Integrated Energy Audit

PG&E Industrial Customer

March 4, 2009
Final Report
Prepared by

PG&E Contracted Energy 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 for this PG&E Customer. 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 PG&E Energy 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 PG&E Energy 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 PG&E Customer. The goal of a PG&E Integrated Energy Audit is to identify potential high-value energy and demand savings by investigating 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 Energy 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. The measures are divided into no-cost, low-cost, and capital investment measures.

1.1 Your Cost Reduction Opportunities

The following two tables summarize the measures recommended for this facility:

1. “Phase 1” measures for immediate implementation in early 2009, as submitted in one NRR incentive application;
2. “Phase 2” measures for implementation in the next fiscal year beginning June 2009.

PG&E Integrated Energy Audit
PG&E Customer
Energy Measures for Early 2009 Implementation

Measure Number	Measure Description	Annual Energy and Cost Savings					Payback with Incentive				
		Peak Savings (kW)	Electricity Savings (kWh)	Gas Savings (therms)	Total Cost Savings	CO_2 Savings (tons/yr)	Measure Cost	Potential 2009 PG&E Incentive	Net Measure Cost	IRR	Simple Payback (yr)
	LIGHTING										
CIM-4C	Replace Metal Halide High Bay Lighting with **T8** Fluorescents (8 lamp in Cooler, 6 in Plant) with Integral Occupancy Sensors and PRS Ballasts	56.8	787,419	0	$ 77,088	432.4	$ 111,024	$ 38,753	$ 72,271	107%	0.9
	AIR COMPRESSORS										
CIM-8B	Install Receiving Tank, Additional Piping, VSD Trim Compressor and Scheduling/Sequencing Controls	66.0	582,329	0	$ 57,010	319.8	$ 74,025	$ 59,014	$ 15,011	380%	0.3
	REFRIGERATION										
LCM-9 (NOT NRR)	Condensers: Modify or Repair Controls to Allow ALL Fans to Operate at Equal Speed	7.5	66,117	0	$ 6,473	36.3	$ 3,000	$ -	$ 3,000	215%	0.5
CIM-11	Reduced Head: Install Discharge Regulators for Ice-Making Hot Gas, Repipe Seven Evaporators to HT Loop, Repipe Small 150hp HT Compressor to LT & MT Loops, Retrofit VFD on One 350 hp Compressor, and Install Controls	65.9	784,664	0	$ 76,819	430.9	$ 126,555	$ 124,287	$ 2,268	3387%	0.0
	SUB-TOTALS, Before Incentive Caps	**196.3**	**2,220,527**	**0**	**$ 217,390**	**1,219.3**	**$ 314,605**	**$ 222,055**	**$ 92,550**	**235%**	**0.4**
NRR TOTALS (NRR measures only, without lighting indirect savings)		**188.7**	**2,028,429**	**0**	**$ 210,917**	**1,219.3**	**$ 311,605**	**$ 155,802**	**$ 155,802**	**139%**	**0.7**

Average Electricity Cost	$ 0.0979	/kWh	(Average for recent 12 months, three accounts)
Summer Peak Electricity Cost	$ 0.2299	/kWh	(Approx AG5B average incl demand charges)
Part- and Off-Peak Electricity Cost	$ 0.0786	/kWh	(Approx AG5B average incl demand charges)
CO2 Reduction Equivalents :	1.098	lbs CO2/kWh	Based on CEC/CPUC Greenhouse Gas Estimator
(marginal energy use reductions)	11.7	lbs CO2/therm	

2009 PG&E Incentives

NRR/DR Incentives	Rate
Cost Cap (each measure)	50%
Peak Electricity Demand	$100.00 per peak kW
Motors / Equipment / Controls	$0.09 per kWh
Lighting	$0.05 per kWh
AC & Refrigeration I	$0.15 per kWh

The Internal Rate of Return (IRR) allows comparison of the financial return of projects through their expected life. Attractive projects have an IRR greater than the cost of money. Precisely, IRR is the discount rate which yields a Net Present Value of zero.

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PG&E Integrated Energy Audit
Site Name
Energy and Demand Response Measures

Measure Number	Measure Description	Annual Energy and Cost Savings					Payback with Incentive				
		Peak Savings (kW)	Electricity Savings (kWh/yr)	Gas Savings (therms/yr)	Total Cost Savings ($/yr)	CO_2 Savings (tons/yr)	Measure Cost	Potential PG&E Incentive	Net Measure Cost	IRR	Simple Payback (yr)
	LIGHTING										
LCM-1	Delamp and Add Occupancy Sensors Control of T5's Under Mezzanine	0.8	6,691	0	$ 655	3.7	$ 720	$ 360	$ 360	182%	0.5
LCM-2	Add Photocell Control of Outside Lighting	0.0	10,768	0	$ 1,054	5.9	$ 1,000	$ 500	$ 500	211%	0.5
LCM-3	Install Occupancy Sensors and Lighting Retrofits in Offices, Mechanical Rooms	2.9	25,135	0	$ 2,461	13.8	$ 5,261	$ 1,544	$ 3,717	66%	1.5
CIM-4B	Replace Metal Halide High Bay Lighting with T8 Fluorescents (8 lamp in Cooler, 6 in Plant)	51.5	536,775	0	$ 52,550	294.7	$ 80,308	$ 31,986	$ 48,322	109%	0.9
CIM-5	Control Proposed Fluorescent High Bay Lighting with Occupancy Sensors (incl. upgrade to program start ballasts)	6.2	250,643	0	$ 24,538	137.6	$ 30,717	$ 15,126	$ 15,591	157%	0.6
	AIR COMPRESSORS										
LCM-6	Air Compressors: Install Scheduling Controls (Time Clocks)	0.0	348,055	0	$ 25,579	191.1	$ 4,224	$ 2,112	$ 2,112	1211%	0.1
LCM-7	Air Compressors: Install Receiving Tank and Reduce Pressure Set Point to 100psig	25.4	102,994	0	$ 11,710	56.6	$ 8,208	$ 4,104	$ 4,104	285%	0.4
CIM-8	Air Compressors: Install VSD Trim Compressor and Sequencing Controls	39.1	158,616	0	$ 18,033	87.1	$ 63,682	$ 18,186	$ 45,496	38%	2.5
	REFRIGERATION										
LCM-9	Condensers: Modify or Repair Controls to Allow ALL Fans to Operate at Equal Speed	7.5	66,117	0	$ 6,473	36.3	$ 5,000	$ 2,500	$ 2,500	258%	0.4
CIM-10	Ice-Making - Install More Efficient Ice-Making System	0.0	893,503	0	$ 70,262	490.6	$ 530,882	$ 134,025	$ 396,857	16%	5.6
CIM-11	Implement Floating Head Pressure Controls	71.0	774,167	0	$ 75,791	425.1	$ 70,000	$ 35,000	$ 35,000	217%	0.5
CIM-12	Evaporator Fans: Install VFD Fan Controls	69.5	608,759	0	$ 59,597	334.3	$ 176,974	$ 52,972	$ 124,002	47%	2.1
	OTHER										
LCM-13	Premium Efficiency Motors - condenser and ice making pumps	3.3	26,645	0	$ 2,609	14.6	$ 6,121	$ 1,847	$ 4,274	60%	1.6
CIM-14	Pressure Coolers: Install VFD Fan Controls	18.5	162,124	0	$ 15,872	89.0	$ 55,140	$ 14,107	$ 41,033	37%	2.6
	SUB-TOTALS	**295.7**	**3,970,991**	**0**	**$ 367,183**	**2,180.5**	**$ 1,038,237**	**$ 314,369**	**$ 723,868**	**49%**	**2.0**

Measure Number	Measure Description	Annual Energy and Cost Savings: Peak Savings (kW)	Electricity Savings (kWh/yr)	Gas Savings (therms/yr)	Total Cost Savings ($/yr)	CO_2 Savings (tons/yr)	Payback with Incentive: Measure Cost	Potential PG&E Incentive	Net Measure Cost	IRR	Simple Payback (yr)
Demand Response								$ 113,264			
DR-1	Shift Pressure Cooling Operations to Off-Peak During DR Event	57.1	2,284	0	$ 1,145	1.3	$ 5,000	$ 2,500	$ 2,500	67%	2.2
DR-2	Shift Vacuum Cooling Operations to Off-Peak During DR Event	194.6	7,784	0	$ 3,902	4.3	$ 10,000	$ 5,000	$ 5,000	85%	1.3
DR-3	Shift Plant Value-Add Operations to Off-Peak During DR Event	487.7	19,507	0	$ 9,778	10.7	$ 30,000	$ 15,000	$ 15,000	78%	1.5
DR-4	Pre-Cool Cold Storage Spaces and Shut Down Refrigeration During DR Event	947.0	37,879	0	$ 18,987	20.8	$ 35,000	$ 17,500	$ 17,500	101%	0.9
DR-5	Reduce Lighting Levels in Warehouses (50%)	52.4	2,098	0	$ 1,051	1.2	$ 10,000	$ 5,000	$ 5,000	53%	4.8
DR-6	Reduce Lighting Levels in Offices (50%)	4.4	175	0	$ 88	0.1	$ 1,000	$ 500	$ 500	51%	5.7
	SUB-TOTALS	**1,743.1**	**69,726**	**0**	**$ 34,950**	**38.3**	**$ 91,000**	**$ 45,500**	**$ 45,500**	**84%**	**1.3**
TOTALS (Recommended Measures)		**2,038.8**	**4,040,717**	**0**	**$ 402,133**	**2,218.8**	**$ 1,129,237**	**$ 359,869**	**$ 769,368**	**53%**	**1.9**

Average Electricity Cost	$ 0.0979	/kWh	(Average for recent 12 months, three accounts)
Summer Peak Electricity Cost	$ 0.2299	/kWh	(Approx AG5B average incl demand charges)
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CO2 Reduction Equivalents :	1.098	lbs CO2/kWh	Based on CEC/CPUC Greenhouse Gas Estimator
(marginal energy use reductions)	11.7	lbs CO2/therm	

2009 PG&E Incentives

NRR/DR Incentives	Rate
Cost Cap (each measure)	50%
Peak Electricity Demand	$100.00 per peak kW
Motors / Equipment / Controls	$0.09 per kWh
Lighting	$0.05 per kWh
AC & Refrigeration I	$0.15 per kWh
Gas	$1.00 per therm
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) allows comparison of the financial return of projects through their expected lives. Attractive projects have an IRR greater than the cost of money. Precisely, IRR is the discount rate which yields a Net Present Value of zero.

Technical Incentive - 2009 TBA	
Expected 2009 Rate	$125.00 per kW
Cost Cap	50%

1.2 Implementation Planning

We encourage you to seriously consider the recommendations contained within this report. The portfolio of projects that we have 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 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 operates a packaging and distribution plant in California. The operation has been growing rapidly with construction of building additions underway. The packaging features exclusive technologies to extend product life. A specialty materials company based in California, acquired this PG&E customer in 1999.

This PG&E Customer's facility includes two primary refrigerated buildings totaling 143,000 square feet. The original 'Cooler' building dates from 1991 and 1995 and is used primarily for rack storage and distribution of both commodity and value-added (packaged) products. The building also houses pressure-cooling and ice-filling operations prior to shipment, and a two-story office area. The 'Plant' building was built in 2001, with additions completed in 2003, 2006, and currently underway. The building includes packaging lines, plus manual operation and storage areas. There is also a two-story office building on the south end of the site.

A site-wide industrial refrigeration system uses anhydrous ammonia refrigerant to provide cooling throughout the site. A complete new 'Engine Room' was completed in 2006. It encloses seven screw refrigeration compressors served by two adjacent over-sized evaporative condensers. There is also an outdoor ice-making operation and three vacuum coolers.

Site Aerial Map

Birds Eye Site View (pre-dating new Engine Room and Plant additions)

(from www.maps.live.com)

2.3 Schedules

The site is busy all year, somewhat slower in November to March, with the Plant being very busy before holidays. Operations currently include two shifts, six days per week.

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

2.4 Energy-Using Systems

Lighting Systems

The light fixtures in the refrigerated warehouses are primarily high-bay 400W metal halide units. These lights are controlled only by main circuit breakers and are likely on almost all of the time. The fixtures include secondary instant-on lamps to provide safety lighting during outages and during start-up of the main metal halide lamps.

In most of the Plant, where manual operations and inspections occur, general lighting is very even and light levels are high. In the Prep Room we measured exceptionally even overall light levels (illuminance) at 37 fc (400 lux), while the Party Tray rooms showed 28-33 fc (300-350 lux). Storage areas metered at 19-23 fc (200-250 lux) in aisles.

In the Cooler, we measured 14-17 fc (150-180 lux) in the aisles.

There are some T5 linear fluorescent fixtures installed under a ~10-foot mezzanine in the Plant. In this area, we measured very high light levels of 45-100 fc (500-1000 lux) and heard that the staff complained of glare.

Exterior lighting features high-pressure sodium wall fixtures with schedule (timer) controls. This lighting came on at 6pm during our visits, while sunset was still hours away.

The office areas and other low-ceiling rooms feature mostly T8 linear fluorescent lighting, with some old T12 fixtures. There are no lighting controls other than manual switches. Most of the office areas in both the office building and the Cooler office areas remained fully lit after 6pm.

Refrigeration System Overview

The site-wide industrial refrigeration system at this PG&E customer site uses anhydrous ammonia (NH_3, R-717) as refrigerant. Compression and heat rejection is performed at an Engine Room with 7 compressors and 2 evaporative condensers in the middle of the site.

Five sets of piping are routed from the Engine Room to cold room evaporators and other users on the site – three sets of suction lines (cold low pressure gas/liquid) for low, medium and high suction; one high side line (high pressure liquid); and one hot gas line.

The three sets of suction lines provide low suction (15 psig) for ice-making, medium suction (29 psig) for cold room evaporators, and high suction (45 psig) for some evaporators in higher-temperature cool rooms. The high-side pressure is usually 155 psig. When ice-making is not running, it can be reduced to 123 psig. This is reported as the minimum required for hot gas defrosting of the farthest evaporators.

Compressors

The following chart lists the compressors.

Qty	Motor hp	Suction Loops piped to		Normal Suction	Normal Suction Sat. Temp	Motor Eff	Mycom Model
	(hp)	Normal	Alternate	(psig)	(degF)		
1	150	High temp	NONE	45	30	94.5%	N160VSD
2	350	Medium temp	High temp	29	16	95.4%	200VLD
2	350	Medium temp	Low temp	29	16	95.4%	200VLD
2	400	Low temp	Medium temp	15	-1	95.0%	250VSD
7	2350						

All compressors are Mycom screw type with variable volume ratio, water-cooled oil cooling, 460VAC motors

One of Four Mycom 350 hp Screw Compressors

Condensers

There are two evaporative condensers located next to the Engine Room, Evapco Model # PMC1762E. They are axial fan updraft type with variable-speed fans. They were specified to be over-sized to allow low head pressure operation.

Each condenser has two cells with a common sump and three fans. The twelve fans are driven by twelve 20 hp motors.

