Integrated Energy Audit

Facility Picture

PG&E Large Commercial Customer
Address, CA

June 5, 2008
Final Report
Prepared by

AUDITOR

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Disclaimer

The intent of this energy analysis report is to estimate energy savings associated with recommended upgrades to the HVAC and lighting systems at this PG&E Customer site. Appropriate detail is included in sections 2-5 of this report to make decisions about implementing energy efficiency measures at the facility. However, this report is not intended to serve as a detailed engineering design document. The descriptions of the improvements are only diagrammatic in nature in order to document the basis of cost estimates and savings, and to demonstrate the feasibility to construct the improvements. It should be noted that detailed design efforts may be required in order 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 are believed to be reasonably accurate, the findings are estimates and actual results may vary. As a result, Pacific Gas and Electric Company (PG&E) and Auditor are not liable if projected estimated savings or economics are not actually achieved. All savings and cost estimates in the report are for informational purposes, and are not to be construed as a design document or as guarantees.

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

1 Executive Summary

Pacific Gas and Electric Company (PG&E) sponsored this Integrated Energy Audit Report for this PG&E Customer. The goal of a PG&E Integrated Energy Audit is to identify potential high-value energy and demand savings by focusing on the following kinds of opportunities:

- Energy conservation
- Energy efficiency
- Time-of-use management
- Demand response
- Self-generation.

The study was conducted by a PG&E contracted auditor in collaboration with PG&E, as part of a comprehensive effort to assist PG&E customers in controlling energy costs and protecting our environment by offering a full spectrum of energy management options.

Based on this study, a number of energy efficiency and demand response measures are identified and evaluated in this report.

Pacific Gas and Electric Company encourages all customers to follow three steps to reduce energy consumption:

1. Take action to implement no-cost, energy-saving measures.
2. Install low-cost, energy-saving measures.
3. Invest in energy-efficient equipment, appliance and building shell retrofits.

Consistent with PG&E's 1-2-3 Tier approach to conducting energy audits, the energy efficiency measures in this report are divided into no-cost, low-cost, and capital investment measures.

1.1 Your Cost Reduction Opportunities

The following table summarizes the measures that are recommended for this facility.

PG&E Integrated Energy Audit

Energy and Demand Reduction Measures

Measure Number	Measure Description	Annual Energy and Cost Savings				Payback		Payback with Incentive			
		Peak Savings (kW)	Electricity Savings (kWh)	Gas Savings (therms)	Total Cost Savings	Measure Cost	Simple Payback (yr)	Potential PG&E Incentive	Net Measure Cost	IRR	Simple Payback (yr)
NCM-1	Modify CRAC Humidification Controls	35.2	308,352	0	$ 41,165	$ -	0.0	$ -	$ -	n/a	0.0
LCM-2	Install High-Capacity Pre-Filters on Supply Fans	3.3	4,631	0	$ 618	$ 327	0.5	$ -	$ 327	89%	0.5
LCM-3	Implement Static Pressure Reset on Supply Fans	0.0	36,652	0	$ 4,893	$ 5,850	1.2	$ 2,925	$ 2,925	167%	0.6
LCM-4	Install VFDs and Controls for Primary Condenser Water Pumps	17.5	86,934	0	$ 11,606	$ 14,737	1.3	$ 6,955	$ 7,783	149%	0.7
CIM-5	Install Photocells to Control Lighting Near Windows	0.0	56,022	0	$ 7,479	$ 13,200	1.8	$ 2,801	$ 10,399	72%	1.4
CIM-6	Implement Data Center Airflow Improvements and Install VFDs on CRAC Fans	12.1	106,174	0	$ 14,174	$ 40,642	2.9	$ 8,494	$ 32,148	44%	2.3
	SUB-TOTALS	**68.1**	**598,765**	**0**	**$ 79,935**	**$ 74,756**	**0.9**	**$ 21,175**	**$ 53,582**	**148%**	**0.7**
Demand Response											
DR-1	Reduce Office Lighting Levels By One-Third	48.1	1,924	0	$ 930	$ 10,000	10.8	$ -	$ 10,000	-1%	10.8
DR-2	Turn Off Garage Lighting	2.5	99	0	$ 48	$ 600	12.6	$ -	$ 600	-4%	12.6
DR-3	Reduce Ventilation by 20%	20.2	808	0	$ 390	$ 1,000	2.6	$ -	$ 1,000	37%	2.6
	SUB-TOTALS	**70.8**	**2,830**	**0**	**$ 1,368**	**$ 11,600**	**8.5**	**$ -**	**$ 11,600**	**3%**	**8.5**
TOTALS (Recommended Measures)		**138.8**	**601,595**	**0**	**$ 81,303**	**$ 86,356**	**1.1**	**$ 21,175**	**$ 65,182**	**123%**	**0.8**

Assuming Electricity Cost	$ 0.1335	/kWh	(Average for recent 12 months, this account)
Assuming Gas Cost	$ 1.49	/therm	(Average GNR1 rate, weighted summer/winter)

2008 PG&E NRR/DR Incentives

Measure Type	Rate
Motors / Controls / DCV	$0.08 /kWh
Lighting	$0.05 /kWh
AC & Refrigeration	$0.14 /kWh
Gas	$0.80 /therm
Itemized Energy Efficiency	
Occupancy Sensors - Wall (L83)	$16.50 /sq.ft.
Occupancy Sensors - Ceiling (L83)	$44.00 each
T12 to T8 Retrofit - 4 ft (L290)	$4.25 per lamp
VFD for HVAC Fans (H148)	$80.00 per hp
Demand Response	
Assumed equivalent DR incentive	$0.35 per kWh
Assume 10 events of 4 hrs each	40 hrs/yr

Notes on IRR

The Internal Rate of Return (IRR) is equivalent to an annual interest rate.
It allows projects to be evaluated on par with other types of investments.
Precisely, it is the discount rate which yields a Net Present Value of zero.

Prepared by
PG&E Contracted Auditor

1.2 Implementation Planning

We encourage you to seriously consider the recommendations contained within this report. The portfolio of projects identified will bring a significant benefit to your bottom line and in most cases improve reliability. Once you have completed a careful review of the technical and financial aspects of the recommendations, PG&E can assist you by facilitating an implementation-planning meeting that will help you act on those measures that meet the fiscal and operational requirements of your facility. In addition, and as a component to the implementation plan, PG&E will help you take full advantage of the financial incentives and technical services that are available to you as a valued customer of PG&E. Please see the following website for further information on available PG&E rebates and incentives:

http://www.pge.com/biz/rebates/rebates_assistance/index.html

The remainder of this report details the recommendations for this PG&E Customer:

- Section 2 documents the project contacts and existing systems and conditions for the site;
- Section 3 shows and discusses the site's energy use and costs;
- Section 4 provides descriptions of each energy opportunity, as well as providing information about how to implement the recommendations;
- Finally, the appendix includes details of the calculations and analysis, and related literature and data.

2
Project Team and Facility Information

2.1 Project Contacts

Name	Role	Organization	Contact Information

2.2 General Site Information

This PG&E Customer site is a worldwide company with their headquarters office in California. The building at this PG&E Customer site has seven stories with a basement parking level, as well as a separate adjacent five story open parking structure. There is a rooftop mechanical room penthouse.

The site was built in 2001 and features concrete and steel construction and many windows. It was built with high-energy efficiency goals; specifically exceeding Title 24 requirements by 10%. All floors are occupied with office spaces. The ground level includes a lobby area, conference rooms, as well as some tenant-occupied exterior retail spaces.

Customer Site Overview Picture

(image from MSN Live Maps)

2.3 Building Occupancy

The building is normally occupied during standard office hours, Monday through Friday about 7am to 6pm.

2.4 Energy-Using Systems

Lighting Systems

The lighting in this building comprises primarily of linear fluorescent T5 fixtures, used for general lighting in most of the building. These lights are controlled by a general scheduling system that turns them on from 6am to 6pm on weekdays, and sweeps lighting off again at 8pm and 11pm. On night hours and weekends, occupancy sensors control the lights and turn on one lamp per fixture when a room is occupied.

In addition to the T5 fixtures, each floor also has compact fluorescent lights (CFLs) that are controlled by the EMS on the same schedule as the T5 fixtures.

T5 Fixtures Used For General Lighting in Typical Floor

Ceiling Occupancy Sensor (left) and Wall Occupancy Sensor Used in Private Offices (right)

Task lighting is provided to each cubicle by 2-foot, 17-Watt 1-lamp T8 fixtures. These are turned on manually by the users.

Private offices each have two one-lamp wall T5 fixtures and one two-lamp ceiling T5 fixture. These three fixtures are controlled by a wall occupancy sensor; a manual switch also allows turning off the wall fixture.

The lobby area has some 50 watt MR16 fixtures as well as architectural lighting.

Architectural Lighting in the Lobby Area

The three stairwells of the building have linear fluorescent T8 lighting; there are 1-lamp fixtures in the stairwell and 2-lamp fixtures in the foyers at each floor. These fixtures are on at all times.

Ventilation

Conditioned air is distributed to the building by two 150-hp centrifugal supply fans located in the penthouse. Both fans are controlled by VFD as well as by a varicone damper with electric actuator, and modulate their speed to maintain a 1.7" duct static pressure.

