EVALUATION, VERIFICATION, AND MEASUREMENT STUDY

FY 2008/2009 PROGRAM

For Silicon Valley Power

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SUMMIT BLUE
CONSULTING, LLC

Submitted to: Silicon Valley Power

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EXECUTIVE SUMMARY

Santa Clara's municipal electric utility (Silicon Valley Power) is an enterprise of the City of Santa Clara, and was established in 1896. Silicon Valley Power (SVP) serves about 51,000 customers and has annual sales approaching 3,000 GWh and a summer peak demand of nearly 500 MW. The largest portion of its electrical sales is to its large commercial and industrial customers (88%) while about 9% of sales are to residential customers. The utility has a high load factor of about 74.6%. SVP owns power generation facilities. More than 30% of its power comes from geothermal, wind, and other eligible renewable sources.

SVP has a number of energy efficiency and renewable energy programs in both the residential and non-residential sectors. However, 95% of the savings achieved through its energy efficiency programs comes from the non-residential sector. Therefore, the impact evaluation efforts for SVP's FY 08-09 are centered on SVP's non-residential custom projects.

In addition to impact evaluation, the Summit Blue team also performed a process evaluation that focused on colocation data centers. Energy Market Innovations, Inc. (EMI), under sub-contract with Summit Blue, conducted this research to provide targeted information on the colocation data center market in SVP service territory.

Background

Two legislative bills (SB1037 and AB2021) were signed into law a year apart. SB1037 requires that the Publicly Owned Utilities (POUs), similar to the Investor Owned Utilities (IOUs), place cost effective, reliable, and feasible energy efficiency and demand reduction resources at the top of the loading order. They must now procure 'negawatts' first. Additionally, SB1037 (signed September 29, 2005) requires an annual report that describes the programs, expenditures, expected energy savings, and actual energy savings.

Assembly Bill 2021, signed by the Governor a year later (September 29, 2006), reiterated the loading order and annual report stated in SB1037 as well as expanding on the annual report requirements. The expanded report must include investment funding, cost-effectiveness methodologies, and an independent evaluation that measures and verifies the energy efficiency savings and reductions in energy demand achieved by the energy efficiency and demand reduction programs. AB2021 additionally requires a report every three years that highlights cost-effective electrical and natural gas potential savings from energy efficiency and established annual targets for energy efficiency and demand reduction over 10 years. The legislative reports require both an on-going assessment of what is occurring within the programs along with a comparison of how much possible savings are left within the SVP service territory.

Objectives

The goals of the EM&V effort at SVP are to provide unbiased, objective and independent program evaluations by giving:

- Useful recommendations and feedback to improve SVP programs.
- Assessment of conservation program effectiveness.

- Assessment of the quality of the program data for impact evaluation purposes.
- Increased level of confidence in conservation program results through transparent protocols.

Process Evaluation

This research identifies different business practices of colocation providers including pricing structures, and the economics and decision-making practices applicable to energy efficiency projects and energy cost reduction. This research also identifies barriers to the participation of colocation providers in energy efficiency programs offered by SVP. A focus was made on operational colocation data centers, as these existing facilities face a number of additional challenges over those faced by new facilities, and so have a higher barrier to participation in data center efficiency programs. Lastly, recommendations are provided based on the findings of this research.

Process Evaluation Conclusions

The research concludes that while there are many barriers to colocation facilities' participation in these programs, there are a number of targeted opportunities to try and affect change in this market and increase the uptake of colocation facilities participating in the SVP energy efficiency programs. Because of the many barriers to existing facilities participating in these programs (including low ROI, high uptime requirements and limited technical staff), the best opportunities may remain in efficiency upgrades to new facilities. SVP can work with current colocation providers and data center engineers to identify these projects and begin discussions early in the project cycles.

Despite the many challenges, some practical opportunities are identified for increasing participation from efficiency upgrades to existing colocation facilities. These can include: providing clear documentation and helpful information for potential applicants; working with local consultants and engineers to identify opportunities; identifying project types applicable to colocation facility upgrades; providing training to local consultants on how to apply for incentives; identifying ways to assist facilities with financing energy efficiency upgrades; and modifying internal policies such as the incentive limit on data center projects and the ability for collocation customers to apply directly for incentives.

In conclusion, many opportunities appear to exist to increase the uptake of participation in energy efficiency programs by colocation facilities. Energy efficiency continues to grow in importance for the data center market, and should continue to push more colocation providers towards energy conservation efforts. Many short and long-term barriers still exist; however some barriers are naturally being addressed by the market such as a move to pricing models that create internal incentives to save energy. Many other barriers may take some intervention to overcome, but by understanding these barriers and making targeted attempts to overcome these barriers, SVP should have targeted opportunities to increase the uptake of these programs in the short and long term.

Impact Evaluation

The impact evaluation was performed for SVP's non-residential custom rebate program. There were 262 non-residential projects that received rebates during FY 2008/2009. Summit Blue conducted a stratified random sample from this universe of projects using ratio stratification and selected 12 sites for on-site evaluation.

The evaluation included three HVAC systems to which economizers had been added, one HVAC system with prescriptive VFDs, two sites with new packaged HVAC systems including economizers, two sites with compressed air system retrofits, two lighting retrofits, one computer control software system, and one refrigeration control system. For two of the economizer sites, the equipment was already in place, but had been disabled for several years. The lighting retrofits primarily involved T12 to T8 retrofits, although luminaries were also delamped in some cases. The lighting, computer controls, and refrigeration sites used prescriptive savings values; the other eight sites all used the custom rebate approach.

Summary of Program Realization Rates

Table EX-1 identifies the claimed and verified savings for the 12 projects evaluated for Non-Residential Program. Based on the combined results from the 12 projects, the program energy realization rate is estimated to be 102%. The demand realization rate is estimated to be 100.3%. The recommended adjustments are attributable to revised savings estimates based on current operation conditions observed during the site visits.

Table EX-1: Custom Program Claimed Savings and Verified Gross Savings

Project	Claimed		Verified	
	kW Savings	Annual kWh Savings	kW Savings	Annual kWh Savings
Site 1	3.7	19,352	2.4	14,214
Site 2	68.8	1,755,550	194	1,698,862
Site 3	142.0	711,000	13	79,000
Site 4	68.2	539,993	45.6	425,376
Site 5	0	331,500	0	180,882
Site 6	0	97,308	27.5	262,281
Site 7	1.8	17,519	1.2	16,379
Site 8	0	5,701,846	0	6,214,299
Site 9	0	1,879,803	0	2,468,465
Site 10	0	391,623	0	321,066
Site 11	0	3,652,522	0	4,139,251
Site 12	0	11,895,500	0	11,623,234
Total	**284.5**	**27,034,016**	**283.7**	**27,443,309**
Percent Realization			**100.3%**	**102%**

1 INTRODUCTION

Santa Clara's municipal electric utility (Silicon Valley Power) is an enterprise of the City of Santa Clara, and was established in 1896. On a not-for-profit basis, Silicon Valley Power owns power generation facilities, has investments in joint ventures that produce electric power, and trades power on the open market. These efforts are directed toward ensuring its retail customers—the citizens, organizations and businesses of the City of Santa Clara—a highly reliable source of electric power at low, stable rates.

Silicon Valley Power (SVP) serves about 51,000 customers and has annual sales approaching 3,000 GWh and a summer peak demand of nearly 500 MW. The largest portion of its electrical sales is to its large commercial and industrial customers (88%) while about 9% sales are to residential customers. The utility has a high load factor of about 74.6%. SVP owns power generation facilities. More than 30% of its power comes from geothermal, wind, and other eligible renewable sources.

1.1 Background

This evaluation plan represents the second year (FY 08-09) EM&V effort designed to respond to California legislative requirements. Two legislative bills (SB1037 and AB2021) were signed into law a year apart. SB1037 requires that the Publicly Owned Utilities (POUs), similar to the Investor Owned Utilities (IOUs), place cost effective, reliable, and feasible energy efficiency and demand reduction resources at the top of the loading order. They must now procure 'negawatts' first. Additionally, SB1037 (signed September 29, 2005) requires an annual report that describes the programs, expenditures, expected energy savings, and actual energy savings.

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The legislative reports require both an on-going assessment of what is occurring within the programs along with a comparison of how much possible savings are left within the SVP service territory. The goal of this FY 08-09 Energy Efficiency Program Plan is to assist Silicon Valley Power to meet these requirements.

The focus of the FY 07-08 EM&V efforts was on SVPs non-residential custom projects, which represent most of the energy savings claimed for all of SVPs residential and non-residential program offerings. The selected projects included:

- Custom Lighting
- Custom HVAC
- Custom Motors/VFDs
- Custom "Other" Measure

EM&V methodologies used to evaluate the FY 07-08 projects followed the International Performance Measurement and Verification Protocol (IPMVP) protocols. Techniques used included review of engineering calculations, short term metering, and billing analysis. The most successful techniques were the review of engineering calculations, and short term metering. The billing analysis provided inconclusive results. Billing analyses were not conducted for the FY 08-09 program year EM&V efforts.

In addition to impact evaluation, the Summit Blue team also performed a process evaluation that focused on colocation data centers. Energy Market Innovations, Inc. (EMI), under sub-contract with Summit Blue, conducted this research to provide targeted information on the colocation data center market in SVP service territory.

1.2 Evaluation Priorities

SVP's non-residential programs constitute the largest component of its DSM portfolio. The non-residential process (motors, VFDs, compressed air), lighting, and HVAC measures provided nearly equally large shares of the FY 07-08 energy savings. Projected FY 08-09 energy savings have these three groupings of measures still providing the bulk of energy. The residential sector provides important contributions, but with the dominant share of savings coming from the non-residential sector, the focus of this FY 08-09 Energy Efficiency Program Evaluation Study, like the FY 07-08 EM&V Study, is on SVP's non-residential programs; particularly HVAC, process, and lighting measures.

As mentioned in the Introduction, the FY 08-09 EM&V Study includes a process evaluation of SVP's colocation data centers and how energy efficiency opportunities can be expanded within the customer segment. Energy Market Innovations, Inc. (EMI), under sub-contract with Summit Blue, conducted this research to provide targeted information on the colocation data center market in SVP service territory.

2 PROCESS EVALUATION

Colocation data centers provide an important service to companies around the world. Colocation providers offer data center infrastructure for different companies to locate the computer servers and storage equipment that run the mission-critical applications relied upon by these businesses. Colocation providers offer companies a highly scalable alternative to developing their own data centers, and also offer the high levels of reliability required for these important applications. Silicon Valley, including Santa Clara, is a business hub for high-tech companies around the world, and therefore has a high concentration of colocation providers taking advantage of the high demand for colocation services. Many of the colocation data center facilities in Silicon Valley have been retrofitted from other facilities or built with a complete focus on reliability and without energy efficiency in mind. In addition, new colocation facilities are built or retrofitted from other facilities to meet continuing demand. As a result, significant opportunities exist for energy savings in these facilities.