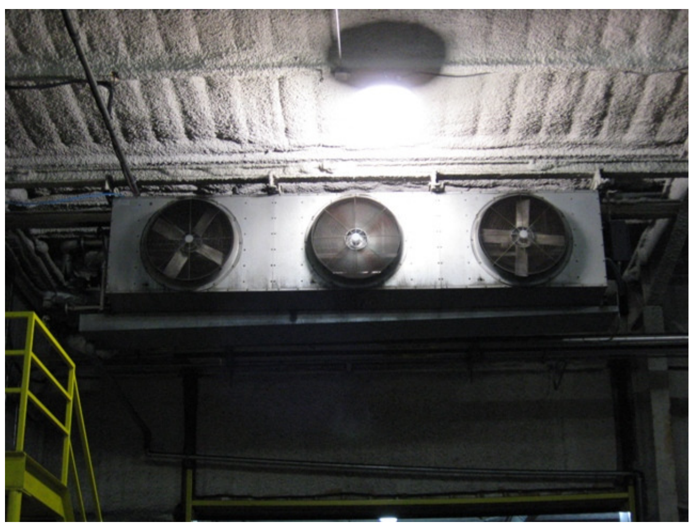
Each condenser cell also has an associated lift pump with a 7.5 hp motor. The four lift pumps run all of the time. Many of the pumps and fans have older, low efficiency motors.

The condensers include water-to-air heat exchangers (HX). Water is circulated between these HX and an oil-to-water HX at each screw compressor, to provide oil cooling. The water is moved by three (two active) 7.5 hp pumps.

Evaporative Condensers

Evaporators

There are three main types of evaporator on this site. The Cooler building has older conventional units, mostly with three fans each. The Plant building has both newer conventional evaporators in packaging areas and new upflow style units in storage areas.



Older Evaporator in Cooler Building

Prep Room Evaporator

Newer UpDraw-Type Evaporator in Plant Storage (note frost buildup)

Defrost Systems

All cold room evaporators and the pressure coolers use hot gas defrost. All defrost cycles are now activated based on scheduling only. Most defrost termination is timer controlled with about 20 minute cycles.

The site believes that it is controlling defrost cycles quite well within limits of the operation. We made defrost control a low priority in this energy study. (Note: Later investigation indicates that there are good opportunities for improvement of defrost controls.)

Other Equipment

This site includes various other types of energy-using equipment including:

- Flake ice making equipment
- Pressure coolers
- Vacuum coolers
- Packaging equipment pumps and blowers
- Hydraulic pump
- Chiller

Compressed Air

Equipment in the Plant uses compressed air at about 120 psig. There is an air compressor room with three Sullair screw compressors (two 100 hp and one 40 hp), plus another 40 hp unit which is currently disconnected. The units are turned on and off manually only, and data logging shows that they often are left running when the Plant is not in use. These units supply air through a dessicant air dryer. We did not find any air storage tanks.

The air compressor room is lit with 400W metal halide fixtures which are always on.

Air Compressor Room

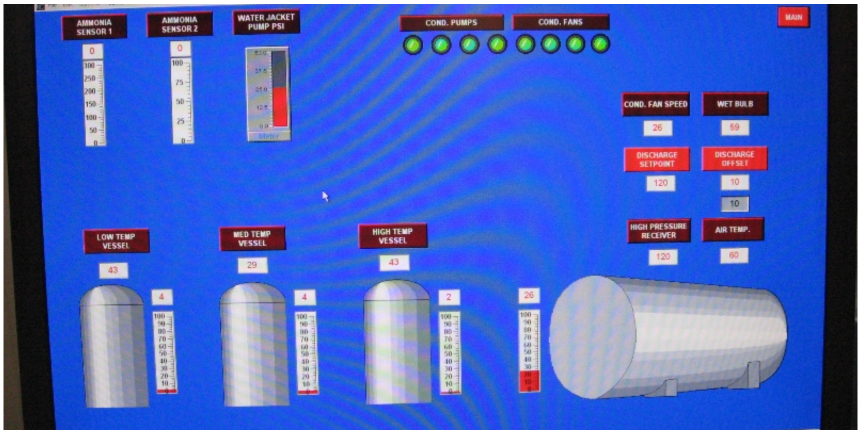
Controls

The refrigeration system is controlled by a PLC-based system with a limited graphical user interface (GUI). Only a few parameters are displayed (and recorded electronically every 15 minutes) including:

- suction pressures of the three loops,
- discharge pressure and set point,
- ambient wet- and dry-bulb temperatures.

Key controls operations including compressor selection and adjustments to the discharge (head) pressure set point are entered manually.

The system does not provide any system energy use data.



GUI Basic Main Control Screen

Lighting controls are limited to timer controls for outside lighting.

3
Site Energy Use and Costs

This PG&E customer procures electricity as a bundled service from PG&E.

Please note that facility energy usage can be viewed through PG&E's InterAct II web site. As a participant, PG&E customers can get access to electricity usage for each quarter-hour (sometimes each hour), updated every morning for the prior day's usage. This allows comparison of one day to another, one week to another, or another time period as desired. Seeing when electricity is used and how that compares in various ways usually leads to making changes that reduce total use, shift use from peak to off-peak hours, and otherwise save money on the electric bill. Contact your PG&E account representative for more information.

3.1 Electricity Consumption

This PG&E customer is served by several meters, including the three largest as follows:

- PG&E AG5B (Agricultural Demand-Metered Time-Of-Use) Service Agreement, for the Plant building including air compressors;
- PG&E AG5B (Agricultural Demand-Metered Time-Of-Use) Service Agreement, for the Cooler building including ice-making;
- PG&E AG5B (Agricultural Demand-Metered Time-Of-Use) Service Agreement, for the refrigeration system (Engine Room).

The AG5B tariff schedule provides large cost discounts for electricity use during off-peak periods. The following table shows recent rates.

Table 3.1: Monthly Electricity Demand, Consumption, and Cost

Rate Schedule	Rate Design	Customer Charge	Season	Time-of-Use Period	Demand Charge[3/] ($/kW)	Energy Charge ($/kWh)	"Average" Total Rate[1/] (per kWh)	Other Charge/ Conditions
AG-5B and AG-5E[2/] [2/]meter installation charge paid	Time-of-use rate: High annual operating hours benefits	$0.98563/day plus Meter charge of $0.19713/day AG-5B $0.03943/day AG-5E	**Summer**	Max Peak	$6.60	**$0.15522**	$0.11027	Summer peak: Noon to 6:00 pm weekdays. Winter partial peak: 8:30 am to 9:30 pm weekdays. All other hours and holidays are off peak for both summer and winter.
				Off-Peak	-	**$0.06557**		
				Maximum	$9.61	**-**		
			Winter	Part-Peak	-	**$0.08117**		
				Off-Peak	-	**$0.05911**		
				Maximum	$3.44	**-**		

During the summer peak period (12 noon to 6pm, May to October), this PG&E Customer's total cost of electricity is approximately $0.21 per kWh. During other periods, it is roughly $0.08 per kWh. See calculation assumptions in the appendix.

The following table and figure show the electricity consumption history for these three main accounts serving this PG&E customer, combined:

Table 3.2: Monthly Electricity Demand, Consumption, and Cost – Three Main Accounts

Month	Peak Demand (kW)	Electricity Consumption (kWh)	Total Electricity Cost ($)
Jun-07	2,733	1,225,600	$139,327
Jul-07	2,599	1,093,000	$123,436
Aug-07	2,664	1,052,200	$121,849
Sep-07	2,747	1,230,500	$136,079
Oct-07	2,499	1,069,000	$120,064
Nov-07	2,633	1,100,500	$86,336
Dec-07	2,751	962,700	$79,843
Jan-08	2,766	993,500	$81,327
Feb-08	2,494	1,014,300	$81,806
Mar-08	2,623	1,063,400	$84,709
Apr-08	2,587	1,149,900	$90,918
May-08	2,698	1,235,800	$146,267
Annual Totals	**2,766**	**13,226,637**	**$1,295,509**
Average Total Cost of Electricity ($/kWh)			**$0.0979**

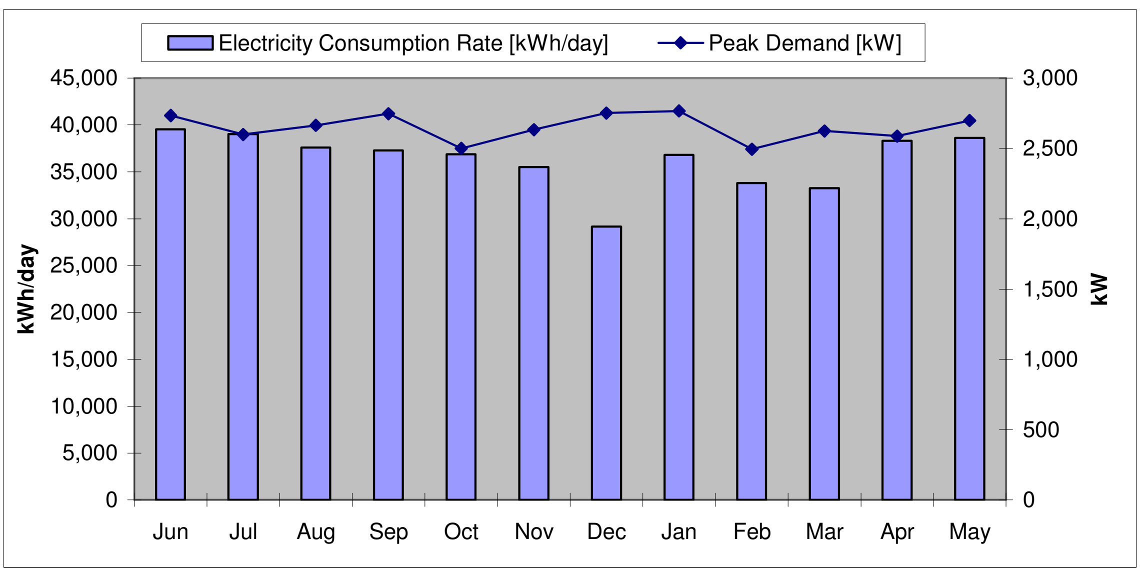


Figure 3.1: Monthly Electricity Consumption and Demand

This figure shows this PG&E Customer's very steady electricity use through the year.

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 does not use natural gas.

3.3 Total Cost of Energy

The total annual cost of energy for this PG&E customer is approximately $1,295,000. The following figure shows the monthly breakdown of electric costs.

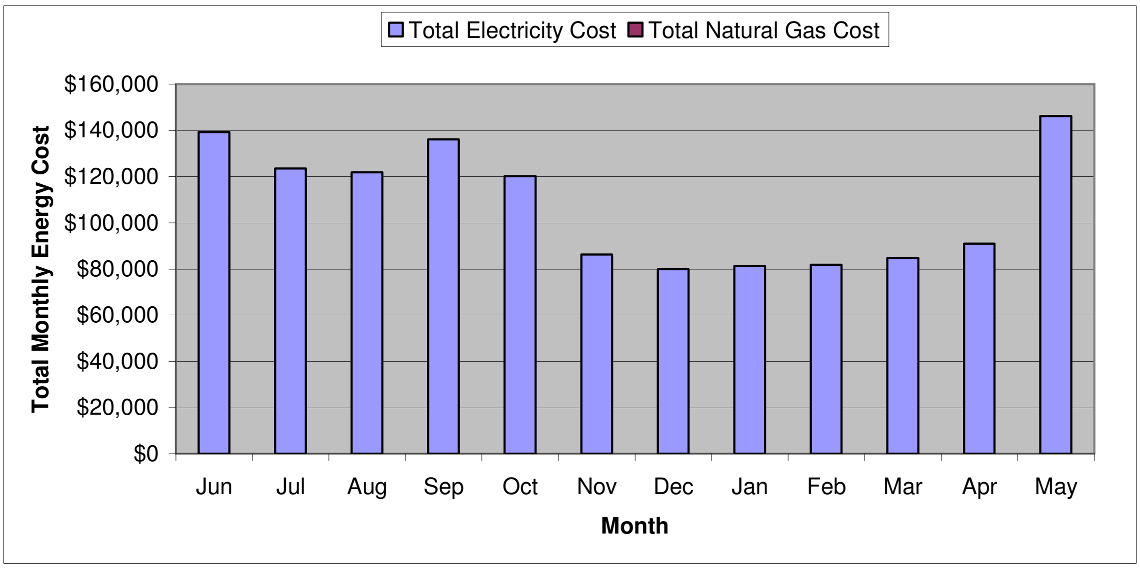


Figure 3.2: Total Monthly Energy Costs

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 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 usage to date (annualized) compares with CEUS data for refrigerated warehouses.

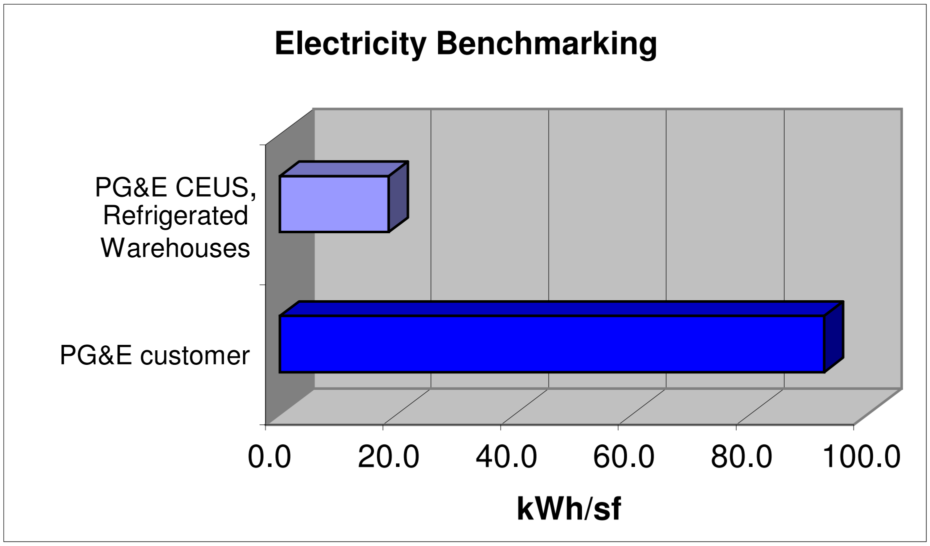


Figure 3.3: Electricity Use Benchmarking

The benchmark shows extremely high electricity use for this PG&E customer, compared to average refrigerated warehouses. We note that this PG&E customer is more than just a warehouse, with ice-making and process equipment. However, energy use is still very high here.

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.