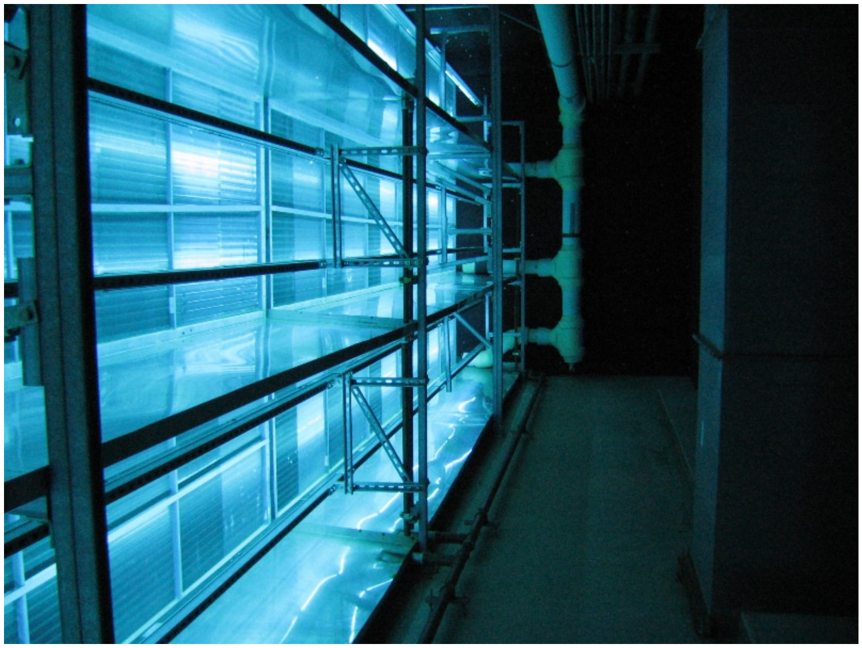
The air handler is equipped with an economizer that mixes outside air and return air. One of the outside air dampers stays open at all times when the fan is on to provide the minimum outside air flow.

Mixed air is passed through a bank of 126 bag filters. The filters currently in use are 8-pocket, 70% capture efficiency bag filters; they are about one year old and are scheduled to be replaced in the near future.

The building pressure is maintained by four VFD-controlled 20-hp exhaust fans, staged on and off.

Exhaust Fans

Two additional 3-hp exhaust fans serve the janitor room and the lobby area.



Cooling

Chilled water is provided to the air handlers' cooling coils by two water-cooled, rotary-screw chillers. These Trane RTHC chillers with respective capacities of 242 tons and 211 tons are controlled by VFDs; their chilled water supply temperature set point is reset between 45ºF and 52ºF.

242-ton Rotary Screw Chiller CH-1

Heat rejection is provided to the chillers by two induced-draft cooling towers (BAC 33340A) located on the roof of the building. Based on building mechanical drawings, these towers each have 347 tons nominal capacity; they modulate their fan speed with

VFDs to meet their condenser water temperature (CWT) set point. It was not clear how this set point is reset.

Induced-Draft Cooling Tower CT-1

The cooling towers are currently each dedicated to one chiller. The towers also provide condenser water to water-source heat pumps in the telecom cabinets of each floor, through a secondary condenser water circuit via a heat exchanger.

Heat Exchanger for Secondary Condenser Water Loop

Additional cooling is provided to the data center area on the 3rd floor by four dedicated Liebert DX computer room air conditioners (CRACs). Heat rejection is by four air-cooled condensers located on the roof of the building. Three units are nominal 24 tons; one is nominal 10 tons. Each has an infrared humidifier, and three stages of electric reheat. These units run to meet individual temperature set points of 68ºF and humidity set points of 45% (+/- 5%). We witnessed all units in humidification mode during our visit.

Liebert Unit (in the Data Center) and Air-Cooled Condensers (on the Roof)

The data center has underfloor air distribution and is partly arranged with a hot aisle – cold aisle configuration, although several flaws make this configuration rather ineffective (see CIM-5 for more details). Return air is drawn from the ambient room air by the CRAC units. It should be noted that there is a server virtualization project currently underway in the data center that will reduce the cooling load. Total power consumed by the servers will be reduced from the current 83kW to 65kW.

Finally, there is one 5-ton air conditioning packaged unit on the rooftop providing cooling to the elevator room. This unit has a 12 SEER rating and has no economizer.

Heating

Hot water is provided to the perimeter heating coils of the building by two gas-fired boilers with 2,500 MBtuh input rating each. The boilers run on a lead-lag basis; they are controlled to supply 180 ºF water. Water is circulated to the reheat coils by two 10-hp VFD-controlled pumps that run one at a time.

Gas-Fired Hot Water Boiler (left) and Hot Water Pumps (right)

Other Equipment

The 3rd floor of the building holds a data center with servers and communication equipment. See the "Cooling" section above for more details.

Server Rack in Data Center

On-site Generation

This building has a large photovoltaic (PV) array covering most of its roof. The PV panels are monocrystalline panels; they are installed flatly on the roof (no tilt). The array has a total capacity of 75 kW, providing about 7 to 8% of the total building power.

Partial View of the Photovoltaic Array on the Roof

Controls

The building has a central EMS DDC controls system, controlling the HVAC equipment and the lighting.

3
Site Energy Use and Costs

This site procures its electricity from PG&E; natural gas is procured through an aggregator and distributed by PG&E.

Please note that this PG&E Customer site facility energy usage can be viewed through PG&E's InterAct II web site. As a participant, you'll get access to your electricity usage for each quarter-hour (sometimes each hour), updated every morning for the prior day's usage. You can compare one day to another, one week to another, or another time period of your choice. You'll also be able to see how changes in weather (temperature) affect your usage. Seeing when you use electricity and how that compares in various ways should give you the power to make changes that reduce total use, shift use from peak to off-peak hours, and otherwise save money on your electric bill. Contact your PG&E account representative for more information.

3.1 Electricity Consumption

This PG&E Customer site is served by three electric Service Agreements:

- PG&E E19S (Medium General Demand-Metered Time-of-Use) Service Agreement XXXXXXXXX.
- PG&E A10S (Secondary Large Demand-Metered Time-Of-Use) Service Agreement XXXXXXXXX.
- PG&E A1P (Basic Service General Rate) Service Agreement XXXXXXXXXX

The following table and figure show the electricity consumption history for this PG&E Customer site.

Month	Peak Demand (kW)	Electricity Consumption (kWh)	Total Electricity Cost ($)
Mar-08	692	332,379	$31,713
Feb-08	667	292,038	$28,350
Jan-08	596	278,215	$27,468
Dec-07	692	311,480	$32,139
Nov-07	796	318,432	$41,305
Oct-07	773	303,590	$48,793
Sep-07	939	336,654	$56,145
Aug-07	883	356,050	$56,342
Jul-07	891	312,446	$52,231
Jun-07	883	310,396	$52,215
May-07	787	313,818	$44,636
Apr-07	628	294,705	$30,501
Annual Totals	**939**	**3,760,203**	**$501,837**
Average Total Cost of Electricity ($/kWh)			**$0.1335**

Table 3.1: Monthly Electricity Demand, Consumption, and Cost

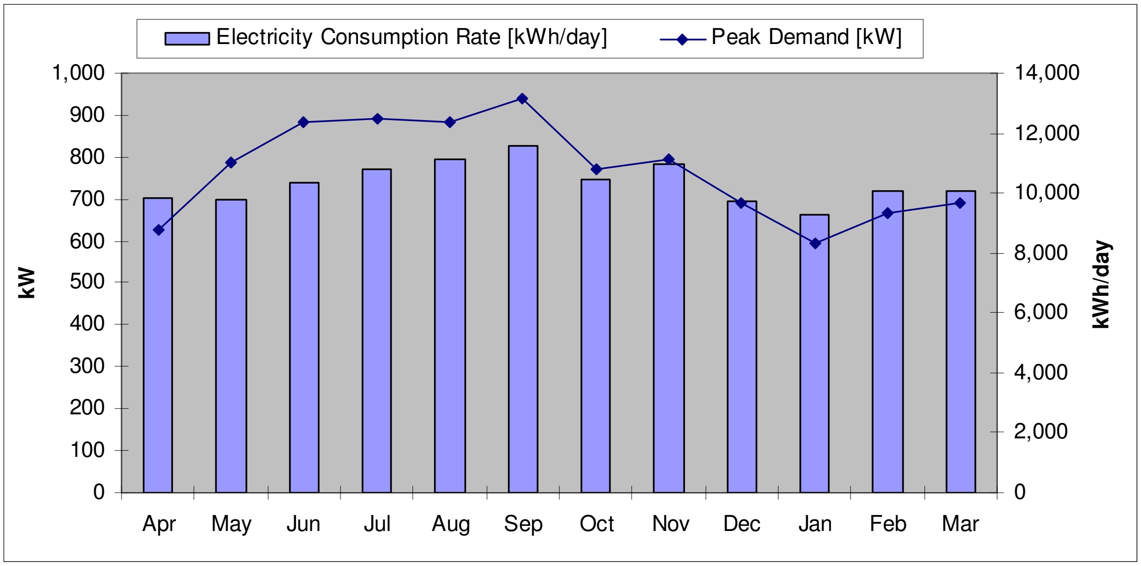


Figure 3.1: Monthly Electricity Consumption and Demand

This figure shows that this site had very steady electricity use through the past year, with peak demand highest in the hot month of September, and lowest in January.

Note that most facilities have energy consumption patterns that vary seasonally. Electricity consumption will be higher in the summer due to increased cooling demand. In fact, most end-users in California require more electricity during the hottest hours of mid-summer days. As a result of peak demand periods like this, PG&E is required to provide excess capacity in its generation and transmission systems. Charging consumers a variable price for electricity, with a higher charge for peak periods, can offset the cost associated with providing this added capacity. This PG&E Customer is enrolled in such a variable rate structure, referred to as Time of Use (TOU).

3.2 Natural Gas Consumption

This PG&E Customer is served by PG&E GNR1 (Small Commercial) Service Agreement XXXXXXXXXX for distribution only. They purchase the gas commodity from a third party.

For our savings calculations, we assumed an average cost of natural gas of $1.49 per therm, based on a season-weighted average of GNR1 total rates.

The following table and figure show the total gas consumption history for This PG&E Customer site.