Under subcontract to Summit Blue, Energy Market Innovations, Inc. (EMI) conducted this research to provide targeted information on the colocation data center market in the Silicon Valley Power (SVP) service territory. This research identifies different business practices of colocation providers including pricing structures and the economics and decision-making practices applicable to energy efficiency projects and energy cost reduction. This research also identifies barriers to the participation of colocation providers in energy efficiency programs offered by SVP. A focus was made on operational colocation data centers, as these existing facilities face a number of unique challenges over those faced by new facilities, and so have a higher barrier to participation in data center efficiency programs.

2.1 Program Overview

2.1.1 Overall Program Summary

The SVP Public Benefit Program provides rebates and incentives for energy efficiency projects within the Santa Clara service area. The overall program had a budget of $3 million dollars in the 2008 – 2009 program year, 90% of which was directed at commercial and industrial efficiency projects.[1] The program had a goal of 26 Million kWh savings in this period. While results from the 2008-2009 program year are still being finalized, the Program Manager indicated that in the previous program year (2007-2008) roughly 60% of energy savings came through data center-related projects.

Funds for these programs are available on a first-come, first-serve basis and customers are limited to $750,000 in incentives for a given program year. Once this limit is reached in a given program year, SVP will not fund any additional projects for that year. In addition, only SVP customers may apply for incentives, though checks can be issued to third parties, such as contractors or tenants of colocation facilities.

[1] In addition to energy efficiency programs, $500,000 of this budget is reserved for photovoltaic rebates.

2.1.2 Applicable Programs for Data Centers

SVP has many different incentives and programs that are applicable to data centers. These include prescriptive rebates, such as those for server virtualization, as well as custom incentives through the SVP Customer Directed Rebate (CDR) program. Customers with data centers less than 10,000 square feet may also take advantage of the Data Center Optimization Program (DCOP), a third party program run by Quantum Energy Services & Technologies (QuEST). In addition, customers can receive an Energy Innovator Grant for demonstrating energy savings for a new technology.

Prescriptive Rebates for Data Centers

SVP has many different prescriptive rebates that are applicable to data centers including a rebate for server virtualization. In addition, data center customers may take advantage of some of the SVP standard rebates, including: lighting, HVAC, motors, VFDs, etc.

The server virtualization program provides a rebate for commercial customers that implement server virtualization projects that result in the removal of servers from the data center. Server virtualization allows multiple “virtual” servers to run on a single piece of hardware, and therefore data centers can consolidate a large number of servers onto a much smaller number of individual machines. Since colocation facilities do not typically operate the servers within the data center, the server rebate program has limited applicability to the colocation owners themselves. However the customers of the colocation facility could receive these incentives. The server virtualization rebate is offered in conjunction with the PC power management incentives (these two incentives are included on a shared application), but the PC power management incentives are not targeted at commercial data centers – these are targeted to commercial office buildings, academic institutions, and other organizations with a high number of desktop PC computers.

To receive a server virtualization rebate, there are a number of requirements that must be met by the customer and the applicable project:

- The customer must retain the virtualized formats for five years following the certified installation date.
- Only removed servers will be eligible for the incentive.
- The incentive rate is $215 per server removed, but the incentive amount is capped at 100% of the cost of the project, including software licensing and installation.

Customer Directed Rebate Program for Data Centers

Customers seeking incentives for measures not covered by the prescriptive program can apply for financial incentives through the Customer Directed Rebate (CDR) program. Custom incentives are based on the verifiable kWh savings per year and require a plan for the measurement and verification of proposed energy savings. For some projects this verification requires direct metering, while some others are based on calculations. Typically, a CDR requires a pre- and post-inspection of the installation to verify the energy saved through the measure. Examples of projects for which data centers in Santa Clara have received CDRs include hot or cold aisle containment, air side economizers, and wireless cooling monitoring.

To receive a CDR, a number of requirements must be met by the customer and the applicable project, including:

- The incentive amount is capped at 80% of the total measure cost.
- The energy efficiency measure must be in place for five years following the certified installation date.

Energy Innovation Grant Program

The Energy Innovation Grant program is similar to the CDR, but provides incentives for new technologies that have not received rebates before. Projects that receive funding through the Energy Innovation Grant program are not subject to the annual incentive cap and customers receiving incentives through this program agree to showcase the project as a demonstration of the energy saving potential of the technology.

Data Center Optimization Program

The DCOP is a third party program run by QuEST and targets data centers under 10,000 square feet. Through this program, QuEST will perform an energy audit of the data center where they perform engineering analysis and recommend energy efficiency measures for the data center. Rebates are paid for recommended measures that are implemented.

2.2 Methodology

2.2.1 Preliminary Research

The first step in this research was to conduct secondary research on the colocation market in Silicon Valley and Santa Clara. Through this research, EMI identified information sources to help support this initiative, collected information available on colocation providers in the SVP service area, and characterized the barriers to the participation of these facilities in energy efficiency programs. This research was conducted through a combination of Internet research, a document study of available papers and reports relevant to this topic, and in-depth interviews and informal conversations with industry members. These methods provided relevant background information for this research and also helped EMI develop a sample for the in-depth interviews. In addition, EMI collected information on the SVP programs applicable to data centers. EMI conducted this research by reviewing publicly available program information from the SVP website and by talking with the SVP program manager who oversees the program.

2.2.2 In-Depth Interviews

An important information source for this project was primary interviews with various stakeholders. The sample of interview subjects focused primarily on colocation providers within the SVP service territory. However, EMI wanted to gain a broader look at this industry to understand activities outside of the SVP service area to help identify barriers specific to SVP or to identify best practices that may be replicated by SVP. To this end, EMI also pursued interviews with colocation providers and utility program managers outside of the SVP service territory and from data center designers and consultants in the industry.

EMI developed an interview sample through a variety of sources, including the following:

- **Internet Research –** EMI conducted Internet research to identify colocation providers with facilities within the SVP service territory. After identifying these facilities, EMI placed cold calls to these companies to identify appropriate contacts for interviews. Many colocation providers are large national or international companies and typically give little information on local facilities, so identifying appropriate local contacts for these companies through this method was often difficult in these situations.
- **SVP Service Representatives –** After identifying colocation facilities within the SVP service territory, SVP provided local contacts from these companies. These contacts were very helpful because they were typically already familiar with the SVP program offerings.
- **Networking Through Industry Events –** In addition, EMI identified some industry contacts through networking at data center industry events.
- **LinkedIn Discussion Boards –** A number of LinkedIn (www.linkedin.com) groups are dedicated to colocation hosting or data center energy efficiency. To support this research, EMI began discussion threads focused on barriers to participation in utility energy efficiency programs by colocation facilities.

Table 2-1, below, indicates the total number of interviews performed for this evaluation.

Table 2-1: Completed Interview Sample

Interview Type	Number of Completed Interviews
SVP Program Staff	1
Program Staff from Other Utilities	3
Colocation Provider Within SVP Service Area	6
Colocation Provider Outside SVP Service Area	1
Data Center Design Consultant	1
Total	12

2.3 Overview of Colocation Business Practices

2.3.1 Types of Colocation Providers

The colocation market can be broadly applicable to a number of different models, all which involve the leasing of data center space or computing capacity.

The first type is the *colocation hosting* facility, which is the focus of this research. In this model customers lease physical space from the data center operators to locate their servers, network equipment and storage equipment. In these cases, the customers can either lease space in preinstalled racks or bare square footage inside the data center for the installation of their own racks and equipment. Typically, the facility is providing power and cooling to the space, but the IT equipment, itself, is still owned by the customer. W*holesale hosting* facilities are a subset of the colocation market. These facilities are larger scale colocation facilities where customers are leasing very large portions of data centers or entire data centers for their equipment. Table 2-2, below, summarizes characteristics of colocation facilities and wholesale data centers as defined by Tier 1 Research.

Table 2-2: Colocation verses Wholesale Datacenters as defined by Tier 1 Research[2]

	Colocation	Wholesale
Lease	1-3 Years	3-7 Years
Size	5 – 50 Cabinets	5,000 sq ft+, 1 MW+
Services	Some managed Services	Limited or no services

Another model is the *managed hosting facility*. In these facilities the IT equipment, itself, is owned and managed by the data center operator, and the facility leases the computing capacity to run the applications for the customers. In some cases the managed hosting facility will also offer support for the operating system or applications. These facilities may be appropriate for both data center and server virtualization programs.

On the opposite side of the spectrum from the managed hosting facility are facilities under a *triple net lease* facility. In these facilities, the building shell is leased to the data center operator, but the data center operator owns and manages all the equipment in the data center, including the power distribution and cooling equipment.

While both managed hosting facilities and buildings under a triple net lease could participate in data center energy efficiency programs, this research focuses exclusively on colocation facilities, including wholesale hosting.

2.3.2 Colocation Pricing Models

Colocation facilities typically use a combination of three main pricing structures: space-based pricing, power-based pricing, and cost-plus pricing. It is important to understand these pricing models, as they affect the desire to save energy and participate in energy efficiency programs for both the colocation provider and the colocation customer. The pricing models primarily differ in how they address space (physical square footage or rack space), power, cooling and other services. The different pricing models identified for colocation facilities are summarized below:

- **Space-Based Pricing –** Customers pay by the rack or square footage, and are usually limited to a certain power budget that is included in the space charges with additional fees if they use power over that limit. With this pricing model there is little financial incentive for the customer to lower their power use unless they are approaching the power limit for their given space. Space-based pricing used to be the standard pricing model for the industry; however, as the ability for data centers to grow becomes increasingly limited by the amount of power and cooling available (rather than by physical space constraints), this pricing model is rapidly being replaced by different models that more directly factor in energy use.
- **Space- and Power-Based Pricing –** Some models use a combination of power-based pricing and space-based pricing. In these models, the customer pays for a certain amount of space, and then also pays directly for power separately. These power charges are typically based on a maximum

[2] Presentation at the Critical Facilities Roundtable meeting 11/6/2009, Tier 1 Research (http://www. t1r.com)

allowable power draw. In cases where power is charged separately, customers have more of a financial incentive to reduce their power use, as it will directly lower their operating costs. In cases where power costs are based on maximum wattage, there is less of a financial incentive to conserve unless the customer is near the wattage limit beyond which they incur higher charges.

- **Cost-Plus Pricing –** Some facilities document all costs to operate the data center and then charge their customers based on these charges with an automatic markup. One multi-tenant wholesale colocation facility in Seattle indicated that they use a variation of this pricing model where they apportion facility costs among the tenants based on the relative amount of electricity they used as measured at the power distribution units (PDUs).

