on secondary pumps to control system differential pressure. In this case, the conversion may also require the installation of a controlled bypass at the chillers to maintain some minimum flow.

Instead of three-way control valves with bypasses, two-way control valves should be used at air handlers to vary flow through the cooling coils without bypassing chilled water around the coil. This can be achieved either by replacing the existing three-way valve with a two-way control valve or by simply closing the bypass on existing three-way valves so they operate as two-way control valves.

With two-way control valves in place on air handlers and cooling coils, the secondary loop becomes a variable flow loop. It is important to then equip the secondary chilled water pumps with VSDs. The VSDs are then modulated to control the pressure differential across the secondary distribution system, allowing the pumps to operate efficiently. By converting the system to variable flow and modulating pumps speed, substantial pumping energy is saved.

Scope of Work

This project involves the following work:

- Convert or replace existing 3-way chilled water control valves at air handlers with 2-way control valves.
- Install suitable variable speed drives on existing pump motors. Verify that the current installed motors are compatible with the VSDs.
- Install new pressure sensor at a suitable location on the chilled water distribution header. Using existing or new controller, program and setup logic to allow the pump VSDs to modulate to control pressure in the chilled water distribution header.
- Confirm proper temperature control at all air handlers and chilled water coils.
- Confirm proper pump and VSD operation by monitoring system pressure and pump speed.

Economics

Implementation of this measure will reduce electric energy usage by 36,884.3 kilowatt-hours each year. The measure will reduce energy costs by $4,795 each year. The incentive is calculated as $150/kW for peak demand reduction and as $0.08/kWh and $1/therm for annual savings. The implementation costs are $40,104 after incentive, with a simple payback period of 8.4 years. Savings, costs, and incentives are estimates.

Table 23. EEM-10: Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	36,884.3 kWh
Peak Electric Demand Savings	4.05 kW
Annual Natural Gas Savings	0.0 therms
Annual Utility Cost Savings	$4,795
Investment Overview (Estimated)	
Project Costs	$43,663
Incentive Available	$3,559
Net Cost to Customer	$40,104
Simple Payback Period With Incentive	8.4 years

Calculation Methodology

Energy savings were estimated using parametric runs in eQUEST. This feature allows comparisons of scenarios by changing only specific parameters for each run (scenario) within the same model. Each run is based on the previous run, in a cascading manner, to account for the interactive effects of the measures. Specifically, these parameters were changed in the parametric run to estimate the savings:

- Change chilled water valve type from 3-way to 2-way valves for all building 2 and 3 air handlers.
- Change secondary pump capacity control from “one speed pump” to “variable speed pump.”
- Secondary pump minimum speed to 0.3 flow ratio.

Measurement & Verification

The proposed measurement and verification method for this measure is to obtain equipment name plate information, verify that the VSD is enabled, and obtain invoices for the implemented measure.

EEM-11: Convert the Chilled Water System to Variable Flow (Bldg. 4)

Existing Condition

Chilled water is currently circulated through building 4 (the behavioral health building) by two chilled water pumps in a constant, primary only pumping configuration. All of the control valves in the building are three way, and chilled water is circulated at a constant and fixed volume regardless of the cooling load.

Proposed Condition

This measure recommends converting the building 4 chilled water loop to variable flow. Since the chilled water system is relatively small, flow variation may be minimal. However, there is still an opportunity to reduce pumping energy that is wasted when the system operates at constant volume.

The conversion requires two basic system changes: the conversion of chilled water control valves (at air handlers) from three-way to two-way control and the installation of variable speed drives (VSDs) on secondary pumps to control system differential pressure. In this case, the conversion may also require the installation of a controlled bypass at the chillers to maintain some minimum flow.

Instead of three-way control valves with bypasses, two-way control valves should be used at air handlers to vary flow through the cooling coils without bypassing chilled water around the coil. This can be achieved either by replacing the existing three-way valve with a two-way control valve or by simply closing the bypass on existing three-way valves so they operate as two-way control valves.

With two-way control valves in place on air handlers and cooling coils, the secondary loop becomes a variable flow loop. It is important to then equip the secondary chilled water pumps with VSDs. The VSDs are then modulated to control the pressure differential across the secondary distribution system, allowing the pumps to operate efficiently. By converting the system to variable flow and modulating pumps speed, substantial pumping energy is saved.

Scope of Work

This project involves the following work:

- Conversion or replacement of existing 3-way chilled water valves at air handlers and fan coil units with 2-way valves.
- Installation of suitable variable speed drives on existing primary pump motors. Verify that the current installed motor is compatible with the VSD.
- Install new pressure sensor at a suitable location on the chilled water distribution header. Using existing or new controller, program and setup logic to allow the pump VSDs to modulate to control pressure in the chilled water distribution header.
- Use safety lockout of the chilled water loop and pump during VSD installation. Ensure that when pumps are taken out of service, all isolation valves are set properly, to avoid water leakage.
- Commission and verify pump performance is in compliance with design intent. Test pumps and VSDs with valves in initial, fully closed, and fully open positions.

Economics

Implementation of this measure will reduce electric energy usage by 21,350.6 kilowatt-hours and increase natural gas usage by 0.0 therms each year. The measure will reduce energy costs by $2,776 each year. The incentive is calculated as $150/kW for peak demand reduction and as $0.08/kWh and $1/therm for annual savings. The implementation costs are $11,081 after incentive, with a simple payback period of 4.0 years. Savings, costs, and incentives are estimates.

Table 24. EEM-11: Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	21,350.6 kWh
Peak Electric Demand Savings	2.55 kW
Annual Natural Gas Savings	0.0 therms
Annual Utility Cost Savings	$2,776
Investment Overview (Estimated)	
Project Costs	$13,171
Incentive Available	$2,090
Net Cost to Customer	$11,081
Simple Payback Period With Incentive	4.0 years

Calculation Methodology

Energy savings were estimated using parametric runs in eQUEST. This feature allows comparisons of scenarios by changing only specific parameters for each run (scenario) within the same model. Each run is based on the previous run, in a cascading manner, to account for the interactive effects of the measures. Specifically, these parameters were changed in the parametric run to estimate the savings:

- Change chilled water valve type from 3-way to 2-way valves for all building 4 air handlers.
- Change secondary pump capacity control from one speed pump to variable speed pump.
- Secondary pump minimum speed to 0.3 flow ratio.

Measurement & Verification

The proposed measurement and verification method for this measure is to obtain equipment name plate information, verify that the VSD is enabled, and obtain invoices for the implemented measure.

EEM-12: Upgrade Boiler #1 Burner (Bldgs. 2 and 3)

Existing Condition

The heating requirements of building 2 and 3 (central and east wings) are currently served by two low-pressure steam boilers. Steam is used in the facility for sterilization, domestic hot water heating, and space heating. The boilers are in reasonably good physical condition, but suffer from significant energy loss.

The existing boilers and burners are significantly oversized for the current loads they are serving. The burners on both boilers are an older style burner with a mechanical linkage. The linkage is difficult to adjust and maintain, resulting in relatively high excess air in the flue gas. In addition, the burners have a limited 3:1 turndown ratio. Given that facility thermal requirements vary widely, the burners frequently cycle on and off at lower part loads.

Figure 47. Building 2 and 3 (Central and East Wings) Boiler #1

Proposed Condition

This measure recommends replacing the existing burner on Boiler #1 with a smaller capacity linkage-less variable-speed direct-drive burner with a lower turndown ratio. The new burner will allow for closer excess oxygen control and better combustion efficiency. The burner will also provide for lower turndown, preventing excessive cycling. The combination of the smaller size and control improvements on the boiler will result in significant natural gas savings as well as electrical savings.

Scope of Work

This project involves the following work:

- Design for and select an appropriate linkage-less burner.
- Apply for appropriate air pollution permits.
- Plan for a temporary shutdown and safety lockout of one of the two existing boilers in order to remove oversized burner.
- Replace oversized burner with smaller burner, and make appropriate electrical, mechanical, and control connections.
- Start up and tune new burner, commission burner operation, controls, and sensors.

- Perform combustion analysis and adjust the boiler to meet local Air Quality Management District regulations.
- Train boiler operators in proper operation of boilers.

Economics

Implementation of this measure will reduce natural gas usage by 5,960.8 therms each year. The measure will reduce energy costs by $4,471 each year. The incentive is calculated as $0.08/kWh and $1/therm for annual savings. The implementation costs are $20,978 after incentive, with a simple payback period of 4.7 years. Savings, costs, and incentives are estimates.

Table 25. EEM-12: Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	0.0 kWh
Peak Electric Demand Savings	0.00 kW
Annual Natural Gas Savings	5,960.8 therms
Annual Utility Cost Savings	$4,471
Investment Overview (Estimated)	
Project Costs	$26,939
Incentive Available	$5,961
Net Cost to Customer	$20,978
Simple Payback Period With Incentive	4.7 years

Calculation Methodology

Energy savings were estimated using parametric runs in eQUEST. This feature allows comparisons of scenarios by changing only specific parameters for each run (scenario) within the same model. Each run is based on the previous run, in a cascading manner, to account for the interactive effects of the measures. Specifically, these parameters were changed in the parametric run to estimate the savings:

- Change heat input ratio (efficiency) from 1.25 to 1.176, the ratio of the energy used by the system to the heating capacity of the system.

Measurement & Verification

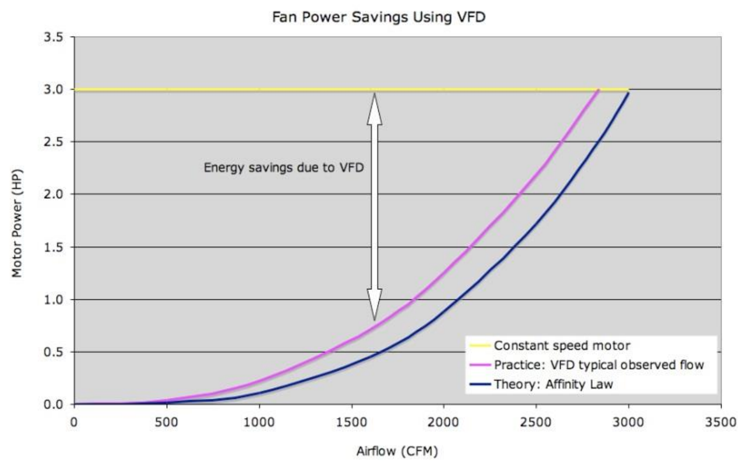
The proposed measurement and verification method for this measure is to obtain equipment nameplate information, flue gas analysis data, and obtain invoices for the implemented measure.

EEM-13: Convert Air Handlers to Variable Air Volume Operation (Bldg. 1)

Existing Condition

The building 1 (west wing) HVAC systems are a combination of mixed air and 100 percent outside air systems, which include packaged single-duct and built-up dual-duct systems. All building 1 single-zone systems as well as all multi-zone systems are constant volume. In constant volume HVAC systems, temperature control within individual spaces is achieved by varying supply air temperature while maintaining constant airflow. This control is stable and reliable, and provides generous ventilation air, but tends to require greater fan energy and greater energy for re-heat than variable air volume HVAC systems.

Figure 48. Example of Fan Power Savings With VSD (energydesignresources.com)



Proposed Condition

This measure recommends converting HVAC systems from constant air volume (CAV) to variable air volume (VAV). In a variable air volume HVAC system, space temperature is primarily maintained by keeping supply air temperature fixed and varying air volume to the space. By varying and reducing air volume, both fan energy and re-heat energy are dramatically reduced.

Dual-duct constant-volume systems typically require greater fan energy than other system types, but their efficiency can be improved by converting mixing boxes to variable flow operation. Zone dampers are normally de-linked, with independent actuators for the hot-deck and cold-deck dampers associated with each zone, to convert the system to variable air volume operation. During most cooling hours, the hot-deck zone dampers will normally be closed. A VSD is then installed on the supply fan (or fans) and modulated to control hot-deck and cold-deck static pressure. Typically the hot-deck and cold-deck temperature set points are then controlled on a programmed temperature reset schedule to maximize savings.

It should be noted that not all spaces can or should be converted to variable air-volume control. Many spaces in hospital environments, particularly operating rooms and patient recovery areas, will need to remain as constant volume spaces. However, converting air handlers to VAV can be achieved even if some of the spaces remain as constant volume spaces. Potential energy savings for the conversion is still substantial.