Month	Natural Gas Consumption (therms)	Total Natural Gas Cost ($)
Mar-08	4,614	$1,158
Feb-08	6,173	$1,542
Jan-08	5,965	$1,578
Dec-07	5,405	$1,603
Nov-07	3,083	$1,046
Oct-07	2,439	$745
Sep-07	1,550	$496
Aug-07	1,887	$597
Jul-07	1,784	$564
Jun-07	1,978	$2,382
May-07	2,774	$3,059
Apr-07	3,436	$3,724
Annual Totals	**41,088**	**$18,491**
Average DISTRIBUTION ONLY Cost of Natural Gas ($/therm)		**$0.450**

Table 3.3: Monthly Natural Gas Consumption and DISTRIBUTION Cost

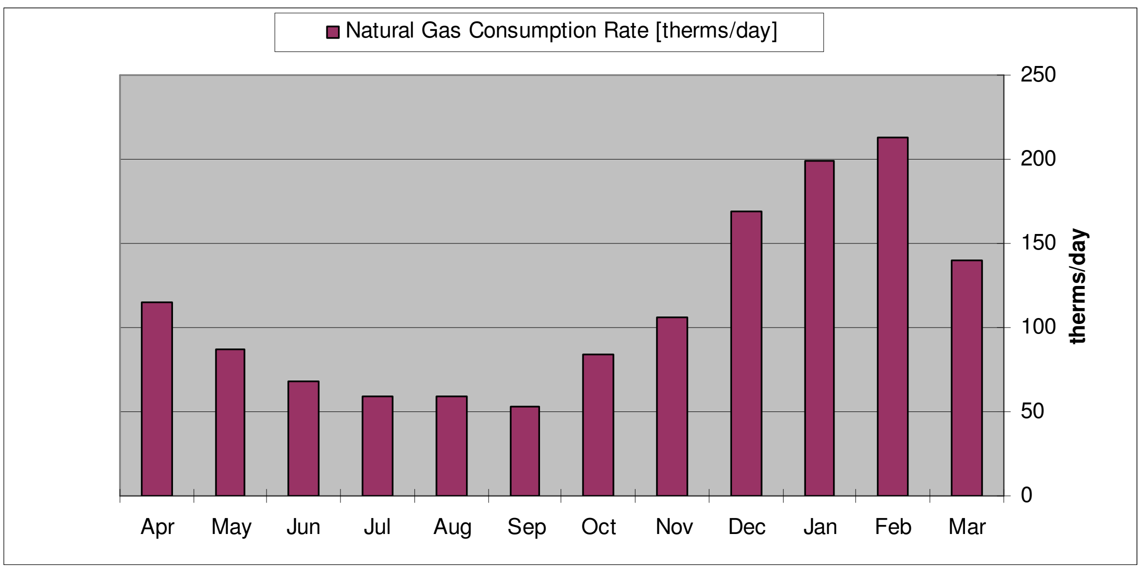


Figure 3.2: Monthly Natural Gas Consumption Rates

Note the moderate baseline gas use throughout the year. This likely indicates some morning warm-up heating demand even during the warmer months.

3.3 Total Cost of Energy

The total annual cost of energy at This PG&E Customer site is approximately $563,000. The following figure shows the monthly breakdown of electric and gas costs.

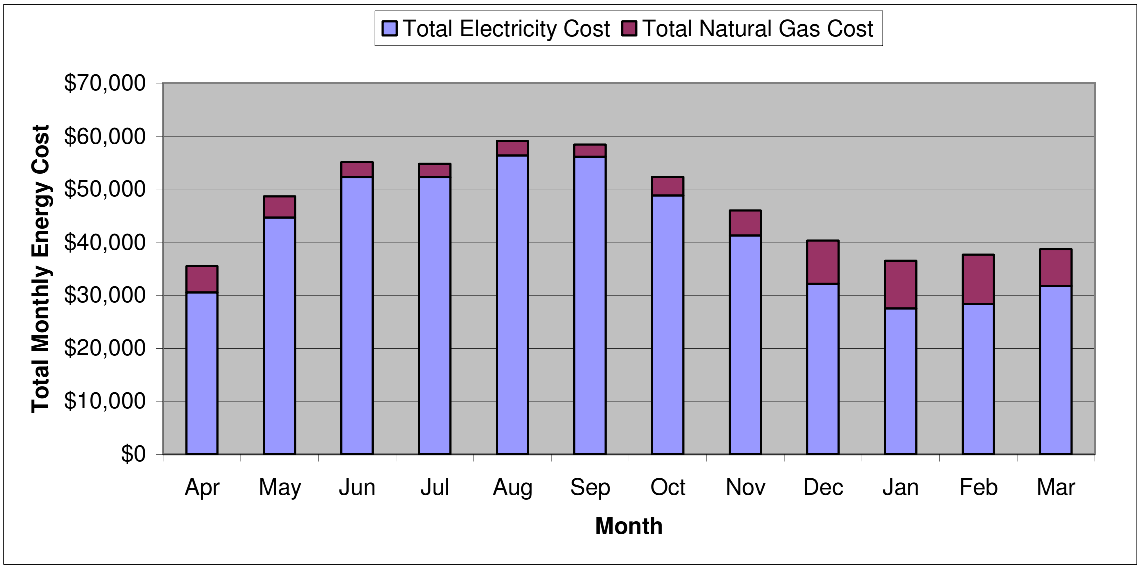
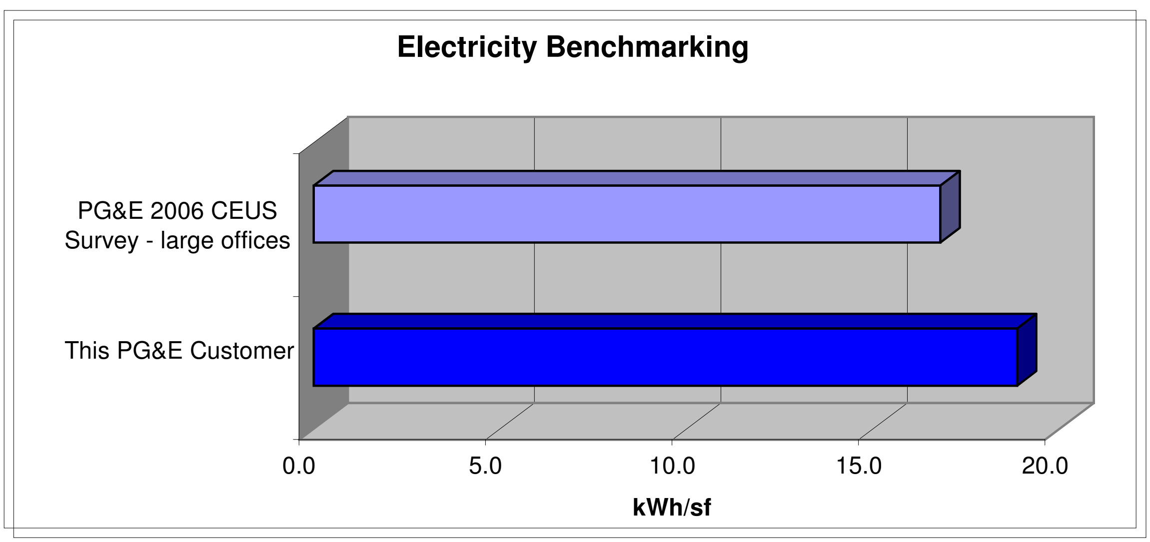


Figure 3.3: Total Monthly Energy Costs

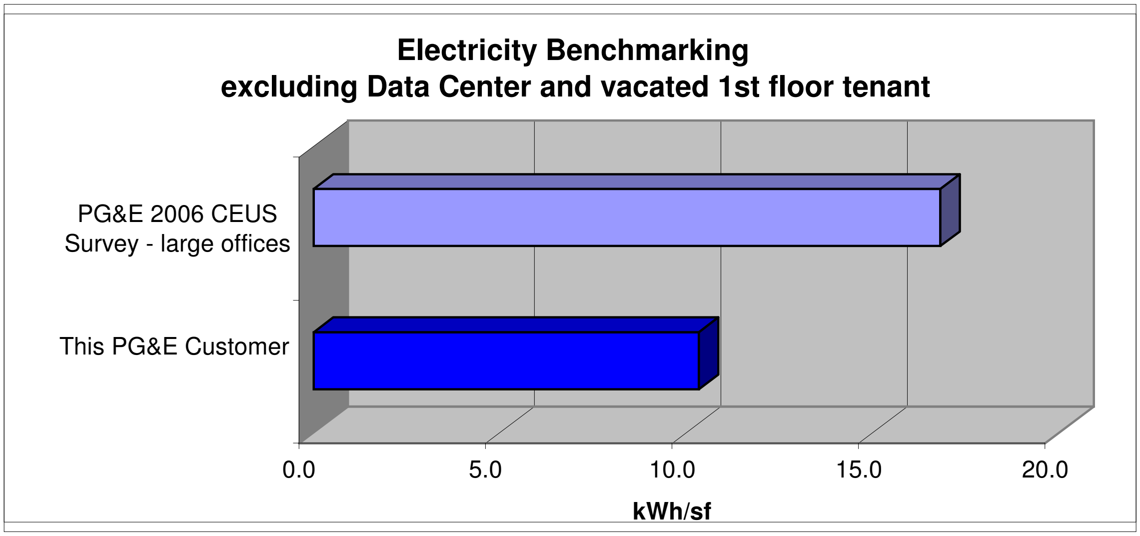
3.4 Energy Use Benchmarks

Benchmarking compares the energy use of a facility to those of similar size and purpose. Typically we compare facilities with survey data of similar facility types in California. To put facilities of different size on an equal footing, the energy use is compared on a "per square foot" basis.