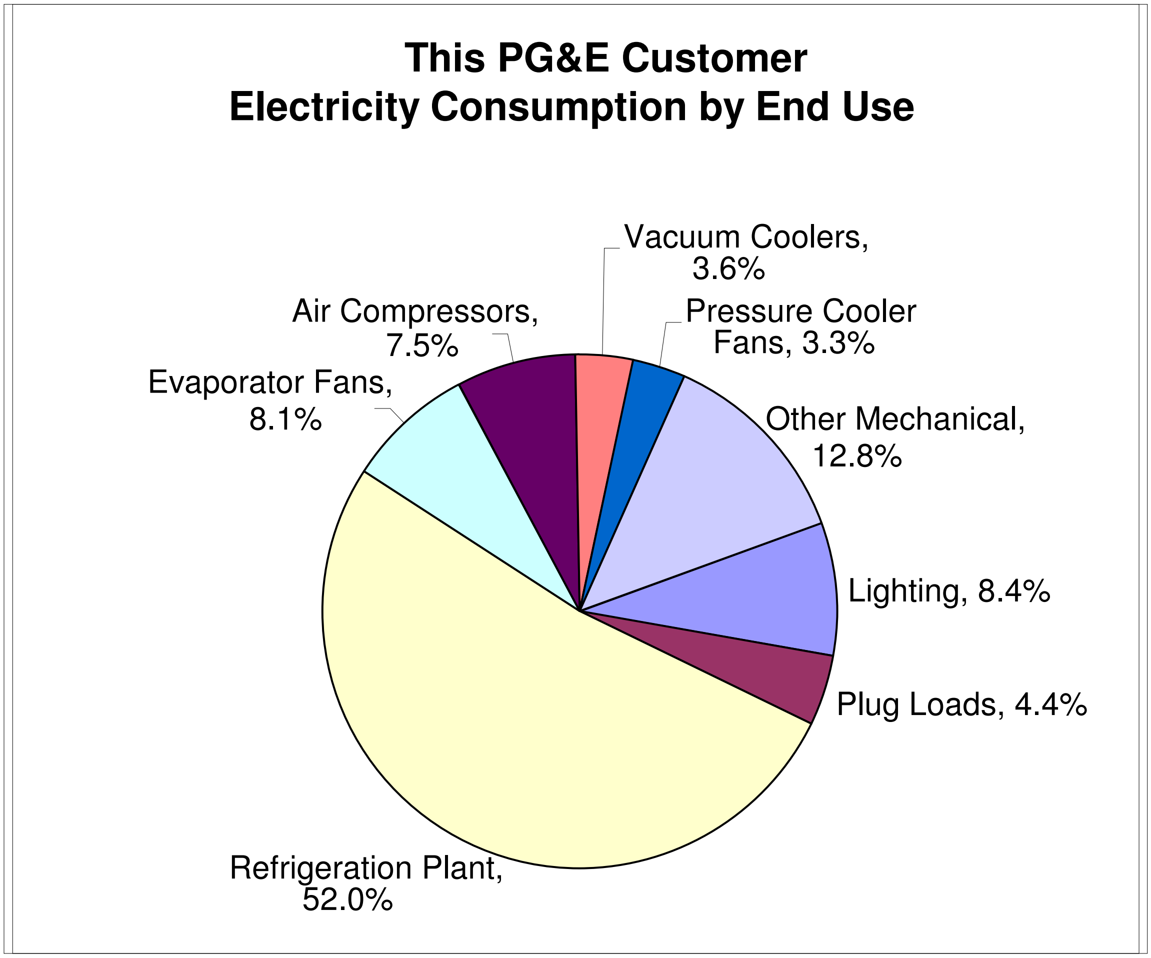


Figure 3.4: Energy Balance - Electricity

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:

- An 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 from TMY3 for nearby airport 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.

The following measures are sorted by energy-using system:

- Lighting
- Air Compressors
- Refrigeration
- General Equipment
- Other Possible Measures

Low-cost measures (LCM) 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. Capital-intensive measures (CIM) are projects with a capital cost of greater than $10,000. These measures significantly reduce energy consumption and costs, but require significant capital investment.

4.3 Lighting Measures

LCM-1: Delamp and Add Occupancy Sensors Controls for T5 Lighting Under Mezzanine (AWAIT PHASE 2)

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)
0.8	7,965	0	$ 780	$ 335	$ 385	202%	0.5

Observations

There are twelve (12) T5 4-lamp linear fluorescent fixtures installed under a ~10-foot mezzanine in the Plant. In this area, we measured very high light levels of 45-100 fc (500-1000 lux) and heard that the staff complained of glare.

T5 Fixtures Under Mezzanine in Plant

Recommendations

We recommend delamping these fixtures from four to two lamps each. We did not check the ballasts for these fixtures. Check to be sure that the ballasts are compatible.

In addition, we recommend adding occupancy sensor controls to switch off these lights when no one is present.

Only dual-technology sensors should be used. There are two types of occupancy sensor technologies: passive infrared and ultrasonic. Infrared sensors are triggered by movement of a heat source such as a person within a space. The sensor must have a direct line of sight to occupants in order to detect motion. Ultrasonic sensors emit high-frequency waves and are triggered by disturbances in the returning signals. Ultrasonic sensors do not need a direct line of sight; however, they often receive false triggers from wind-blown curtains or papers. As the name implies, dual-technology occupancy sensors combine both infrared and ultrasonic technologies in a single sensor. This creates a sensor with the accuracy of an infrared sensor and the sensitivity of an ultrasonic sensor. The dual-type sensor is essential in this application, where equipment or materials can block infrared sensor lines of sight, and where airflow can false-trigger ultrasonic sensors.

The sensors should be set with a fairly long dwell (delay) time, so that once triggered, the lights stay on for a reasonable time. This will avoid frequent switching, and help ensure that appropriate lights are on whenever someone is present.

Costs and Assumptions

We assumed that these lights currently remain on essentially 24/7, and that occupancy sensor control will reduce these operating hours by the maximum 45% for warehouse, industrial and process areas allowed by the NRR-DR incentive program. All lighting energy in cold spaces must be removed by the refrigeration system, so we also included refrigeration savings based on the current overall site refrigeration efficiency.

Installation costs for three sensors were obtained from 2007 MEANS Electrical Data, with added allowance due to the small size of the project.

The potential incentive was based on the direct calculated savings only (excluding refrigeration savings) at $0.05 per kWh for Lighting, which was higher than the Lighting Rebate Program's rebate of $44.00 per installed ceiling mounted sensor (L860, controlling >500 W each). Please see the following web link for information on applying for customized (calculated) incentives:

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

For reference, please see the following web link for information on itemized lighting rebates:

http://www.pge.com/mybusiness/energysavingsrebates/rebatesincentives/ref/lighting/

LCM-2: Add Photocell Control of Outside Lighting (AWAIT PHASE 2)

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	10,768	0	$ 1,054	$ 500	$ 500	211%	0.5

Observations

Exterior lighting features high-pressure sodium wall fixtures with schedule (timer) controls. This lighting came on at 6pm during our visits, while sunset was still hours away.

Outside Lighting On at 6pm

Recommendations

We recommend adding photocell control for all exterior lighting. This can supplement the timer controls if desired. Photocell control will switch the exterior lighting based on the ambient light level, turning them on at sunset and off at sunrise.

This measure will require a qualified electrician to locate and identify the circuit(s) controlling these lights, and to specify, install and wire photocell relay switch(es) in an appropriate location. The sensitivity of the photocell control should then be set conservatively to switch on the lights whenever needed to maintain adequate lighting levels.

Costs and Assumptions

We estimated an exterior lighting count of 50, and assumed that each fixture holds one 250W high pressure sodium (HPS) lamp. Based on observation during our visits, we assumed that current run hours are 14 hours per day, or 5,100 hours per year. We assumed that photocell control will reduce this to 12 hours per day on average, or 4,380 hours per year.

We did not assess details of the existing exterior lighting wiring and controls. Our cost estimate is a rough allowance.

The potential incentive was based on the calculated savings at $0.05 per kWh for Lighting (but limited to 50% of the measure cost), which was higher than the Lighting Rebate Program's rebate of $7.00 per installed photocell (L36). Please see the following web link for information on applying for customized (calculated) incentives:

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

If this measure is submitted for NRR incentives, we recommend that fixture wattage and exact counts be inspected and confirmed.

LCM-3: Install Occupancy Sensors and Lighting Retrofits in Offices and Mechanical Rooms

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)
2.9	25,135	0	$ 2,461	$ 1,257	$ 4,004	61%	1.6

Observations

The office areas and other low-ceiling rooms feature mostly T8 linear fluorescent lighting, with some old T12 fixtures. There are no lighting controls other than manual switches. Most of the office areas in both the office building and the Cooler office areas remained fully lit after 6pm.

Lab Unoccupied with Lighting On after 6pm

Recommendations

We recommend retrofitting all remaining old T12 fixtures with more efficient T8 fixtures featuring latest-generation F28T8 lamps and premium electronic ballasts. We recommend installing 4-foot T8 fluorescent lamps that meet the 2008 NRR-DR Program requirements and replacing the existing standard magnetic ballasts with premium electronic ballasts. Programmed start ballasts should be used when the replaced fixture is being controlled by an occupancy sensor (to maximize lamp life) while instant start electronic ballasts can be used if the fixture is manually switched. Ballasts should be specified to be high frequency (>10 kHz), UL listed, and warranted against mechanical or electrical defects for five years. Ballasts should have a power factor of at least 0.9. The new T8 lamps should have a color rendering index (CRI) of at least 80 (we recommend specifying an 82 CRI) and a rated life of at least 18,000 hours (at 3hr/start connected to instant start ballast). Several lamps on the market have T8 lamps that last for up to 30,000 hours. In most cases, the added cost of longer life lamps is made up in maintenance cost savings.

In addition, we recommend adding occupancy sensors controls to switch off these lights when no one is present. As noted in a previous measure, we recommend dual-technology sensors. For private offices and small rooms, we recommend wall-mounted sensors replacing existing light switches. In other spaces, ceiling-mounted sensors are required.

The old T12 fixtures are in the Cooler office lunch room, and some private offices. Some other fixtures may also be T12.

The occupancy sensor recommendation applies to lighting in all open and private offices, Cooler office lunch room and lab, the Plant smock room, cardboard box rooms, and shop below the air compressors, plus the engine room control room.

Costs and Assumptions

We assumed that these lights currently remain on essentially 24/7, and that occupancy sensor control will reduce these operating hours by the maximum allowed by the NRR-DR incentive program for the type of space.

Installation costs for the sensors were obtained from 2007 MEANS Electrical Data, with added allowances.

The potential incentive was based on the calculated savings at $0.05 per kWh for Lighting, which was higher than the Lighting Rebate Program's rebates (6x L82, 16x L859, 5x L955). See Incentive Calculator in appendix for details. Please see the following web link for information on applying for customized (calculated) incentives:

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

CIM-4C: Replace Metal Halide High Bay Lighting with T8 Fluorescents with Integral Occupancy Sensors and PRS Ballasts

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)
56.8	787,419	0	$ 77,088	$ 38,753	$ 72,271	107%	0.9

Observations

The light fixtures in the refrigerated warehouses are primarily high-bay 400W metal halide units. These lights are controlled only by main circuit breakers and are likely on almost all of the time. The fixtures include secondary instant-on lamps to provide safety lighting during outages and during start-up of the main metal halide lamps.

In most of the Plant, where manual operations and inspections occur, general lighting is very even and high. In the Prep Room we measured exceptionally even overall light levels (illuminance) at 37 fc (400 lux), while the Tray Prep rooms showed 28-33 fc (300-350 lux). Storage areas metered at 19-23 fc (200-250 lux) in aisles. In the Cooler, we measured 14-17 fc (150-180 lux) in the aisles.

Metal halides have a fairly long switch-on time of several minutes, which makes use of automatic controls (such as occupancy sensors) impractical.

John well-lit by MH fixtures in the Prep Room

Recommendations - Fixtures

We recommend retrofitting the current lighting scheme with a more efficient system. First, we recommend replacing the current metal halide fixtures with linear fluorescent T8 fixtures. These lamps are great energy savers; a 6-lamp fixture will provide about the same mean light levels over their lifetimes as a 400W metal halide, while consuming about half the power. This is partly because fluorescent lights maintain their light output much better through their lifetime; at average life, metal halide lamps can lose up to 25% of their initial lumen output, versus only 6% for fluorescent lamps. In addition, fluorescent lights put out less heat than metal halides, thus add less load on the refrigeration system and provide further savings.

The fixtures installed should be specifically designed for cold storage environments. They should have enclosed sealing and the ballast should be able to start at low temperatures. See the next section for examples of manufacturers that specialize in cold storage fixtures.

The T8 lighting will provide many benefits, including:

- Energy savings;
- Much longer lamp life;
- Higher Color Rendering Index (CRI);
- Comfortable white light with more ‘readable’ light quality;
- Instant on ability;
- Much less lumen depreciation (reduction in brightness with age);
- Less point-source glare.

The existing metal halide fixtures should be replaced one-for-one with new high-performance T8 fixtures with high-light-output ballasts with a ballast factor of 1.15 and high lumen lamps with at least 2950 mean lumens and a color temperature of at least 5000K. Currently, these lamps are available from most major manufacturers:

- General Electric's 4 Foot T8 Ecolux High Lumen (F32T8/XL/SPX50/HL/ECO)
- Osram-Sylvania's Octron 800 XPS (FO32/850/XPS/ECO)
- Philips' ALTO Advantage (F32T8/ADV850/ALTO)

For the 153 high bay metal halide fixtures in the Plant, where current light levels are very good, we recommend the standard replacement with 6-lamp T8 fixtures. For the 76 fixtures in the older Cooler building, where light levels are not as good, we recommend installing 8-lamp T8 fixtures.

Note that T5 lighting has been the most common high-bay fluorescent technology in recent years. However, we recommend premium T8 lighting in this application for two main reasons. First, T8 lights perform much better at low temperatures, such as these fixtures will encounter when first lit after an idle time. T5 lamps are designed to achieve optimum performance at 95°F. At 40 °F, a T5 lamp light output can be reduced by as much at 75%; whereas T8 lamp output at the same temperature is only reduced by 42%. Second, today's premium T8 lamps and ballasts provide equal or better energy performance vs. T5's, while being significantly cheaper, more common, and more robust.

Please see the appendix for full detailed comparison of the existing metal halide versus proposed T8 lighting for this application.

Fixtures should be specified for the cold and sometimes wet environments in this application.

Recommendations - Controls

In addition, we recommend controlling the T8 fixtures with occupancy sensors. This way, the lights will be at full power only when the spaces are occupied.

We recommend opting for integrated sensors installed on each fixture, rather than for ceiling-mounted sensors that would control several fixtures at a time. The per-unit material costs for both options are similar; however, fixture-integrated sensors have no additional installation costs, while ceiling-mounted sensors are labor intensive. Based on our estimates, the total cost for one ceiling mounted sensor is about 4 times the total cost for an integrated sensor ($200 vs $50 – see below for cost references), which offsets the fact that the integrated sensors option requires more sensors.

Sample High Bay Fluorescent Lighting Installation – Even Bright Light, Reduced Glare, Automatic Controls

In terms of controls, the integrated sensors will provide more reliable control as they will each have smaller floor areas to cover. This will also allow for a more aggressive controls strategy, with a shorter delay time, and higher energy savings.

At least some of the fixtures may be specified for bi-level operation. That is, some fixtures may be configured to keep some (eg. 2) of their lamps on even in unoccupied mode. Some sites view this as a safety issue. Of course, using bi-level operation reduces energy savings. We generally recommend that lights should be configured to fully switch off in unoccupied mode, especially where each fixture has its own occupancy sensor. Again keep in mind that unlike the existing metal halide fixtures, these lights light instantly. However, keeping some fixtures partly on at all times in main aisles and near exits is frequently specified.

In this application we recommend using passive infrared technology sensors. Passive infrared sensors are triggered by movement of a heat source such as a person within a space. They must have a direct line of sight to occupants in order to detect motion. Given the density of sensors that we recommend, each sensor will have to cover only a relatively small area and will have a direct line of sight to most of the space it controls.

Another technology for occupancy sensors is ultrasonic detection. Ultrasonic sensors emit high-frequency waves and are triggered by disturbances in the returning signals. Ultrasonic sensors do not need a direct line of sight; however, they often receive false triggers from wind-blown movement. These are not appropriate for this application, where the evaporator fans create high air flows that could false-trigger an ultrasonic sensor.