Scope of Work

This project involves the following work:

- Inspect and repair terminal boxes and confirm each is in good working condition.
- Convert constant volume terminal boxes to variable volume in applicable zones, including necessary room thermostats and zone-level temperature controls.
- Install variable speed drives on affected HVAC systems on both supply and return fans. Install duct pressure sensors in the supply duct system.
- Install and upgrade air handler controls to provide for fixed supply air temperature control and variable speed fan operation. Confirm proper fan response to changing air requirements as well as proper supply air temperature control.
- Confirm proper zone temperature control and confirm that all zones are receiving proper amounts of outside and ventilation air under all conditions.

Economics

Implementation of this measure will reduce electric energy usage by 55,114.0 kilowatt-hours and reduce natural gas usage by 22,135.8 therms each year. The measure will reduce energy costs by $23,767 each year. The incentive is calculated as $150/kW for peak demand reduction and as $0.15/kWh and $1/therm for annual savings. The implementation costs are $746,563 after incentive, with a simple payback period of 31.4 years. Savings, costs, and incentives are estimates.

Table 26. EEM-13: Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	55,114.0 kWh
Peak Electric Demand Savings	5.95 kW
Annual Natural Gas Savings	22,135.8 therms
Annual Utility Cost Savings	$23,767
Investment Overview (Estimated)	
Project Costs	$777,859
Incentive Available	$31,296
Net Cost to Customer	$746,563
Simple Payback Period With Incentive	31.4 years

Calculation Methodology

Energy savings were estimated using parametric runs in eQUEST. This feature allows comparisons of scenarios by changing only specific parameters for each run (scenario) within the same model. Each run is based on the previous run, in a cascading manner, to account for the interactive effects of the measures. Specifically, these parameters were changed in the parametric run to estimate the savings:

- Change cooling fan control from constant volume to Fan EIR fPLR, the ratio of the energy used by the system to the cooling capacity of the system with a multiplier based on a part-load function.
- Edit flow parameters for overall minimum flow to 0.3 ratio.

- Change cooling fan EIR f(PLR) to "Typical VSD Fan (Jeff Stein's curves)"
  - The curve is based on an ASHRAE white paper by Jeff Stein from Taylor Engineering predicting fan performance using the characteristic curve fan model and intended to provide a more accurate curve than the default eQUEST fan curves.

Measurement & Verification

The proposed measurement and verification method for this measure is to obtain equipment nameplate information, verify that the air handlers are converted to variable volume, and obtain invoices for the implemented measure.

EEM-14: Install Window Film (Bldgs. 2 and 3)

Existing Condition

There are several windows are located throughout buildings 2 and 3 (central and east wings). All windows are from the original construction and are single pane, non-tinted, and metal framed. Single pane windows allow for the rapid transference of radiant heat through the glass—out of the building during winter and into the building during summer. Clear, non-tinted, and non-coated glass has a very high emissivity and solar heat gain.

Building 4 has similar windows; however, due to building orientation and the arrangement of the windows, building 4 does not get much direct sunlight throughout the day.

Figure 49. Building 3 (East Wing) Windows

Proposed Condition

This measure recommends installing window film on windows on all floors of buildings 2 and 3 (central and east wings). Window film reduces radiant heat gain during the summer and provides protection to building occupants and contents from exposure to UV radiation. Standard clear glass does not prevent all incoming UV rays. However, window film on a single-pane, plain-glass window stops up to 99 percent of the UV rays.

Window film reduces excess glare and darkens the windows to cut back on excessive light during regular daylight hours.

Scope of Work

This project involves the following work:

- Select appropriate window film type and size.
- Install window film.

Economics

Implementation of this measure will reduce electric energy usage by 325,897.6 kilowatt-hours and reduce natural gas usage by 26,428.5 therms each year. The measure will reduce energy costs by $62,188 each year. The incentive is calculated as $150/kW for peak demand reduction and as

$0.08/kWh and $1/therm for annual savings. The implementation costs are $16,071 after incentive, with a simple payback period of 0.3 years. Savings, costs, and incentives are estimates.

Table 27. EEM-14: Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	325,897.6 kWh
Peak Electric Demand Savings	59.40 kW
Annual Natural Gas Savings	26,428.5 therms
Annual Utility Cost Savings	$62,188
Investment Overview (Estimated)	
Project Costs	$77,481
Incentive Available	$61,410
Net Cost to Customer	$16,071
Simple Payback Period With Incentive	0.3 years

Calculation Methodology

Energy savings were estimated using parametric runs in eQUEST. This feature allows comparisons of scenarios by changing only specific parameters for each run (scenario) within the same model. Each run is based on the previous run, in a cascading manner, to account for the interactive effects of the measures. Specifically, these parameters were changed in the parametric run to estimate the savings:

- eQUEST glass library performance data
  - Glass Selection 1411 with a U-value (heat transfer rate) of .88 Btu/f^2·h·°F for ASHRAE winter conditions and a solar heat gain coefficient of .25 for ASHRAE summer conditions

Measurement & Verification

The proposed measurement and verification approach for this measure is to confirm quantities using the final invoices and to confirm installed window films on the building windows.

EEM-15: Install an Evaporative Pre-Cooler on the Condensing Unit for Air Handler S-15 (Bldgs. 2 and 3)

Existing Condition

The cafeteria and kitchen area for buildings 2 and 3 (central and east wings) is currently conditioned by air handler S-15. Air handler S-15 uses a 60 ton condensing unit for cooling. During the hottest periods of the summer, it appears the unit lacks sufficient cooling capacity, which results in excessive condensing pressures and temperatures and a loss of cooling capacity.

Facility personnel have employed a makeshift water spray system in order to lower the refrigerant head pressure and provide more cooling capacity. The sprayed water ensures that the condenser will run at a marginally cooler temperature; however, the method will eventually result in degradation or destruction of the condenser coil.

Constant water sprayed on the condensing unit will cause calcium and other minerals in the water to build up on the aluminum coil and will rust the steel casing and structure of the unit. When minerals build on the coil, the result is less airflow, which translates to less efficiency. When a brace in the steel rusts loose, vibrations damage the aluminum coil. The existing condition also results in wasted water and sewage costs.

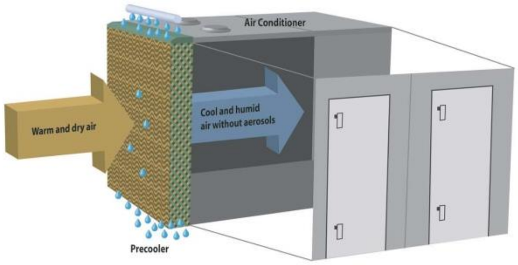
Figure 50. S-15 Condensing Unit With Misters

Proposed Condition

There are a number of approaches to addressing the lack of condenser capacity for air handler S-15. One solution is to replace the existing condensing unit with a larger condenser or with a water-cooled condenser. However, replacing the unit will be costly and probably not cost-effective from an energy perspective.

Another approach is to install an evaporative pre-cooler on the existing unit. This would have a similar affect to spraying the coils, but with better and more predictable performance. Installing an evaporative pre-cooler would also eliminate the detrimental effect of spraying water directly on the coil. The evaporative pre-cooler would be easier to maintain, as well. Willdan recommends this measure over replacing the unit, based on energy economics.

Figure 51: Evaporative Pre-Cooler (Left; energydesignresources.com), Pre-Cooler Installed in Existing Condenser (Right; uschillerservices.com)



Scope of Work

This project involves the following work:

- Size and specify an appropriate evaporative pre-cooler. Identify a good local fabricator or supplier.
- Purchase pre-coolers and install them. Provide new water supply to the system.
- Set up system control to operate pre-coolers during times of higher ambient temperatures, >75°F.
- Confirm proper system operation so that no water carry-over occurs to the coil and that there is a proper water bleed or minerals purge on the system.
- Monitor refrigeration system performance and ensure that cooling and condensing requirements are met.

Economics

Implementation of this measure will reduce electric energy usage by 2,668.8 kilowatt-hours each year. The measure will reduce energy costs by $347 each year. The incentive is calculated as $150/kW for peak demand reduction and as $0.08/kWh and $1/therm for annual savings. The implementation costs are $29,651 after incentive, with a simple payback period of 85.5 years. Savings, costs, and incentives are estimates.

Table 28. EEM-15: Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	2,668.8 kWh
Peak Electric Demand Savings	1.17 kW
Annual Natural Gas Savings	0.0 therms
Annual Utility Cost Savings	$347
Investment Overview (Estimated)	
Project Costs	$30,041
Incentive Available	$390
Net Cost to Customer	$29,651
Simple Payback Period With Incentive	85.5 years

Calculation Methodology

Energy savings were estimated using parametric runs in eQUEST. This feature allows comparisons of scenarios by changing only specific parameters for each run (scenario) within the same model. Each run is based on the previous run, in a cascading manner, to account for the interactive effects of the measures. Specifically, these parameters were changed in the parametric run to estimate the savings:

- S-15 Condenser Cooling Energy Input Ratio (EIR) set to 0.3047, the ratio of the energy used by the system to the cooling capacity of the system.

Measurement & Verification

The proposed measurement and verification method for this measure is to obtain equipment name plate information, verify that the unit is enabled, and obtain invoices for the implemented measure.

EEM-16: Install Bi-Level Lighting in Stairwells (Bldg. 1)

Existing Condition

The stairwells of building 1 (west wing) are currently illuminated by ceiling-mounted 150 W metal halide fixtures. As required by code, these fixtures operate 24/7. Willdan will confirm with the contractor the lamp type and wattage.

Proposed Condition

This measure recommends replacing the existing fixtures with bi-level controlled LED fixtures. In addition to consuming less energy, LED fixtures have a longer-rated life (typically 50,000+ hours) and better lumen maintenance. Maintenance cost savings are a significant benefit but are not estimated.

Bi-level fixture controls use an occupancy sensor with passive infrared technology to detect motion in the sensor's coverage area, dimming light levels when the area is unoccupied and returning to full output when occupancy is detected.

Note: Incentives are available for eligible LED fixtures only. To confirm eligibility, see the current Qualified Products List on the DesignLights Consortium website, https://www.designlights.org/QPL, or Table of Pre-Qualified LED Fixtures/Luminaires on the PG&E website, http://www.pge.com/led.

Scope of Work

This project involves the following work:

- Perform design engineering and determine lighting fixture specifications.
- Procure and install the new lighting fixtures.
- Remove and discard the previous fixtures.

Economics

Implementation of this measure will reduce electric energy usage by 22,150.9 kilowatt-hours each year. The measure will reduce energy costs by $2,880 each year. The incentive is calculated as $150/kW for peak demand reduction and as $0.08/kWh and $1/therm for annual savings. The implementation costs are $2,157 after incentive, with a simple payback period of 0.7 years. Savings, costs, and incentives are estimates.

Table 29. EEM-16: Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	22,150.9 kWh
Peak Electric Demand Savings	5.81 kW
Annual Natural Gas Savings	0.0 therms
Annual Utility Cost Savings	$2,880
Investment Overview (Estimated)	
Project Costs	$4,800
Incentive Available	$2,643
Net Cost to Customer	$2,157
Simple Payback Period With Incentive	0.7 years

Calculation Methodology

This measure uses engineering calculations to estimate the energy savings. The existing fixture wattage is from the Table of Standard Fixture Wattages in the *Statewide Customized Offering Procedures Manual for Business*. The proposed fixture wattage is from a lighting manufacturer's table of standard LED equivalents. The actual wattage and quantity of installed fixtures will be used to make the final incentive calculation.

The baseline energy use for existing fixtures, as well as the installed energy use for all proposed fixtures, was calculated on the basis of 8,760 operating hours per year (continuous operation). The reduction in operating time due to the occupancy sensor came from the DEER Database.

Measurement & Verification

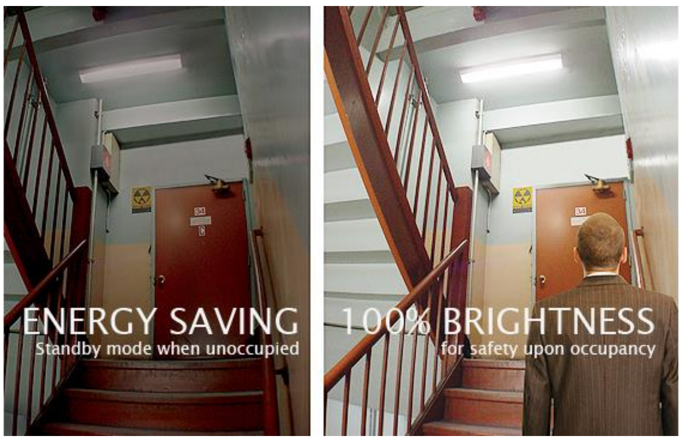
The proposed measurement and verification approach for this measure is to confirm fixture quantities using the final invoices and to confirm installed controls during a post-installation site visit.