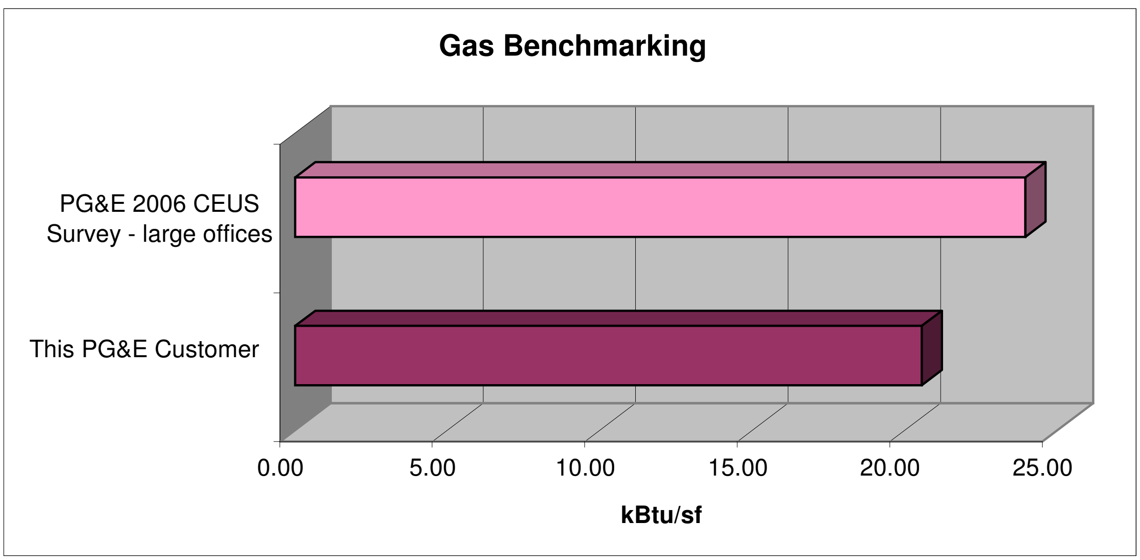
The PG&E CEUS benchmark is average end use intensity for offices from PG&E's 2006 Commercial Building Survey Report (Commercial End Use Survey) in all climate zones served by PG&E. The charts below show how This PG&E Customer's energy use to date (annualized) compares with CEUS data for large offices.



The benchmark shows slightly high electricity use. However this high electricity use is mainly due to the continuous data center equipment load and associated cooling loads at this site. The following chart shows the relatively low electricity consumption of this site when the data center consumption is excluded.



With data center use excluded, electricity consumption at this site is low.



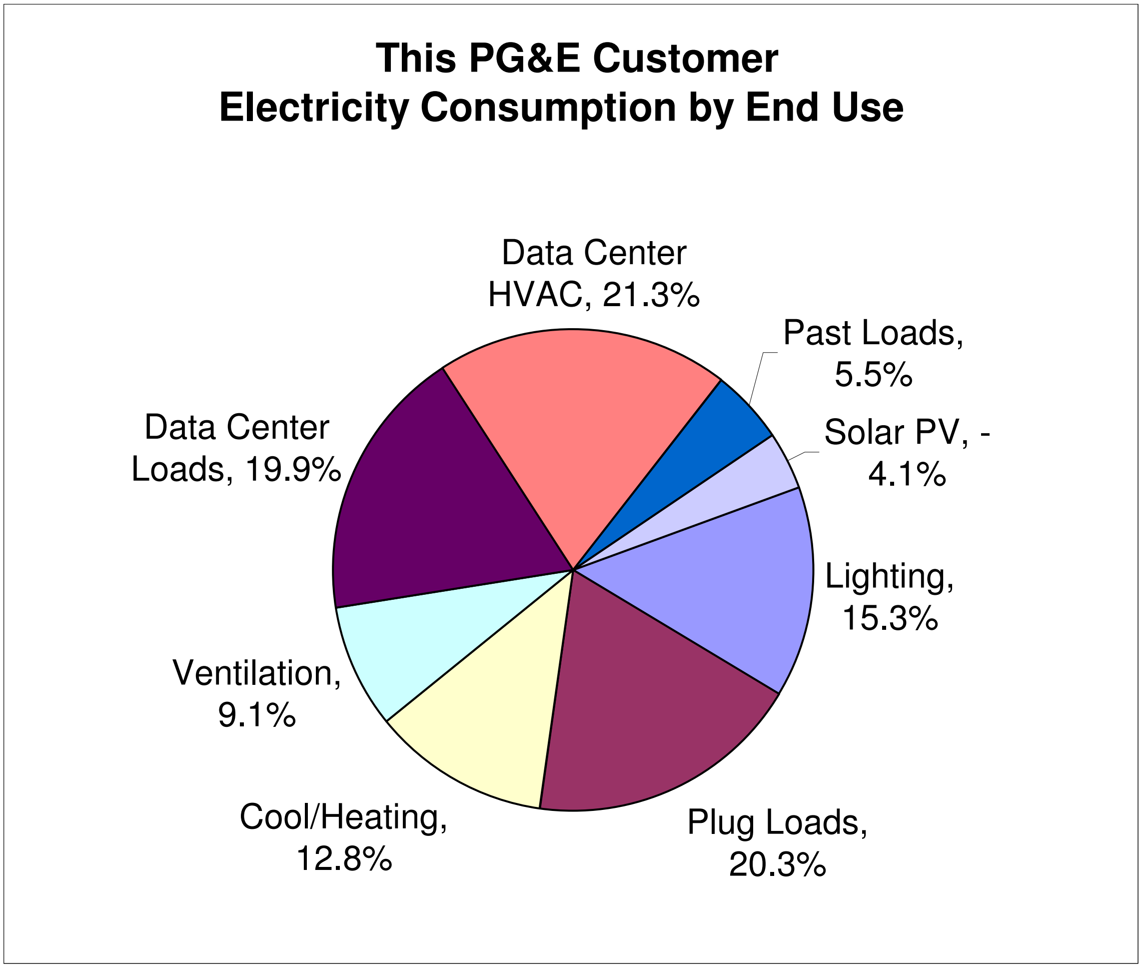
The gas benchmark shows slightly low gas use at this PG&E Customer.

3.5 Energy Balance

In order to estimate potential energy savings, an energy use baseline is necessary. The baseline conditions represent how the facility operates without proposed energy efficiency measures in place. The collected information was used to perform an energy balance at the facility. The usage of the various components of the lighting and mechanical systems were estimated and compared with the utility bills. These estimates were adjusted using engineering judgment until a good agreement was found between historical energy use and the estimated baseline use found through engineering calculations.

An electricity end-use breakdown based on that analysis is shown in the following chart.

Note that the data center and associated HVAC loads account for **over 40%** of the building's electricity use.



4
Energy Project Opportunities

4.1 Energy Analysis Methodology

An energy survey was performed on-site to collect nameplate and operational data for mechanical equipment, the lighting systems, and to identify potential energy efficiency measures. During the site visit, engineers collected the following data:

- A partial inventory of lighting fixtures and controls
- Mechanical system nameplate specifications and control means
- Operation documents and mechanical drawings
- Observations and photographs of conditions and controls.

Spreadsheet models were used to estimate energy savings from potential measures in mechanical and lighting systems. More information about specific methods is provided below in this section.

Measure Order

There are interactive effects among several of the measures modeled in the analysis that may overstate or understate the savings for any individual measure. The sequence of measure implementation was that recommended by the California Energy Commission's *Guide to Preparing Feasibility Studies for Energy Efficiency Projects*, which recommends analyzing measures that affect load first, then working "upward" from load to plant. When reviewing the results of this report, please note that the best estimate of actual savings will be for the entire package of measures recommended. The savings of individual measures may be more or less than shown if not all of the other measures are implemented.

4.2 Spreadsheet Simulations

Weather

Weather data for California Energy Commission Climate Zone XX was summarized into 5-degree bins for the analysis.

Lighting Spreadsheet

Portions of the lighting were counted on-site and the existing wattage for each fixture was multiplied by the corresponding annual hours. This determines the baseline lighting usage. For the proposed case, the corresponding retrofit light fixture wattage was gathered from the standard lighting wattage table from PG&E's incentive programs. The proposed wattage multiplied by the annual hours yielded the proposed lighting usage. Subtracting the proposed usage from the baseline usage provided the total lighting savings. The baseline lighting usage and demand were included in the energy balance.

Temperature Bin-Simulations

The air handler model uses a temperature-bin method approach to estimate the energy use of the HVAC system. The model uses HVAC performance data to calculate the efficiency under the existing and proposed operating conditions. The efficiency is multiplied by the HVAC load at the facility, which is based on the design conditions at the site and a linear load profile. The equipment demand is then multiplied by the hours of operation in each temperature bin to determine the energy consumption. Standard performance curves for all the air-side fans are used to estimate the existing and proposed fan energy consumption. The results of this simulation at existing conditions were used for the energy balance.

The central plant model also uses a temperature-bin method approach to estimate the energy use of the chillers, cooling towers, and pumps. The model uses the chiller staging sequences and loading profile described by facility staff during the site visit. Unless noted otherwise in the appendix, full load efficiency listed in manufacturers specifications and DOE2-2 unloading curves are used to predict chiller energy consumption at specified loading, and entering and leaving water temperatures. The cooling tower model calculates the cooling tower loading based on chiller load and chiller efficiency. Manufacturer's specifications and information gathered during the site visit, such as condenser water set-point, are used to predict cooling tower energy consumption.

4.3 No-Cost Measures

No-cost measures are energy conservation, energy efficiency, or time-of-use management projects that have no associated cost (not including internal labor). These measures reduce energy usage and costs with no capital investment, except for the time and effort of the on-site maintenance personnel.

NCM-1: Modify Data Center CRAC Unit Humidification Controls

Annual Savings				Payback			
Peak Period Savings (kW)	Electricity Savings (kWh)	Gas Savings (therms)	Total Cost Savings	Potential PG&E Incentive	Net Measure Cost	IRR	Simple Payback (yr)
35.2	308,352	0	$ 41,165	$ -	$ -	n/a	0.0

Observations

Modern servers do not require tight humidity control, while sensor drift makes achieving tight humidity control very unlikely anyway. Except for data centers with very sensitive equipment (such as tape drives), a minimum humidity level of 30% relative humidity is now considered appropriate. Please see the following reference for further information:

http://hightech.lbl.gov/documents/DATA_CENTERS/06_DataCenters-PGE.pdf (pp. 42-46)

The four Liebert DX computer room air conditioners (CRACs) in the third floor data center all feature humidity controls. They are equipped with infrared humidifiers (heat lamp water boilers) for adding humidification plus electric reheat to add heat when de-humidifying. Both of these operations use a lot of energy. Meanwhile there is little supply of outside air to the data center space and the server equipment does not change humidity, so humidity changes in the room are mostly caused by the CRAC units themselves. Specifically, condensation occurs at the cooling coils of the CRAC units, removing humidity (moisture) from the air. In turn, the CRACs then boil water to add humidity, and the cycle continues forever. Adding humidity by boiling water, while removing it at the cold cooling coils as condensation, is highly energy intensive and wasteful.