As power densities in data centers continue to increase, data centers are becoming increasingly power limited and less limited by space. Recognizing this, many colocation facilities are switching to pricing models where customers are paying more directly for the power they consume. Notably, "32 percent of all leased data center space in the U.S. will come up for renewal between now and 2013. Nearly all of those leases were based on square footage, while power capacity will be the key issue in many renegotiations."[3]

In a similar manner to the way power is treated in regard to colocation pricing, additional charges might be levied for cooling. The method used to charge for cooling will also affect the desire of the colocation provider and/or customer to make efficiency upgrades. Some facilities may have separate charges for cooling load – often calculated based on a multiplier applied to the electric power consumed by the customer. In such cases the provider may have cooling charges included in the space-based or power-based charges. In addition, some colocation facilities are operated in buildings owned and operated by a separate company from the colocation provider. In these cases, the colocation facility might be charged directly by the building operator for the cooling load on the data center. One utility interviewed for this research indicated that a facility of this type had no interest in energy efficiency improvements as the building owner perceived this as something that would lessen the profitability of the business as their profit was made by charging directly for cooling load.

In addition, colocation facilities may have a number of additional charges for different levels of service. These can include installation charges, network capacity charges, cross-connect charges (to be connected to more than one telecom provider), and general managed service charges.

2.3.3 Priorities for Colocation Facilities

Colocation providers have many different priorities they must consider in the operation of their facilities. These priorities respond to the needs of their customers, and help data center operators keep costs low while maintaining high levels of reliability and uptime in their facilities, thus contributing to their competitiveness in the market. These priorities include:

- **Reliability –** Colocation providers make a business out of providing high reliability infrastructure for companies to house IT equipment used for mission-critical applications. The redundancy and reliability of the data center, or the "Tier" level, of the data center is an important metric for potential customers. The different Tiers are expressed in levels I – IV, with I having the least redundancy and IV having the most[4]. Reliability of a data center is often also expressed in the

[3] Data Center Leasing: It's All About the Megawatts, Data Center Knowledge, 11/11/2009, http://www.datacenterknowledge.com/archives/2009/11/11/data-center-leasing-its-all-about-the-megawatts/.

[4] Tier levels are defined by the Uptime Institute (http://www.uptimeinstitute.com).

number of “nines” – a facility with 99.999% uptime would be considered to have “five nines” of reliability.

- **Security –** Data centers require a high level of security because the information contained inside is mission-critical to many customers that do not want that data lost or stolen. As a result, data centers have high levels of security and tracking of who enters and exits a facility. Some facilities even employ biometrics (retina or handprint scanners) to control access to a facility. In colocation facilities, customers often have sole access to their equipment which is isolated in separate rooms or chain link “cages”.
- **Geographical Location –** Although data centers can be located anywhere on the globe, many customers want to stay physically close to their equipment in case they need emergency access to the data center. This is a contributing factor to the number of data centers in Silicon Valley. However, proximity is not the only geographical consideration for data center location. Many colocation providers consider the surrounding environment and the prevalence of natural or manmade disasters around a potential site, as such catastrophes can threaten the uptime of a facility.
- **Power and Fiber Availability –** Because of the power concentration of data centers, colocation companies will typically site facilities near available power infrastructure (such as a utility substation) or in areas with available fiber infrastructure. Data center developers will consider the quality of power and the availability of power in a particular location. Many of the colocation providers interviewed for this research indicated that an advantage to siting a data center in Santa Clara was that SVP power was more reliable than power from Pacific Gas and Electric (PG&E), the neighboring utility.
- **Energy Efficiency –** The direct operating costs for colocation providers are largely based on the amount of energy used to power and cool the IT equipment of their customers. For this reason many colocation facilities are focusing on energy efficiency for new facilities. This seems to be a new trend, however, as colocation facilities built as little as two or three years ago did not seem to be built with energy efficiency in mind. However, with the recent advances in the power density of IT equipment, many facilities now pay more attention to efficiency so that they can fit more IT equipment into a facility of a given power budget.

2.3.4 Processes for Decisions That Affect Energy Use

Energy efficiency projects are initiated for a variety of reasons. One reason frequent given is to replace aging equipment. Equipment may be perceived to be less reliable as it ages and maintenance costs may increase over the years. In this sense, equipment might be replaced because it is perceived to be at the end of life or no longer becomes cost effective. In these cases, staff may look for more efficient options with replacement equipment. In other cases, new equipment may be needed to increase the capacity of a facility. For instance, if a colocation facility is built out in stages, more cooling or power distribution equipment may be needed to support the additional build outs. In other cases, as IT equipment power densities increase in a colocation facility (perhaps as customers swap out older equipment with equipment of higher power density), extra cooling equipment may need to be added to support the higher densities.

Simply replacing equipment with higher efficiency units is less common in the colocation data center market; because reliability and uptime are so important they cannot suffer any downtime to replace equipment. Any work on the critical components of the facility could threaten an outage, which would adversely affect the business and profitability of the colocation facility. While some minor upgrades to the facility are possible with minimal disruption to the facility (e.g., VFDs on air handlers, lighting projects, etc.), many aspects of the facility (e.g., the central chiller plant) cannot often be replaced or modified without bringing down the facility and suffering downtime for the customers. While most data centers have a sufficient level of component redundancy that they should be able to replace some components without bringing down the entire facility, such operations would still lower the overall redundancy of the facility; this would create larger chance of suffering downtime during the operation, which could be perceived as too high of a risk for facility managers.

Data center managers interviewed for this evaluation indicated that energy conservation or efficiency projects are typically identified by staff at the colocation provider or by external designers or engineers. Smaller companies with single or localized facilities often must get internal approval for projects from the company managers (company principals, president, or vice president). National and international companies however, have more vertical structures and often need centralized approval from company headquarters to initiate a conservation or efficiency project. To get approval for energy efficiency upgrades, the two key decision points are the return on investment (ROI) of the project and the effect of the project on the uptime of the facility. One data center manager indicated that it is typical to look for a ROI of two years or less to justify the execution of a project.

More detailed descriptions of how these decision-making processes create barriers to participation in data center programs by colocation facilities are offered in the next section.

2.4 Identified Barriers to Colocation Facilities Participation in Energy Efficiency Programs

A primary goal of this research was to identify barriers to colocation facilities participating in SVP energy efficiency programs for data centers. Barriers were identified through document review as part of the preliminary research and through stakeholder interviews.

Split Incentives

A number of barriers from colocation facilities are a result of the split of responsibility between the facilities and the IT equipment in these facilities. One persistent barrier for energy efficiency in the data center is the split incentive between the facilities and IT departments. In general, IT departments specify the equipment needed to run their applications and the facilities staff is responsible for integrating those resources into the data center and providing reliable power and cooling. Because the IT department does not pay for the power or cooling required to operate their equipment, they have no incentive to invest in equipment that is more efficient. Some large companies have overcome this barrier by charging IT departments for the power they use in the data center. By making the IT purchaser responsible for the power used by their equipment, this arrangement creates a financial incentive to consider energy use in the decision making process.

Colocation facilities have an even more extreme example of this split incentive, as the IT and facilities are owned not only by different divisions of the same company (as is typical for corporate enterprise data centers), but also by separate companies entirely. In facilities with pure space-based pricing, customers have no incentive to save energy in their IT equipment because they are not directly responsible for the cost of power and cooling for this equipment. On the opposite side of the spectrum, in cases where customers may be paying directly for infrastructure costs (such as power distribution and cooling costs), the colocation facility may not have an incentive to increase the efficiency of the facility, because their customers would then have lower infrastructure charges and the facility might make less money.

The ideal scenario for energy efficiency improvements would be to have the customer pay directly for power consumed by the IT equipment and the colocation facility include infrastructure costs in the space-based charges. This scenario would lead to an incentive for the customer to invest in efficiency, since they pay for it directly, and for the colocation provider to invest in efficiency, since lower infrastructure costs would mean more profit for the facility. Unfortunately this model is not widely used. Instead, models where customers pay for a maximum allotted power are more prevalent, and these models only create an incentive for efficiency when the customer approaches the defined power limit.

Uptime / Reliability Requirements

The key concern of the colocation tenants is availability of their software applications. As a result, colocation companies are extremely sensitive to anything that might affect the continuous operation of the facility. For this reason colocation facilities will not perform any upgrades that would require the facility to be nonoperational – even for a brief period. Some upgrades may be able to be performed without bringing down the facility due to the high level of redundancy in the equipment. Others might require shutting down all or parts of the facility, which would be disastrous to the colocation business model which relies on continuous operation. Facilities managers might even resist projects that, in theory, should not affect the continuous operation of the facility on the grounds that any change could potentially threaten the uptime of the facility. Many of these managers have maintained their reputations based on being conservative and extra cautious in an industry where even a minor outage could threaten their employment. This creates a large barrier to efficiency upgrades once a facility is operational and populated with customers.

In addition, among many of the interview respondents there was the perception that there is not a market for energy efficiency in the colocation industry, and so colocation facilities are not motivated to pursue energy efficiency over other business interests. A number of the interview respondents stated that their tenants' primary concerns were not related to energy efficiency of the facility because their primary concerns were availability and bottom line price. Furthermore, most interview respondents indicated that customers did not ever ask about the efficiency of the facilities or inquire about energy efficiency upgrades. Many of these customers are attracted to the colocation providers within the SVP service territory because of the low electricity prices. Review of the online marketing materials from colocation providers in Santa Clara revealed that none of the facilities identified for this research marketed their energy efficiency. Some colocation facilities in other service territories were identified that do market energy efficiency. This is particularly true of new facilities; with the increased attention on data center energy use and efficiency, many new facilities are trying to market this issue to create a competitive advantage in the market.

Perceived Complexity of Incentive Application Process

A number of colocation providers indicated that the complexity of the SVP incentive application process and the time taken to move through the process were barriers to participating in the SVP programs. While receiving rebates for prescriptive measures can be relatively straightforward, custom measures can involve complex calculations to determine the savings from a particular measure. One colocation provider indicated that it is difficult to determine verifiable savings for many of the technologies that offer high savings potential in the data center, such as airside economizers or raised data center temperatures. While some larger colocation companies may have access to the technical engineering expertise to perform these calculations, some smaller colocation facilities may not have this expertise at their disposal. While SVP offers assistance to customers to complete applications for incentives, some customers may not be aware of these offerings. One interview subject noted, "We're basically an IT department with some sales people." He indicated that they filled out an incentive application two times and had trouble getting the application approved. The final time, an engineer they hired as part of the commissioning process filled out the application and it was finally accepted.

In addition, some projects are planned and installed too quickly or are too small to consider rebates. In these cases, the extra time taken to apply for a rebate may deter someone from looking for an incentive since it could slow down the project or the financial reward might not be worth this extra effort. This would be especially true for custom efficiency measures.

Another barrier specific to the colocation tenants getting involved in energy efficiency programs is that only customers on record with SVP may apply for incentives, although those incentives may be sent to a third party. As a result, a customer in a colocation facility would need to have the colocation facility apply for any incentives such as server virtualization project, for example. One colocation data center manager interviewed indicated that they applied for an incentive for one of their customers and that this counted against the incentive limit for the colocation company. This also creates a barrier, because the colocation provider would be assuming a level of risk for the project because they face the possibility of having to pay back the incentive (through extra charges levied on the utility bill) if the energy efficiency measure is removed before the five year period is up. This could happen due to a tenant going out of business, moving out, or simply removing the measure.