EEM-17: Install Bi-Level Lighting in Stairwells (Bldgs. 2 and 3)

Existing Condition

The stairwells of the facility towers are currently illuminated by wall-mounted linear fluorescent fixtures featuring two first-generation, 700 series T8 lamps and electronic ballasts. As required by code, these fixtures operate 24/7. Willdan will confirm with the contractor the lamp type and wattage.

Figure 52. Occu-Smart Lighting Example



Proposed Condition

This measure recommends retrofitting the existing fixtures to operate as bi-level fixtures, using passive infrared occupancy sensors to detect stairwell occupancy.

When the stairwell is unoccupied, the fixture will operate a 3 W cold cathode lamp, which exceeds the Uniform Building Code requirement of one foot-candle of light in stairwells when any part of the building is occupied. When the sensor detects movement, the fixture will increase light levels by switching on its T8 linear fluorescent lamp.

To maximize the energy savings, Willdan recommends a 25 W T8 lamp. However, if higher light levels are required, 28 W or 32 W T8 lamps will result in similar energy savings.

Willdan also recommends program-start ballasts bi-level stairwell fixtures based on the frequent on/off operation. Program-start ballasts go through a soft-start sequence that gently starts the lamp without thermal shock. Lamps on program-start ballasts withstand 50,000 to 100,000 on/off cycles before burning out.

By contrast, instant-start ballasts, which are frequently used with linear fluorescent lamps, provide full voltage and current instantly to the lamp cathodes. This creates a thermal shock to the cathodes that will degrade the cathode and may cause the lamp to fail prematurely. As a result, lamps on instant-start ballasts will withstand only about 12,000 to 15,000 on/off cycles before burning out. Given this drastic difference in lamp life between the two ballasts, Willdan highly recommends program-start ballast specification for lamps turned on and off more than six times a day.

Scope of Work

This project involves the following work:

- Perform design engineering and determine lighting fixture specifications.
- Procure and install the new lighting fixtures.
- Remove and discard the previous fixtures.

Economics

Implementation of this measure will reduce electric energy usage by 8,216.9 kilowatt-hours each year. The measure will reduce energy costs by $1,068 each year. The incentive is calculated as $150/kW for peak demand reduction and as $0.08/kWh and $1/therm for annual savings. The implementation costs are $2,755 after incentive, with a simple payback period of 2.6 years. Savings, costs, and incentives are estimates.

Table 30. EEM-17: Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	8,216.9 kWh
Peak Electric Demand Savings	2.25 kW
Annual Natural Gas Savings	0.0 therms
Annual Utility Cost Savings	$1,068
Investment Overview (Estimated)	
Project Costs	$3,750
Incentive Available	$995
Net Cost to Customer	$2,755
Simple Payback Period With Incentive	2.6 years

Calculation Methodology

This measure uses engineering calculations to estimate the energy savings. The existing fixture wattage is from the Table of Standard Fixture Wattages in the *Statewide Customized Offering Procedures Manual for Business*. The proposed fixture wattage came from the manufacturer's specification sheet in appendix D (see "Blinky T-8 Replacement Fixtures"). The actual wattage and quantity of installed fixtures will be used to make the final incentive calculation.

The baseline energy use for existing fixtures, as well as the installed energy use for all proposed fixtures, was calculated on the basis of 8,760 operating hours per year (continuous operation). The reduction in operating time due to the occupancy sensor came from the DEER Database.

Measurement & Verification

The proposed measurement and verification approach for this measure is to confirm fixture quantities using the final invoices and to confirm installed controls during post-installation site visits.

EEM-18: Partially De-Lamp Fixtures and Install Lighting Controls for Library and Medical Records (Bldg. 4)

Existing Condition

The Library and Medical Records Rooms located in building 4 (behavioral health) are illuminated by ceiling-mounted linear fluorescent fixtures featuring four first-generation, 700 series T8 lamps and electronic ballasts. Lighting measurements taken during the site survey were averaging 850 lux. IES illuminance recommendations for this area type fall between 300 lux and 500 lux. Lighting control is simple light switches that rely on occupants to turn lights off when not in use.

Proposed Condition

This measure recommends de-lamping half of the existing fixtures and replacing the remaining fixtures with third generation, 800 series T8 linear fluorescent lamps with high efficiency ballasts.

De-lamping the fixtures reduces the overall energy consumption for lighting by fifty percent while still maintaining adequate lighting power density. In addition to consuming less energy, the third generation T8 fixtures have a significantly longer-rated life (40,000+ hours) compared to the first generation counterparts (20,000 hours).

This measure also recommends installing passive occupancy sensors to control the lights in these spaces.

Installing an occupancy sensor to control lighting reduces the "on" time of these lights. Sensors turn the lights on when they sense someone entering a room or area, and then turn the lights off some time after sensing the room is empty.

Sensors are best deployed in spaces with many lamps that are used infrequently or unpredictably, such as conference rooms, private offices, storage areas, and restrooms. Sensors can be wall- or ceiling-mounted, based on the size and shape of the room.

Note: Incentives are available for eligible LED fixtures only. To confirm eligibility, see the current Qualified Products List on the DesignLights Consortium website, https://www.designlights.org/QPL, or Table of Pre-Qualified LED Fixtures/Luminaires on the PG&E website, http://www.pge.com/led.

Figure 53. Medical Records Lighting

Scope of Work

This project involves the following work:

- De-lamp half of the existing fixtures for each area.
- Identify occupancy sensor locations for each area.
- Install occupancy sensors.

- Adjust occupancy sensor "on" time and sensitivity depending on the area's general activity type.

Economics

Implementation of this measure will reduce electric energy usage by 19,146.4 kilowatt-hours each year. The measure will reduce energy costs by $2,489 each year. The incentive is calculated as $150/kW for peak demand reduction and as $0.08/kWh and $1/therm for annual savings. The implementation costs are $5,722 after incentive, with a simple payback period of 2.3 years. Savings, costs, and incentives are estimates.

Table 31. EEM-18: Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	19,146.4 kWh
Peak Electric Demand Savings	3.64 kW
Annual Natural Gas Savings	0.0 therms
Annual Utility Cost Savings	$2,489
Investment Overview (Estimated)	
Project Costs	$7,800
Incentive Available	$2,078
Net Cost to Customer	$5,722
Simple Payback Period With Incentive	2.3 years

Calculation Methodology

This measure uses engineering calculations to estimate the energy savings. The existing and proposed fixture wattages are from the Table of Standard Fixture Wattages in the *Statewide Customized Offering Procedures Manual for Business*. The actual wattage and quantity of installed fixtures will be used to make the final incentive calculation.

The baseline energy use for existing fixtures was calculated on the basis of 5,260 operating hours per year (DEER Annual Operating Hours). The reduction in operating time due to the occupancy sensor came from the DEER Database.

Measurement & Verification

The proposed measurement and verification approach for this measure is to confirm fixture quantities using the final invoices and to confirm installed controls during post-installation site visits.

EEM-19: Install LED Parking Lot Lighting

Existing Condition

The lower floor of the parking structure is illuminated by 61 ceiling-mounted first-generation, 700 series T8 fluorescent fixtures. The top level of the parking structure is illuminated by five pole-mounted 175 W metal halide fixtures. The surrounding parking lot is illuminated by eight pole-mounted 150 W high pressure sodium fixtures. Willdan will confirm with the contractor lamp type and wattage.

Figure 54. Parking Lot Lights (Clockwise From Top: Linear, Post-Top, and Shoebox Fixtures)

Proposed Condition

This measure recommends a 3 to 1 fixture replacement ratio of the ceiling-mounted T8 fixtures and installing third generation, 800 series T8 lamps with high efficiency ballasts.

This measure also recommends replacing the existing pole-mounted fixtures with bi-level controlled LED fixtures. In addition to consuming less energy, LED fixtures have a longer-rated life (typically 50,000+ hours) and better lumen maintenance. Maintenance cost savings are a significant benefit of this measure but are not estimated for this report.

Bi-level fixture controls use an occupancy sensor with passive infrared technology to detect motion in the sensor's coverage area, dimming light levels when the area is unoccupied and returning to full output when occupancy is detected. Bi-level controls also increase safety and security because, as individual fixtures change light levels between high and low, both drivers and pedestrians are alerted to other (possibly unseen) parking lot occupants.

Note: Incentives are available for eligible LED fixtures only. To confirm eligibility, see the current Qualified Products List on the DesignLights Consortium website, https://www.designlights.org/QPL, or Table of Pre-Qualified LED Fixtures/Luminaires on the PG&E website, http://www.pge.com/led.

Scope of Work

This project involves the following work:

- Perform design engineering and determine lighting fixture specifications.
- Procure and install new lighting fixtures.
- Remove and discard the previous fixtures.

Economics

Implementation of this measure will reduce electric energy usage by 17,195.6 kilowatt-hours each year. The measure will reduce energy costs by $2,235 each year. The incentive is calculated as $0.08/kWh and $1/therm for annual savings. The implementation costs are $14,754 after incentive, with a simple payback period of 6.6 years. Savings, costs, and incentives are estimates.

Table 32. EEM-19: Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	17,195.6 kWh
Peak Electric Demand Savings	0.00 kW
Annual Natural Gas Savings	0.0 therms
Annual Utility Cost Savings	$2,235
Investment Overview (Estimated)	
Project Costs	$16,130
Incentive Available	$1,376
Net Cost to Customer	$14,754
Simple Payback Period With Incentive	6.6 years

Calculation Methodology

This measure uses engineering calculations to estimate the energy savings. The existing fixture wattage is from the Table of Standard Fixture Wattages in the *Statewide Customized Offering Procedures Manual for Business*. The proposed fixture wattage is from a lighting manufacturer's table of standard LED equivalents and from the manufacturer's specification sheets in appendix D (see "Cree WS4 4' LED Wet Location Linear" and "Neptun Light LED Post-Top Acorn Fixtures"). The actual wattage and quantity of installed fixtures will be used to make the final incentive calculation.

The baseline energy use for existing fixtures, as well as the installed energy use for all proposed fixtures, was calculated on the basis of DEER Annual Operating Hours. The reduction in operating time due to the occupancy sensor came from the DEER Database.

Measurement & Verification

The proposed measurement and verification approach for this measure is to confirm fixture quantities using the final invoices and to confirm installed controls during post-installation site visits.

EEM-20: Install Heat Pumps on Backup Generator Heat Pumps (Bldg. 1)

Existing Condition

The facility is equipped with two backup electrical generators. The generators are critical to operations, because they provide immediate backup electrical power to emergency circuits in the event of a power loss from the utility system. Reliable startup of an emergency generator is critically important, which requires that the engine block be heated at all times, even during the coolest outside conditions.

To keep the engine up to temperature at all times, each backup generator has an electric resistance block heater. The block heater is rated at 9,000 watts.

Figure 55. Generator Block Heater

Proposed Condition

This measure recommends using air-source heat pumps for most of the heating, moving ambient air heat using a refrigerant and transferring it to the engine oil via a coaxial heat exchanger. A small circulating pump (100 W) maintains a relatively uniform engine block temperature. Air-source heat pumps have a coefficient of performance (COP) of about 4.2, compared with the electric resistance heater COP of 1.0. For further product information, see the manufacturer's specification sheet in appendix D (see "Geo-Thermal Systems Heat Pump").

An air-source heat pump uses less energy and operates fewer hours. On a typical backup generator, an air-source heat pump can use 75 percent less electric energy than a resistance immersion heater, according to an analysis done for Southern California Edison in 2009.

An air-source heat pump is sufficient when air temperature is above 40°F. The existing electrical resistance heater should remain to provide heating below 40°F and to supply additional system redundancy.

Scope of Work

This project involves the following work:

- Procure and install the heat pumps at each generator. Identify a location for each heat pump unit and coordinate space allocation and structural layout, if necessary.
- Replace and salvage the existing electric heaters.

- Connect the new heat pump control module with the existing generator control system. Verify proper power, refrigerant, and associated connections.
- Configure and tune the generator and heat pump per manufacturer's specifications.
- Start up and commission the heat pump block heaters.