These CRAC units are each set to try to maintain a relative humidity set point of 45% (+/-5%). Each has its own humidity sensor, and when we visited the units were showing relative humidity readings in the range of 30-40%. This means a dewpoint temperature of between 36-43 °F at the return air temperature of 68 °F. On each of our two site visits, all four units were humidifying. This humidification uses 35 kW of power. These humidifiers are likely running all of the time, in which case they are consuming 308,000 kWh of electricity worth over $41,000 annually.

Humidity Set Point at 45%RH

Recommendations

We recommend setting the minimum relative humidity level of the CRAC units at 30% RH. We also recommend regular calibration of the four humidity sensors, at least twice yearly.

Alternately, we recommend simply shutting off the humidification and reheat systems of these units.

At the current return air temperature (RAT) set point of 68 degF, 30% RH corresponds to a dewpoint temperature of 36 degF. The evaporator cooling coils of the CRAC units should not drop below this dewpoint temperature, so condensation will not occur. Without condensation at these coils, room humidity levels should remain very steady and humidification will not be normally required.

Costs and Assumptions

Note that a partial server virtualization project is underway at this data center. This applies to 80 of the servers, representing 18 kW (21%) of the current 83 kW load noted during our site visit. Virtualization will reduce the heat load in the data center, which will further reduce the demand on the CRAC units. It is likely that the savings from this measure will not be affected, as the condensation/humidification cycle will continue.

We assumed that this measure could be implemented by in-house staff at effectively no cost.

No incentives apply for this operational change measure.

4.4 Low-Cost Measures

Low-cost measures are energy conservation, energy efficiency, or time-of-use management projects with a capital cost of less than $10,000. These measures significantly reduce energy consumption and costs while requiring relatively little capital investment.

LCM-2: Install High-Capacity Pre-Filters on Air Handlers

Annual Savings				Payback			
Peak Period Savings (kW)	Electricity Savings (kWh)	Gas Savings (therms)	Total Cost Savings	Potential PG&E Incentive	Net Measure Cost	IRR	Simple Payback (yr)
3.3	4,631	0	$ 618	$ -	$ 327	89%	0.5

Observations

The filters for supply fans SF1 and SF2 are due for replacement soon. The filters to be installed are a bank of standard capacity pleated pre-filters and final bag filters. The filters currently in place are 75% efficiency bag filters, with no pre-filters. The bag filters envisioned are 8-pocket, 85% efficiency bag filters. They have a MERV rating of 13, with a media area of 42 sq. ft. for the 24x24x15” size. The pre-filters envisioned are 24x24x2” standard capacity filters. The replacement schedule is expected to be every 6 months for the pre-filters, and every 24 months for the final filters.

Pressure drop across filters contributes significantly to fan load. Pressure drop increases dramatically as filters collect dirt through their installed life.

Recommendations

We recommend upgrading the pre-filters to high-capacity pleated filters. These filters have the same initial pressure drop as the envisioned pre-filters (0.28” w.c.), but more importantly, they have a 45% greater media area than the current filters. This will yield a slower increase of the pressure drop across the filters as they become loaded with dirt, which will result in lower average fan energy consumption.

The recommended pre-filters will reduce the average pressure drop through the pre-filters by 18%, resulting in a 3% reduction in the average energy consumption of the fans.

Costs and Assumptions

Filter specifications and purchase costs were obtained from the building engineer’s filter supplier. Energy savings were estimated by applying the basic fan laws and assuming a linear increase of the pressure drop through time. The savings calculations are based on the average filter pressure drop.

The replacement schedules are based on staff interview.

No incentives apply for this measure that has a useful life below 5 years.

LCM-3: Implement Static Pressure Reset on Supply Fans

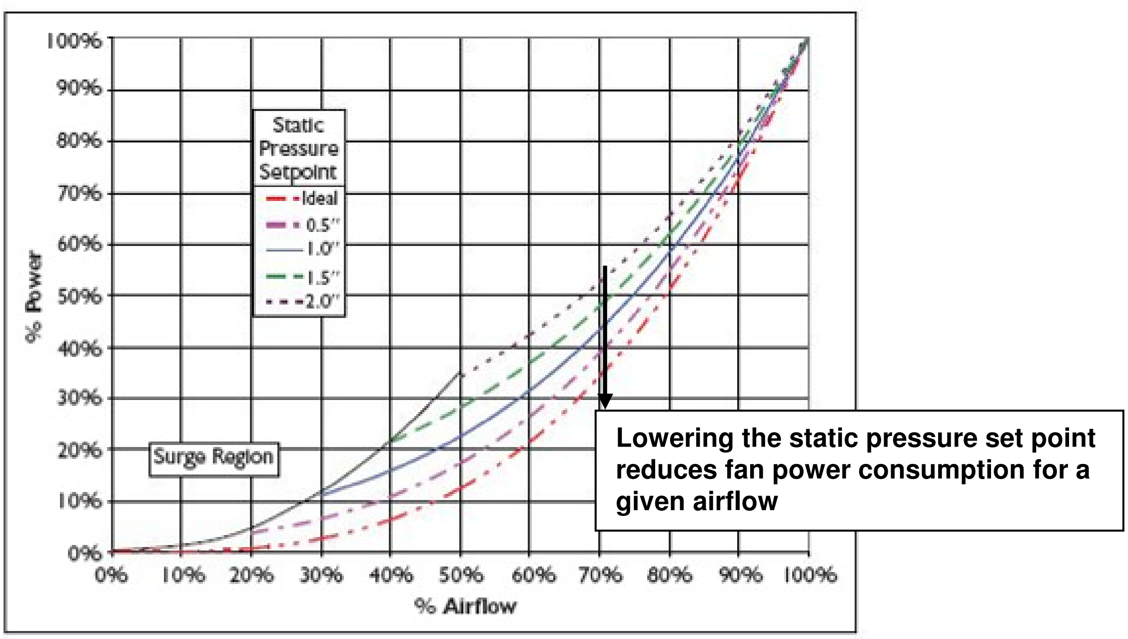
Annual Savings				Payback			
Peak Period Savings (kW)	Electricity Savings (kWh)	Gas Savings (therms)	Total Cost Savings	Potential PG&E Incentive	Net Measure Cost	IRR	Simple Payback (yr)
0.0	36,652	0	$ 4,893	$ 2,925	$ 2,925	167%	0.6

Observations

Air is distributed to the building's VAV boxes by two 150 hp supply fans. At present, these ventilation supply fans are controlled to maintain a duct static pressure set point of 1.7"w.c. at all times when scheduled. As individual VAV boxes open or close to supply air as needed in each zone, the static pressure in the supply duct changes. The EMS responds by adjusting the speed of the supply fans in order to maintain duct static pressure set point. Inn low demand conditions, most VAV boxes are closed, so the supply fan is blowing hard against mostly closed dampers. This is like driving a car with the brakes on.

There is opportunity to save energy by automatically adjusting the duct pressure set point based on demand. When demand is low, the set point can be lowered, causing more VAV boxes to open, and reducing throttling losses. This saves fan energy while still meeting system air needs.

Supply fans operate more efficiently at lower static pressures (see graph below). While it is necessary to have high static pressure to meet peak zone demands, at most times most VAV boxes are not fully open and could operate with lower static pressures, saving considerable amounts of energy on the supply fans.



VAV Performance as Function of Static Pressure Set point

Recommendations

We recommend implementing an automatic reset of duct static pressure at this site.

The control system features required to implement this measure already exist at this facility. Specifically, zone-level direct digital controls (DDC) as well as a signal from the VAV box controllers back to the DDC system indicating VAV box damper position are already in place, allowing this measure to be implemented with additional EMS programming only.

The following recommended controls method will maintain a high static pressure only when zone demand is near maximum, and will reduce the set point when zones are satisfied.

Control Sequence

Specifically, we recommend the following control sequence, called “trim and respond” (based on ASHRAE June 2007, “Increasing Efficiency with VAV System Static Pressure Setpoint Reset”, S. Taylor):

- The static pressure (SP) set point will vary between 0.5” w.c. and 1.7” w.c.
- When the fan is off, the set point should be 0.5” w.c. (this will also be the startup set point)
- When the fan is proven on, every four minutes, the set point is recalculated with the following logic:
    - If there are two zones or fewer zone pressure requests, trim (decrease) the set point by 0.04” w.c., but no lower than the minimum pressure of 0.5”w.c.
    - If there are more than two zone pressure requests, respond by increasing the set point by 0.06” w.c.

“Pressure requests” should be programmed to be generated by a VAV box when the VAV damper is greater than 95% open until it drops to 80% open.

This control sequence should be commissioned. Most parameters in the sequence can be adjusted when the measure is being commissioned: ie. the timing parameter (here 4 minutes), the trim and response rates (here 0.04” / 0.06”), the minimum pressure set point (here 0.5”), and the minimum number of zones pressure requests (here 2). A slower trim rate will give a more stable system; a faster response rate will give a faster-responding system, but a too high response rate can create instabilities. A higher time parameter can improve the system’s stability, but will also affect its responsiveness.

By setting a threshold of at least 2 pressure requests before increasing the set point, this logic also allows for easily ignoring the “rogue zones” – zones that are undersized and whose VAV boxes are therefore 100% open at all times (eg. telecom cabinets). These zones should be identified and treated separately from this measure; supplying them with 100% air at all times is not going to solve the rogue zones’ issues, and would make this measure ineffective.

Costs and Assumptions

To estimate savings, a fan model was developed using manufacturer’s data and a 2004

ASHRAE paper[1]. This model allows predicting the fan energy consumption at any given static pressure and airflow. A temperature-bin simulation was used to model the building's loads.

Costs for this measure were estimated by roughly assuming 30 hours of controls work at $150 per hour, plus an additional 30% contingency.