Incentive Limits

Some interview respondents indicated that the maximum incentive offerings were too low, and that these maximums should be based on a per facility basis and not on a per customer basis. This way, a campus with a number of separate colocation facilities or a provider with multiple sites throughout the area could get an allotment of incentives for each facility. While giving customers access to higher incentive caps may increase participation in these programs, these levels have been set based on the limited budget for the SVP Public Benefit Programs. Higher caps may increase participation from some large colocation customers, but this would consume much of the funds and limit the number of customers that could participate in the program.

Difficulty in Financing Energy Efficiency Projects

Some colocation providers mentioned a number of financial barriers that are encountered for energy efficiency upgrades. Some interviewers indicated that the Return on Investment (ROI) of efficiency projects is often not quick enough, as companies tend to look for an ROI of under two years to justify a project, especially an upgrade. This seems to especially be a problem in the SVP service territory because the electricity prices for SVP are lower than surrounding areas, which results in a longer ROI for efficiency upgrades. This low electricity price (along with the high reliability of the power) is one thing that makes Santa Clara an attractive place to locate data centers and colocation facilities.

In addition, one colocation provider indicated that it was very difficult to get financing for energy efficiency projects and that the banks they had spoken with did not understand the business case for investing in energy efficiency upgrades. This was a smaller operation; therefore lack of available capital created a large barrier to investing in energy efficiency projects.

2.5 Key Findings & Recommendations

The key findings from this research include observations of successful current processes used by SVP to increase participation from this industry, as well as some targeted recommendations for process improvements. These findings are based on the information gathered on the colocation market and on the decision making practices of colocation providers, as well as some recommendations which came directly from the interview respondents, themselves.

2.5.1 Key Findings

Significant Barriers Exist to Wider Participation from Colocation Facilities

This research confirmed that significant barriers exist to wider participation from colocation facilities in the SVP Public Benefits program. Many of these barriers are a result of the unique business models of colocation facilities, such as, split incentives, typical colocation pricing structures, and the emphasis on reliability over energy efficiency in the industry. In addition, some barriers are due to limitations on the SVP programs (such as overall program budget) and the need to properly mitigate the risk that energy saving measures will not stay installed for the five-year period needed to ensure full savings. In all, older operational facilities face the deepest challenges, as these facilities focus mainly on continuous operations. New facilities or existing buildings being retrofitted as data centers are more likely to invest in energy efficiency because they can include more energy saving measures before the facility comes into operation.

Funding for the SVP Public Benefits Program is Too Limited to Meet Demand

Data centers are very power dense and require a large amount of equipment (both IT and infrastructure equipment) for continuous operation. This provides a large opportunity for energy savings, but a lot of the possible efficiency upgrades are extremely capital intensive. As a result, one identified barrier was that some colocation facilities felt that the incentive cap was too low, as the incentive cap is limited by the overall funding for the Public Benefits Program as a whole. This indicates that the demand for energy efficiency incentives for data centers exceeds the possible funding of the program. This creates a limitation for colocation facilities that need additional funding to perform their desired energy efficiency upgrades. In addition, because many colocation providers have multiple data centers within the SVP service area, they are further limited because they must split the limited incentives amongst all of their facilities.

Misperceptions About the SVP Programs and Service Offerings

The research EMI conducted for this process evaluation focused on interviews with staff from colocation data centers within the SVP service area. In the course of this research, it was apparent that there were some misperceptions about the offerings of SVP. For example, many interviewees expressed that the perceived complexity of the application process was a barrier to participation in the SVP programs. This seemed to be a barrier despite SVP offering assistance to all its customers on completing the application forms. In addition, since many of the colocation providers are large companies with many data centers locally, nationally and internationally, it is possible that some of these misperceptions may be a result of confusion with other utility sponsored energy efficiency programs such as the local PG&E programs which cover most of the areas surrounding the SVP service territory. A number of colocation providers within the SVP service territory have other facilities within the PG&E service territory, as well as key staff that have previously worked in data centers in the PG&E service territory.

Pricing Models Impact Decisions Relating to Energy Efficiency Improvements

EMI focused part of this research on understanding the different pricing models and how they affect decision making in regard to energy efficiency improvements. Colocation data centers use a variety of pricing models to charge their tenants for hosting IT equipment in their facilities. These pricing models include different models for charging for space in the data center, power use in the facility or for use of cooling in the data center. These pricing models affect the motivation to participate in energy efficiency projects of both colocation customers and their tenants, as different pricing models affect whether more money is saved/spent due to efficiency improvements. Ideally, a colocation facility would charge their customers a fixed space/cooling charge as well as charge through power directly to the tenant. This would mean both the facility and tenant would save money by applying efficiency upgrades directly to the portion of the facility under their control.

Facilities and Upgrades Most Relevant to Operational Colocation Facilities

This research revealed that there are certain operational facility characteristics and energy efficiency upgrades most relevant for the SVP programs. For example, colocation facilities that are close to capacity will be most likely to consider energy efficiency upgrades because, assuming their pricing model supports it, increased infrastructure efficiency improvements might allow the facility to increase its number of tenants and therefore increase their revenue while decreasing their costs. These facilities might also be more willing to work with their tenants to help them invest in virtualization, as this might also free up excess capacity to increase their customer base or allow their tenants to include more compute capacity within the facility. Facilities that are not near capacity, in contrast, will be working to fill out that capacity before they will be willing to contemplate efficiency upgrades.

2.5.2 Recommendations

Collaborate With Other Utilities to Identify Prescriptive Rebate Opportunities for Data Centers

One difficulty in increasing participation from data centers in energy efficiency programs is the lack of prescriptive rebates for data center-specific equipment. As a result most data center-specific efficiency measures must apply for custom incentives. Custom incentives involve a more difficult application process as the applicant must provide sufficient information on the baseline conditions and energy savings through the custom measures. Other utilities are offering or developing prescriptive measures for data center-specific efficiency measures. SVP should collaborate with these other utilities to identify prescriptive methods to add to the SVP program offerings.

Continued Emphasis on New Colocation Facilities

There are many barriers identified in this research which are applicable to existing facilities and which will be difficult to surmount in the short term. These barriers include: the reluctance to upgrade facilities while populated and operational, the perceived lack of a market for efficiency improvements among colocation customers in the SVP service territory and the difficulty in financing or justifying efficiency projects based on the ROI for efficiency upgrades. While there should be some opportunities for efficiency upgrades (as outlined in subsequent recommendations) the bulk of easily achievable savings will be in new construction or retrofit colocation data centers. SVP should continue to conduct local outreach (through sponsoring and attending industry events and targeted marketing toward these facilities) as well as continue to stay in touch with local designers and consultants to learn about upcoming projects. SVP should also continue to stay in close contact with existing colocation providers to learn about expanding facilities or new facilities being constructed by these companies. Staying updated on new projects as they are planned will help ensure new facilities consider energy efficiency upgrades early in the development cycle of a new facility design.

Perform Additional Targeted Research

To increase participation from colocation facilities and their tenants, SVP should continue to explore targeted research to follow up on issues identified in this process evaluation. For example, SVP could explore the willingness of colocation providers to work with their tenants to participate in SVP programs for virtualization. These providers have specific barriers that may keep them from working with their customers such as assuming the risk for energy efficiency measures that my be removed prior to the end of the five year commitment, or from the perception (or actuality) of their tenants' participation hurting their bottom line. Through targeted research and working with these customers, SVP could identify ways to disperse the risk taken up by the facility or work on altering the way incentives are dispersed to give colocation providers more incentive to work with their tenants for increased energy efficiency.

Continue Offering and Marketing Support for the Application Process

SVP should continue offering support for customers to complete applications and should make sure to promote this offering to potential participants. One colocation provider indicated that a list of consultants or engineers that were familiar with the process would be valuable to facilities looking to participate in projects. SVP could possibly reference different consultants or engineers that have completed training on the application process or that have worked with applications before. Working closely with consultants in this way would put information in the hands of people who would help sell efficiency upgrades to the colocation facilities and, by giving colocation providers access to information on knowledgeable consultants, give the colocation facilities more confidence that they can retain someone that is familiar with how to navigate the process of applying for an incentive.

2.6 Conclusion

EMI's research into colocation data centers participation in energy efficiency programs revealed that SVP is already taking many appropriate steps towards increasing participation in these programs. However, significant barriers still exist to increased participation. While the SVP programs have been successful given the level of funding and current policies, there still remain some targeted opportunities to affect change in this market and increase the uptake of colocation facilities participating in the SVP Public Benefit Program. Because of the many barriers to efficiency improvements in operational facilities, the best opportunities likely still remain in efficiency upgrades to new facilities. SVP can work with current colocation customers and data center engineers to identify these projects in order to intervene early in the design phase.

Despite the many challenges, some practical opportunities are identified for increasing participation from efficiency upgrades to existing colocation facilities. These can include: marketing assistance for completing program paperwork, identifying colocation facilities most likely to perform retrofits; providing information to customers on consultants familiar with the application process; and finding a way to work with colocation providers to increase the participation of their tenants.

In conclusion, many opportunities appear to exist to increase the uptake of participation in energy efficiency programs by colocation facilities. Energy efficiency continues to grow in importance for the data center market, and should continue to push more colocation providers towards more energy efficient facilities. Many short and long-term barriers still exist, however some barriers are naturally being addressed by the market such as a move to pricing models that create internal incentives to save energy. Many other barriers may take some intervention to overcome, but by understanding these barriers and making targeted attempts to chip away at these barriers, SVP should have targeted opportunities to increase the uptake of these programs in the short and long term.

3 IMPACT EVALUATION

For this report, impact evaluations were performed for a sample from all the FY 2008/2009 non-residential rebate recipients. The rebates covered a wide array of technologies including:

- Cooking
- Compressors
- Data center virtualization
- Economizers
- HVAC
- Lighting
- Motors/VFDs
- Refrigeration

3.1 Customer Sample

There were a total of 262 non-residential projects that received rebates during FY 2008/2009. Summit Blue conducted a stratified random sample from this universe of projects using ratio stratification based on estimated energy savings across three strata. This method insures that the projects with the most claimed energy savings are part of the evaluation along with a random sample of the smaller projects. Evaluations were completed for 12 of the projects, which met the stratified survey needs for a statistically valid customer survey at the 90% confidence +/- 10% level. The 12 sites included 61% of the total claimed energy savings from these 262 projects.