Economics

Implementation of this measure will reduce electric energy usage by 119,611.3 kilowatt-hours each year. The measure will reduce energy costs by $15,549 each year. The incentive is calculated as $150/kW for peak demand reduction and as $0.08/kWh and $1/therm for annual savings. The implementation costs are $3,431 after incentive, with a simple payback period of 0.2 years. Savings, costs, and incentives are estimates.

Table 33. EEM-20: Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	119,611.3 kWh
Peak Electric Demand Savings	13.33 kW
Annual Natural Gas Savings	0.0 therms
Annual Utility Cost Savings	$15,549
Investment Overview (Estimated)	
Project Costs	$15,000
Incentive Available	$11,569
Net Cost to Customer	$3,431
Simple Payback Period With Incentive	0.2 years

Calculation Methodology

This measure uses engineering calculations to estimate energy savings. The engineering calculations use a calculation methodology referred to as bin calculations. Bin calculations use hourly weather data to determine the average number of hours during a year for a particular weather condition. Willdan obtained existing equipment information from nameplate data and observed on-site conditions.

Because the generators are located in outdoor enclosures, or in a non-conditioned space, the calculation accounts for outdoor-temperature impact on heat-pump efficiency. Key inputs to the calculation are:

- Hourly weather data for site's specific Climate Zone
- Electric resistance block heater wattage: 9,000 W
- Baseline electric resistance COP of 1.0
- Proposed heat pump COP of 4.2

Measurement & Verification

The proposed measurement and verification approach for this measure is to confirm installation during post-installation site visits.

EEM-21: Replace Air Handler S-21 With a New Air Handler With a Variable Speed Drive on the Supply Fan (Bldg. 3)

Note: Willdan recommended this measure in a preliminary report on April 11, 2014.

Existing Conditions

The fifth floor medical unit in building 3 (east wing) is served by a variable-air-volume system with terminal reheat. As a variable-air-volume system, the existing terminal box in each patient room has a modulation damper to control the airflow. The terminal boxes receive supply air from air handler S-21. However, the air handler's supply fan is not equipped a variable speed drive to operate the fan motor more efficiently.

Each patient room is equipped with its own thermostat. Conditioned air is delivered to the patient rooms via terminal reheat boxes that heat the conditioned air based on the room thermostat set point. The medical unit operates 24/7; however, the occupancy of each patient room can vary. The existing operation of air handler S-21 causes excess energy usage during part-load conditions, when it is unnecessary to operate the supply fan at full speed.

Figure 56. Air Handler S-21

Proposed Conditions

This measure recommends installing a new, high efficiency air handler with a variable speed drive on the supply fan.

Energy usage for reheating conditioned air will be reduced using the existing modulation dampers to control the airflow. Controlling the airflow in effect modulates the duct static pressure. Fan energy usage will be reduced, because the fan speed can be modulated to maintain a duct static pressure set point. The air handler's hot water and chilled water valves will be modulated by the control system to maintain 55°F supply air.

Scope of Work

This project involves the following work:

- Obtain the proposed equipment prior to the demolition of the existing equipment (due to the critical nature of this equipment). All work shall be scheduled in a manner not to cause any unauthorized shutdown or disruption of normal operations.

- Measure and record the existing airflow at the duct location furthest away from the air handling unit. Ensure that this airflow rate is maintained throughout the construction process.
- Install the new unit opposite to the supply air drop on the roof, per OSHPD and fire requirements.
- Connect the new unit's coils to the chilled water and hot water systems.
- Install wiring and connect the new unit to the electrical system.
- Set up, test, and commission the new unit's operating controls, supplying the owner with a written control sequence.
- Connect the new system to the supply air drop on the roof, and disconnect and remove the old system.
- Patch and seal all remaining penetrations on the roofing.
- Ensure that air balance requirements are maintained.

Economics

Implementation of this measure will reduce electric energy usage by 25,702.0 kilowatt-hours and reduce natural gas usage by 1,924.0 therms each year. The measure will reduce energy costs by $4,784 each year. The incentive is calculated as $150 for peak demand reduction and as $0.15/kWh and $1/therm for annual savings. The implementation costs are $28,414 after incentive, with a simple payback period of 5.9 years. Savings, costs, and incentives are estimates.

Table 34. EEM-21: Energy Savings and Cost Overview

Annual Savings Summary (Estimated)	
Annual Electric Energy Savings	25,702.0 kWh
Peak Electric Demand Savings	2.70 kW
Annual Natural Gas Savings	1,924.0 therms
Annual Utility Cost Savings	**$4,784**
Investment Overview (Estimated)	
Project Costs	$34,463
Incentive Available	$6,049
Net Cost to Customer	**$28,414**
Simple Payback Period With Incentive	**5.9 years**

Calculation Methodology

For the preliminary report on April 11, 2014, the energy savings were estimated with the Statewide Customized Calculation Tool (CCT). The energy savings will be recalculated with the eQUEST model after installation to determine the final incentive.

Measurement and Verification

The proposed measurement and verification method for this measure is to inspect the installed equipment, photograph the equipment nameplate, verify that the equipment is connected to the building management system, and obtain invoices for the implemented measure.

5.2 Measures Recommended for Future Consideration

Willdan identified additional measures that were not evaluated in this Detailed Energy Assessment Report. Either utility incentives are not available for these measures, or some information required to quantify potential energy savings was not available. These measures are included as recommendations (Rec) instead of energy efficiency measures (EEM).

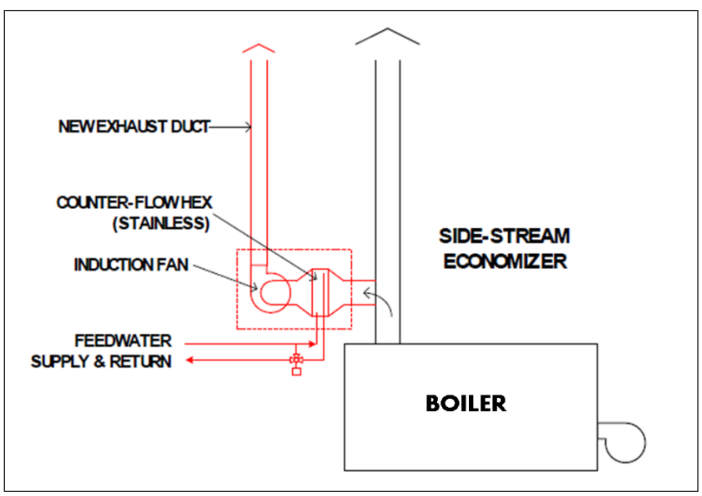
Rec 1: Install Boiler Side-Stream Economizer for Low Pressure Boilers (Bldg. 1)

Building 1 (west wing) heating requirements are currently served by two low-pressure steam boilers. Under normal operations, one operating boiler is sufficient to meet steam demands in the facility while the second boiler is kept in a hot stand-by mode. Steam from the low-pressure boilers is used in the facility for domestic hot water heating and space heating. Neither boiler is currently equipped with an economizer. Although flue gas exiting the boilers may range from 340 °F to 420 °F, there is no effort currently to recover boiler waste heat.

This recommendation proposes the installation of a two-stage flue gas economizer to pre-heat both the boiler feed water (feed water pre-heater) and/or domestic hot water. The proposed system would be a “side-stream” system, located completely separate from the existing boiler stack. The unit would use a variable-speed induction fan to draw flue gas from the main boiler stack across two new finned-coil heat exchangers intended to preheat boiler feed water and domestic hot water.

The new heat recovery system would operate independently from the existing boiler controls and would not affect normal boiler operation. By recovering heat from the boiler flue gas, boiler efficiency would dramatically improve and steam and natural gas consumption would be dramatically reduced. The figure illustrates the concept.

Figure 57. Side-Stream Economizer Diagram



Rec 2: Install Boiler Side-Stream Economizer for Central-East Boilers (Bldgs. 2 and 3)

Rec 1 (above) can also be applied to buildings 2 and 3 (central and east wings). This recommendation proposes the installation of a two-stage flue gas economizer to pre-heat both the boiler feed water (feed water pre-heater) and/or domestic hot water. The proposed system would be a “side-stream” system, located completely separate from the existing boiler stack.

Rec 3: Install Boiler Side-Stream Economizer for Boilers (Bldg. 4)

Rec 1 (above) can be applied to building 4 (behavioral health). This recommendation proposes the installation of a two-stage flue gas economizer to heat the domestic hot water. The proposed system would be a "side-stream" system, located completely separate from the existing boiler stack. It is possible that the entire domestic hot water load can be supplied by this system due to the light occupancy loads of Building 4.

Rec 4: Install Variable Speed Drives on Heating Hot Water Pumps (Bldgs. 2 and 3)

In buildings 2 and 3 (central and east wings), hot water for space heating is currently circulated by two heating hot water pumps in a constant flow, primary-only pumping configuration. The heating hot water is circulated through the distribution piping and to air-handlers and fan coils that provide space heating.

In the current configuration, three-way control valves located at air handlers control the flow of hot water through the heating coils, bypassing the remainder of the water around the coils. Using three-way control valves, the system is constant flow.

This recommendation proposes converting the hot water distribution system to variable flow. As with the variable flow chilled water system conversion described in other measures, the conversion requires two basic system changes: conversion of hot-water control valves (at air-handlers) from three-way to two-way control, and installation of VSDs on the heating hot water pumps to control system differential pressure.

Instead of three-way control valves with bypasses, two-way control valves should be used at air handlers to vary flow through the heating coils without bypassing hot-water around the coil. This can be achieved by either replacing the existing three-way valves with a two-way control valves, or by simply closing the bypasses on existing three-way valves so they operate as two-way control valves.

With two-way control valves in place on air handlers and heating coils, the distribution system becomes variable flow. It is important to then equip the heating hot water pumps with VSDs. The VSDs are then modulated to control the pressure differential across the distribution system, allowing the pumps to operate efficiently. By converting the system to variable flow and modulating pump speed, substantial pumping energy is saved.

Rec 5: Repair or Replace Steam Traps (Bldgs. 2 and 3)

Buildings 2 and 3 (central and east wings) currently operate boilers that generate steam up to 100 PSIG for various direct-end uses, as well as multiple steam-to-hot-water heat exchangers. The steam generated at the central plant is distributed to various areas of the facility through steam lines that deliver steam to heat exchangers. As the heat energy contained in the steam is transferred to its end use through heat exchangers or is lost through piping, condensate forms and collects within the steam lines and heat exchangers.

To prevent the free flow of steam through the system, to separate steam from condensate, and to assist with returning condensate back to the boilers, the steam system uses approximately 30 steam traps located throughout the facility. When operating correctly, the steam traps allow condensate to pass through the trap while preventing steam from passing through the trap. Condensate collects in the condensate-return tanks and is pumped back to the central plant deaerator tank before being pumped back to the boilers.

Currently, as reported by maintenance staff, as many as ten steam traps are leaking to some extent. Leaking steam traps result in free steam flow through the system where it is eventually vented to atmosphere. The loss of steam represents a high energy loss to the system and greater natural gas consumption.

This recommendation proposes that a detailed steam trap survey and study be conducted and that all of the leaking steam traps be either repaired or replaced. Repairing or replacing the leaking steam traps will reduce steam loss and boiler natural gas consumption.

6. Environmental Benefits

Assembly Bill 32 (AB 32), the California Global Warming Solutions Act of 2006, mandates that California reduce its greenhouse gas emissions to 1990 levels by 2020. Additionally, Senate Bill 1368, also signed in 2006, requires the Public Utilities Commission and the Energy Commission to limit emissions resulting from electrical energy generation to 1,100 pounds of carbon dioxide (CO_2) per megawatt-hour of delivered energy. In order to comply with these laws, mitigate climate change, and protect air quality and public health, PG&E implemented energy efficiency programs such as the Healthcare Energy Efficiency Program. This project, the energy saved through its implementation, and the incentives recovered are a direct result of that commitment to improve environmental quality and reduce greenhouse gas emissions.

Reducing energy usage decreases the need for energy production, and greenhouse gas emissions are reduced as a result. To illustrate this reduction, this report estimates annual CO_2 emissions reductions in terms of both pounds of avoided CO_2 and the equivalent number of passenger vehicles removed from the road. Table 35 lists the calculated environmental benefits specific to this project.