The sensors should be set with an appropriate dwell (delay) time, so that once triggered, the lights stay on for a reasonable time (eg. 5-15 minutes). This will avoid frequent switching, and help ensure that appropriate lights are on whenever someone is present. For warehouse spaces with fork truck activity only, experience at other sites indicates that a 5 minute dwell or less is sufficient. In production areas such as the trim room, longer dwell times are advisable to avoid nuisance switching.

Sensors should be specified for the cold and sometimes wet environments in this application.

Costs and Assumptions - Fixtures

The savings for this measure are based on detailed lighting counts completed on site. We assumed all existing fixtures are 400W metal halides. The current and proposed wattage input of fixtures was based on the current NRR-DR lighting wattage table. Based on staff interviews, we assumed that these lights currently remain on essentially 24/7.

To check that the current light levels would be maintained, we compared the lumen output of 6-lamp and 8-lamp T8 fixtures to the average mean lumen output of metal halide fixtures. This average was calculated based on the specification sheets of several typical 400 W lamps, obtained on the Grainger website (www.grainger.com). It showed that 6-lamp T8 fixtures provide slightly higher design pupil lumen output (+11%) than standard 400W metal halides, while 8-lamp T8 fixtures provide significantly higher output (+48%).

Costs were obtained from C.I.M. Electric, as quoted to this PG&E customer.

The potential incentive was based on the direct calculated savings only (excluding refrigeration savings) at $0.05 per kWh plus $100 per peak kW for Lighting. This provided higher incentives than offered by the Deemed Rebate incentives of $100 per 6-lamp Plant fixture installed (L292, new fixture of less than 244W, replacing 400W base case) and $75 per 8-lamp Cooler fixture (L896, new fixture of less than 360W replacing 400W base case). See the Incentive Calculator in the appendix for details. Please see the following web link for information on applying for Deemed lighting rebates:

http://www.pge.com/mybusiness/energysavingsrebates/rebatesincentives/ref/lighting/

Costs and Assumptions - Controls

We assumed that these lights currently remain on essentially 24/7, and that occupancy sensor control will reduce these operating hours by the maximum 45% for warehouse, industrial and process areas allowed by the NRR-DR incentive program. This is equivalent to shutting off the lights 75 hours per week, which is reasonable based on the typical 2-shift 5-day operating schedule.

All lighting energy in cold spaces must be removed by the refrigeration system, so we also included refrigeration savings based on the current overall site refrigeration efficiency. These indirect savings were NOT included in incentive calculations.

We assumed peak period demand savings for this measure to be 10% of total demand of the new T8 lighting.

Costs were obtained from C.I.M. Electric, as quoted to this PG&E customer.

The integrated sensors should be specified as an option when ordering the fixtures.

The potential incentive was based on the calculated direct savings (excluding refrigeration savings) at $0.05 per kWh plus $100 per peak kW for Lighting including Lighting Controls. The cost cap limit of 50% was applied on a whole-project basis. The calculated incentive was higher than the itemized incentive at $20 per sensor (L861 - for fixture-integrated sensors with fixtures > 12' high). Please see the following web link for information on applying for customized (calculated) incentives:

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

4.4 Air Compressor Measures

CIM-8B: Install Receiving Tank, Additional Piping, VSD Trim Compressor and Scheduling/Sequencing 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)
56.8	787,419	0	$ 77,088	$ 38,753	$ 72,271	107%	0.9

The three individual measures below (6, 7, 8) were combined into measure CIM-8B as a complete air compressors plan for this PG&E customer.

Background and Data Logging:

General Observations

Equipment in the Plant uses compressed air at 120 psig. We did not study end uses of air during the site visit. We recommend that changes to the system begin with detailed evaluation of end uses, to reduce air requirement (flow and pressure) wherever possible.

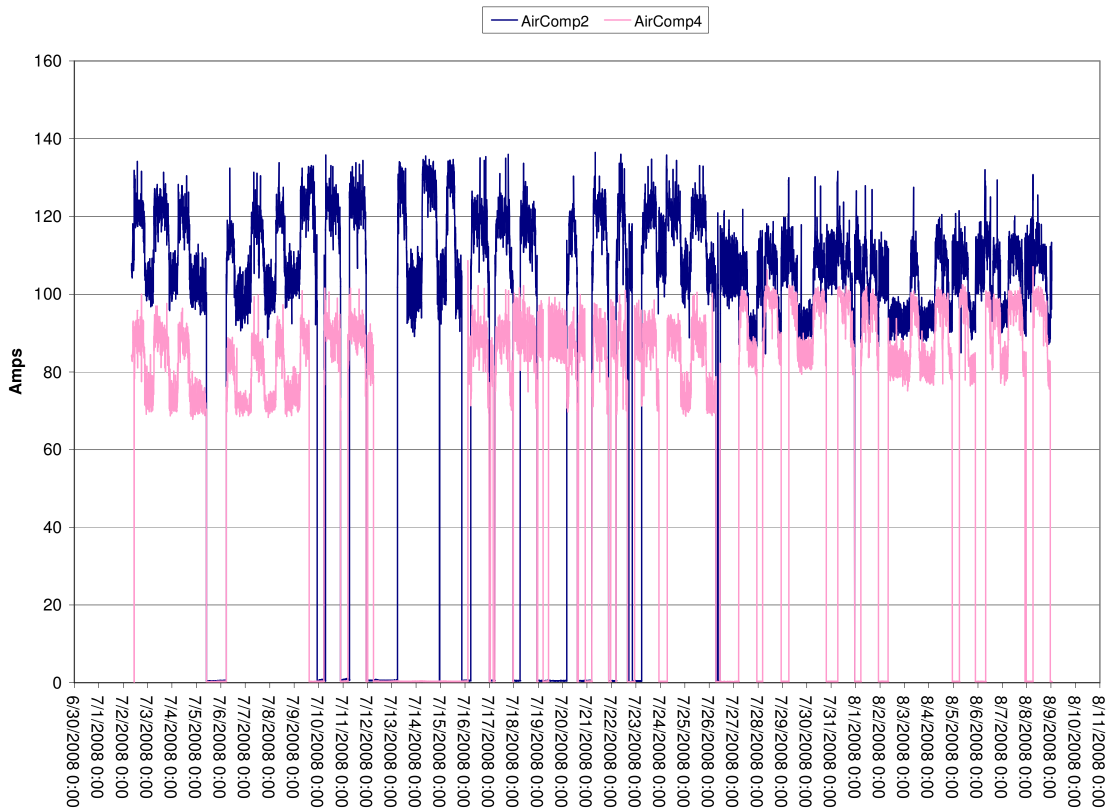
Partial View of Prep Room in Plant

There is an air compressor room with three Sullair screw compressors (two 100 hp and one 40 hp), plus another 40 hp unit which is currently disconnected. The units are turned on and off manually only, and data logging shows that they often are left running when the Plant is not in use. These units supply air through a dessicant air dryer in the room below. There are no air storage (receiver) tanks.

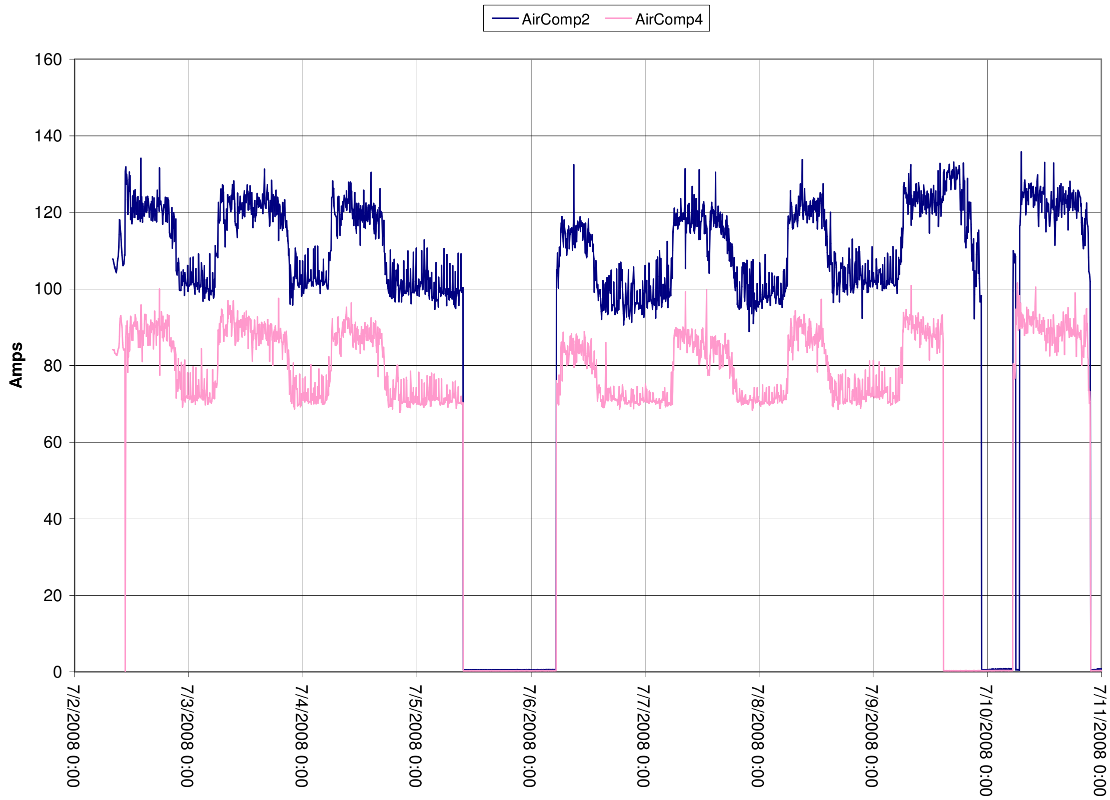
Air Compressor Room

Each compressor operates independently, and features inlet modulation control to maintain a target outlet pressure set point. Each unit has a set point of about 120 psig.

The following charts present results of data logging results for the two larger air compressors over five weeks. The trends are of current (amps) draw.



Current Draw for Air Compressors #2 (LS200) and #4 (V160) [Five Week Trend]



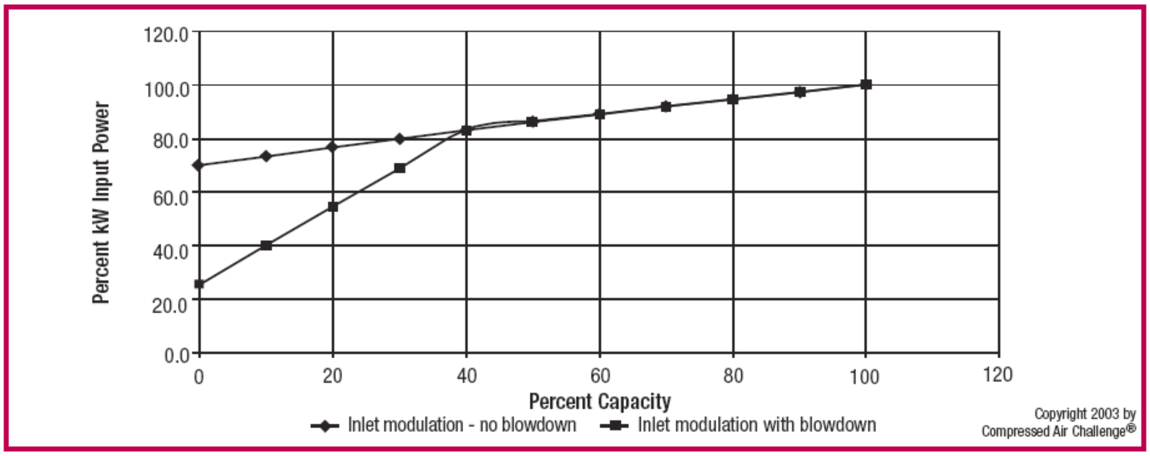
Current Draw for Air Compressors #2 (LS200) and #4 (V160) [One Week Trend]

This data reveals a number of issues:

1. Scheduling: The air compressors are not consistently shut off when the Plant is not in operation. The newest unit (AC#2) was shut down for part of 11 out of 38 possible nights. In fact it ran essentially 24/7 for the second half of the logging period.

   Clearly there is an opportunity for energy savings through automated compressor shutdown.

2. "Unloaded" Energy Use: The compressor power draw remains very high even when the Plant is not in operation. For example, unit #2 (blue line) only drops from about 125 amps to about 105 amps (84%) draw when the Plant is down overnight. This indicates first that the compressors use inlet modulation only for capacity control. Inlet modulation provides very poor efficiency in part-load conditions. See the following chart. Even when operating at zero capacity, such compressors still use 70% of full-load power.



Power Curve - Lubricant-Injected Screw with Inlet Modulation

(lower line with unloading below 40% capacity)

In addition, the data could also indicate high leakage keeping air demand high even when equipment is inactive.

Finally, note that this also makes it essentially impossible for someone at the compressors to know what the actual demand for air is, making it impossible to know when it is OK to shut off compressors without checking all end uses first.

We did not study compressed air end uses during the audit visit. End uses should be further evaluated to identify where air can be shut off whenever possible even while the Plant is in operation. This can be automated. For example, solenoid valves can be installed to shut off air when no product is present at a process, reducing load on the compressors and saving energy. Also, end uses which only blow air can usually use low-pressure blower air rather than the high-pressure compressed air. Air blowers use far less energy than air compressors.

3. Controls Change: Evidently a change was made on July 26th which reduced the load on AC2 and increased it on AC4, bringing the trendlines closer together. We do not know why. We suspect that one or both operating pressure set points were changed. This highlights the possibility of adjusting (and optimizing) load between compressors with even simple controls changes.

LCM-6: Air Compressors: Install Automatic Scheduling Controls (Time Clocks)

Observations

As noted above, the air compressors are left running for many hours when the Plant is shut down. There are roughly at least 3,400 hours per year when the Plant is not in use and compressed air is not needed. During these hours, if compressors are left running, the load on the compressors remains very high.

During our logging period, AC#2 was on 83% of the time. AC#4 was on 71% of the time.

Recommendations

We recommend automating the shutdown of the air compressors when the Plant is down overnight and on weekends. This can be achieved by several different methods.

One of the simplest methods is to install time clocks to shut off the air compressors during off-hours. However for optimum savings, the time clocks will need some manual adjustment as production schedules vary.

Another possible control strategy, no matter what controls are in place in the air compressor room, is to install automated shut-off solenoid valves at each major end use, with controls linked to the equipment controls; Ie. when a packaging line is shut down, a valve should also isolate the compressed air supply for that line.

Costs and Assumptions

Data from amps logging and spot power measurements was used. Average amp draw during "unloaded" periods was used to calculate power use of air compressors #2 and #4 as 66 kW and 45 kW, respectively. We estimated the "unloaded" power draw of smaller unit #1 as 18 kW. That is, the average total power use for these three compressors when the Plant is not in operation is estimated at 129 kW.

We calculated the basic annual unscheduled hours as 90 hours per week, 52 weeks per year, or 4,680 hours. Based on the data logging, we assumed that the compressors are currently shut down one-third of this time. During the remaining 3,120 hours we assume they are on and using 129 kW.

We estimated costs for the installation and wiring of three separate time clocks. Cost savings were based on average off-peak electricity rates.