3.2 Objectives

The objectives of the verification activities were to complete site visits and collect key energy program performance metrics including:

1. Establishing the presence of energy efficient measures by comparing the number of installations observed with the number of installations recorded in the rebate application.
2. Providing input on the quality of installations observed – including whether or not they were operating correctly.
3. Where observed equipment did not match program reported installations, determine if retrofits/installations were ever present, and/or the reason that the installation plan changed.
4. Recording key facility performance data, such as daily schedules, seasonal variations in schedules, and control strategies.
5. Where energy usage is not well documented, log energy use at the installation site.

3.2.1 Program Sample

The evaluation included three HVAC systems to which economizers had been added, one HVAC system with prescriptive VFDs, two sites with new packaged HVAC systems including economizers, two sites with compressed air system retrofits, two lighting retrofits, one computer control software system, and one refrigeration control system. For two of the economizer sites, the equipment was already in place, but had been disabled for several years. The lighting retrofits primarily involved T12 to T8 retrofits, although luminaries were also delamped in some cases. The lighting, computer controls, and refrigeration sites used prescriptive savings values; the other eight sites all used the custom rebate approach. Figure 3-1 shows the breakdown of measures by savings.

Figure 3-1: Verified Program Installations and Savings

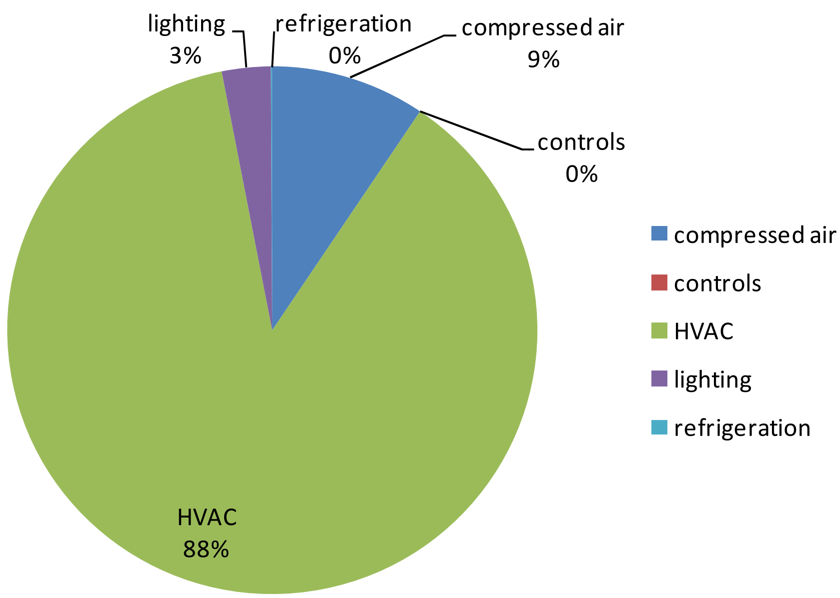


Table 3-1 details the verification results of the energy efficient installations and savings sampled that occurred under the Non-Residential Program offered by Silicon Valley Power. For privacy, the customer names are not given, but rather a site number assigned.

The lighting retrofits involved T12 to T8 replacements with both fixture replacements and retrofits of existing units. The lighting retrofits showed some variation from the expected installations. The smaller site was missing a few fixtures from those listed on the application and the larger site received a rebate based on a retrofit from incandescent to T8 fluorescents instead of T12 to T8 units, as was actually the case.

In evaluating these projects, particular attention was paid to reviewing the program documents and supplementing it with field verifications. The evaluation of the lighting retrofits involved the IPMVP Option A approach by reviewing engineering calculations and performing site interviews.

Table 3-1: Verified Program Installations and Savings

Customer	Measures	kW	kWh
Site 1	T12 to T8 lighting retrofit	2.4	14,214
Site 2	Compressed air retrofit	194	1,698,862
Site 3	T8 lighting retrofit	13	79,000
Site 4	VFD air compressor	45.6	425,376
Site 5	Computer power controls	0	180,882
Site 6	Prescriptive VFDs on air handlers of HVAC system	27.5	262,281
Site 7	Refrigeration controls	1.2	16,379
Site 8	Packaged HVAC units with economizers and VFDs	0	6,214,299
Site 9	Packaged HVAC units with economizers and VFDs	0	2,468,465
Site 10	Economizers on HVAC system	0	321,066
Site 11	Economizers on HVAC system	0	4,139,251
Site 12	Economizers and VFDs on HVAC system	0	11,623,234

For lighting systems and prescriptive VFDs, deemed values were compared to calculated savings values. Where deemed savings are available, they are considered an acceptable alternative to calculated values for CEC verification. T12 to T8 retrofits have standard deemed savings values. In each case these results were compared to the calculated values. The custom projects did not have deemed savings for comparison.

The evaluation used the DEER defined peak definition period of 2:00 PM to 5:00 PM during the three consecutive weekday periods containing the weekday with the hottest temperature of the year for CZ04, for demand savings in all projects. Consequently, the economizer projects do not show any demand savings since economizers are not in use during peak temperature periods.

Site Activities

Field activities typically involved two components:

1. Evaluators coordinated with the implementation contractor and primary customer contacts to establish field activity dates and identify site level contacts.
2. While on-site, the evaluation team conducted an area-by-area, measure-by-measure audit, noting retrofit count, type, and operating conditions. Interviews were also conducted at the site representative's convenience. Where appropriate, the evaluation team took spot measurements of operating equipment power usage and installed logging equipment to measure consumption over a period of several weeks. In some cases, facility logs were used to evaluate savings.

Field evaluation activities were conducted on November 16-19, 2009. At the time, it was anticipated that all expected installations were completed and finalized.

3.3 Impact Assessments

Verification work, discussions with participants subsequent to field verification activities, and an analysis of the verified installations indicated that the installations attributed to the Non-Residential Custom Program were installed, but the savings were not necessarily accurately calculated.

3.3.1 Site 1

Site 1 replaced T12 fixtures with more efficient T8 alternatives in four external facilities. Project incentives were paid on a prescriptive basis dependent upon the number of fixtures delamped and replaced.

The project application claimed to delamp 52 four-lamp T12 fixtures, and replace the older ballasts and reflectors to accommodate high efficiency, two-lamp T8 fixtures. The project application also claimed to install four LED exit signs as part of the upgrade.

A visual verification confirmed that a majority of retrofits were properly installed for the designated areas specified in the rebate application. However, the restroom fixture retrofits were not installed, nor were the LED exit signs. Similarly, one of the facilities claimed savings from 12 retrofit fixtures when only 10 where installed.

The verification effort confirmed:

1. 184 T12 lamps were removed from 46 fixtures and replaced with 92, high-efficiency T8 lamps;
2. 16 T12 lamps remain in 4 fixtures; and
3. LED exit signs were not installed.

This is in contrast to the application's count of 208 T12 lamps upgraded to104 T8 lamps in 52 fixtures, with an additional 4 LED exit signs.

The project representative interviews revealed that the facilities are occupied and illuminated from 7:30AM to 4:00PM, 186 days a year, not including holidays. Based on this estimate, 1,581 hours/year of operation were used for the savings analysis.

This evaluation used the DEER[5] defined peak definition period of 2:00 PM to 5:00 PM during the three consecutive weekday periods containing the weekday with the hottest temperature of the year for each of the four IOUs, for each for the 16 Title-24 climate zoned impacted by the individual project to estimate peak savings. It was established that the facilities were unoccupied during this period resulting in peak demand savings of 0 kW.

Table 3-2 identifies the site claimed, verified, and deemed savings. The energy realization rate of 73.4% is based on the deemed savings estimate. The relatively low realization rate is attributed to a lower than originally claimed number of fixtures installed.

Table 3-2: Site 1 Installation and Savings

	kW Savings	Annual kWh Savings
Claimed Savings	3.68	19,352
Verified Calculated Savings	4.8	7,564
Deemed Savings	2.4	14,214

[5] Database for Energy Efficient Resources, http://www.energy.ca.gov/deer/

3.3.2 Site 2

Site 2 was a large manufacturing facility which replaced an old 1,750 HP centrifugal air compressor with a new three stage centrifugal unit. Two additional older centrifugal compressors remained installed, but were used as backup for the new unit. The site was also operating three other reciprocating air compressors. Although only four compressors were in use, there were a total of nine units at the site. Originally the process and plant portions of the facility had largely separate compressed air systems; however a crossover valve was opened further as part of the project to permit additional flow between the systems. The facility monitored process, plant, and crossover airflows separately.

Because of the medium voltage, 4,160 VAC, used to power the air compressors, Summit Blue did not take any on site measurements of power consumption. Instead facility logs were used to calculate savings. Unfortunately, although logs of each compressor's operation were available for a few weeks, not all of these logs were recorded simultaneously. However, total facility airflow was available with these logs, as well as airflow for some of the individual compressors. These logs were used along with compressor specifications to calculate total power usage, both for the old system and the new one.

The new compressor averaged about 87 kW less than the old unit. It also produced an average of 660 cfm more than the old unit, although its maximum capacity was significantly higher than that of the old unit. The crossover airflow was increased by an average of 553 cfm during the available data time periods. It should be noted that because of significant variations in production type and amount, it is difficult to produce savings values with high precision. However, the following assumptions were made in estimating savings from the replacement of the compressor:

1. Compressor 7 operated similarly to the old compressor 9, which was the same type of compressor.
2. The average difference between the old and new compressor power over the logged interval corresponded to demand savings.
3. When increased crossover flow permitted, a reciprocating compressor would be shut off.
4. Although the plant and process operating conditions differ over the two logged periods, the average operation is similar.

Based on these assumptions, similar savings to those seen in the initial verification report were observed. Since many of the data logs provided for this calculation were also available for the initial verification, this is to be expected. A 97% energy realization rate was observed relative to the original study, however variations in plant operation could easily affect savings. Additionally, adjustments to the sequencing controls for the reciprocating compressors will affect savings. Finally, as the initial report indicated, opening the crossover valve between the plant and process areas would likely further increase savings. Table 3-3 identifies the claimed and the verified energy and demand savings.

Table 3-3: Site 2 Installation and Savings

	kW Savings	Annual kWh Savings
Claimed Savings	68.8	1,755,550
Verified Calculated Savings	86.8	1,698,862

3.3.3 Site 3

Site 3 involved two lighting retrofit projects replacing T12 fixtures with new T8 direct-indirect fixtures within a large office building. Only one of these projects was chosen to be evaluated through the impact evaluation sample. However, because it was not possible to disaggregate the individual impacts of each project on-site, full lighting counts were conducted on several floors to confirm the overall installation rates across both projects.

The project application claimed savings from the retrofit of 1,000 two-lamp, T12 fixtures to new, high efficiency, and two-lamp T8 fixtures. The retrofits comprised 750 four-foot, two-lamp linear fluorescents and 250 two-foot, two-lamp U-lamp fluorescent fixtures.

A visual verification confirmed the retrofits were installed in the office spaces specified on the project application. However, during normal business hours, it was noted that approximately 23% of the surveyed fixtures were not in use. This finding was accounted for in the subsequent savings analysis. And although office areas within the building had different operating hours, occupant interviews were used to establish hours of operation for each of the floors surveyed during the site visit.