Table 35. Calculated Environmental Benefits

Annual Electric Energy Savings (kWh)	Annual Natural Gas Savings (therms)	Annual Equivalent CO_2 Reduction (pounds)	Annual Equivalent Passenger Vehicles Removed
1,412,796.2	100,759.8	2,095,121	198

Notes: PG&E's Carbon Footprint Calculator uses embedded assumptions to estimate CO_2 emissions reductions resulting from energy efficiency projects. The calculator uses a conversion factor of 0.524 pounds of CO_2 per kWh and 13.446 pounds of CO_2 per therm. The U.S. Environmental Protection Agency's Green Power Partnership estimates passenger vehicle CO_2 emissions, using a factor of 4.8 metric tons of CO_2 per passenger vehicle per year. The most accurate measure of emissions from power generation entails calculating the emissions from each plant operating in the portfolio of generating assets for each hour of the day and year—which can vary considerably by time of day, by year, and with seasonal variations in weather. To avoid this complex approach, it is common to approximate emissions from electric usage through an average such as PG&E's Carbon Footprint Calculator assumptions, an approach that is approved by the California Public Utilities Commission (CPUC). This reasonable approximation is based on the average emissions rate for PG&E's electric portfolio, consistent with the emissions rate independently certified and registered each year between 2001 and 2010 with the California Climate Action Registry (CCAR), www.climateregistry.org, and now with The Climate Registry (TCR), www.theclimateregistry.org.

7. Disclaimer

The intent of this Detailed Energy Assessment Report is to estimate energy savings associated with recommended upgrades to the HVAC, lighting, and refrigeration systems at your facility. Sufficient detail is included in this report to support decisions about implementing energy efficiency measures at the facility. However, this report is not intended to serve as a detailed engineering design document. The improvement descriptions are diagrammatic in nature only, in order to (a) document the basis of cost estimates and savings and (b) demonstrate the feasibility of constructing the improvements. Detailed design efforts may be required to implement several of the improvements evaluated as part of this energy analysis. As appropriate, costs for those design efforts are included as part of the cost estimate for each measure.

While the recommendations in this report have been reviewed for technical accuracy and we believe them to be reasonable and accurate, the findings are estimates, and actual results may differ. As a result, PG&E and Willdan are not liable if projected estimated savings or economies are not actually achieved. All savings and cost estimates in the report are for information purposes and are not to be construed either as design documents or as guarantees.

The incentive is calculated based on the estimated energy savings and estimated total project cost. The total project cost shown includes analysis, design, engineering, construction, materials, permits, fees, overhead, and labor. The total incentive available cannot exceed 50 percent of the total project cost.

In no event will PG&E or Willdan be liable for the failure of the customer to achieve a specified amount of energy savings, for the operation of customer's facilities, or for any incidental or consequential damages of any kind arising in connection with this report or from the installation of recommended measures.

8. Appendices

8.1 Appendix A: Program Overview

8.2 Appendix B: On-Bill Financing Fact Sheet

8.3 Appendix C: eQUEST Calibration Summary

8.4 Appendix D: Specification Sheets

8.1 Appendix A: Program Overview

8.1.1 Program Overview

PG&E's Healthcare Energy Efficiency Program (HEEP) supports qualifying customers with financial incentives for energy-saving projects and measures.

HEEP provides healthcare facilities with a wide range of support services, including energy assessments, engineering analysis, project implementation oversight, financial incentives, and retrocommissioning assistance. These services are designed to address the many barriers to energy efficiency and savings that exist in this continuously evolving market. The program targets healthcare facilities receiving electric and (or) gas service from PG&E, including medical office buildings, skilled nursing facilities, acute care hospitals, and other ancillary building types.

Through PG&E and Willdan as a third party, HEEP offers cash incentives for the implementation of eligible energy-saving measures either by retrofitting existing equipment or by installing new energy-efficient equipment. Incentives are based on the amount of energy saved; savings calculations are completed within the requirements accepted by PG&E and the California Public Utilities Commission (CPUC).

8.1.2 Program Incentive Rates

HEEP offers financial incentives for energy efficiency projects based on the calculated peak demand savings (kW), electric energy savings (kWh), and natural gas savings (therms). All incentives are limited to 50 percent of the total project costs. The incentive rates are based on the applicable measure category, as listed in the HEEP Incentive Rate Structure provided. Financial incentives are available on a first-come, first-served basis until allocated funds are depleted.

Table 36. HEEP Incentive Rate Structure

Measure Category	Annual Energy Savings Incentive Rate	DEER[1] Peak Demand Reduction Incentive Rate
Standard Lighting: Fluorescent, metal halide or other lighting installations and lighting controls	$0.03 per kWh saved	$100 per kW
Targeted Lighting: LED retrofits and advanced controls	$0.08 per kWh saved	$100 per kW
Other Equipment: Air compressors, BMS controls, motors, process and other specialized equipment	$0.08 per kWh saved	$100 per kW
Air Conditioning and Refrigeration (AC&R): Chillers, cooling towers, refrigeration systems, packaged units greater than 63.3 tons	$0.15 per kWh saved	$100 per kW
Retrocommissioning (RCx): An in-depth investigation that identifies specific operations and maintenance (O&M) improvements to HVAC mechanical equipment, lighting, refrigeration, and related controls	Custom incentive up to $0.08 per kWh saved	$100 per kW
Natural Gas	$1.00 per therm	

[1] Database for Energy Efficiency Resources

8.1.3 Program Milestones and Deadlines

For the purposes of customer participation, HEEP runs from January 1, 2013, through December 15, 2014.

Table 37. HEEP Milestones and Deadlines

Milestone	Deadline
Program participation agreement executed	October 1, 2014
Project installation completed	November 1, 2014
Project inspection completed	November 15, 2014
Incentive payment issued	December 15, 2014

8.1.4 On-Bill Financing (OBF)

Customers participating in HEEP are eligible for on-bill financing, or OBF, a program that provides qualified PG&E customers with interest-free loans to make energy-saving facility improvements. The loans are repaid through the customer's monthly PG&E bills. Business customers may qualify for loans of $5,000–$100,000, with loan periods up to 60 months. Loans must be used to purchase and install qualifying energy-efficient equipment. Details regarding OBF can be found in appendix B.

8.1.5 Demand Response (DR)

PG&E's DR programs are designed to enable customers to contribute to energy load reduction during times of peak demand. The programs offer incentives for businesses that volunteer to participate by reducing electricity use temporarily when demand could outpace supply. Demand response strategies for healthcare facilities may include:

Hospitals

- Turn off all nonessential indoor/outdoor lighting, signage, window displays, and office equipment not in use (e.g., printers, copiers, shredders, coffee makers)
- Turn off all decorative features, such as fountains, lighting, and ambient audio and video displays
- Turn off beverage vending machines and shift use of ice makers to before or after a DR event
- Reduce use of nonessential testing and diagnostic equipment
- Reduce lighting and air conditioning in back office areas

Medical Office Buildings/Elder Care Facilities

In addition to strategies listed previously, strategies include:

- Turn off excess elevator banks and escalators (as permitted).
- Reduce nonessential testing and diagnostic equipment use.
- Conduct dishwashing, housekeeping, waste processing, and laundry activities before or after a DR event.
- Turn off nonessential food preparation equipment not in use.

- Where feasible, pre-cool work areas and then cycle constant-air-volume heating, ventilation, and air-conditioning (HVAC) units, temporarily reset static pressure in variable-air-volume HVAC, turn off ceiling fans and room fans, and raise temperature settings.
- Conduct meetings during DR events to minimize equipment use.
- Some facilities with package AC units can do load cycling, temperature reset, and possibly pre-cooling.
- Charge batteries and battery-operated equipment prior to a DR event, then unplug battery chargers and use only pre-charged equipment during a DR event.
- Adjust employee schedules and shifts so that increased production or energy use occur before or after planned DR events.

To further explore DR potential, customers should contact their PG&E account representative. Using this report as a starting point, the account representative will be able to identify a DR solution that best fits customer needs.

8.2 Appendix B: On-Bill Financing Fact Sheet (beginning next page)

Pacific Gas & Electric Company

Energy Efficiency Retrofit Loan Program
On-Bill Financing

No-interest financing for business customers and government agencies

Do you want to make facilities improvements that will save you energy and money? Do you have projects in mind, but need to avoid large outlays of cash, and high-interest costs? The Energy Efficiency Retrofit Loan Program, also known as On-Bill Financing (OBF), helps eligible customers pay for energy-efficient retrofit projects with no-interest loans that are repaid through their monthly PG&E bills.

What kinds of projects are eligible?

Financing is available to fund many technologies, including lighting, refrigeration, HVAC, and LED street light projects. To qualify, a project's estimated monthly energy cost savings must be sufficient to repay the loan within the maximum loan term limits.

The project must qualify for a rebate or incentive through a PG&E program, including the Customized Incentive Program (CIP), certain PG&E third-party programs, the LED Street Light Program and many Energy Efficiency Rebates for Business.

You may install the equipment yourself or hire a contractor to perform the work. PG&E will need to inspect the site before you remove old equipment, and will perform another inspection upon project completion.

How much can my business or agency borrow?

Business customers may qualify for loans between $5,000 and $100,000, with loan periods up to 60 months. Government agencies may qualify for loans between $5,000 and $250,000 per PG&E meter, with loan periods up to 120 months. Loan funds must be used to purchase and install qualifying energy-efficient equipment.

How is the loan term calculated?

To qualify for financing through the Energy Efficiency Retrofit Loan Program, a project's estimated energy savings must be sufficient to repay the loan during the maximum allowable payment term. The monthly payment is calculated based on estimated monthly energy savings.

For example:

Project cost	$100,000
Energy efficiency rebates and/or incentives	$25,000
Loan amount (remaining costs to be funded)	$75,000
Estimated monthly energy savings from retrofit	$3,000
Monthly loan installment billed on your utility bill	$3,000
Simple payback period (loan amount divided by monthly payment amount)	25 months

The loan terms for the customer in this example would be $3,000 per month for 25 months.

If you close your PG&E account before your loan term ends—for example, if your business closes or you move to a new location—you must pay off your loan balance when you settle your final bill.

Does my business or agency qualify?

Before beginning your retrofit project, contact your PG&E Account Representative to make sure that your energy efficiency upgrades qualify for On-Bill Financing. To be eligible, customers must have a PG&E account that has been continuously active for the past 24 months and has been in good standing for the past 12 months. Business customers are also subject to a commercial credit review.

Next Steps

Visit the OBF program Web site at www.pge.com/obf to review program details and a list of energy efficiency rebate and incentive programs that qualify for financing through the Energy Efficiency Retrofit Loan Program. You may also contact your PG&E Account Representative or call the PG&E Business Customer Service Center at 1-800-468-4743 for assistance.

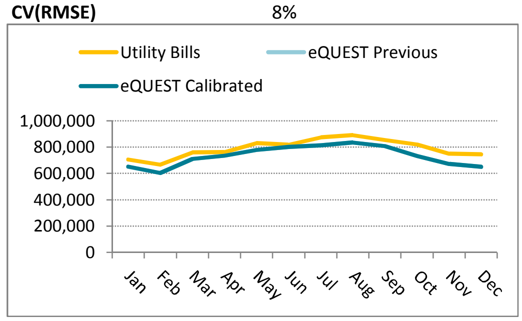
On-Bill Financing is provided to eligible PG&E customers on a first-come, first-served basis until program funds are no longer available. These offerings are funded by California utility customers and administered by PG&E under the auspices of the California Public Utilities Commission.
PG&E prints its materials with soy-based inks on recycled paper. September 2011 CTM-0811-1065

8.3 Appendix C: eQUEST Calibration Summary (beginning next page)

Monthly Electric Energy Usage (kWh) Calibration

Month	Utility Bills	eQUEST	Error	Error %
Jan	705,464	651,011	-54,453	-8%
Feb	667,758	602,746	-65,012	-10%
Mar	759,481	711,425	-48,056	-6%
Apr	761,859	734,831	-27,028	-4%
May	829,192	779,248	-49,944	-6%
Jun	817,704	800,759	-16,945	-2%
Jul	873,843	812,842	-61,001	-7%
Aug	889,286	834,524	-54,762	-6%
Sep	853,155	807,979	-45,176	-5%
Oct	821,064	733,514	-87,550	-11%
Nov	749,576	672,668	-76,908	-10%
Dec	744,515	648,783	-95,732	-13%
Total	**9,472,897**	**8,790,330**	**-682,567**	**-7%**

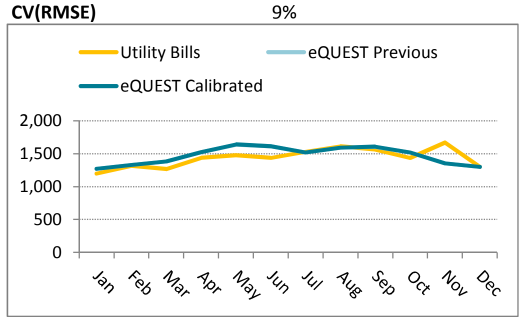
Annual Error	-7%
Max Monthly Error	13%
Min. Monthly Error	2%
CV(RMSE)	8%