The potential incentive was based on the calculated savings at $0.08 per kWh for Motors and Other Equipment (including Controls) and limited to 50% of the measure cost. Please see the following web link for information on applying for customized (calculated) incentives:

http://www.pge.com/mybusiness/energysavingsrebates/rebatesincentives/ief/

LCM-4: Install VFDs and Controls for Primary Condenser Water Pumps

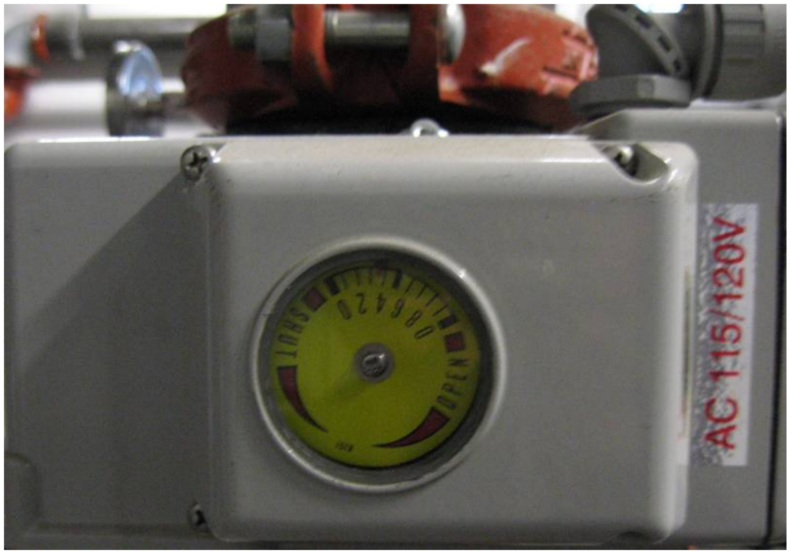
Annual Savings				Payback			
Peak Period Savings (kW)	Electricity Savings (kWh)	Gas Savings (therms)	Total Cost Savings	Potential PG&E Incentive	Net Measure Cost	IRR	Simple Payback (yr)
17.5	86,934	0	$ 11,606	$ 6,955	$ 7,783	149%	0.7

Observations

The existing primary condenser water (CW) distribution system uses two pumps in parallel. As described in Section 2, the primary condenser water system is used to provide heat rejection for the chillers, and for a heat exchanger to a secondary circuit for water-cooled heat pumps located in telecom rooms on each floor. One primary pump runs all of the time to serve the secondary condenser water loop, and to serve the lead chiller when it runs. When a second chiller starts, the second pump starts as well.

There are two modulating isolating valves on the circuit, one for each chiller. They are two-position valves, either closed to isolate the chiller, or open at a fixed position ("40%" open based on audit observations), thus throttling the condenser water flow.

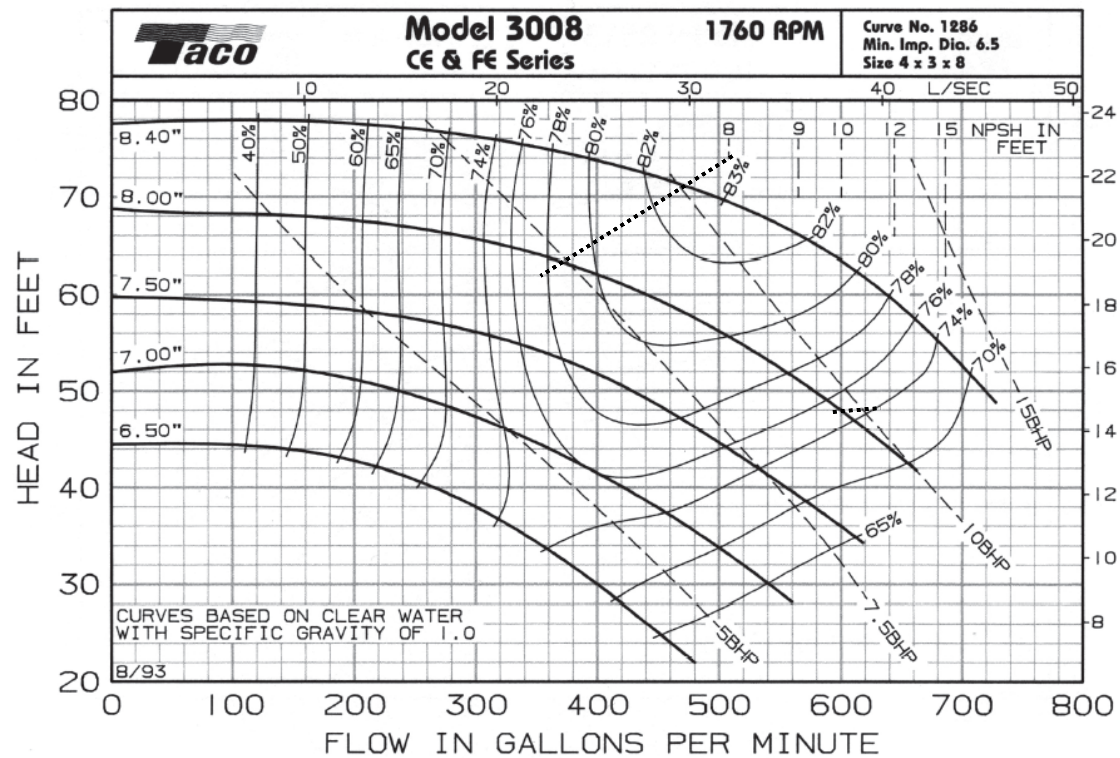
[1] Development and Testing of the Characteristic Curve Fan Model



Condenser Water Valve Open to 40%

The pumps are currently operating far away from their design conditions. They were designed for a 65 ft pressure drop, and a 480 gpm condenser water flow. However, based on the readings on the pump gauges, they are actually operating at a 37 ft pressure drop, which corresponds to a 1,000 gpm flow and a low 70% pump efficiency based on the pump curve. The combination of significant flow throttling and low actual pressure across the pump indicates that these condenser water pumps are over-sized.

16 psi (=37 ft wc) Pressure Drop Across Condenser Water Pump



Pump Curve Showing Design and Operating Points (7.75" Impeller)

Recommendations

We recommend installing VFDs to the primary condenser water pumps to allow control of their speed, and thus of the condenser water flow. This will provide savings in two ways, without affecting chiller operation.

We conservatively recommend that when a chiller is operating, flow to the chiller should be at a constant rate as specified by the chiller manufacturer. This will be achieved with a constant but reduced pump speed, in combination with fully-opened throttling valves. A new water balance must be performed to determine the required pump speed to achieve specified flow. For the hours that one or two chillers is operating, this measure will save energy by running the pumps at lower speed while providing full constant flow to the chillers.

In addition, there are over 5,000 hours per the year when chillers are off and the condenser water is only being used to remove heat from the secondary heat pump circuit. In these conditions, actual CW flow can be significantly reduced, and still meet the heat rejection needs of the secondary loop. We recommend reducing the pump speed to 60% (36 Hz) during these hours. This speed will maintain flow above the typical minimum flow required by cooling towers to avoid fouling and other issues.

Note - Alternately, some of the energy savings could be achieved by installing smaller pump impellers to reduce the capacity (and power demand) of the pumps at all times. This is a relatively inexpensive option.

The following summarizes the recommended control strategy.

1. When no chillers are operating, set CW pump speed to 60% (36 Hz).
2. When a chiller is operating, run its corresponding CW pump at a constant speed. A water balance is required to determine this speed. The required speed is to be determined by measuring condenser water flow at the chiller. The pump speed must provide recommended design CW flow to each chiller.
3. When two chillers are operating, both pumps operate at the same speed.
4. The two chiller isolation valves are to open fully when their corresponding chiller is operating.

Costs and Assumptions

We evaluated the proposed case by assuming a linear pumping profile that follows the chiller load profile, which in turn is linked to the load on the cooling coil, accounting for economizer operation.

We used the pump curve, observed pressure reading, and design flow to estimate that the pump speed during chiller operation will be reduced to approximately 75%, with pump efficiency improved from 70% to 83%.

Costs were based on RS Means data for installation of two custom-engineered 15-hp VFDs, 16 hours of controls and commissioning work at $150 per hour, and an allowance for water balancing.

The potential incentive was based on the calculated savings at $0.08 per kWh for Motors and Other Equipment (including Controls). Please see the following web link for information on applying for customized (calculated) incentives:

http://www.pge.com/mybusiness/energysavingsrebates/rebatesincentives/ief/

4.5 Capital-Intensive Measures

Capital-intensive measures are energy conservation, energy efficiency, or time-of-use management projects with a capital cost of greater than $10,000. These measures significantly reduce energy consumption and costs, but also require significant capital investment.

CIM-5: Install Photocells To Control Lighting Near Windows

Annual Savings				Payback			
Peak Period Savings (kW)	Electricity Savings (kWh)	Gas Savings (therms)	Total Cost Savings	Potential PG&E Incentive	Net Measure Cost	IRR	Simple Payback (yr)
0.0	56,022	0	$ 7,479	$ 2,801	$ 10,399	72%	1.4

Observations

The extensive windows provide significant levels of daylighting in perimeter areas. However, the current control strategy doesn't account for daylight. In private offices, the lights are controlled only based on occupancy; however, during our audit we measured satisfactory light levels from daylight alone. More precisely, we measured the following light levels in a North-facing office with the blinds open, on a slightly cloudy day, at about 11am:

All lights off	68 FC
Overhead fixture on only	84 FC
Overhead and wall fixtures on	93 FC

Private Office with Overhang and Wall Fixtures On

The IESNA recommends light levels of 50 FC in private offices; therefore, in this case, using only daylight and keeping the fixtures off would provide adequate light levels.

In open offices, all fixtures are kept on during business hours; daylight could provide satisfactory light levels to an area up to 15 feet away from the windows. Currently, lights are scheduled to be on during the day independently from daylight levels.

Recommendations

We recommend installing daylighting controls to reduce artificial lighting levels in certain areas when natural daylighting can provide satisfactory light levels. The first two fixtures away from the windows can generally be controlled based on daylighting levels; fixtures located further than 15 feet away from the windows should not be controlled based on daylight levels. This is based on LBNL daylighting recommendations[2]: the daylighting zone should extend to about 1.5 times the distance from the floor to the top of the window.