The incentive was paid on a prescriptive basis dependent upon the number of fixtures delamped and lamps replaced. Table 3-4 identifies the site claimed, verified, and deemed savings. The energy realization rate is a very low 11.1%. The low realization rate is reflective of the correction of the baseline. The application was based on replacing incandescent fixtures with T8 linear fluorescents, but the actual retrofit involved removing T12 fixtures to install T8 units.

Table 3-4: Site 3 Installation and Savings

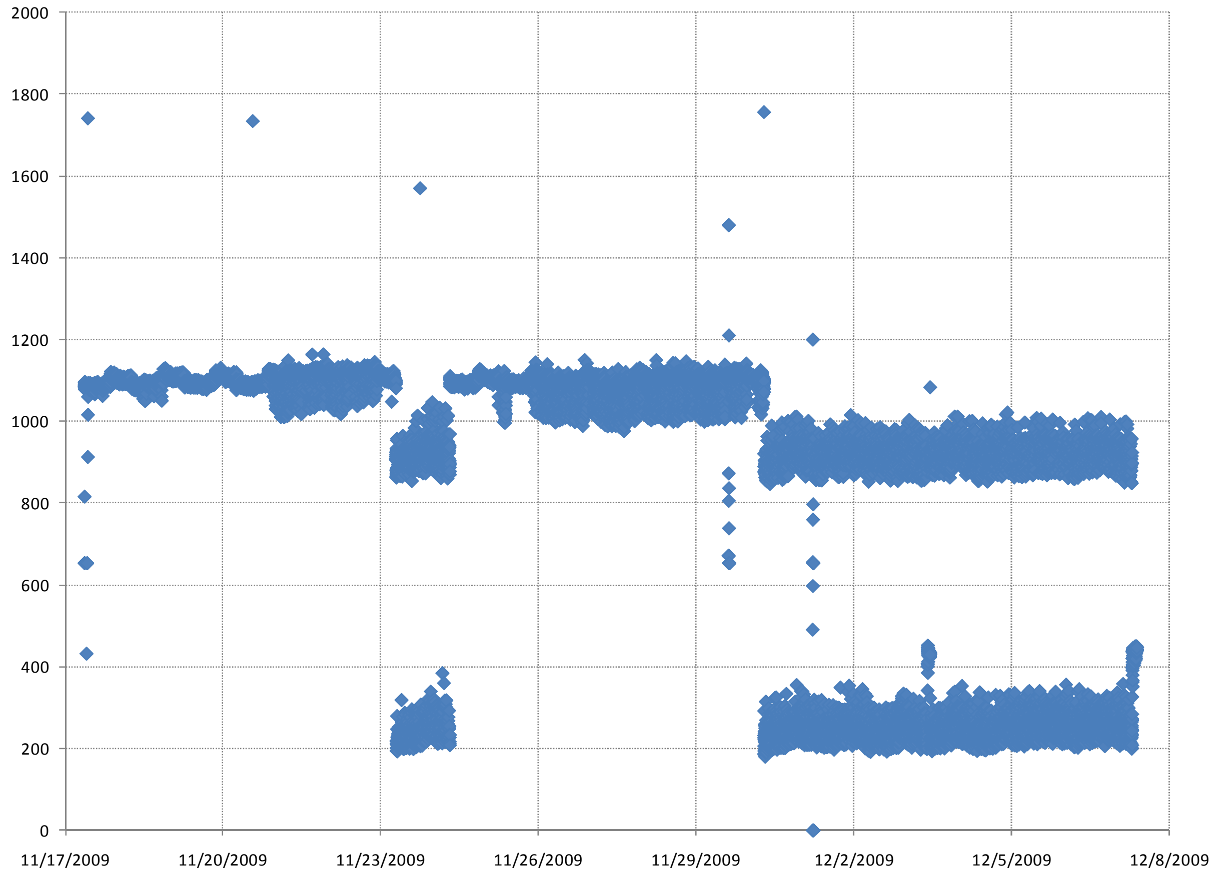
	kW Savings	Annual kWh Savings
Claimed Savings	142	711,000
Verified Calculated Savings	13.2	53,444
Deemed Savings	13	79,000

3.3.4 Site 4

Site 4 installed a new 100 horsepower variable speed air compressor in addition to the two existing 150 horsepower load/unload units. The two old load/unload air compressors remained in the system. Compressed air supplies a variety of equipment in the facility, which operates continuously, 24 hours a day, seven days a week, although loading varies with work hours.

During the site visit, spot measurements were taken of compressor power for all three units. In addition, current loggers were installed on a single phase of each unit to track consumption over a period of three weeks. These currents were used along with voltages and power factors from the spot measurements to calculate compressor power use. Compressor specifications and CAGI data were used to estimate airflow for the system, which is shown in Figure 3-2.

Figure 3-2: Site 4 Compressed Air Flow in CFM



The three weeks of logged data were assumed to be typical and extrapolated to a full year. The two older compressors were capable of supplying the highest airflow observed, so the baseline was the observed airflow supplied by the two older compressors.

Table 3-5 summarizes both the claimed and adjusted energy savings for Site 4. A 78.8% energy realization rate was observed relative to the original study. The reduced savings are due to the differences in loading compared to the predicted conditions. Since the site is continuing to make changes in the compressed air system this may not reflect savings at the time of the initial installation, however current savings are lower than were originally expected.

Table 3-5: Site 4 Installation and Savings

	kW Savings	Annual kWh Savings
Claimed Savings	68.2	539,993
Verified Calculated Savings	45.6	425,376

3.3.5 Site 5

Site 5 involved the installation of centralized software controls on personal computers at satellite locations to control their power savings settings and operation. The incentive was paid on a custom basis; calculated using the number of computers controlled and estimated reduction in hours of operation.

The installed software was designed to enforce an administrator defined power scheme uniformly across all of the terminal computers in the participant's network. The power scheme comprised two components:

1. The computers were set to sleep after 2 hours of inactivity. The monitors were set to sleep after 20 minutes of inactivity.

2. The computers were shutdown at 11 PM each night.

Software generated reports were used to support the project savings analysis. These reports provided details on the models of computers controlled, the hours of "up time" seen in a sample period, and a record of the last time the power scheme was invoked.

Table 3-6 identifies the site claimed and verified savings. The energy realization rate is estimated to be 54.6%. The low project savings realization rate was attributed to an incorrect operating assumption. The original estimates assumed that the computers would otherwise be left on 24 hours a day, seven days a week. Upon closer review of the participant operating schedule, it was determined that the site was only open for 186 days per year. Summit Blue's calculated savings also assumed that each computer was used at least once per day, which was optimistic, but reasonable.

Table 3-6: Site 5 Installation and Savings

	kW Savings	Annual kWh Savings
Claimed Savings	0	331,500
Verified Calculated Savings	0	180,882

3.3.6 Site 6

Site 6 added variable frequency drives to six supply fans on rooftop HVAC units at two locations. The first building installed VFDs on one 10 HP and one 5 HP fan. The second building installed VFDs on two 20 HP and two 25 HP supply fans of four separate HVAC units. All of the fans had previously operated with dampers to control airflow, so no HVAC savings were included in calculations. According to facility personnel, the 10 HP fan did not actually vary in operational speed, so the VFD was not providing any savings in that case.

Summit Blue took onsite power measurements for all six fans. In addition, current draw was logged for two weeks on the four larger units. All units operated within certain speed ranges during the logging period, showing minimal or no temperature dependence. However, there was some correlation with time of day, so occupancy is believed to be the main variable affecting usage. Based on this, seasonal variations are expected to be minimal, and the three weeks of logged data have been extrapolated to estimate overall savings.

Table 3-7 shows the total estimated savings. The claimed values are based on deemed values used by the program on a kW/HP basis. The installation is running significantly below the predicted operation and so is seeing significantly higher savings. The realization rate of 269.5% is based on the large verified calculated savings.

Table 3-7: Site 6 Installation and Savings

	kW Savings	Annual kWh Savings
Claimed Savings	0	97,308
Verified Calculated Savings	27.5	262,281
Deemed Savings	0	97,304

3.3.7 Site 7

Site 7 installed a refrigeration control system and ECMs on the evaporator fans of four walk-in coolers. The refrigeration equipment was on the roof. It was not feasible to take spot measurements of power consumption during the site visit so system data was used to estimate savings.

The installed controller contained average operation data for the preceding one week period. This showed that the average cooler compressor motor had operated 42.3% of the time and the freezer compressor had operated 92.8% of the time. The average outside temperature at the nearby San Jose airport for the week had been 51.8 °F, less than the TMY winter average temperature of 54.6 °F. Based on this, the estimated winter compressor operation of 35% provided on the application is believed to be too low. An estimate of 45% for winter operation is believed to be more realistic. Summer operation is expected to be heavier as well. The application predicted 55% operation during summer months, which have an average temperature of 62.9 °F. Since no logged data is available for the summer, it is difficult to provide a reliable evaluation of the actual operation. However, since no savings were attributed to compressor reductions, it is assumed that the baseline usage was also higher than estimated in the application and this should not affect savings.

Ten evaporator fans were installed in the four coolers. According to nameplate information these used 1/20 HP motors. No efficiency data was provided on the nameplates. However, the application estimates total baseline fan power at 1.39 kW, which would correspond to 27% efficiency for the fan motors. There is minimal information available on fractional horsepower fan efficiency, however rated nameplate current values for similarly sized motors indicate that the efficiency is likely to be that low. The application assumed 5,538 hours of operation. The single week of available data corresponded to operation 70.4% of the time, the equivalent of 6,167 hours per year. The application assumed an 85% reduction in motor load associated with replacing the existing motors with ECMs, which is consistent with typical ECM savings. An additional 4,250 kWh savings was attributed to reduced need for cooling, using a factor of 1.8 for cooling efficiency. However, since any savings due to this should be included in the observed compressor operation, the verified savings do not include a separate calculation for this effect.

Table 3-8 shows the total estimated savings. The claimed kW and kWh savings are based on the application. An energy realization rate of 93.5% is estimated. The cooling reduction is calculated using a cooling efficiency of 1.8 and 28% effect as in the application. The fan savings are calculated using 70% operation and 85% reduction for ECM installation. The peak kW savings are based on only the fan power reduction due to ECM installation.

Table 3-8: Site 7 Installation and Savings

	kW Savings	Annual kWh Savings
Claimed Savings	1.85	17,519
Verified Calculated Savings	1.18	16,379

3.3.8 Site 8

Site 8 was a new data center facility. As part of the initial construction, the facility installed variable frequency drives and economizers on the typical rooftop HVAC units. The facility installed a total of 16 HVAC units serving the data center areas and 8 serving the electrical rooms. Although all of these units included both economizers and VFDs on supply and exhaust fans, the economizer savings for only 8 of the data center units were included in savings on the application. The remaining 8 data center units are not currently in use as the data center includes room for expansion. The economizers on the electrical room HVAC systems were also not included in savings on the application. It is unclear if they were submitted as part of a separate application or if there are unclaimed savings at this site. All of the VFDs were included in the rebate applications reviewed, using a prescriptive rebate with a deemed savings value of 926.7 kWh/HP installed.