The potential incentive was based on the calculated savings at $0.08 per kWh plus $100 per peak kW. The cost cap limit of 50% was applied on a whole-project basis. Please see the following web link for information on applying for customized (calculated) incentives:

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

LCM-7: Air Compressors: Install Receiving Tank(s), Increase Size of Main Supply Header, and Reduce Compressor Pressure Set Points

Observations

There are no receiver tanks in the compressed air system. All three active compressors feed into 2" lines which connect into the main 3" line to a desiccant dryer and on to the plant.

Compressed Air Pipes, under Compressor Room

(Drops from compressors on right, into common line feeding through dryer on left)

Receiver tanks provide a buffer of air supply to allow variable peak demands to be handled without the need for excessive compressor air pressure.

Also, undersize pipe headers produce unnecessary pressure drops. At best, the current header size was likely established based on air demands when the system was first built. Building space, air loads and compressors have since been added, increasing air flows. The header is too small for the current high flows.

Recommendations

We recommend reducing the compressor pressure set point. The current set point of 120 psig is higher than most industrial systems require.

To allow a lower pressure set point while ensuring that adequate flow is provided during peaks of air use, we recommend adding receiver tank storage. Typically a receiver tank is installed near the compressors. Based on our very limited study of this air system, we recommend a receiver of at least 200 gallons as a bare minimum (1,000 to 2,000 recommended).

Regarding the location of the receiving tank, the following is excerpted from the DOE Compressed Air Sourcebook:

> There are two differing points of view on the location of a primary air receiver in a plant air system. If the receiver is located soon after the compressor discharge and the compressor(s) is a piston-type, the receiver acts as a dampener for pressure pulsations. If the receiver is located before the compressed air dryer, the receiver will provide additional radiant cooling and drop out some of the condensate and entrained oil, benefitting the dryer. However, the receiver will be filled with saturated air, and if there is a sudden demand that exceeds the capacity rating of the compressor and matching

> dryer, the dryer can be overloaded, resulting in a higher pressure dew point. If the air receiver is located after the compressed air dryer, some of the above advantages are lost. However, the receiver is filled with compressed air (which has been dried), and a sudden demand in excess of the compressor and dryer capacity rating will be met with dried air. The dryer is not overloaded, since it is seeing only the output of the compressor, so the pressure dew point is not affected.

We recommend installing the receiver upstream from the dryer.

Depending on details of the distribution piping, it may also be appropriate to add storage capacity close to air uses. This is especially true for variable air users, located far from the compressors. Variable air users are often systems with air cylinders or related components which use air in bursts for mechanical movement.

Finally, we also recommend considering increasing the size of the main piping header, or adding an additional line directly to the high-use bagging machines. The header is small for the quantity of compressed air now being used. Flow velocity guidelines for main headers call for 20 fps or less to avoid energy-using turbulence. (For line drops and feed lines, a velocity greater than 30 fps is needed to transport any water and debris in the air stream). For a three inch pipe, 20 fps corresponds to a flow of only 59 cfm. For main headers, there is no such thing as too big a pipe. An 8” pipe would flow seven times as much air - 420 cfm at 20 fps.

Costs and Assumptions

We roughly estimated savings from pressure set point reduction using storage upgrade based on the following DOE rules of thumb. According to the DOE Compressed Air Sourcebook:

> A rule of thumb for systems in the 100 psig range is: for every 2 psi increase in discharge pressure, energy consumption will increase by approximately 1 percent at full output flow. …
>
> There is also another penalty for higher-than needed pressure. Raising the compressor discharge pressure increases the demand of every unregulated usage, including leaks, open blowing, etc. Although it varies by plant, unregulated usage is commonly as high as 30 to 50 percent of air demand. For systems in the 100 psig range with 30 to 50 percent unregulated usage, a 2 psi increase in header pressure will increase energy consumption by about another 0.6 to 1.0 percent because of the additional unregulated air being consumed. The combined effect results in a total increase in energy consumption of about 1.6 to 2 percent for every 2 psi increase in discharge pressure for a system in the 100 psig range with 30 to 50 percent unregulated usage.

We assumed energy savings of 1.6% per 2 psig drop, or 13% for a drop from 116 (observed actual) to 100 psig. We assumed the previous scheduling measure was already implemented. We calculated cost savings based on weighted average electricity rates during Plant operating hours.

We estimated costs based on a 200 gallon tank, and labor and materials for installation and piping, plus a contingency. We consider this to be the bare minimum storage capacity needed by this system.

The potential incentive was based on the calculated savings at $0.08 per kWh plus $100 per peak kW. The cost cap limit of 50% was applied on a whole-project basis. This assumes the measure is treated as a Storage Upgrade, as pressure set point changes alone are not eligible for incentives. Please see the following web link for information on applying for customized (calculated) incentives:

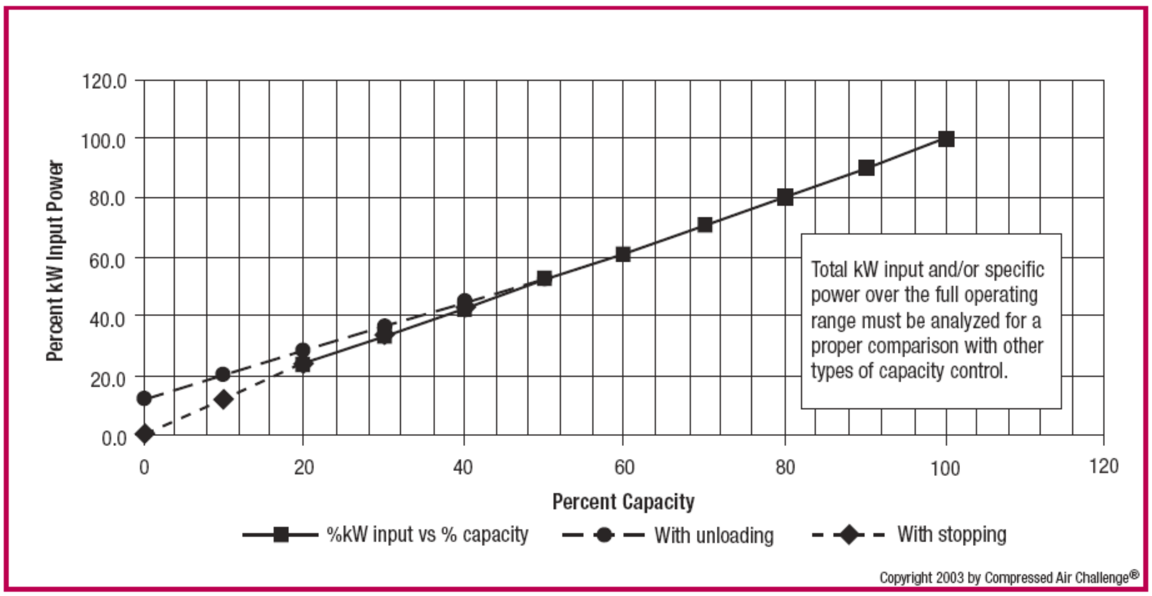
http://www.pge.com/mybusiness/energysavingsrebates/rebatesincentives/ief/

CIM-8: Install High-Efficiency Trim Compressor and Sequencing Controls

Observations

As discussed above, the three active compressors operate independently to achieve similar pressure set points. These compressors use inlet modulation to adjust their capacity, which provides poor part-load efficiency. This means that as Plant air requirements vary to below full load, the current compressor system operates quite efficiently.

For part-load conditions, screw compressors with load/unload capability are more efficient at very low loads, while those with variable speed drive controls (VSD) are the most efficient at all part loads. See the following chart for VSD-controlled compressors.



Power Curve (Lubricant-Injected Screw with VSD Control)

Unlike compressors with inlet modulation only, the power draw of VSD machines drops proportionately at reduced capacity. For example, at 40% capacity, a VSD machine uses just over 40% of full load power, compared to an inlet modulation machine using over 80% of full load power. Ie. The VSD machine uses only half the power.

Recommendations

We recommend creating an efficient sequencing plan for the air compressor system as a whole, to provide good efficiency at all typical levels of air load. This involves two steps:

1. We recommend adding a new compressor with VSD capacity control, rated at about the same flow as AC#2. This new unit will act as a trim machine, efficiently adjusting its output to provide the air needed. Alternately, a cheaper option is to install a trim compressor with unloading controls (or retrofit existing machines), but this will offer less savings.
2. We recommend installing a sequencing control system to stage the compressors. Sequencing should stage compressors on as needed to meet demand, with the new efficient VSD machine acting as trim at all times, and existing constant-speed compressors staging on at or near full-load only (not falling below 80% loading).

Ideally the sequencing details of this measure should be finalized once loads and hours are reduced and stabilized. That is, the first steps for the air compressor system should be:

- Detailed evaluation of end uses to reduce air requirement (flow and pressure) wherever possible, and
- Installation of the previous two measures (LCM-6 and 7).

Costs and Assumptions

For our savings calculations, we assumed that the two previous measures are implemented first. Alternatively, all three measures could be completed together, which would increase the available incentive and provide an excellent overall payback period.

We assumed that the proposed case will keep existing compressors near full load (and full load efficiency), while the new VSD compressor will provide trim capacity as needed.

The VSD compressor is assumed to provide constant efficiency (kW per unit flow capacity) at all times. This efficiency is assumed similar to the average of existing compressors at full load, but less an allowance for VFD (in-)efficiency of a constant 97%. Proposed case efficiency of existing compressors near full load is also conservatively de-rated to 97%.

Existing compressor efficiency is assumed to follow standard curves. Maximum and minimum kW draws recorded during logging are assumed to represent the fully loaded and unloaded conditions, with capacity at unload being 0% and at full load being 100%, varying linearly between, and adjusted with engineering judgment to obtain near 70% power at 0% capacity. Note that air compressors typically reach rated capacity with motors slightly over-loaded (but within their service factors, which are 1.20 for all existing compressors).

This analysis is based on average of logged conditions only. Logging indicates that air requirements are fairly steady.

Costs presented were provided by this PG&E customer as obtained from their suppliers.

The potential incentive was based on the calculated savings at $0.08 per kWh plus $100 per peak kW. The cost cap limit of 50% was applied on a whole-project basis. Please see the following web link for information on applying for customized (calculated) incentives:

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

Refrigeration Measures

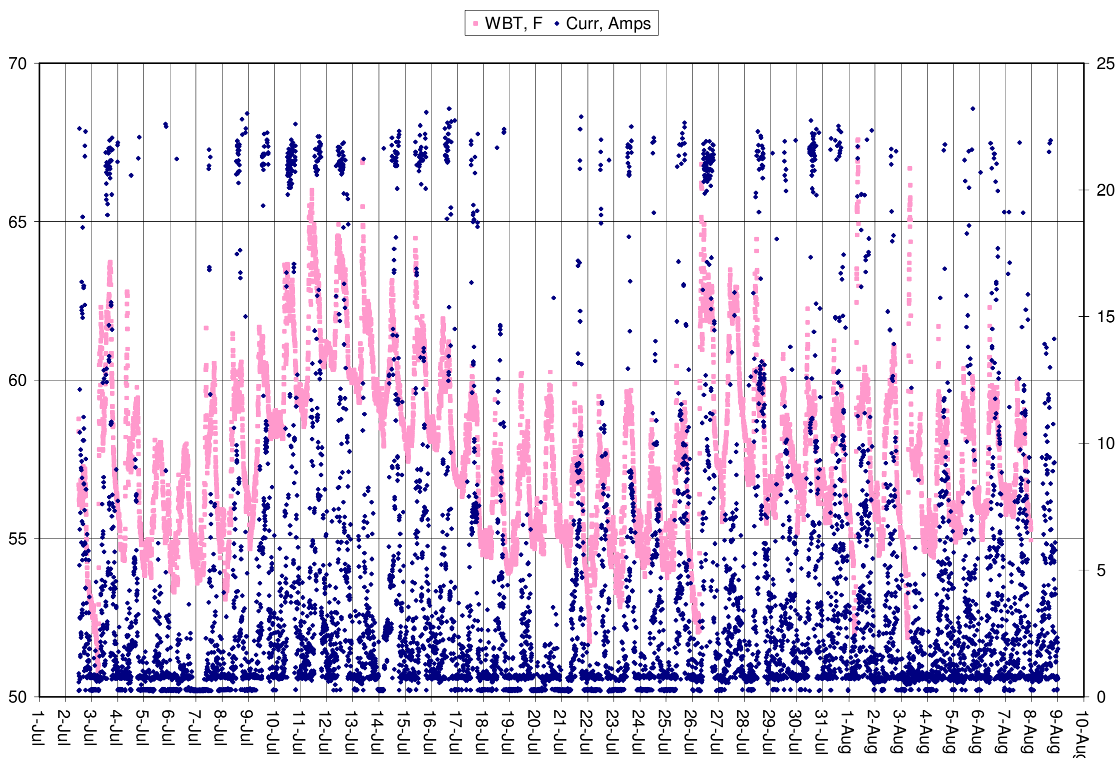
LCM-9: Condensers: Modify or Repair Controls to Allow ALL Fans to Operate at Equal Speed

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)
7.5	66,117	0	$ 6,473	$ -	$ 3,000	215%	0.5

Observations

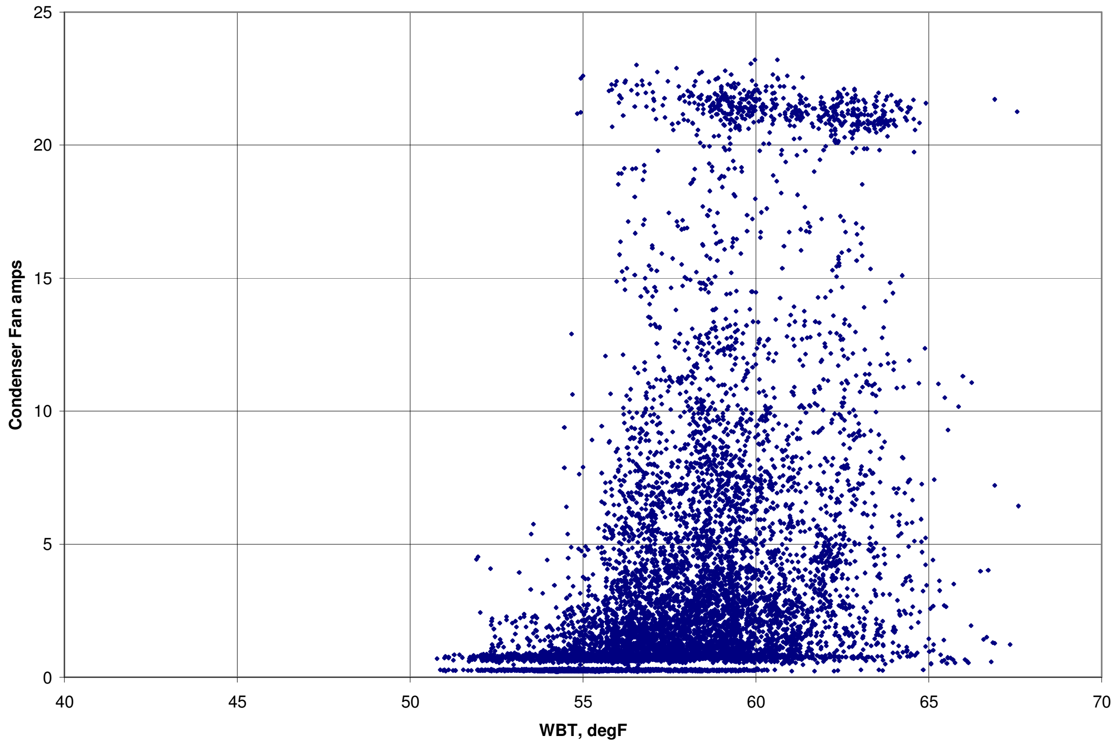
There are two evaporative condensers which are piped and controlled to operate as one. There are a total of twelve 20 hp motors driving the fans. They are all controlled by VFDs, but two of the 12 VFDs are in manual mode running at half speed (30 Hz) at all times. The remaining fans are controlled to run at a common speed.