Particular care should be given to the sensor location. We recommend opting for an open-loop control system (that is, a control system that is solely based on daylighting levels, rather than on combined daylighting and artificial lighting). The sensors should be located close to the windows and directed towards the outside, so as to measure daylight levels only.

[2] LBNL "Tips for daylighting with windows – the integrated approach", pg 3-3 - http://windows.lbl.gov/daylighting/designguide/dlg.pdf

Open-loop configurations are easier to tune and are more forgiving as to the sensor location[2]. Closed-loop controls systems are also better suited for dimmable ballasts, which we do not recommend here.

We recommend a three-level configuration:

	Fixtures closest to the windows (1st row of fixtures)	Fixtures further from the window (2nd row of fixtures)
High daylight levels	both lamps off	one lamp off, one lamp on
Medium daylight levels	one lamp off, one lamp on	two lamps on
Low daylight levels	two lamps on	two lamps on

Recommended Control Strategy

Costs and Assumptions

Detailed lighting drawings were used to estimate the number of fixtures for which daylighting control would be feasible. We assumed that fixtures located further than 15 feet from the windows would not be controlled by the daylighting system. Daylighting was assumed to be available for 40% of the time, based on a study[3] by Energy Design Resources. To simplify the analysis, we only modeled the two extreme levels of daylight controls (high daylight levels / low daylight levels).

The scope of work to achieve this measure depends largely on details of the existing lighting wiring, which we did not investigate. We roughly estimated that this project could be completed by an electrician and assistant in two weeks.

The potential incentive was based on the calculated savings at $0.05 per kWh for Lighting, which was higher than the itemized incentive. Please see the following web link for information on applying for customized (calculated) incentives:

http://www.pge.com/mybusiness/energysavingsrebates/rebatesincentives/ief/

CIM-6: Implement Airflow Improvements and Install VFDs on Larger CRAC Fans in Data Center

Annual Savings				Payback			
Peak Period Savings (kW)	Electricity Savings (kWh)	Gas Savings (therms)	Total Cost Savings	Potential PG&E Incentive	Net Measure Cost	IRR	Simple Payback (yr)
12.1	106,174	0	$ 14,174	$ 8,494	$ 32,148	44%	2.3

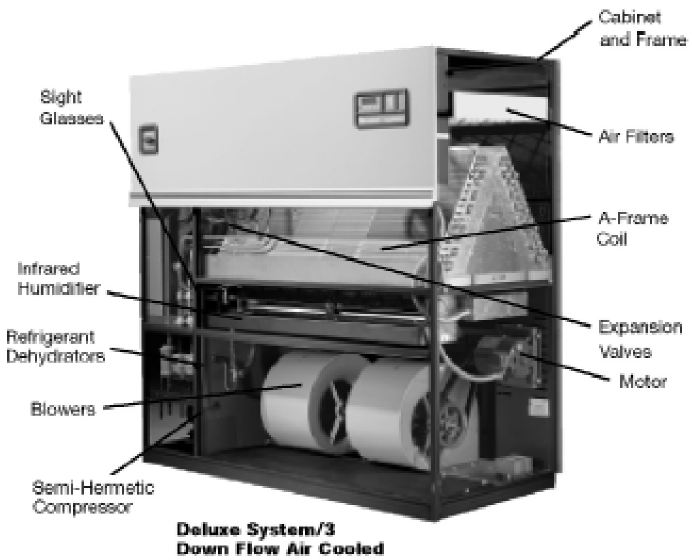
Observations

All of the Liebert computer room air conditioner (CRAC) units serving the data center have constant speed 7.5 hp fans. All CRAC fans operate 24/7. They use 145,000 kWh of electricity costing $19,400 per year.

The CRAC units are operating well below capacity. This is evident by the indicated active compressor stages (observed cycling 0 to 50%), as well as by the low temperature

[3] http://www.energydesignresources.com/docs/dl-05.pdf

drop (delta-T) across the inlet and outlet of the CRAC. The average supply temperature into the space is about 60 °F, while the return temperature is 68 °F at each unit. This delta-T of only 8 °F is very low compared to efficient data centers with delta-T's of 25 °F or higher. This means that energy is being wasted with excessive airflow. In addition, this means that the effective capacity of the CRACs is much lower than is possible for these units.



Cutaway of Liebert Downflow DX CRAC

The data center servers are using about 83 kW of power. (A server virtualization project currently underway will reduce this by 18 kW.) Adding heat loads from lighting and a 20% safety factor yields a total data center heat load of only about 102 kW or 29 tons. The CRAC fans alone add another 4.7 tons or 20% to this load. Meanwhile the combined nominal rated capacity of the CRAC units is 83 tons.

UPS Readout – 83 kW Power Use

In raised floor data center type spaces, the efficiency and capacity of the CRAC units is maximized by avoiding mixing of hot and cold air as much as possible. Airflows must be controlled carefully. Efficient airflows with minimal mixing are indicated by high temperature differences (delta-T) across CRAC units.

That is, there should be good separation of cold supply air, and hot return air. Ideally, data center equipment should receive undiluted cold air at its air intakes. Hot exhaust air should travel as directly as possible back to the CRAC intake. The average delta-T across the lightly-loaded CRACs at this site is only 8 °F. A fully utilized CRAC unit serving an area with minimal mixing can have a delta-T of 25 °F or higher (eg. 55 °F supply air, 80 °F return air). The average lightly-loaded CRAC at this site is therefore providing about 32% of its potential capacity.

One essential practice today is to orient the equipment to create hot aisles and cold aisles. That is, equipment should be placed in rows and oriented consistently to pull cool air in from one side (with floor openings providing cool sub-floor air in this cold aisle) and exhaust heated air out the other side (where this hot aisle air rises and then travels along the ceiling to the inlets of the CRAC units). This site generally uses a hot aisle-cold aisle approach, but detail issues are hurting the effectiveness of this approach.

Cold Aisle Air Supply Tiles

In addition to hot/cold aisles, other air flow improvements require many small detail changes which, taken together, will make a significant impact on the cooling effectiveness of the data center.

With efficient airflow and minimal mixing, heat load capacity is increased. Less airflow is needed meaning CRAC fans can be slowed further, saving energy.

Recommendations

We recommend making airflow improvements in the data center to reduce mixing and allow CRAC fan speed reductions, saving energy. We also recommend installing VFDs to provide fan speed control of the three larger CRAC units. This is an increasingly common retrofit measure for data center CRAC units.

The power demand of a fan drops dramatically as its speed (and flow) is reduced. For example, slowing a fan by just one tenth reduces its power use by about one quarter. Meanwhile the prices of variable frequency drives (VFDs) have fallen steadily over recent years and today, they are relatively inexpensive.

Because the data center loads are very steady, we recommend that each CRAC fan speed can simply be set manually based on conditions after airflow improvements are complete. Some variation in fan speeds between CRACs may be needed to achieve acceptable flows in all areas. Lower fan speeds will increase operating delta-T's; ie. return air flows will be warmer. Speeds should be reduced in stages, and care taken to ensure coil freezing will not occur.

To allow lower fan speeds, detailed airflow improvements need to be implemented to improve air flow and reduce hot/cold mixing, including:

- Supply air tiles should not be located in hot aisles, or near the hot air outlets of individual racks, or under racks. They should be in cold aisles only.
- For high heat load equipment, direct return air ducting can be installed to send hot return air directly to the intakes of CRAC units. This is an important step to reduce hot/cold mixing. One inexpensive option is to use the ceiling space as a return duct, by adding openings over the hot aisles, and ducting directly from the ceiling to CRAC intakes. With this measure, the RAT set point of the CRAC units can be increased significantly.

An Example of Warm Return Air Ducted Direct from Ceiling Space to CRAC

- If necessary, direct supply air ducting (or baffling) can also be installed to further help with any "hot spot" equipment.
- Recirculation of hot air exiting the back of a rack into the front of the rack must be eliminated. Install filler or blanking panels on racks as needed to prevent air recirculation. (More serious efforts can include full dividers separating hot and cold aisles, often using clear panels to build removable walls).

No Blanking Between Aisles – NOT GOOD

- Supply air tiles should be redistributed and optimized to provide cool air directly to high heat load equipment only, specifically to their cool air intakes.
- Supply air tiles should not be located too close to CRAC units. In areas under the raised floor where air velocities exceed about 530 CFM, usually within about six tiles of the unit discharges, a venturi effect may be created where room air will be sucked downward into the sub-floor (instead of being blown out of the tile).

Supply Tiles Very Close to CRAC Unit – NOT GOOD

- Unnecessary floor openings, such as at cable entry points, should be sealed using products designed for this task. There are brush or bristle-type seals available which provide cable access while blocking most air flow. When floor openings are not sealed, an easy short-circuit route is provided for cool sub-floor air to enter the room where it is not needed.

Cable Openings Without Seals

- Old unused cabling, which blocks air flow in the sub floor, should be removed.
- Cables should be routed and tied down as needed to minimize obstruction of desired air flows into racks.
- Baffling may be added in the sub-floor to ensure even air distribution as fan speeds (and sub-floor pressurization) are decreased.

These recommendations represent the basics of good data center airflow management. For further information about data center optimization, please see the following Lawrence Berkeley National Lab website:

http://hightech.lbl.gov/DCTraining/best-practices-technical.html

As airflow improvements are made, reducing mixing of hot and cold air, the return air temperature set points of the CRACs should be increased. The CRAC fans will be able to operate at lower speeds while meeting the same equipment cooling loads.

Costs and Assumptions

We calculated fan energy savings based on current typical temperature difference (delta-T) across the CRAC units. The same amount of cooling can be achieved by each CRAC by operating at a lower flow rate (slower fan) and higher delta-T. We added a safety factor of 50% to the observed delta-T as a % of 25 degF. We then assumed that the CRAC fan speed could be reduced to this level, limited to a minimum speed of 50%. In this case, this effectively means that we calculated savings based on fan speeds being reduced to the 50% minimum. We calculated fan power demand using ASHRAE power demand curves for HVAC fans with VFDs at reduced speeds. We assumed a VFD efficiency of 98%.