The site operates continuously, 24 hours a day, 365 days a year, without any significant variations in occupancy or usage. TMY3 data for the nearby San Jose airport was used to calculate annual hours for two degree temperature bins. The EER of 9.9 for the installed HVAC units was used to calculate cooling power from load. This resulted in an efficiency of 1.21 kW/ton, which is significantly better than the value of 1.76 kW/ton used in the application. Additionally, the application assumed 80 °F return air temperature, but system logs indicated that 75 °F was a more realistic estimate. The application used 50 °F supply air temperature which appeared consistent with system data.

The baseline system was a chiller with an efficiency of 0.529 kW/ton. In addition 30 kW were included for the cooling tower, a total of 153 kW for three water pumps, and 10.6 kW for control room air handlers to cool the system. These values were used on the application and Summit Blue found them to be reasonable for the baseline. A similar nearby data center was recently constructed with a chiller water cooling system, so this was considered to be an acceptable baseline for a facility of this size.

The VFDs on the supply fans are currently not in use, and all supply fans operate at 60 Hz when in use. Additionally, the HVAC units which are not in use do not have any savings associated with the return fans as they are shut off. The VFD operation of the return fans is linked to the use of the economizers, such that the speed is roughly linear with opening of the economizer. However, the static pressure in the building is also used to shut off the fans and the observed operational hours were relatively low. The baseline system would also run the fans minimally since there would be only a small amount of outside air is being used. The fans for which enough data was available to calculate reliable savings showed between 100 and 500 kWh/HP savings, significantly below the deemed value. Consequently, deemed savings have been used for all of the VFDs in this project.

Table 3-9 shows the total estimated savings. An energy realization rate of 109% is estimated. There are no demand savings because the economizers are not in use during the peak demand period. Additionally, the deemed savings used for the VFDs do not have any demand savings as the value is for HVAC fans specifically. The increased savings are primarily the result of the increased cooling efficiency used based on the unit EER rather than the higher value used in the application.

Table 3-9: Site 8 Installation and Savings

	kW Savings	Annual kWh Savings
Claimed Savings	0	5,701,846
Verified Savings Using Deemed Values for VFDs	0	6,214,299

3.3.9 Site 9

Site 9 was a new data center facility, very similar to site 8, although the site was around half the size. As part of the initial construction, the facility installed variable frequency drives and economizers on the typical rooftop HVAC units. The facility installed a total of 8 HVAC units serving the data center areas and 4 serving the electrical rooms. Although all of these units included both economizers and VFDs on supply and exhaust fans, the economizer savings for only 3 of the data center units were included in savings on the application. The remaining 5 data center units are not currently in use as the data center includes room for expansion. The economizers on the electrical room HVAC systems were also not included in savings on the application. It is unclear if they were submitted as part of a separate application or if there are unclaimed savings at this site. All of the VFDs were included in the rebate applications reviewed, using a prescriptive rebate with a deemed savings value of 926.7 kWh/HP installed.

The site operates continuously, 24 hours a day, 365 days a year, without any significant variations in occupancy or usage. TMY3 data for the nearby San Jose airport was used to calculate annual hours for two degree temperature bins. The EER of 9.7 for the installed HVAC units was used to calculate cooling power from load. This resulted in an efficiency of 1.24 kW/ton, which is significantly better than the value of 2.11 kW/ton used in the application. The reason for the value used on the application is unclear, particularly because 9.7 is the required minimum efficiency for these units under 2005 Title 24. The application also assumed 80 °F return air temperature, but system logs indicated that 75 °F was a more realistic estimate. The supply air temperature was 50 °F both on the application and in the calculations for this report.

The baseline system consisted of equivalent HVAC units without economizers or VFDs. This was chosen because the system installed did not exceed the Title 24 minimum efficiency requirement. Since the facility was smaller than site 8, a chilled water system was significantly less likely choice for cooling and was not used as the baseline.

The VFDs on the supply fans are currently not in use, and all supply fans operate at 60 Hz when in use. Additionally, the HVAC units which are not in use do not have any savings associated with the return fans as they are shut off. The VFD operation of the return fans is linked to the use of the economizers, such that the speed is roughly linear with opening of the economizer. However, the static pressure in the building is also used to shut off the fans and the observed operational hours were relatively low. The baseline system would also run the fans minimally since there would be only a small amount of outside air being used. The fans for which enough data was available to calculate reliable savings showed between 100 and 500 kWh/HP savings, significantly below the deemed value. Consequently, deemed savings have been used for all of the VFDs in this project.

Table 3-10 shows the total estimated savings. An energy realization rate of 131.3% is estimated. There are no demand savings because the economizers are not in use during the peak demand period. Additionally, the deemed savings used for the VFDs do not have any demand savings as the value is for

HVAC fans specifically. The increased savings are primarily the result of the increased cooling efficiency used based on the unit EER rather than the higher value used in the application.

Table 3-10: Site 9 Installation and Savings

	kW Savings	Annual kWh Savings
Claimed Savings	0	1,879,803
Verified Savings Using Deemed Values for VFDs	0	2,468,465

3.3.10 Site 10

Site 10 repaired six non-operational economizers on individual rooftop units. The HVAC units were located on two buildings within a multi-building campus. Two of the units were on a single story building containing offices, meeting rooms, and training rooms and the other four were on a three story office building. The units are in use 24 hours a day, 7 days a week, and 52 weeks a year. However, building occupancy varies greatly with office hours. The facility is sparsely occupied outside of work hours, and shut down for maintenance one week a year.

Summit Blue's analysis was preformed based on trend data collected through the building management system. On-site staff was able to provide a record of energy use of the systems of interest over a period of more than a year, including both pre- and post-installation measurements. It was not feasible to take onsite power measurements, but the system provided individual power data for each HVAC unit. Occupancy hours were estimated to be between 6:00 AM and 7:00 PM on weekdays and separate averages were created for these conditions, both before and after the retrofit. These data were trended as a function of temperature at the nearby San Jose airport. Figure 3-3 shows the average data for one of the HVAC units. Zero data points are due to lack of data and were not used for calculations.

Linear extrapolations were made to determine approximate power usage where no data were available, and the actual average power under each condition was used with 2 °F temperature bins based on TMY3 data for the San Jose airport to calculate energy savings. Occupied and unoccupied conditions were treated separately. Savings for each HVAC unit were calculated separately. In a few cases where there was limited data and it appeared to be anomalous, zero savings were assumed. This was only an issue with a portion of the data for AC Unit 1 on the larger building.

The application used measured savings over period of a few weeks to estimate energy savings. The estimated savings were 142,507 kWh for the single story building and 249,116 kWh for the three-story building. Table 3-11 shows the total claimed and estimated savings based on the provided power data. There are no demand savings because the economizers are not operational during peak demand times due to the high temperatures. The energy savings for the three story building are 177,117 kWh and the savings for the one story building are 143,950 kWh per year. An energy realization rate of 82% is estimated.

Figure 3-3: Site 10 HVAC Average Power vs. Temperature

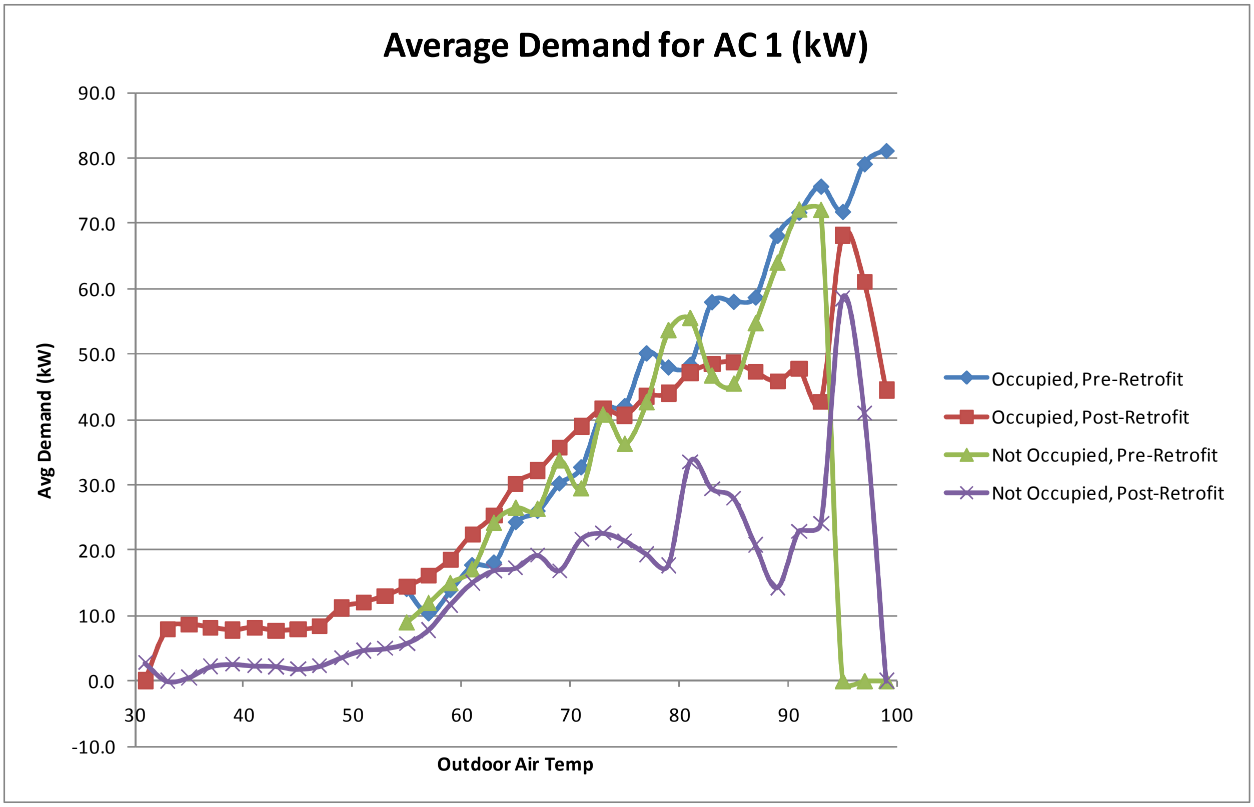


Table 3-11: Site 10 Installation and Savings

	kW Savings	Annual kWh Savings
Claimed Savings	-	391,623
Verified Calculated Savings	-	321,066

3.3.11 Site 11

Site 11 replaced non-operational economizers with new, functional dampers. The installation and operation of the new dampers were visually confirmed. Controls for the new dampers were handled via the building automation software.