Monthly Electric Demand (kW) Calibration

Month	Utility Bills	eQUEST	Error	Error %
Jan	1,196	1,272	76	6%
Feb	1,316	1,329	13	1%
Mar	1,267	1,382	115	9%
Apr	1,435	1,521	86	6%
May	1,475	1,637	162	11%
Jun	1,434	1,610	176	12%
Jul	1,529	1,518	-11	-1%
Aug	1,612	1,589	-23	-1%
Sep	1,564	1,603	39	2%
Oct	1,435	1,518	83	6%
Nov	1,668	1,353	-315	-19%
Dec	1,301	1,300	-1	0%
Max	**1,668**	**1,637**		

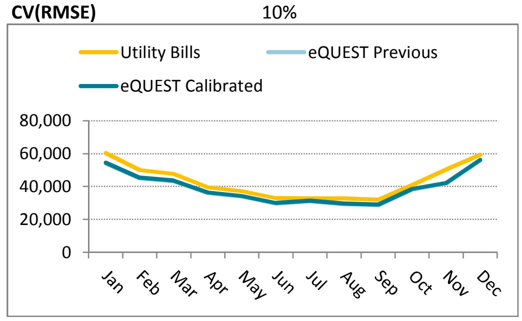
Max Monthly Error	19%
Min. Monthly Error	0%
CV(RMSE)	9%



Monthly Natural Gas Usage (therms) Calibration

Month	Utility Bills	eQUEST	Error	Error %
Jan	60,245	54,487	-5,758	-10%
Feb	50,025	45,354	-4,671	-9%
Mar	47,713	43,648	-4,064	-9%
Apr	39,589	36,426	-3,163	-8%
May	37,212	34,347	-2,865	-8%
Jun	32,907	30,027	-2,880	-9%
Jul	32,634	31,423	-1,211	-4%
Aug	32,728	29,679	-3,050	-9%
Sep	32,000	28,996	-3,003	-9%
Oct	40,897	38,605	-2,292	-6%
Nov	50,451	42,276	-8,175	-16%
Dec	59,266	56,317	-2,949	-5%
Total	**515,667**	**471,586**	**-44,081**	**-9%**

Annual Error	-9%
Max Monthly Error	16%
Min. Monthly Error	4%
CV(RMSE)	10%



Calibration Goals (Typical)

Annual Error	± 10%
Max Monthly Error	± 20%
CV(RMSE)[1]	± 10%

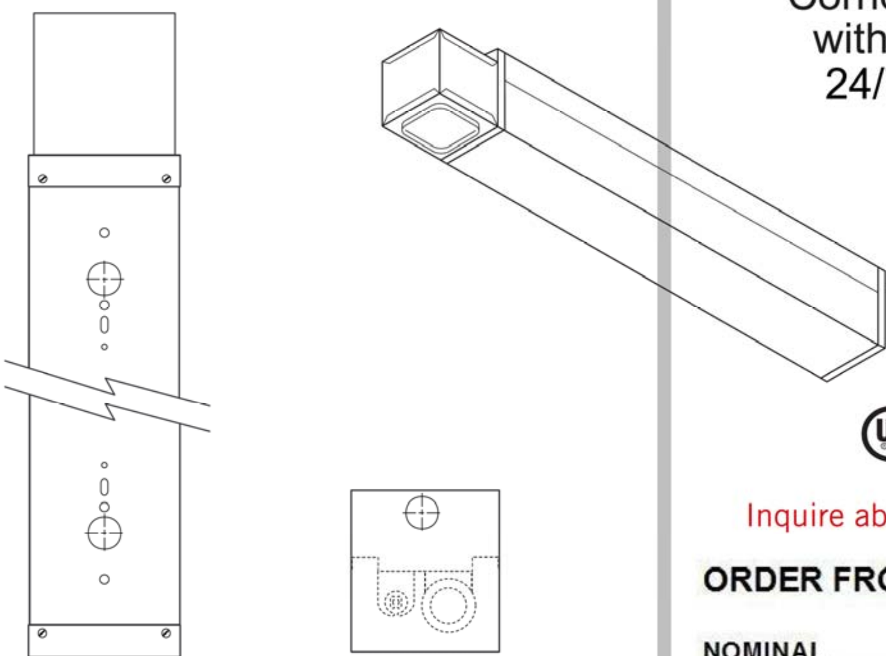
[1]CV(RMSE) = Coefficient of Variation of the Root Mean Squared Error and is a measure of uncertainty in the model.

8.4 Appendix D: Specification Sheets
(beginning next page)

Blinky Inc.

NEXT GENERATION ENERGY OPTIONS

Blinky T-8 Replacement Fixtures



Blinky T-8 Replacement Fixture

Multi-purpose Stairwell, Corridor or Garage Fixture with 3 Watt Cold Cathode 24/7 Night Light and PIR Sensor Add-On

PATENTED
MADE IN THE USA

Inquire about Retrofit Kit possibilities

FEATURES:

- GE Programmed Start Ballast
- Surface or pendant ceiling/vertical or horizontal wall mount
- Painted High Reflectance Finish
- Available with White Opal Diffuser or Clear Prismatic Lens
- Utilizes:
  - One (1) 3W Cold Cathode Lamp for night light operation mounted in fixture
  - One (1) Passive Infrared [PIR] 360 sensor
- Cold Cathode 24/7 lamp rated for 25,000 hours of operation
- Factory installed Emergency Ballast 25,000 hours of operation
- Warranties
  - GE Programmed Start Ballast (5 years)
  - PIR Sensor (5 years)
  - 3W CC Lamp (25,000 Hours)
- Patented

ORDER FROM THESE CONVENIENT SIZES:

NOMINAL SIZE	LAMPS	CATALOG NUMBER
Blinky 2'	1L 1-F017	A or P-124-T8/1CC-3-Volt
Blinky 3'	1L 1-F025	A or P-136-T8/1CC-3-Volt
Blinky 4'	1L 1-F028/32	A or P-148-T8/1CC-3-Volt
Blinky 4'	2L 1-F025 & 1–F032	A or P-148-T8/136-T8/1CC-3-Volt
Blinky 6'	2L 2-F025	A or P-136-2T8/1CC-3-Volt
Blinky 6'	3L 3-F025	A or P-136-3T8/1CC-3-Volt
Blinky 8'	2L 2-F028/32	A or P-148-2T8/1CC-3-Volt
Blinky 8'	3L 3-F028/32	A or P-148-3T8/1CC-3-Volt

A = White Opal Acrylic Diffuser
P = Clear Prismatic Lens
* Volt = Indicate if electrical supply is 120V or 277V

Separate PO Line Numbers Required

Tamper Proof Screws	STPS-1
Spanner Head Screwdriver	SHSD-1
* Required with STPS-1 Option	
Sensor Fixture Bracket	FB-1
* Only need if wanting to adjust the height of the sensor for range adjustments	
Emergency Ballast	EM
Wire Guard Option	WG-4'
Additional Sensors	CRMB-6 or CMRB-9

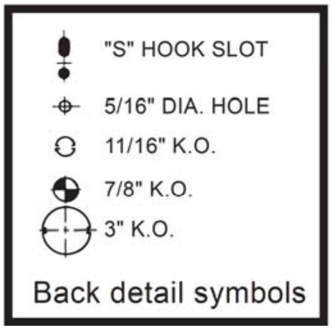
NOTES: 1. Mounting hardware not included

Blinky, Inc. 5 12th Avenue San Mateo, CA 94402
phone: 650-773-4026 fax: 760 216-6111
web: www.blinkyinc.com email: sales@blinkyinc.c

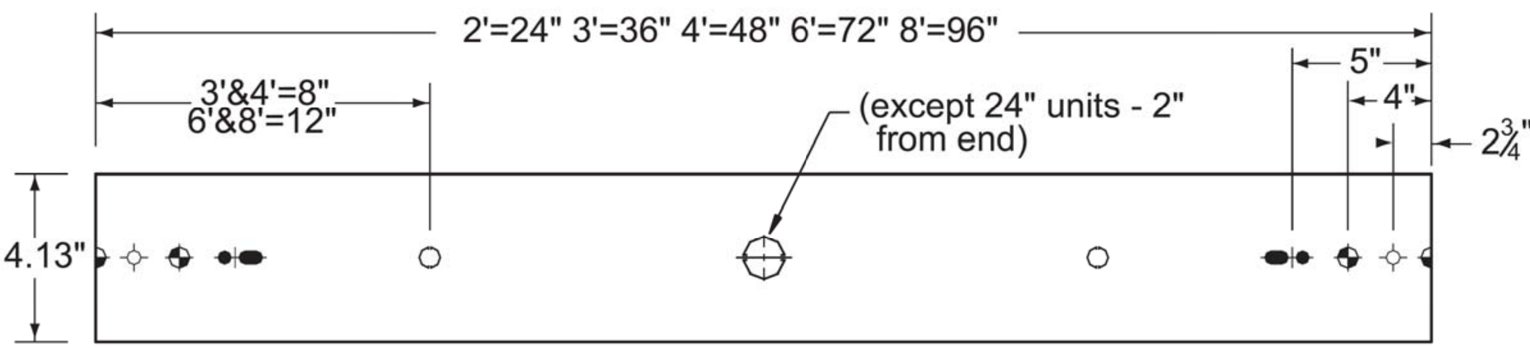
VMC 2240 DS-1 1/05
SQ rev 9/05

Blinky, Inc.

Next Generation Energy Options



BACK DETAIL



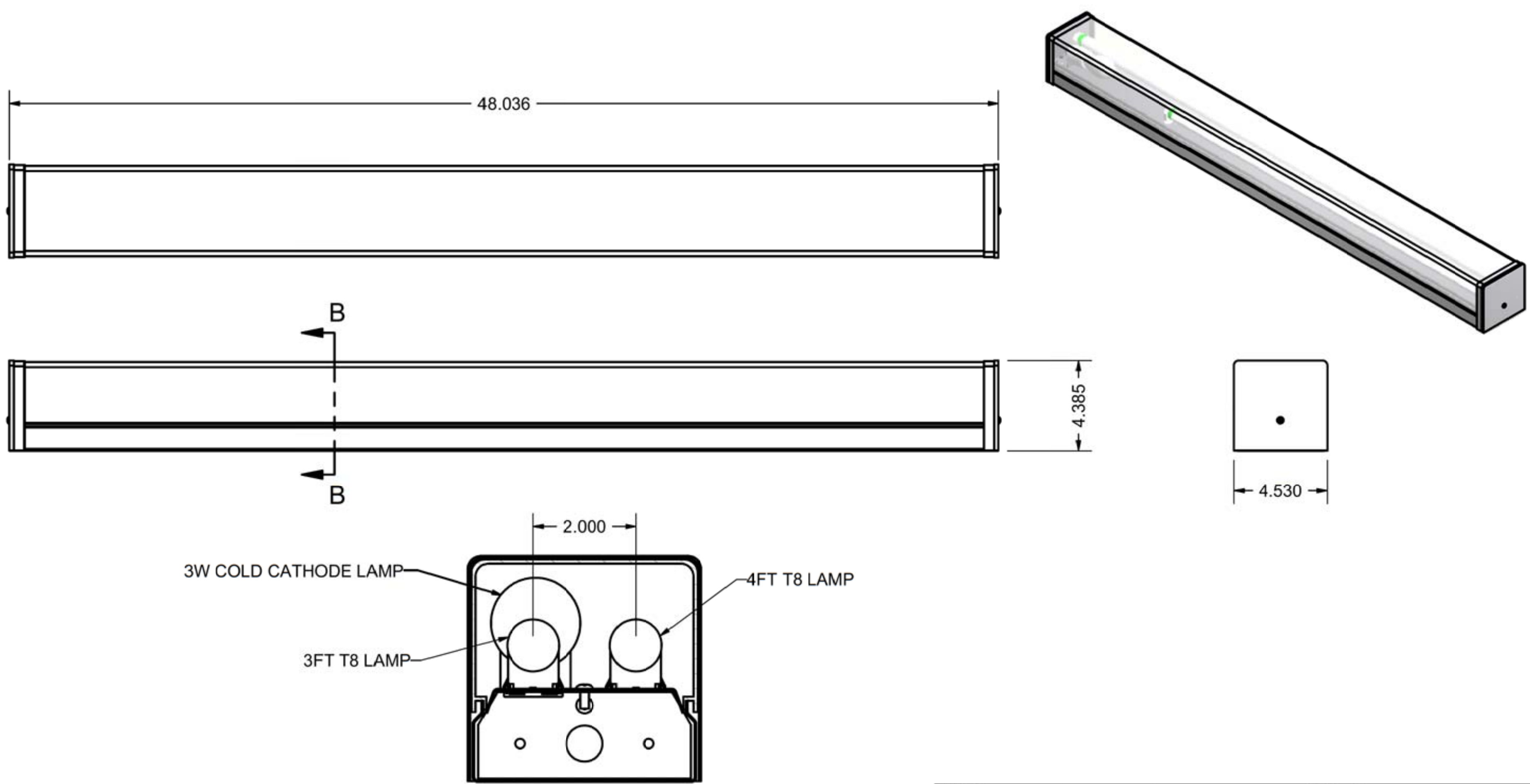
NOTES:
WITH END CAPS OVERALL LENGTH OF 182 SERIES IS 3/4" GREATER THAN SHOWN
11/16" KNOCK OUT NOT SUPPLIED ON 2' UNITS.
NO 3" KNOCK OUT IN 2' UNITS.