We logged the current draw of one of the controlled VFDs during July-August 2008. The current draw of one of the actively controlled fan VFDs is shown in blue, with the ambient wet bulb temperature WBT in pink.



Condenser Fan Current Draw Trend

The following chart shows the current draw of the condenser fan against wet bulb temperature (WBT). During this logging period, the condenser fan draw was clearly more dependent on other variables than WBT.



Condenser Fan Current Draw vs. Wet Bulb Temperature

Recommendations

We recommend modifying or repairing the condenser fan VFD controls to have all twelve fan VFDs operate at equal speed at all times. This will provide energy savings, and will allow the full condenser capacity to be used when needed.

We do not know the issue(s) that led to these two fan VFDs being placed in manual mode.

Costs and Assumptions

This calculation estimates the energy savings possible if all twelve fans are actively controlled, based on average conditions during the July logging period.

We logged amps draw on one of the active fans. Condenser capacity is assumed to vary linearly with fan speed, with a 10% capacity at zero fan speed. Speed of the actively controlled fans is estimated based on adjusted fan laws assuming power varies with speed to the power of 2.4 (reduced from ideal 3). Maximum draw for one fan was about 22 amps.

This measure would also increase condenser maximum capacity by 6%.

For costs, we do not know what is needed to address this issue. We assumed costs of $3,000 in our calculations.

This repair measure is not eligible for PG&E incentives.

CIM-10: Ice-Making – Install More Efficient Ice-Making System (ON HOLD)

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	893,503	0	$ 69,334	$ 125,090	$ 405,792	15%	5.9

Observations

This PG&E customer uses flake ice to pack into cases of their product before shipping them out. Two old flake ice-making units are installed outside the Cooler building. The larger unit dates from 1991 and this PG&E customer considers it to be capable of making about 160 tons of ice in 24 hours. The smaller unit is older, and produces perhaps 50 tons of ice in 24 hours. The ice is made using make-up water reported to be at about 60 °F.

Flake Ice-Making Equipment

Ice Bins

The units use ammonia refrigerant from the Engine Room. The suction pressure required is about 15 psig (0 °F). The compressors which normally serve the low-temperature ice-making loop are the two 400 hp Mycom screws. The units are estimated to use at least 2.2 tons of refrigeration (TR) per ton of ice produced.

This PG&E customer has recently begun trying to shut ice-making production off during the PG&E summer peak billing period (Monday-Friday, 12 noon to 6pm) to reduce their energy costs. The cost of electricity during the summer peak period is about $0.21 per kWh, more than twice the average off-peak charge of about $0.08 per kWh.

The existing units are at their limit of capacity trying to produce enough ice during off-peak hours only. A typical day requires roughly 150 tons of flake ice, with a maximum requirement of about 250 tons. Considering available storage on site, the site estimates they need a maximum flake ice production of 215 tons per day.

The site reports ongoing reliability issues with these old ice-making systems, especially the smaller one. The maintenance manager reports particular ongoing problems with check valves which use high gas discharge to set the valves. A high side ammonia pressure of 155 psig (discharge condensing pressure) is reported to be needed to allow the ice-making systems to operate correctly (although data trending shows an estimated average discharge pressure of about 147 psig when ice-making is believed to be operating). All compressors in the Engine Room are currently piped together to one condensing system, so when ice-making is running, all compressors must run at a higher discharge pressure. Without ice-making, trend data shows the medium and high-temperature loop compressors currently run at a discharge pressure of 123 psig.

Recommendations

We recommend installing a new, more-efficient flake ice-making system with greater capacity. While this report focuses on the energy savings possible with a new ice-making system, the primary benefits of this investment are ongoing reliability and higher capacity.

The system will provide the following advantages which result in energy savings:

- Higher operating efficiency will decrease demand and save energy on the low-temperature compressors;
- Lower requirement for high side ammonia pressure will decrease demand and save energy on all compressors when ice is being made;
- Higher capacity will reduce ice-making operating hours,
  - allowing medium and high-temperature compressors to operate at lower discharge pressures using less energy during these hours, and
  - reducing energy costs by ensuring ice-making during summer peak can be avoided.

We analyzed the possible energy savings from this measure based on a system currently under consideration by the site. The proposed system would include two Tigar 36" plate series flake ice makers, Model 36-56 with these performance specifications:

- Each nominally rated at 143.1 tons capacity of ¼" flake ice per 24 hours;
- Using 233.6 TR, or 1.63 TR per ton ice;
- These rating are at suction temperature of 0 °F (15.6 psig), 60 °F entering water temperature, and 90 °F ambient temperature.

Costs and Assumptions

We do not have metering data for the low-temperature (ice) compressors alone. We therefore needed to estimate energy use of these compressors. For our calculations, PG&E Engine Room interval kW metering data for July 2008 was analyzed. This PG&E customer's data recording of operating conditions was used to determine when ice is being made. Average conditions were determined and used to estimate average energy use by LT ice compressors from compressor performance specifications.

Potential energy savings with proposed new ice-making system were based on average energy use with the proposed-case higher rated efficiency (from TR per ton of ice produced). Ice production rate was assumed to be the average estimated for our logging period in July 2008.

We assumed that ice was being made when the LT ice loop suction pressure was no higher than 28 psig, and Discharge Pressure was no lower than 128 psig. We assumed the ratio of nominal rated loads on each loop was constant, and we adjusted assumed load factors for each loop based on typical operations until total TR load was consistent with the PG&E kW metering data. Efficiency of existing ice-making equipment was assumed at 2.2 TR per ton of ice per 24 hours, based on site information. We conservatively de-rated the manufacturer-rated efficiency of proposed new equipment by 10% to 1.63 TR per ton of ice per 24 hours. Please see detailed calculations in the appendix.

The cost estimate is for the base equipment costs only, from a recent quote from C.I.M.

Electric. Cost savings for this measure were based on average non-peak electricity cost of $0.08 per kWh, since ice is now generally not made during summer peak period hours.

The potential incentive was based on the calculated savings at $0.15 per kWh for Refrigeration, but 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/

If this measure is submitted for NRR incentives, we recommend that the efficiency of existing ice-making equipment be confirmed.

CIM-11: Reduced Head: Install Discharge Regulators for Ice-Making Hot Gas, Re-pipe Seven Evaporators to HT Loop, Re-pipe Small 150hp HT Compressor to LT & MT Loops, Retrofit VFD on One 350 hp Compressor, and Install 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)
65.9	784,664	0	$ 76,819	$ 124,287	$ 2,268	3387%	0.0

Summary of Overall Measure Plan

The refrigeration compressors at this PG&E customer site consume about 48% of the electricity used at the site. They compress ammonia gas from a low suction pressure to a high head pressure. The increase in pressure is called the lift. Minimizing the lift of refrigeration compressors reduces their energy use dramatically.

All of the compressors currently operate at a common head pressure. This measure includes several sub-measures which will allow the system head pressure to be reduced from a current average of over 136 psig to a greatly reduced level of 115 psig. On average, the compressor lift will be reduced by about 20%, providing significant energy savings year-round.

Each of the sub-measures addresses a current barrier to head pressure reduction, and some of them also provide direct energy savings of their own.

The first barrier is the hot gas pressure needed for the ice-making equipment, which requires about 145 psig. This is addressed by installation of a discharge pressure regulator on one compressor serving the low-temperature (ice-making) loop, so that this compressor can operate at 145 psig to provide hot gas to the ice-makers, while allowing the rest of the system to operate at a lower head.

Evaporator defrosting is another user of hot gas which can limit the reduction of head pressure. This proposal includes re-piping of seven evaporators serving relatively warm rooms to the high temperature suction loop, eliminating the need for defrost and therefore the need for hot gas. This sub-measure provides its own energy savings by serving these evaporators with ammonia at higher suction pressure. It also shifts refrigeration load from the medium to the high temperature loop, requiring the following compressor changes.

The small 150 hp compressor currently serving the high temperature loop is no longer sufficient. The next larger compressor size is 350 hp, and one of these four units needs to be switched from the medium to the high temperature loop (using existing piping). Since the 150 hp unit is currently only piped to the high temperature loop, piping must be added to allow it to serve other loops. Finally, a VFD is added to the 350 hp high temperature compressor to allow it to operate more efficiently at part load.

With these changes, the system can operate at a reduced head pressure of 115 psig. The evaporative condensers are already sized large enough to provide sufficient heat rejection capability at this head pressure to meet typical loads in almost all historical weather conditions (see CIM-11d below for more details).

Following is a separate description of each sub-measure.

CIM-11a: Install Discharge Regulator on Compressor for Ice-Making

Observations

The existing ice-making equipment requires hot gas at about 145 psig to operate correctly. Currently this forces all compressors serving all loads to operate at 145 psig head pressure when an ice-maker is running, which is most of the time outside of peak period hours. Normally two compressors are needed to serve the two ice-makers.

Recommendations

We recommend installing a discharge regulator on at least one of the compressors which serve the ice-making equipment. With this regulator, the compressor will operate at 145 psig head pressure providing the hot gas required for the ice-makers. The regulator will drop the pressure of the remaining hot gas from that compressor to match the lower pressure of the other compressors (115 psig) as supplied by one common pipe to the condensers.

Costs and Assumptions

Savings result from the second low-temperature compressor operating at reduced head pressure (115 vs 145 psig) when ice is being made. See detailed assumptions and calculations in the appendix.

CIM-11b: Re-Pipe Seven Plant Evaporators from Medium to High Temperature Suction Loop

Observations

The older warmer portions of the Plant building (west end) are currently cooled by seven evaporators piped as part of the medium temperature (MT) suction loop. The areas include the Prep Room (aka Room “D”) and Tray Prep Room 1 (aka Room “E”). The design target temperature for these spaces is 45 °F, although we measured the space temperatures in both rooms as 42 °F. These evaporators have a total nominal rated capacity of 121 tons of refrigeration (TR).

Prep Room Evaporators

The medium temperature suction loop operates at a saturated suction temperature of 16 °F, which is lower than is required to maintain a 42-45 °F space temperature. The high temperature (HT) suction loop operates at a saturated suction temperature of 30 °F. At this suction temperature, these spaces could be served with a temperature difference (TD) of 12-15 °F, which is reasonable.

Cooling these spaces with an excessively low suction temperature is inefficient, using compressors operating at a higher lift than needed. In addition, using the medium temperature loop at 16 °F means that defrost is needed, with its associated energy use. Using the high temperature suction loop at 33 °F would practically eliminate the need for defrost. This is significant because the need for high-pressure hot gas for defrost is a barrier to implementation of reduced head pressure.

Recommendations

We recommend re-piping these seven evaporators into the high temperature suction loop. This measure will help enable implementation of reduced head pressure, as well as providing direct refrigeration energy savings. Savings result from higher compressor efficiency (lower lift) and elimination of defrost requirement.

Costs and Assumptions

Savings result from higher compressor efficiency (lower lift) and elimination of defrost requirement. These savings may be partly offset by increased evaporator fan demand due to the lower temperature difference (TD) between the evaporator suction temperature and the ambient air temperature. We conservatively assumed that evaporator fan duty will increase to 100% in the proposed case. Please see the appendix for detailed assumptions.

CIM-11c: Add Piping to Allow the 150 hp Compressor to Serve the Low or Medium Temperature Suction Loops, and Install VFD Control on One 350 hp Compressor To Serve the High Temperature Suction Loop

Observations

This measure will cause a shift in refrigeration loads between the different suction loops. The re-piping of seven evaporators (see CIM-11b above), along with recent installation of a 180 ton water chiller in the Plant, will increase loads on the high temperature suction loop beyond the capacity of the current 150 hp high-temperature compressor. This means that a re-working of the allocation of compressors is required to meet the new load distribution.

The efficiency of a screw compressor with standard slide valve modulating control begins to drop off quickly below about 70% capacity. If a screw compressor must operate many hours at below 70% capacity, part-load energy savings can be obtained by installing a VFD to reduce compressor speed before closing the slide valve.

Recommendations

The next larger compressor size is 350 hp, so one of these four units needs to be switched from the medium to the high temperature loop. This can be done by simply moving valves on existing piping. Next, since the 150 hp unit is currently only piped to the high temperature loop, piping must be added to allow it to serve other loops.

Finally, since a 350 hp compressor serving the high temperature loop will typically be only partly loaded (up to ~60%), we recommend retrofitting it with VFD speed control to improve its part-load efficiency. At 50% loading, VFD speed control reduces energy use by about 25% compared to constant speed (slide valve control only).

Costs and Assumptions

The energy use of the larger, partly loaded 350 hp compressor with VFD control in the proposed case is conservatively assumed to be similar to the base case energy use of the smaller 150 hp compressor now serving the high temperature loads.

CIM-11d: Reduce Compressors Operating Head Pressure to 115 psig

Observations

Compressors operate significantly more efficiently as their overall pressure lift (the increase in pressure from the suction side to the high discharge side) is decreased. For example, for the four 350 hp compressors (Mycom 200 VLD) now serving the medium temperature loop, their energy use increases by about 45% if their discharge pressure is increased from 103 to 151 psig saturated condensing pressure SCP (65 to 85 °F SCT).[1]

[1] Increase from 0.52 to 0.76 kW/TR, at 29 psig saturated suction pressure (SSP) or (16 °F SST), from Mycom full load performance ratings

The discharge or head pressure set point for the compressors is manually set, currently based primarily on whether or not ice-making is in production. The existing ice-makers require a higher discharge pressure to provide sufficient hot gas pressure for valve seating. When ice-making is off, discharge pressure is lowered to about 123 psig. According to site staff, this pressure is maintained to provide sufficient hot gas pressure for effective hot gas defrosting of the cold room (medium temperature) evaporators. These defrosts are currently scheduled to occur around the clock.

Another key limit to how low the discharge pressure can be set is evaporative condenser capacity for the ambient conditions. At too high a SCT, the condensers may not be able to dispose of all the heat to fully condense the refrigerant. Condenser capacity depends on fan speed and ambient wet-bulb temperature, in addition to entering gas temperature.

Recommendations

We recommend installing controls to reduce head pressure. Based on completion of the above sub-measures, we recommend running the system at 115 psig discharge (SCT). To achieve this, each limitation to lower head pressure must be addressed, as recommended in the above sub-measures a, b, c.

Note that further head pressure reductions are likely possible with additional system upgrades and modifications. Such future measures as central control of evaporator defrosts and active floating head pressure controls could allow further head pressure reductions and associated energy savings during many operating hours. In addition, upgraded controls will provide improved load shifting and demand response opportunities, which can provide further energy cost savings.

The following text presents some additional information including alternatives considered.