The savings analysis was performed based on trend data collected through the building management system. Project representatives were able to provide system consumption logs over a 10 day test period. The measurements given in these reports were validated through spot measurements taken during the site visit. Facility personnel also confirmed that only half of the mechanical cooling equipment was needed to meet building loads. The other half of the roof top units were redundant to the 6 primary units. For this reason, Summit Blue de-rated the supply CFM to match the values used by the site in their rebate application (54% of full load capacity).

Table 3-12 shows the total estimated savings. The difference between claimed and verified savings was primarily due to an incorrect supply air temperature (SA) set point assumption. The set point given in the rebate application was assumed to be 55F. Verification efforts confirmed that the set point was actually 60F. An energy realization rate of 113.3% is estimated.

Table 3-12: Site 11 Installation and Savings

	kW Savings	Annual kWh Savings
Claimed Savings	0	3,652,522
Verified Calculated Savings	0	4,139,251

3.3.12 Site 12

Site 12 added variable frequency drives and economizers to an existing HVAC system. The HVAC system consisted of 31 RTUs with supply fans and 27 separate exhaust fans. Each HVAC unit had four compressors, two of which could operate in partial load conditions, for a total of eight possible stages and a single 57 BHP supply fan. The exhaust fans were each designed for 6.35 BHP and 54,000 cfm.

The facility tracked not only compressor, fan, and economizer operation, but also the overall HVAC power consumption. Although only a few weeks of data were available from the system, temperatures during this time ranged from 42-72 °F. Since data centers such as this have no variation in occupancy or operation with time of day, weekday, or seasons the data provided a broad picture of HVAC operation which was used to estimate overall savings.

Figure 3-3 shows the facility HVAC power as a function of outdoor air temperature. The green markers show the average power at each measured temperature. This matches the two-part linear trend of the overall data fairly well.

Average power was used for operation at temperatures where measurements were available. HVAC power was extrapolated to additional temperatures. The high points were assumed to be maximum power, which would be used when the economizers were not in use. This gave 3,135 kW, slightly less than the extrapolated 3,305 kW from the available data. The power appeared to drop to a minimum around 1,460 kW when the economizers were fully open. TMY3 data for the nearby San Jose airport was used to calculate annual hours of operation in two degree temperature bins.

Table 3-13 shows the total estimated savings. No demand savings are included as the system is operating at maximum power during peak demand periods. The calculated savings show a 98% energy realization rate.

Figure 3-3: Site 12 HVAC Power

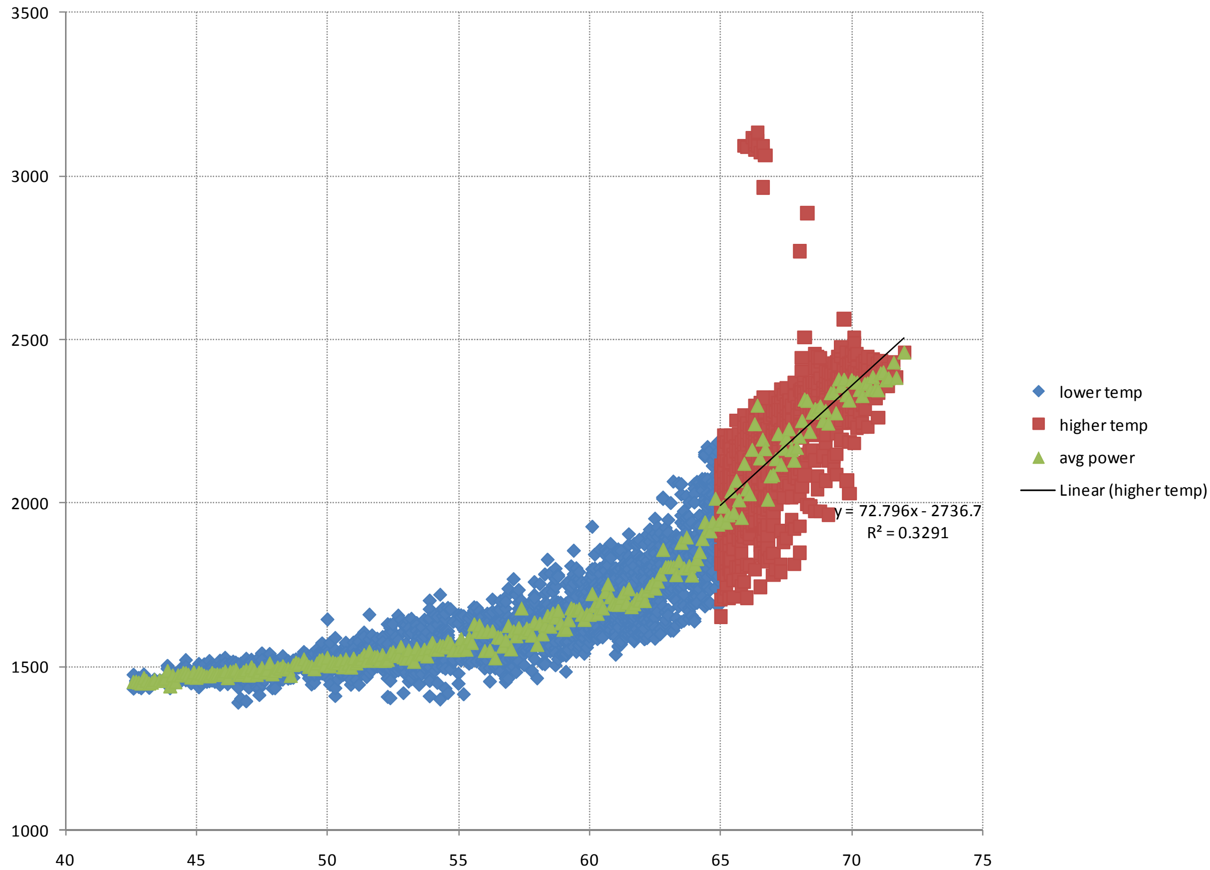


Table 3-13: Site 12 Installation and Savings

	kW Savings	Annual kWh Savings
Claimed Savings	0	11,895,500
Verified Calculated Savings	0	11,623,234

3.4 Non-Residential Impact Evaluation Results

Table 3-14 identifies the claimed and verified savings for the 12 projects evaluated for Non-Residential Program. Based on the combined results from the 12 projects, the program energy realization rate is estimated to be 102%. The demand realization rate is estimated to be 100.3%. The recommended adjustments are attributable to revised savings estimates based on current operation conditions observed during the site visits.

The larger of calculated or deemed energy savings have been used to obtain kWh, where applicable. The demand savings used are the corresponding values. Only some of the projects had deemed savings available, particularly the lighting and VFD prescriptive rebates. Deemed VFD savings of 926.7 kWh/HP have been used based upon the prescriptive rebates issued by SVP. Site 5 used savings of around 125 kWh/computer, but this was not treated as a deemed savings value for comparison since inadequate data is available to deem this type of project.

Table 3-14: Custom Program Claimed Savings and Verified Gross Savings

Project	Claimed		Verified	
	kW Savings	Annual kWh Savings	kW Savings	Annual kWh Savings
Site 1	3.7	19,352	2.4	14,214
Site 2	68.8	1,755,550	194	1,698,862
Site 3	142.0	711,000	13	79,000
Site 4	68.2	539,993	45.6	425,376
Site 5	0	331,500	0	180,882
Site 6	0	97,308	27.5	262,281
Site 7	1.8	17,519	1.2	16,379
Site 8	0	5,701,846	0	6,214,299
Site 9	0	1,879,803	0	2,468,465
Site 10	0	391,623	0	321,066
Site 11	0	3,652,522	0	4,139,251
Site 12	0	11,895,500	0	11,623,234
Total	**284.5**	**27,034,016**	**283.7**	**27,443,309**
Percent Realization			**100.3%**	**102%**

3.5 Non-Residential Program Site Observations

Only three of the projects sampled for on-site verification used deemed savings through purely prescriptive rebate programs. The other sites used primarily calculated savings, although some also received prescriptive VFD rebates. There were two significant issues with the applications:

1. *Inconsistencies between the application and the actual installation.* Variances, although not severe were present. Itemized invoices might help in some cases. Confusion over where the retrofit had taken place for the lighting retrofits might be clarified if some sort of statement of the location was included with the application. In the case sites 8 and 9, it is unclear why not all the operational economizers were included in savings.
2. *Variations in operational conditions compared to applications.* In the custom program, several sites had different operational temperatures or loading than what was expected. This may be the result of changes since the installation or it could be due to errors in the application. More detailed descriptions of values used in calculating savings for the rebate would help to clarify this in some cases.

3.6 Non-Residential Program Record Observations

The final program records submitted by the implementation contractor to the Silicon Valley Power were analyzed for accuracy and consistency, and to ensure that the underlying assumptions were reasonable. The key documents analyzed included the following:

- The project applications provided to the program for each site
- The invoices provided to the utility, where applicable

The primary observations from this review were that although the majority of the sites installed the measures listed on the applications, savings were adjusted due to discrepancies between the applications' savings estimates and those found during the onsite visits.

Based on the review of program documents and on-site verification activities, the following conclusions were reached.

1. The adjusted final realization rate for the program was less than 100% due to the use of values for estimated savings that did not match the standard ones in the E3 calculator shown in the appendix.
2. The measure savings assumptions were calculated to be representative of the Program installations.
3. Itemized purchase orders should be required for applications, along with a list of the final retrofit plan and system setpoints.
4. Customers should be encouraged to report all savings associated with a project.

APPENDIX A: NON-RESIDENTIAL MEASURE DATA

Table A-1. Deemed Savings for Selected Measures

Category	Measure	Peak kW Savings	Annual kWh Savings
Computer controls	Computer controls	0	125 kWh/unit
Non-Res Cooling	VFD on Supply/Return Fan	0	926.7 kWh/HP
Delamping	Delamp 4’ lamp	0.040	235
T8 linear fluorescent	T12 to T8 2’ lamp	0.008	47
T8 linear fluorescent	T12 to T8 4’ lamp	0.006	37

Source: SVP E3 Calculator

Table A-2. TMY3 Data for SJC

max temp	min temp	avg temp	annual hours
100	98	99	0
98	96	97	1
96	94	95	1
94	92	93	5
92	90	91	4
90	88	89	7
88	86	87	30
86	84	85	39
84	82	83	61
82	80	81	88
80	78	79	120
78	76	77	76
76	74	75	159
74	72	73	228
72	70	71	240
70	68	69	482
68	66	67	322
66	64	65	430
64	62	63	616
62	60	61	884
60	58	59	551
58	56	57	921
56	54	55	775
54	52	53	612
52	50	51	747
50	48	49	387
48	46	47	288
46	44	45	185
44	42	43	154
42	40	41	88
40	38	39	103
38	36	37	68
36	34	35	71
34	32	33	17
32	30	31	0