NOTE
All fixtures must be installed, wired and grounded in accordance with the National Electric Code and all other applicable codes.

!!! WARNING !!!
RISK OF FIRE OR ELECTRICAL SHOCK. ELECTRICAL PARTS MAY BE DAMAGED WHEN DRILLING OR USING "TEK" SCREWS FOR INSTALLATION OF MOUNTING HARDWARE. CHECK ENCLOSED WIRING AND COMPONENTS. USE CAUTION WHEN DRILLING "TEK" SCREWS INTO A BLIND AREA. TO PREVENT WIRING DAMAGE DO NOT EXPOSE WIRING TO SHARP EDGES.

Blinky, Inc. 5 12th Avenue San Mateo, CA 94402
phone: 650-773-4026 fax: 760 216-6111
web: www.blinkyinc.com email:sales@blinkyinc.com

Blinky Inc.
NEXT GENERATION ENERGY OPTIONS



SECTION B-B
SCALE .5

THE INFORMATION CONTAINED HEREIN IS STRICTLY CONFIDENTIAL AND IS FURNISHED WITH THE UNDERSTANDING THAT IT WILL NOT BE DISCLOSED TO OTHERS WITHOUT PRIOR WRITTEN CONSENT.

REV	BY	DESCRIPTION	DATE	APPR

DRAWN D.Dimino	6/1/2009
CHECKED	
APPROVED	

TOLERANCES UNLESS OTHERWISE NOTED:
.XX = +/- .030
.XXX = +/- .015
.XXXX = +/- .005
FRAC = +/- 1/32
ANGLE = +/- 1/2 DEG

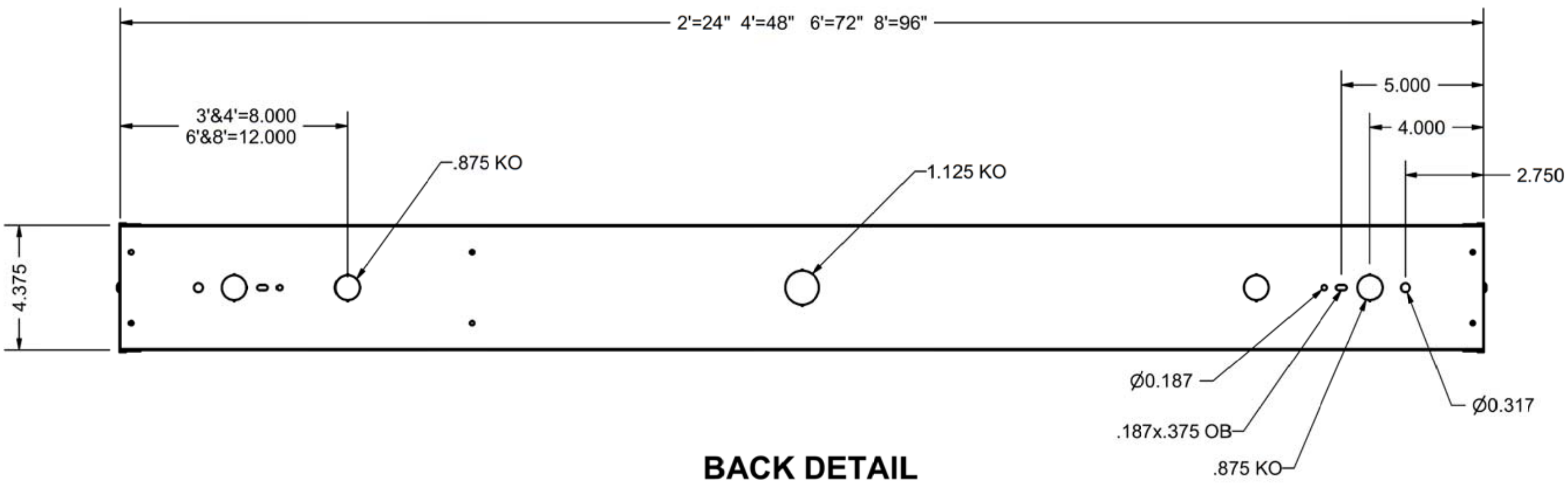
Blinky Inc.
5 12th Avenue San Mateo, CA 94402
phone: 650-773-4026 fax: 760-216-2611

TITLE
BLINKY 2L 4ft ASS'Y

SIZE	PROJECTION	DWG NO	REV
B		90191-1 BLINKY ASS'Y	-
SCALE AS NOTED		SHEET 1 OF 2	

Blinky Inc.

NEXT GENERATION ENERGY OPTIONS



BACK DETAIL

REV	BY	DESCRIPTION	DATE	APPR

THE INFORMATION CONTAINED HEREIN IS STRICTLY CONFIDENTIAL AND IS FURNISHED WITH THE UNDERSTANDING THAT IT WILL NOT BE DISCLOSED TO OTHERS WITHOUT PRIOR WRITTEN CONSENT.

DRAWN D.Dimino	6/1/2009
CHECKED	
APPROVED	

TOLERANCES UNLESS OTHERWISE NOTED:
.XX = +/- .030
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TITLE
BLINKY 2L 4ft ASS'Y

SIZE	PROJECTION	DWG NO	REV
B		90191-1 BLINKY ASS'Y	-
SCALE AS NOTED		SHEET 2 OF 2	

F:\INVENTOR DATABASE\WORK FILE\CUSTOM\BLINKY\BLINKY 4 ft ASSY.iam

WS4™

4′ LED Wet Location Linear

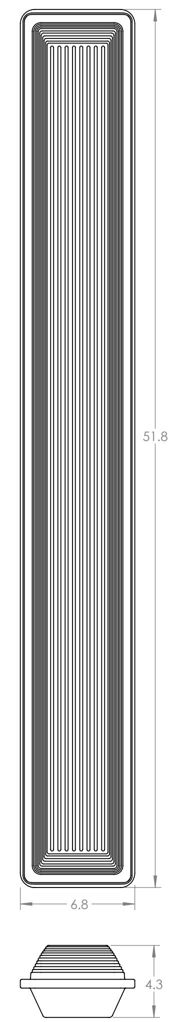
Product Description

The versatile Cree WS Series wet location linear luminaire is suitable for indoor and outdoor applications. Constructed of one-piece molded, durable fiberglass-reinforced polyester and UV-stabilized, impact-resistant diffused acrylic shielding, the Cree WS Series is wet location listed and water-tight sealed for IP65 rating, which provides protection from external elements. The operating temperature range is -25°C to 35°C, allowing for cold to hot weather environment installations.

WS4™

Performance Summary

Cree Full Definition
Delivered Light Output: 4700, 5000, 5900 and 6300 lumens
Efficacy: Up to 98 LPW
CRI: FD (Full Definition) color - minimum 80 CRI
CCT: 3500K, 4000K, 5000K, 5700K
Input Voltage: 120-277 VAC
Lifetime: Designed to last 70,000 hours at 25°C
Warranty: 10 years†
Dimensions: L 51.8″ x W 6.8″ x H 4.3″
Weight: 12 lbs.
Mounting: Ceiling or wall
Dimming: 0-10V dimming: 10% - 47L and 50L; 15% - 59L and 63L*



Ordering Information

Example: WS4-59L-35K-10V-FD

WS Series						
Product	**Lumen Output**	**Color Temperature**	**Voltage**	**Dimming**	**Color/CRI**	**Options**
WS4	**47L** 50W 4700 lumens - 94 LPW (35K) 50W 4700 lumens - 94 LPW (40K) **50L** 51W 5000 lumens - 98 LPW (50K) 51W 5000 lumens - 98 LPW (57K) **59L** 63W 5900 lumens - 94 LPW (35K) 63W 5900 lumens - 94 LPW (40K) **63L** 64W 6300 lumens - 97 LPW (50K) 64W 6300 lumens - 97 LPW (57K)	**35K** 3500 Kelvin **40K** 4000 Kelvin **50K** 5000 Kelvin **57K** 5700 Kelvin	**Blank** 120-277 VAC	**10V** 0-10V dimming (standard)	**FD** FD = Full Definition Color - CRI 80 (standard)	**SSL** **Stainless Steel Latches**

Accessories

Accessories
WS4TPK Tamper Proof Kit (includes four tamper proof screws and bit) **WSSSL4TPK** Tamper Proof Kit (for stainless steel latches; includes four tamper proof screws and bit) **WS4MBK** Mounting Bracket Kit (includes two stainless steel surface mount brackets)** **WS4CSK** Cable Suspension Kit (includes two stainless steel brackets with 5′ aircraft cable)**

† See www.cree.com/lighting for warranty terms.
* Reference www.cree.com/lighting for recommended dimming controls and wiring diagrams.
** Reference to installation sheet for details.

c UL US

Rev. Date 11/08/2013

CREE®

U.S.: www.cree.com/lighting T (800) 236-6800 F (262) 504-5415 Canada: www.cree.com/canada T (800) 473-1234 F (800) 890-7507

Product Specifications

CREE FULL DEFINITION
Providing color quality that meets the needs of many spaces and is superior to most incumbent lighting technologies while at the same time minimizing expenses without impacting quality and safety, Cree Full Definition is a cost-effective lighting solution for lower-traffic areas.

CONSTRUCTION & MATERIALS

- Constructed of fiberglass reinforced polyester.
- Polycarbonate latches.
- Two 1/2" entry points are provided (one at each end of the housing) for continuous feed.
- Top of housing has six embossments providing mounting flexibility to uneven surfaces.

LUMEN MAINTENANCE FACTORS

- Reference www.cree.com/lighting for detailed lumen maintenance factors.

OPTICAL SYSTEM

- Full Definition LEDs.
- Frosted injection molded acrylic shielding.
- Polyurethane gasketing is poured in place, providing a continuous, seamless seal.
- Highly reflective reflector plate provides maximum efficiency.

ELECTRICAL SYSTEM

- **Power Factor** = 0.9 nominal.
- **Input Power**: Stays constant over life.
- **Input Voltage**: 120-277 VAC.
- **Temperature Rating**: Designed to operate in temperatures -25°C to 35°C.
- **Total Harmonic Distortion**: < 20%.

CONTROLS

- Continuous dimming with 0-10V DC control protocol.*

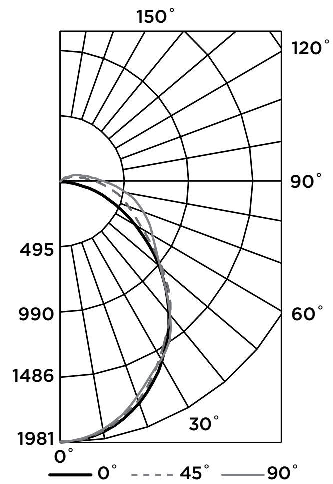
REGULATORY & VOLUNTARY QUALIFICATIONS

- cULus listed.
- IP65 rated.
- UL listed for wet locations.

Photometry

WS4™
WS4-59L-35K-10V-FD / Based on DTC Report Test #: 38552

Fixture photometry has been conducted by a NVLAP accredited testing laboratory in accordance with IESNA LM-79-08. IESNA LM-79-08 specifies the entire luminaire as the source resulting in a fixture efficiency of 100%.