Condenser Capacity

The first issue is condenser capacity. The site has already installed excess condenser capacity which is not being put to use, so total capacity is not an issue even at quite low head pressures. There are two identical Evapco evaporative condensers but they are piped together in parallel and effectively operate as one. These condensers could handle the typical 1200 TR total load measured[2] at SCT as low as 70 °F (corresponding to 115 psig SCP) for 99.8% of the time. In a worst case scenario, total load might reach about 80% of maximum nominal loads, or about 1600 TR. Even in this case, the condensers have sufficient capacity 97.3% of the time to run at this low head pressure.

Hot Gas Defrost

The other significant issue limiting the reduction of head pressure is the need for minimum hot gas pressure to serve hot gas defrosting of evaporators on the medium temperature loop. There are several possibilities for addressing this issue:

1. Reduce the minimum hot gas pressure required for defrosts once the sub-measure CIM-11b to re-pipe some medium-temperature evaporators to the high-

[2] Calculated based on data logged period in July-August 2008, compared to Evapco capacity data and considering historical weather data for a nearby location.

temperature loop is implemented. These evaporators are currently some of the farthest from the Engine Room. They will no longer require defrost.

2. Re-evaluate the minimum hot gas pressure required for hot gas defrosts generally. Usually, hot gas is regulated within the coil to a pressure of 65-90 psig. Often a master regulator in the engine room is set to 100 or 110 psig. Defrosts can take slightly longer at reduced pressure, so this measure may require tolerating a slightly longer defrost cycle. Although there is very little difference in the latent heat of ammonia at 125 or 100 psig, the reduced delivery pressure can result in a lower flow rate of ammonia early in a defrost cycle. After the coil has warmed and the regulator begins throttling flow, the system head pressure no longer matters.[3]
3. Consider scheduling defrosts for specific time slot(s) at night (when electricity rates are lowest), and increasing system head pressure for only these scheduled defrost periods. This would at least limit the high head pressure penalty (both energy and compressor wear) to specific defrost hours. The defrost requirements of some specific processes, notably the pressure coolers, must be investigated further. This option may require additional central control capability.
4. If necessary, a compressor can be dedicated for defrost duty, providing hot gas production at higher head pressure than other compressors. A regulator is installed in the discharge line of the defrost compressor to elevate its discharge pressure, and all hot gas can be supplied from this one compressor. This would need to be controlled automatically. Again, as above, this dedicated compressor mode would be best operated only for specific scheduled defrost hours. This step would involve capital costs for additional piping and controls. This option is similar to CIM-11a above but for all hot gas uses (not only ice-making).

Liquid Pressure Limits

In addition, there may be other systems we did not identify which require a minimum high-side liquid pressure to operate correctly. In this case, it is possible to add liquid pressure booster pumps to raise the supply pressure of liquid ammonia. The energy penalty for such pumps is very small relative to compressor energy. Also, the cost is small compared to the savings potential of this measure. In addition, booster pumps can be equipped with VFD control to maintain a more consistent liquid pressure in the system, providing operational benefits due to more steady system conditions.

Screw Compressor Oil Separator Performance

Another possible issue at low head pressures is oil separation in screw compressors. The compressor manufacturer should be consulted to confirm minimum operating pressures to ensure oil separation.

Costs and Assumptions

The savings calculation estimates average compressor energy savings at proposed SCP compared to average current SCP used (when ice-making is not underway). These savings are partly offset by increased condenser fan energy, which is again estimated based on all

[3] "Industrial Refrigeration Best Practices Guide", Industrial Efficiency Alliance, December 2004.

average conditions. Compressor energy is based on full load ratings from Mycom. Base case energy use is from PG&E interval data for the Engine Room in July 2008 only. Sequencing of compressors and part load efficiency reductions are ignored as these issues are likely to affect both base and proposed cases similarly.

Historical weather data, specifically wet bulb temperatures (WBT), was analyzed from TMY3 data for a nearby location. According to the historical data, WBT does not normally rise above 67 °F. Based on the Condenser Capacities chart with extrapolations (see sheet), condenser capacity is sufficient to meet typical loads at proposed new SCP lower limit in all but 0.2% of ambient conditions.

A heat rejection factor (HRF) table was obtained for the existing evaporative condensers, to calculate actual Condenser Capacity in different WBT and SCP conditions. HRF values for low SCT's were extrapolated using 2^{nd}-order polynomial equations generated in MS Excel to represent the data. HRF values for low WBT conditions were extrapolated linearly from the data at lowest provided WBT's.

An allowance of $5,000 was included for controls upgrades and programming for this measure, including compressor controls set-up by a Mycom technician.

The potential incentive was based on the calculated savings at $0.15 per kWh for Refrigeration plus $100 per peak kW. The cost cap limit of 50% was applied on a whole-project basis. Please see the following web link for information on applying for customized (calculated) incentives:

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

CIM-12: Install VFDs and Controls for Evaporator 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)
69.5	608,759	0	$ 59,597	$ 48,701	$ 128,274	45%	2.2

Observations

In the refrigerated spaces, evaporators are controlled to maintain zone temperatures. Evaporator fans are cycled on and off.

The heat removal by evaporators can be achieved with greater consistency and using less energy by running fans continuously at reduced speed.

Example Four-Fan Evaporator Coil in Refrigerated Space

Recommendations

We recommend installing VFDs to continuously control evaporator fan speed. Normally one VFD can be installed per evaporator or zone, driving two or more fan motors together.

This measure will save energy due to the fan affinity laws. Slowing a fan by even 10% reduces its power demand by 25%. In addition, slower fans reduce noise dramatically. And continuous control will help improve the stability of temperatures in each cold room and the stability of pressures in the entire refrigeration system.

The costs and savings for this measure are calculated for all evaporator fans at this site. However, this measure should be installed in stages. Evaporators where fans cycle off frequently, and with inverter-rated motors, will provide the best payback. We recommend that this measure be first tested in one cold room to demonstrate its effectiveness and benefits.

The fan VFDs should be controlled in series with the existing controls (eg. liquid solenoid or back pressure regulators). Fan speed will be reduced from maximum (typically 80 to 100% speed) to minimum speed (typically 40 to 50%). If additional evaporator coil capacity reduction is required, the solenoid or back pressure regulator can then be used.

The site has concerns about warm spots in far corners of refrigerated spaces if fan speed is reduced. However, case studies have shown that this is rarely a problem. To avoid problems, zone temperature sensors should be properly placed. Additional sensors in far areas may be added to ensure problems are avoided.

Product quality is not expected to be an issue. Many case studies in refrigerated fruit storage warehouses in the Pacific Northwest have shown that fruit quality improved with installation of evaporator fan VFDs.

Fan motors may need to be replaced with units rated for VFD applications. Where inverter-rated motors are not available, VFDs should be installed with an output filter to provide an acceptable voltage waveform to the motor.

Fan VFDs should be installed on direct expansion evaporator coils with extra care. At reduced air flow, the TXV may not close enough to maintain proper superheat at the coil exit, resulting in flood back. However, with careful application, fan VFDs can work properly on direct expansion coils.

Costs and Assumptions

Based on logging data and calculations for the previous ice-maker measure, we estimated that evaporator fans currently run about 60% of the time, on average, through the year. To calculate proposed case energy use, we assumed that the VFD-controlled fans would, on average, operate at 70% speed. At 70% speed, a fan with VFD draws about 44% as much power as at constant full speed.

We also calculated overall refrigeration energy savings based on the reduced fan motor heat load, and the current overall refrigeration efficiency.

For costs, we assumed that one VFD would be installed for every evaporator, controlling all fan motors together. We used RS Means for installed custom-engineered VFD costs, with adders for design and engineering, commissioning, plus a contingency. We ignored any costs for replacing motors. New higher efficiency motors would also further increase energy savings.

The potential incentive was based on the direct calculated fan savings only (excluding refrigeration 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/

If this measure is submitted for NRR incentives, we recommend that evaporator fan power measurements be taken for all evaporators.

4.5 General Equipment Measures

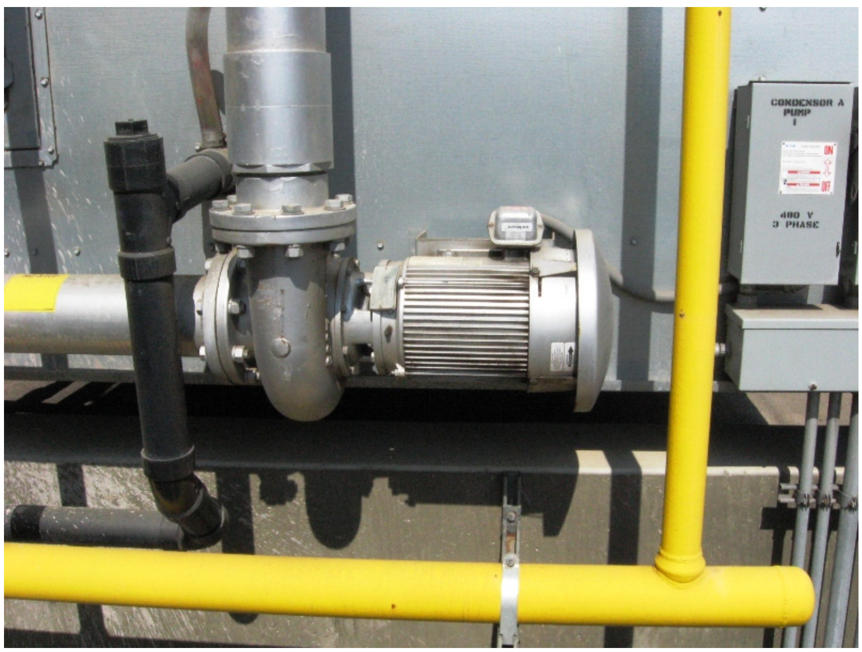
LCM-13: Install Premium-Efficiency Motors on Condenser and Ice-Making Pumps

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)
3.3	26,645	0	$ 2,609	$ 1,847	$ 4,274	60%	1.6

Observations

There are several relatively inefficient motors on various pumps.

All together, these motors currently consume 375,000 kWh, costing $37,000 per year.



Condenser Water Lift/Spray Pump, with Motor only 84% Efficient

Recommendations

We recommend replacing these inefficient motors with premium efficiency motors (see list below).

MOTORS LIST	Count	hp	Current Motor Effic'y (Note 4)	Premium Motor Effic'y	kWh / yr Savings	Simple Payback after incentive (yr)
condenser lift/spray pumps	4	7.5	84.0%	91.7%	15,678	1.0
oil cooling water pumps	2	7.5	84.0%	89.5%	5,737	1.7
ice making *ammonia duty*	1	7.5	84.5%	91.7%	2,581	2.6
ice making	1	15.0	88.5%	92.4%	2,649	4.2

List of Motors Recommended For Efficiency Upgrade

When purchasing motors, specify premium efficiency motors by the actual Nominal Full Load Efficiency. Please see the appendix for a guideline to nameplate efficiencies that meet the new premium efficiency criteria set by the National Electrical Manufacturers Association (NEMA) and the Consortium for Energy Efficiency (CEE). Relying on motor distributors' and suppliers' designations for premium efficiency motors is not a reliable way to specify the equipment. Instead, use the attached guidelines to specify nominal efficiencies explicitly. Updated guidelines for premium efficiency levels can be obtained from CEE's website at www.cee1.org.

Costs and Assumptions

The measure cost includes the purchase of premium efficiency motors, plus professional labor to install them. Installed cost data was obtained from RS Means. Please refer to the appendix for details.

The potential incentive was based on the calculated savings at $0.08 per kWh for Motors and Other Equipment. The ice-maker motors were assumed to be not eligible for preferred Early Retirement treatment (maximum 13 years old). Minimum CEE motor efficiency requirements were used to calculate the incentive. Please see the following web link for information on applying for customized (calculated) incentives:

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

CIM-14: Pressure Coolers: Install VFD Fan 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)
18.5	162,124	0	$ 15,872	$ 12,970	$ 42,170	36%	2.7

Observations

At this PG&E customer site, there are seven pressure coolers used for rapid cooling of products packed in paletted boxes. These units use refrigeration coils on the medium temperature (MT) refrigeration suction loop. Each has a 20 hp motor driving a fan which pulls air through the pallets and blows it out over the top of the pallets, which are generally covered.

Two Pressure Coolers

The pressure coolers are located in rooms within the Cooler building, but these rooms are open to the rest of the warehouse. We measured air temperatures of 31 °F in the pressure coolers, and 33 °F outside the rooms. Each pressure cooler is nominally rated at 20 TR of cooling at 33 °F.

We measured the power draw of one fan at 20 kW. We installed a logger to record the current draw of all the pressure coolers for five weeks in July-August 2008. The trend data showed that the fans were operated an average of 35% of the time, drawing an average total of 50 kW. This equates to electricity use of 438,000 kWh, costing about $43,000 per year for the fans alone.

Based on the nominal cooler ratings, the energy use by the refrigeration system for the pressure coolers is approximately 293,000 kWh costing about $29,000 per year. The strong fans add their own heat load which must be removed by the refrigeration system. This load is 40 TR with all fans running, with an average of over 14 TR through the year.

Pressure Cooler Open Rooms

Warehouse Outside Pressure Cooler Rooms

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. Also the prices of variable frequency drives (VFDs) have fallen steadily over recent years and today, they are relatively inexpensive.

Recommendations

We recommend installing variable frequency drives (VFDs) to control and reduce the speed of the pressure cooler fans.

We recommend first installing this measure for one pressure cooler, for testing. Different fan speeds can be tested while checking product temperature and quality. It is also possible to control fan speed to drop over time to match the ability of the product to give off heat.

In addition, we recommend installing doors to close off the pressure cooler rooms from the rest of the warehouse. The MT coils operate with a SST of 16 °F, and the room air temperature is 31 °F. It is room air which is pulled in through the product. By enclosing the rooms, less refrigeration will be needed to maintain 31-33 °F in the rooms. We did not analyze savings and costs for this recommendation.

Costs and Assumptions

We calculated potential fan energy savings by assuming fan speed could be reduced to 75%, while increasing cooling time by one-third to provide the same total cooling effect. We ignored any impacts on refrigeration energy efficiency, except accounting for reduced refrigeration load from the reduced fan heat load.

Costs were estimated using RS Means data for custom-engineered VFD installations, including City Cost Index adjustment. We also included allowances for design and engineering, commissioning, plus a contingency.

The potential incentive was based on the direct calculated savings only (excluding refrigeration 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://pge.com/mybusiness/energysavingsrebates/rebatesincentives/ief/

4.6 Other Possible Energy Efficiency Measures

Air Compressors: Repair Leaks

Air leaks are generally very significant consumers of compressed air in most facilities. The DOE states that typically 30 to 50% of air use is unregulated. Based on our logging, it appears that this PG&E customer is no exception. We recommend implementing a regular program to identify and repair air leaks on a routine basis. This measure could offer substantial savings at low cost.

Leak listening tools can be borrowed for PG&E's Pacific Energy Center Tool Lending Library at no charge. See:

http://www.pge.com/mybusiness/edusafety/training/pec/toolbox/tll/

Air Compressors: Reduce Loads

We did not study compressed air end uses during the initial audit visit. End uses should be further evaluated to identify where air can be shut off whenever possible even while the Plant is in operation. This can be automated. For example, solenoid valves can be installed to shut off air when no product is present at a process, reducing load on the compressors and saving energy. Also, end uses which only blow air can usually use low-pressure blower air rather than the high-pressure compressed air. Air blowers use far less energy than air compressors.