We ignored the cooling savings which will be enjoyed due to the reduced heat load from the fans themselves.

We ignored the virtualization project for these calculations. Depending on future additional virtualization plans including any layout adjustments, it may be possible to simply shut off one of the existing CRAC units. This will provide savings at little or no cost.

We estimated VFD costs based on 2007 Means data for the installation of one custom-engineered VFD per CRAC unit. We allowed a 15% contingency factor, plus 15% for design and engineering and 15% for controls and commissioning costs. This is a general cost estimate. Of course, detailed vendor quotes will need to be obtained. We also allowed a very rough cost allowance of $20,000 for airflow improvements. Many improvements can be made for essentially zero cost (relocating supply air tiles) but costs rise quickly when changes such as ductwork additions are required.

The potential incentive was based on the calculated savings at $0.08 per kWh for Motors and Other Equipment under PG&E's NRR-DR program. This calculation yielded a higher incentive than the itemized catalog rate for VFDs on HVAC fans (H148, $80 per hp). The incentive is likely to be cost-capped at 50% of costs for this attractive measure. Please see the following web link for information on applying for customized (calculated) incentives:

http://www.pge.com/mybusiness/energysavingsrebates/rebatesincentives/eefficiency/ief/

4.6 Additional Recommendations

Reduce Equipment Cycling; Recommission Controls

When we visited, we observed significant regular fluctuations on the exhaust fans, the condenser tower temperature, and the supply fans, over short periods of time (less than five minutes for the condenser water temperature, 10 to 20 seconds for the exhaust and supply fans). This indicates some controls issues.

Cycling equipment consumes more energy; in the case of the condenser water temperature, it can also make the chiller operate away from its design conditions and be less efficient. Here are suggestions to address this issue:

- fine-tune the PI or PID loops controlling the exhaust fans, condenser water temperature, and supply fans speed;
- instead of using instantaneous input signals for building pressure, condenser water temperature, duct static pressure, use sliding averages over 30 seconds to 2 minutes. This will smooth out the input signal and reduce the variations in the output of the loops, while still providing adequate response to the building loads.

Install Stack Dampers on the Boilers

Heating is provided to the building by two 3,500 MBtuh boilers. There is currently no stack damper installed on the boilers.

We recommend that a damper be installed in the boiler stack to minimize convective heat losses from the boiler chamber when the boiler's burner is not firing.

The hot water boiler is a natural draft type unit with a vertical stack. A damper will reduce convection losses during times when the boiler is not firing.

Implement Automatic Reset of Heating Hot Water Temperature

The heating hot water is maintained at 180 degF at all times. Gas savings can be achieved by installing an automatic reset to reduce this temperature when heating demands are low.

Check and Reduce Chilled Water Pump Capacity

The chilled water pumps appear to be oversized. Additional functional performance testing is needed to confirm this. Energy savings can be achieved by installing a smaller impeller in the pumps, to reduce their capacity and power demand.

4.7 Measures Analyzed But Not Recommended

Convert Chilled Water Pumping System to Variable Volume

The existing chilled water (CHW) distribution system is a primary only, constant flow system. The system is designed so that one 15 hp CHW pump is turned on with each chiller. We analyzed the potential savings and costs to convert this system to variable volume.

Based on the estimated savings and costs, we do not recommend this measure because it would yield a long payback. Resources would be better utilized in other projects that will yield more energy savings.

4.8 Demand Response and Reliability Measures

Demand response and reliability programs – also known as load shifting, load curtailment, peak load reduction, peak shaving, or load shedding – are similar, but not exactly the same. Both provide incentives for reducing or shifting electricity use out of peak demand hours (the 80 to 100 highest demand hours out of 8,760 hours a year). All of these programs ask or cause participating customers to respond to a signal to reduce demand in return for a variety of financial incentives that reflect the value of what the customer is providing: response time and surety of delivery.

Demand response programs address supply or price concerns that can be forecasted the day ahead, enabling you to initiate solutions to be carried out on the critical day. By contrast, reliability programs are designed for response on very short notice, usually just minutes, to mitigate unpredictable power plant or grid emergencies.

Current demand response options include the following:

Demand Bidding Program (DBP) – DBP asks you to bid a load reduction quantity based on day-ahead Alert Notices from the California Independent System Operator (CAISO). Participants receive payment equivalent to the day-ahead market price plus a premium (up to a certain cap) for their demand reductions.

Critical Peak Pricing (CPP) Tariff – CPP operates on up to 12 critical peak days a year by issuing day-ahead notices to reduce or shift load. It offers lower rates on electricity used during non-critical periods, and higher peak rates during critical periods.

California Power Authority's Demand Reserves Partnership (CPA-DRP) – This program treats your load like a generation resource and pays both for committed capacity every month and for actual load reductions on critical days. This is not a PG&E program, but PG&E can provide the information you need to get started.

Current reliability options include:

Base Interruptible Program – You receive monthly incentives for your commitment to reduce demand to a pre-determined level on short notice, and pay penalties if you do not reduce demand to your committed firm service level.

Optional Binding Mandatory Curtailment Program – This curtailment program exempts you from rotating outages in return for reducing a portion of the demand on the circuit that serves you to agreed-upon levels with 15 minutes' notice.

Scheduled Load Reduction Program – This summer-only program pays you for qualifying load that you reduce on a schedule that you set in advance.

For the recommended measures, the credits and/or incentives are based on PG&E's day-ahead Demand Bidding Program, assuming a four-hour event that takes place 10 times per year. It is also possible to participate in a day-of Demand Bidding Program, which offers a significantly larger credit. *The minimum required demand reduction for participation in the Demand Bidding program is 50 kW.*

DR-1: Reduce Lighting Levels in Office Spaces – Estimated Maximum 48.1 kW Demand Reduction

Annual Savings				Payback			
Average Demand Reduction (kW)	Electricity Savings (kWh)	Gas Savings (therms)	Total Cost Savings	Potential PG&E Technical Incentive	Net Measure Cost	IRR	Simple Payback (yr)
48.1	1,924	0	$ 930	$ -	$ 10,000	-1%	10.8

Observations

The lighting in this building accounts for a large fraction of electricity consumption. Altogether, lighting of the interior spaces of the building uses 144 kW.

Recommendations

A possible demand response measure may be to reduce lighting levels during a demand response event. It may be possible to shut off approximately one-third of all active lighting fixtures in offices and still maintain occupant productivity. The reduced level of lighting is likely to be sufficient for many tasks, especially in perimeter areas near windows, and where most work is on a computer.

This measure would require modifications to some lighting circuits to allow control of particular fixtures. Careful implementation would be needed, including detailed study to determine which fixtures can be shut off. Lighting could then be reduced remotely via a PG&E CLIR box. The controls contractor will also need to add program lines to the EMS system that will command switching to reduced light levels. The controls screen enabling reduced light levels should be easily accessible.

We also recommend testing the measure on a sample floor portion and measuring occupant satisfaction to ensure that the reduced light levels are not excessively disturbing to occupants.

Costs and Assumptions

Costs were roughly estimated at $10,000 for re-wiring and EMS programming.

The possible DR incentive was estimated at approximately $0.35 per kWh reduction for ten four-hour events per year.

DR-2: Turn Off Garage Lighting – Estimated Maximum 2.5 kW Demand Reduction

Annual Savings				Payback			
Average Demand Reduction (kW)	Electricity Savings (kWh)	Gas Savings (therms)	Total Cost Savings	Potential PG&E Technical Incentive	Net Measure Cost	IRR	Simple Payback (yr)
2.5	99	0	$ 48	$ -	$ 600	-4%	12.6

Observations

The garage is primarily lit by 2-lamp, 4-foot T8 fixtures. Lighting is currently partly turned off during the day – only about 20% of the fixtures are on during daytime. During our audit, we shut off fixtures that were turned on and still measured acceptable light levels close to the fixtures (35 vertical lumen with lights off vs. 45 vertical lumen with lights on), indicating that all lighting could be turned off.

Recommendations

A possible demand response measure is to switch off all lights in the parking garage during a demand response event. Based on our measurements, this strategy will still provide adequate light levels.

Costs and Assumptions

Costs were roughly estimated at four hours of EMS programming.

The possible DR incentive was estimated at approximately $0.35 per kWh reduction for ten four-hour events per year.

DR-3: Reduce Ventilation – Estimated Maximum 41.4 kW Demand Reduction

Annual Savings				Payback			
Average Demand Reduction (kW)	Electricity Savings (kWh)	Gas Savings (therms)	Total Cost Savings	Potential PG&E Technical Incentive	Net Measure Cost	IRR	Simple Payback (yr)
20.2	808	0	$ 390	$ -	$ 1,000	37%	2.6

Observations

The air distribution system for this building is a VAV system with two 150 hp supply fans.

Recommendations

A possible demand response measure is to reduce the air flow to the offices during a demand response event. The supply fan speeds could be slowed by 20%. Assuming the fans would otherwise be operating at 85% speed (51 Hz) during the hot curtailment day, this will reduce fan power by a maximum of 41.4 kW. Based on our simulations and historical weather data, the average demand reduction during the summer peak period hours (May through October, 12 noon to 6pm) would be 20.2 kW.

The reduced airflow will mean that cooling coil heat transfer will be reduced. Cooling will be reduced in at least some zones, and some zone temperatures may increase.

Once the time period has lapsed, control should default back to normal operation.

Costs and Assumptions

Costs were roughly estimated at $1,000 for programming of the EMS.

We assumed that fan speeds could be reduced by 20%.

The possible DR incentive was estimated at approximately $0.35 per kWh reduction for ten four-hour events per year.

4.9 Self-Generation Measures

Self-Generation Measures involve installing equipment on-site that allows the facility to generate its own electricity. In some cases, waste heat from electricity generation may be used in the facility as well.

This site already has a solar PV array on its roof. We did not identify any other economic self-generation measures for this site.

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Appendix: Calculations and Supplemental Information