Coefficients Of Utilization

RCC %:	80			
RW %:	70	50	30	0
RCR: 0	1.18	1.18	1.18	1.18
1	1.06	1.00	.95	.91
2	.96	.87	.79	.73
3	.87	.76	.67	.61
4	.80	.67	.58	.51
5	.73	.60	.51	.44
6	.68	.54	.45	.39
7	.63	.49	.40	.34
8	.59	.45	.36	.31
9	.55	.41	.33	.27
10	.51	.38	.30	.25

Effective Floor Cavity Reflectance: 20%

Zonal Lumen Summary

Zone	Lumens	Luminaire
0-30	1,482	24.9%
0-40	2,387	40.2%
0-60	4,075	68.6%
0-90	5,556	93.5%
0-180	5,941	100%

Reference www.cree.com/lighting for detailed photometric data.

Average Luminance Table (cd/m2)

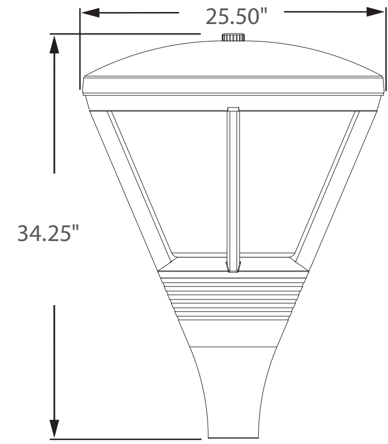
Horizontal Angle

Vertical Angle	0°	45°	90°
0°	1,992	1,992	1,992
45°	1,152	1,163	1,170
55°	831	878	889
65°	530	586	731
75°	278	357	597
85°	86	192	425

NEPTŪN LIGHT

LED
POST-TOP ACORN FIXTURES

Dark Sky FRIENDLY



Incredible 70,000 hrs

GENERAL DESCRIPTION

Neptun's LED post top fixture features a traditional decorative style to make it an excellent choice for new construction or retrofit applications. The 92 series offers excellent illumination and uniformity. The cut-off hood allows for use in Dark Sky applications. Offered in a variety of wattages, it can replace existing HID & HPS fixtures up to 250W.

APPLICATION

- Street Lighting
- Parking Lot Lighting
- Security Lighting
- Decorative Post-Top Lighting
- Area Lighting
- Walkway Lighting

STRUCTURE, MATERIALS, & FEATURES

- Fiberglass reinforced composite housing for excellent durability and strength.
- High Efficiency, heat and impact resistant, UV protected, non-yellowing polycarbonate refractor.
- Corrosion resistant electrocoat black finish (custom colors available).
- 3" I.D. Slip Fitter Accepts up to 2-7/8" Pipe or Tenon. (hardware included)
- Continuous silicone gasket surrounds lens for weather - tight seal.
- Supplied with 360° LED self- ballasted lamp.
- High power factor, low THD driver.
- Instant-On flicker-free Cold Start and Hot Re-Start.
- High quality glare-free light with high CRI above (83).
- Bright white light (5000˚K) for greater visibility and safety.
- Advance phosphors for high lumen output and high lumen maintenance.
- Up to 15 year maintenance free operation.
- 5 Year Warranty.

ORDERING INFORMATION

Sample Number: LED-92040-UNV-850-BLK
Custom options and accessories available. Please consult factory

Source	Series	Lamp Wattage	Voltage	Color Temp	Color
LED = LED	**92** = Acorn / Post Top	**040** = 40 W **060** = 60 W **080** = 80 W	**UNV** = 120-277 VAC	**830** = 3000°K **841** = 4100°K **850** = 5000°K	**BLK** = Black * Custom Colors Available

LEAD FREE RoHS COMPLIANT

lightinnovations@work™

NEPTUN LIGHT

LED
POST-TOP ACORN FIXTURES

PRODUCT INFORMATION

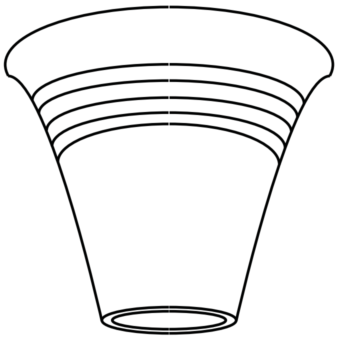
Model No.	Description	Rated Watts	Input Watts	Initial Lumens	Universal Line Voltage (VAC)	Max Line Current (Amp) @ 120 - 277	THD	Power Factor	Weight
LED-92040-UNV	LED Post-Top Acorn Fixture	40	42	3,600	120-277	0.34 - 0.15	<20%	>0.98	38 lbs
LED-92060-UNV	LED Post-Top Acorn Fixture	60	62	5,100	120-277	0.52 - 0.22	<20%	>0.98	38 lbs
LED-92080-UNV	LED Post-Top Acorn Fixture	80	82	6,800	120-277	0.69 - 0.30	<20%	>0.98	38 lbs

SPECIFICATIONS

- LED Driver .... Constant Current
- Power Supply 350mA
- Start Method .... InstantON
- Hot Re-start .... InstantON
- Universal Input Line Voltage .... 120-277 VAC
- Input Line Frequency .... 50/60 Hz
- Ballast Off-State Draw .... 0 Watts
- Sound Rating .... Class A
- ANSI Surge Protection .... Class A
- LED / Driver System Life .... 70,000 Hrs.
- Lumen Maintenance @50,000Hrs .... > 70%
- Color Temperature .... 3000°K, 4100°K 5000°K
- Color Rendering Index (CRI) .... > 80
- Minimum Starting Temperature .... -40°C
- Maximum Starting Temperature .... 50°C
- Lumens per Watt .... > 80
- Shock / Vibration Resistant .... Yes
- Power Factor .... > 0.98
- Total Harmonic Distortion .... < 20%
- Inrush Current Peak .... < 10 Amp
- ETL Listed / UL Standard 1598 .... Yes
- FCC Compliance .... Part 18, Subp. C
- IP Rating IP65
- EPA Rating 1.80
- Warranty .... 5 Year

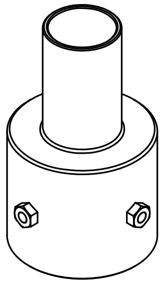
MOUNTING OPTIONS

SLIP-FIT MOUNT



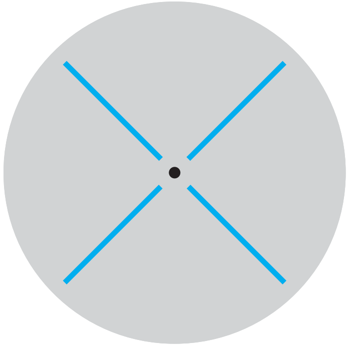
Accepts up to 2-7/8" O.D. Round Tenon or Pole

IOP-RPTR (contact factory)



Round Pole Tenon Reducers available for 3", 4", & 5" O.D. Poles

PHOTOMETRICS (See Complete IES File)



Type V Distribution

Neptun Light, Inc.
13950 Business Center Drive
Lake Forest, IL 60045
Fax: 847.735.8004

Spec. Rev. 2-2014

Reduce energy consumption and save costs with

GEO-THERMAL SYSTEMS®, INC.

ENERGY CONSERVATION:

The patented process Geo-Thermal Systems, Inc. Heat Pump will save your electric power usage by up to 84%.

Your stand-by Diesel Generator must be kept hot at all times so that it can start instantaneously during a power outage. This heating process costs money. Using a patented process, Geo-Thermal Systems®, Inc. (GTS), Heat Pump is the most efficient way to heat emergency diesel generators. GTS Heat Pump users have reported power savings as high as 84% vs. heating with resistance heaters that come installed with emergency diesel generators as standard equipment.

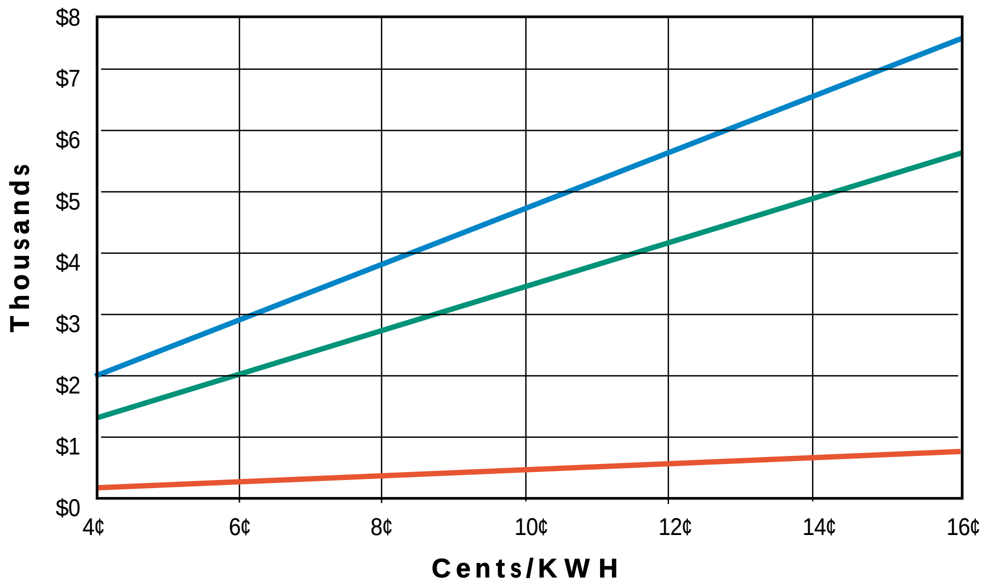
Isn't it time you put some energy savings money in your pocket? Every day your generator is needlessly consuming excess energy. Resistance heaters are continuously burning your hard earned dollars and wastefully increasing your costs. It's time you started saving with GTS Heat Pumps.

Act now!
Start saving power by installing a GTS Patented Process Heat Pump today!

GEO-THERMAL SYSTEMS, INC.®
We transfer efficiency into savings.

711 S. Delaware Avenue • Tampa, Florida 33606 • (813) 251-1477 • fax (813) 254-5135

GTS Heat Pump vs Resistance Heaters*



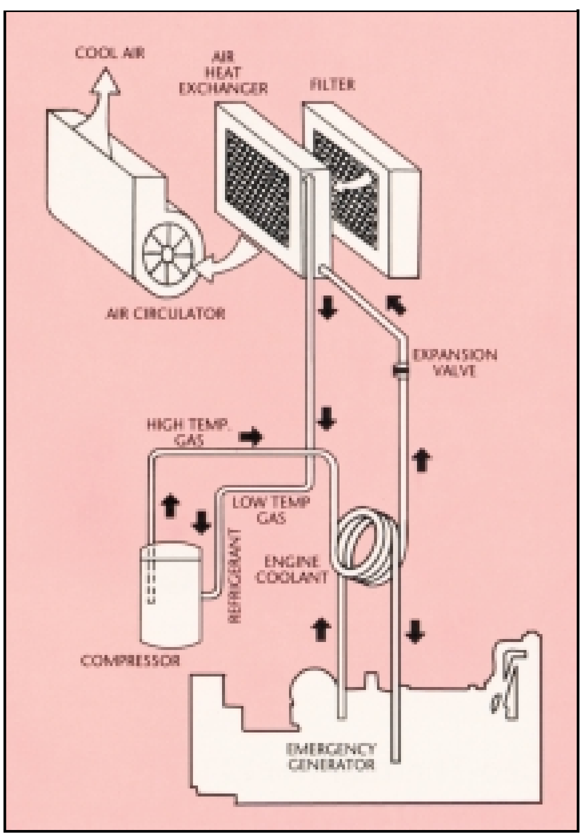
Annual Operating Costs

- 8 KW Resistance Heater
- 6 KW Resistance Heater
- GTS Heat Pump

* GTS Heat Pump 60% run time and resistance heaters at 70% run time.

How it works:

Heat pump technology takes available heat out of the air and transfers it efficiently to the engine coolant system by using refrigerant under pressure.



Specifications
Heat Pump Model DH-12

Heating Capacity	19,800 BTU/Hr*
Cooling Capacity	15,200 BTU/Hr*
Voltage	208/230 phase 1
Circuit Ampacity	40 AMP
Power Consumption	1.4 KW/Hr
C.O.P.	4.2*
Dimensions	24” x 24” x 39”
Weight	160 Lbs.

GEO-THERMAL SYSTEMS, INC.®
We transfer efficiency into savings.

* 90º F entering air and 100º F entering water

711 S. Delaware Avenue • Tampa, Florida 33606 • (813) 251-1477 • fax (813) 254-5135