Air Compressors: Duct Cooler Outside Air to Intakes

Air compressors operate more efficiently when supplied with cooler intake air because cool air is more dense. The air compressor room is quite warm due to the heat from the compressors. We measured the ambient air at 83 °F during our visit (see photo). Meanwhile the average outside air temperature is only 56 °F.

Warm Ambient Temperature in Air Compressor Room

Packaging Lines: Install Controls to Shut Off Equipment When Inactive

During our visits, we observed that much of the packaging and process equipment in the Plant remains active even when no product is being processed. This includes pumps, conveyors, blowers, etc. Electricity as well as compressed air is consumed when not required.

We estimate the annual energy use of equipment in the Plant to be nearly 1,700,000 kWh, costing about $166,000 per year. This is the total billed kWh less our estimates for Plant lighting and air compressors. This measure could offer substantial savings and is worth further investigation.

Empty Packaging Line with Pumps, Conveyors, Blowers Still Running

Building Shell: Full Insulation Evaluation and Improvements

We recommend that a full evaluation of building shell insulation and sealing be completed for the older Cooler building. For example, the ceiling and walls of the Cooler building are insulated by spray foam insulation, perhaps 3 inches thick. We measured most zone temperatures in this building at 37 to 43 °F, and about 33 °F in front of the pressure tunnels. The annual average outside temperature is 56 °F. Modern refrigerated warehouses use more insulation to minimize heat gain from outside.

Building Shell: Cool Roof

When the Cooler is due for a new roof, a white cool roof should be installed to reduce solar heat gain, as installed on the newer buildings.

Cooler Ceiling and Walls Spray Foam Insulation

Refrigeration: Replace Old Evaporators in Cooler with More Efficient Units

The evaporators in the Cooler building are older units dating from about 1991. Fan energy may be reduced by installing new evaporators such as upflow-style units as used in Plant cold rooms, providing improved airflow distribution. Energy use for defrost cycles may also be reduced.

Refrigeration: Install Central Control of Evaporators Defrosts with Automatic Sensing

The evaporators in the Cooler building have scheduled defrosts based on time clocks installed throughout the building. On a return visit we checked each of these time clocks and found clock times set incorrectly, simultaneous defrosts, and program errors. Many of the units are defrosting four times per day. In the Plant building, defrosts are also controlled by schedules only, although with a central PLC control.

Twenty of the 36 evaporators are scheduled to defrost during the expensive Peak Billing period (M-F 12-6pm).

With central defrost control and automatic sensing, defrosts can be optimized, saving energy and energy costs and minimizing peak hot gas demands. Controlling hot gas demands could help allow further reductions in refrigeration compressor head pressure much of the time, providing additional significant energy savings.

See the appendix for full documentation of current defrost schedules as checked on site.

Refrigeration: Install Automatic Staging / Sequencing Controls and Trim Compressor(s)

The refrigeration load of the site varies continuously, for each of the three suction loops. To meet varying loads, at least some of the compressors must operate at part-load conditions for much or all of the time.

The efficiency of a screw compressor with standard slide valve modulating control begins to drop off quickly below about 70% capacity. If a screw compressor must operate many hours at below 70% capacity, part-load energy savings can be obtained by installing a VFD to reduce compressor speed before closing the slide valve. However, this can be expensive for these applications.

An alternative is unloading reciprocating compressors. These can serve as excellent trim units because their part-load efficiency is good. Installing an appropriately-sized trim compressor for a given suction line would allow the other (screw) compressors to operate at or near full load (and maximum efficiency) at all times.

Compressor sequencing is presently manually controlled. If trim compressors are installed, we recommend developing automatic controls for compressor staging / sequencing to ensure that the most efficient combination of compressors is used as much as possible.

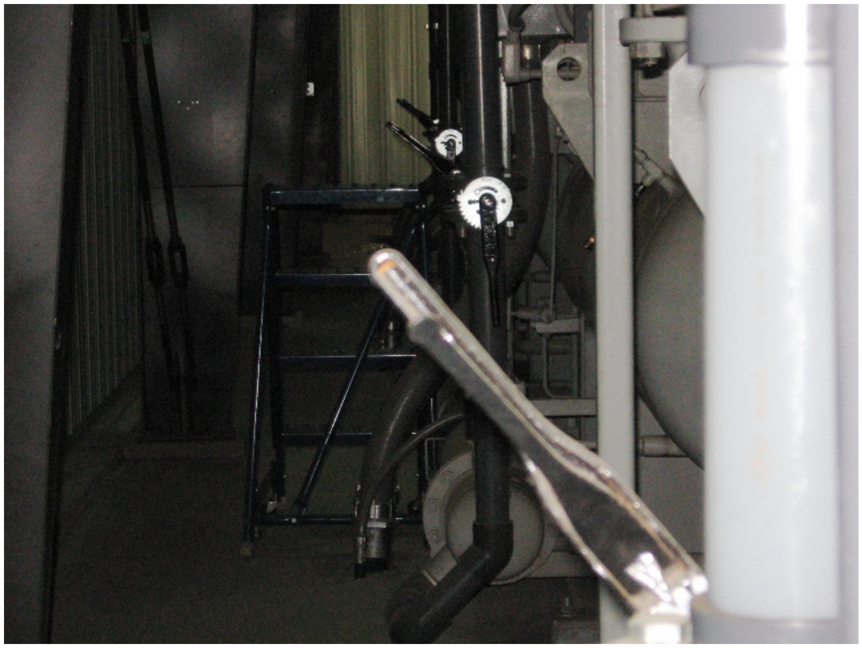
This measure needs to be evaluated once loads on each line stabilize. Coming projects will significantly alter the typical refrigeration loads on each line. (eg. Plant expansion with added loads, repiping of evaporators from MT to HT loop, floating head pressure, new ice-makers, etc).

Other than this one smaller HT compressor, all of the existing compressors are of similar size, so staging of compressors for maximum efficiency will not be possible. Installation of additional trim compressor(s) will make sense where loads are such that large compressors need to run many hours at part load of under 70%.

Compressor Oil Cooling: Open Balancing Valves and Trim Pump Impellers (or VFD)

The oil of the refrigeration compressors is cooled via two water cooling loops to coils in the evaporative condensers. These loops use two circulating pumps with 7.5 hp motors operating 24/7.

The water piping to each compressor includes a balancing butterfly valve. All of these balancing valves were throttled equally, closed to about 50% open. See photo below.

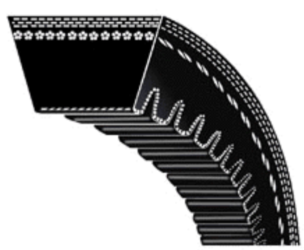


All Water Balancing Valves Equally Throttled

We recommend reducing the output and energy use of the pumps and opening all of the throttled valves. This can be achieved either by installing smaller pump impellers (or trimming existing ones), or by installing a VFD to control the pumps. The VFD option is more expensive, but would allow flow adjustment as need changes (ie. addition of new compressors for future loads).

Replace Standard V-Belts with Cogged V-Belts

Cogged V-belts have notches which add flexibility, and require less horsepower. They also have a higher coefficient of friction over standard V-belts. The higher coefficient of friction provides reduced slippage. Cogged V-belts (see figure below) have slots that increase their efficiency by 2% compared to normal V-belts. According to studies[4], V-belt drive efficiency deteriorates by as much as 5% over time as a result of slippage when the belt is not periodically re-tensioned.



Cogged V-Belt

[4] Office of Industrial Technologies, Energy Efficiency and Renewable Energy, U.S. Department of Energy http://www.p2pays.org/ref/17/16937.pdf

We recommend that standard V-belts be replaced with cogged belts on all belt drives, such as on the condenser fans.

Additional Rapid Roll-Up Doors

Rapid roll-up doors between refrigerated and non-refrigerated spaces minimize air flows and heat transfer, even where regular forklift traffic occurs. We recommend installation of more rapid roll-up doors where temperature differences exist between spaces. For example, replacing wind drapes at an outside door to a cold room with a rapid roll-up door will save refrigeration energy.

The Cooler building has outside doors with wind drapes. These use vestibules with two sets of wind drapes, which is far better than a single wind drape curtain. However rapid roll-up doors are still better at air sealing when closed.

Outside Door from Cooler with Wind Drape Vestibule

4.7 Measures Analyzed But Not Recommended

Refrigeration: Install Chiller to Pre-Cool Water for Ice-Maker

The incoming water used for ice-making is reported to be at about 60 °F. Using the LT compressors to cool the water down towards freezing temperature is inefficient. It would be more efficient to complete most of this initial chilling using refrigerant from the high temperature loop.

We estimated the possible savings as about 30,000 kWh per year valued at about $3000 per year. This is based on recent ice-making rates and assumes installation of the proposed new ice-makers and floating head pressure measures.

Cost for this measure would include adding piping of the high temperature suction loop to the ice makers, plus installation of the pre-cooling chiller. There is an existing used chiller on site which could be used for this application, with modifications. We also obtained a quote from Mueller for a new chiller for this application.

We do not recommend this measure because we believe the relatively small energy savings potential does not justify the expected measure cost accompanied by added equipment and operational complexities.

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: Shift Pressure Cooling Operations to Off-Peak During DR Events – Maximum 140 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)
57.1	2,284	0	$ 1,106	$ 2,500	$ 2,500	66%	2.3

Observations

The pressure coolers are used during the peak period. When all seven units are on, their fans currently consume 140 kW. During our data logging, their average demand was 57.1 kW during the summer peak period of weekdays 12-6pm.

Recommendations

We recommend that the pressure coolers could be shut off during demand response events, and these operations shifted to off-peak hours.

Additions and improvements to control systems may be required to readily implement this measure, such as from a central control station.

Costs and Assumptions

This measure ignores refrigeration savings, which are considered for the whole refrigeration site in a following measure. We assume that energy efficiency measures recommended in this report are not yet implemented.

Costs were roughly assumed for controls additions to enable straightforward implementation of this measure.

The possible DR incentive was estimated at approximately $0.35 per kWh reduction for ten four-hour events per year. In addition, we assumed an electricity cost savings equal to the difference of average electricity cost in the summer peak period vs part and off-peak billing periods.

Finally and significantly, a Technical Incentive (TI) is expected to be available in 2009 to pay down the capital costs of implementing this measure. The 2009 TI is expected to be $125 per kW, up to 50% of the full cost.

DR-2: Shift Vacuum Cooling Operations to Off-Peak During DR Events – Maximum Over 195 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)
194.6	7,784	0	$ 3,768	$ 5,000	$ 5,000	83%	1.3

Observations

The vacuum coolers are used during the peak period, being typically started at 10-11am and run until after midnight. Based on spot metering and our energy balance analysis, the average combined demand of their motors is 194.6 kW.

Recommendations

We recommend that the vacuum coolers could be shut off during demand response events, and these operations shifted to off-peak hours.

Additions and improvements to control systems may be required to readily implement this measure, such as from a central control station.

Costs and Assumptions

This measure ignores refrigeration savings, which are considered for the whole refrigeration site in a following measure. We assume that energy efficiency measures recommended in this report are not yet implemented.

Costs were roughly assumed for controls additions to enable straightforward implementation of this measure.

The possible DR incentive was estimated at approximately $0.35 per kWh reduction for ten four-hour events per year. In addition, we assumed an electricity cost savings equal to the difference of average electricity cost in the summer peak period vs part and off-peak billing periods.

Finally and significantly, a Technical Incentive (TI) is expected to be available in 2009 to pay down the capital costs of implementing this measure. The 2009 TI is expected to be $125 per kW, up to 50% of the full cost.

DR-3: Shift Plant Operations to Off-Peak During DR Events – Maximum Over 488 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)
487.7	19,507	0	$ 9,442	$ 15,000	$ 15,000	77%	1.6

Observations

The Plant operates during the peak period, with packaging lines, chillers, lighting and air compressors consuming electricity. Based on our metering and energy balance analysis, we estimate the combined average demand of these operations at 487.7 kW.

Recommendations

We recommend that the Plant operations could be shut off during demand response events, and these operations shifted to off-peak hours. This measure would include significant re-scheduling of personnel.

Additions and improvements to several control systems will be required to readily implement this measure, such as from a central control station.

Costs and Assumptions

This measure ignores refrigeration savings, which are considered for the whole refrigeration site in a following measure. We assume that energy efficiency measures recommended in this report are not yet implemented.

Costs were roughly assumed for multiple controls additions to enable straightforward implementation of this measure.

The possible DR incentive was estimated at approximately $0.35 per kWh reduction for ten four-hour events per year. In addition, we assumed an electricity cost savings equal to the difference of average electricity cost in the summer peak period vs part and off-peak billing periods.

Finally and significantly, a Technical Incentive (TI) is expected to be available in 2009 to pay down the capital costs of implementing this measure. The 2009 TI is expected to be $125 per kW, up to 50% of the full cost.

DR-4: Pre-Cool Cold Storage Spaces and Shut Down Refrigeration System During DR Events – Maximum 1729 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)
707.3	28,290	0	$ 13,693	$ 17,500	$ 17,500	85%	1.3

Observations

While ice-making is currently being regularly shut down during the peak period, the refrigeration system remains running to maintain temperatures in cold storage spaces, and to serve other auxiliary systems such as pressure cooling, vacuum cooling, and Plant value-add operations listed above.

If the above DR measures are implemented, then during DR events the refrigeration system will be left serving the cold storage space evaporators only. It may be possible to shut down refrigeration service to these systems as well, allowing a complete shutdown of the refrigeration plant compressors, condensers, pumps, etc. This would mean letting the cold storage space temperatures float up during the event, and would likely require over-cooling of the spaces before the event.

Based on PG&E interval data for July 2008 and our metering and energy balance analysis, we estimate the combined maximum demand of the refrigeration system (including refrigeration service for the systems listed in measures DR-1,2,3 above, and for ice-making, plus evaporator fans) at 1729.0 kW. We estimate the average demand during summer peak period, with ice-making off, as 707.3 kW.

Recommendations

We recommend that the refrigeration system, including the whole Engine Room, might be shut down during demand response events. To achieve this, space temperature setpoints would need to be lowered ahead of the event to over-cool the cold storage areas.

Obviously, the extent of this over-cooling would need to consider the tolerance of all products in storage. In addition, some spaces may be likely to retain their temperatures better during a refrigeration shutdown. In particular, the newer Plant buildings with superior insulation and doors will be less sensitive than the older Cooler building.

Alternatively, as a minimum, the space temperature setpoints of less-sensitive spaces could be increased during DR events to reduce refrigeration load while keeping the refrigeration system running to serve other critical or more-sensitive spaces.

In any case, additions and improvements to the refrigeration control system will be required to implement this measure.

Costs and Assumptions

We assume that energy efficiency measures recommended in this report are not yet implemented.

For the calculations, we assumed that the whole refrigeration system could be shut down. We ignored any overall efficiency penalties which may result from pre-cooling.

Costs were roughly assumed for multiple controls additions to enable straightforward implementation of this measure.

The possible DR incentive was estimated at approximately $0.35 per kWh reduction for ten four-hour events per year. In addition, we assumed an electricity cost savings equal to the difference of average electricity cost in the summer peak period vs part and off-peak billing periods.

Finally and significantly, a Technical Incentive (TI) is expected to be available in 2009 to pay down the capital costs of implementing this measure. The 2009 TI is expected to be $125 per kW, up to 50% of the full cost.

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.

We did not evaluate any self-generation measures for this site.

5
Appendix: Calculations and Supplemental Information