2002 STATEWIDE NONRESIDENTIAL STANDARD PERFORMANCE CONTRACT PROGRAM MEASUREMENT AND EVALUATION STUDY

IMPACT EVALUATION REPORT

FINAL

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ES. EXECUTIVE SUMMARY

In this report, we present results from the impact evaluation activities conducted for California's Nonresidential Standard Performance Contract Program (SPC) for program year 2002 (PY2002). The PY2002 evaluation scope includes process, market, and impact evaluation components. This report covers only the gross and net impact evaluation objectives. The companion process and market evaluation report was published separately in March 2004.[1]

This impact evaluation volume provides results on verification, ex post energy savings estimates, gross savings realization rates,[2] and the net-to-gross ratio (NTGR). Although the objectives of the impact evaluation are fairly comprehensive, the resources available to conduct it were limited. The level of ex post site analysis and measurement conducted for this study was significantly less than what was typical during the 1990s for IOU custom incentive programs following the CADMAC impact evaluation protocols.

Historically, the SPC has fulfilled a critically important role in the portfolio of nonresidential energy-efficiency programs by supporting complex and comprehensive energy-efficiency projects that offer large, and very cost-effective, energy savings and peak demand reductions from projects that would otherwise not be captured through prescriptive approaches. The Program has gone through several very significant changes since its inception in 1998, particularly with respect to measurement and application requirements. These changes have been made in response to evaluation findings, program administrators' self-assessment of market needs, and changes in CPUC policy energy efficiency policy goals. Significant strides have been made to streamline the application process, standardize calculation methodologies, and simplify the review process.

In this report, we suggest several ways that energy savings estimates in this program might be further improved. Most of these changes should be relatively easy to address and are aimed at increasing the certainty of the program's resource value without unduly increasing the burden of participating in the program. Recommendations in this report related to pre- and post-measurement of savings must be considered within the context of the role of M&V throughout the history of the Program. (readers are strongly encouraged to review evaluations of the Program for PY1998 and PY1999 when in-program measurement was required for all projects). Similarly, this report extends recommendations for reducing free ridership, which have been made in previous evaluations. For further perspective, readers may also be interested in *Volume NR5 – Large Comprehensive Nonresidential Programs* of the recently completed *National Energy Efficiency Best Practices Study*, in which the features of the California SPC program are compared to programs targeted at similar markets around the country (Quantum, 2005).

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[1] Quantum, 2004. *PY2002 SPC Process Evaluation and Market Assessment Report*, prepared for Southern California Electric Company, March 2004. See http://www.calmac.org/publications/ 2002_SPC_Final_Report.pdf

[2] Realization rates are developed for each site and the program as a whole and are defined as the ratio of program ex ante savings divided by the ex post savings estimated by the evaluation team.

ES.1 SUMMARY OF GROSS REALIZATION RATE AND NET-TO-GROSS RESULTS

The impact evaluation results are based on a sample of 40 customers out of an initial 2002 SPC program population of 261. A site-specific engineering approach was utilized that included limited use of measurement and billing data. The key steps involved in developing the overall savings estimate for the program were to independently verify reported measure installation records, develop ex post estimates of the energy savings for each project in the sample, and to statistically apply those findings to the full participant population.

The overall weighted program realization rate (weighted by energy savings) and the associated confidence interval are shown in Exhibit ES-1. The overall weighted realization rate is 0.79 with a 90 percent confidence interval of 0.73 to 0.85. By comparison, the unweighted realization rate for the sample is 0.92. The weighted realization rate is lower because of low realization rates for one large site and the process end use. The weighted average realization rate is the primary result of interest since it captures the relative contribution of different sized projects to overall program savings. As discussed in this report, this underscores the importance of focusing extra analytical resources and attention on the very largest projects in the program.

Note that the confidence interval does not capture any of the uncertainty in the ex post savings estimate. The confidence interval only captures the effect of the variation in the ex post to ex ante ratio of the sample with a finite population factor correction that reflects the population of program participants. That is, it is as if the ex post values were known precisely without measurement error. This approach used to develop the confidence interval is consistent with similar studies conducted under the CADMAC evaluation protocols and is constrained by the practical limitations associated with aggregating results from complex, site-specific projects that use a variety of estimation approaches. Nonetheless it is important to keep in mind that the uncertainty around the ex post savings estimates is not incorporated into the confidence interval and that, if it were, the confidence interval would likely be considerably wider.

Exhibit ES-1
Overall Program Realization Rate

Total Weighted Program Realization Rate	0.79
90 Percent Confidence Interval	0.73 to 0.85

Our estimated net-to-gross ratio for PY2002 is 0.6, which is somewhat lower than the value of 0.7 adopted by the CPUC in the Energy Efficiency Policy Manual but within the range observed from previous SPC evaluations. The value adopted in the policy manual was based on a multi-year analysis (for PY1998 through PY2001) that took into account limitations in the free ridership method utilized and other factors such as participant spillover. Given the uncertainty around these estimates and year-to-year fluctuations, we do not believe that the current results warrant a change in the adopted NTGR value of 0.7 in the policy manual. The adopted NTGR should be reconsidered after conducting another multi-year analysis that includes results for 2003 through 2005.

ES.2 SUMMARY OF OTHER FINDINGS

In developing the ex post savings estimates, a significant effort was put into reviewing the SPC application files with respect to project documentation and the technical review conducted by the program administrators and their support contractors. In Section 5, we provide a discussion of the issues developed from our review. These issues are briefly summarized below:

- **Wide Range in the Quality of Applications and Supporting Documentation**. There are numerous examples of applications that are well documented. For these sites, we found clear descriptions of the proposed and installed energy saving measures, a comprehensible presentation of the energy savings calculations, and a verifiable description of the completed installation. There are, however, some sites where the rationale for the energy savings is less clear, the supporting documentation inadequate, or the description of the verified installation difficult to follow.

- **Need for Increased Verification and Documentation of Assumptions**. In a number of cases we found assumptions for the program calculations were unverified or undocumented. Some of this may be attributable to the fact that the program is now based on calculated instead of measured savings and the fact that the program appropriately sought to decrease application costs and paperwork based on findings from the 1998 and 1999 SPC evaluations; however, as we discuss in Sections 5 and 6 of this report, increased documentation of input assumptions for savings estimation is needed, particularly, for larger and more complex sites. In addition, some applications do not contain a clear enough description of how the proposed retrofit will reduce energy consumption.

- **Varying Experience and Expertise Levels of the Reviewers**. Review of the program files indicates that there may be a wide range in the experience level and expertise of the individuals reviewing the SPC applications. Some of the applications have very detailed reports including documented inquiries to the project sponsor requesting more precise information to support the application. However, in some cases the reviewers did not request the kind of information required to develop an appropriate understanding of the proposed project.

- **Difficulty in Assessing Complex Industrial Process Projects**. Related to experience level and expertise of the reviewer is a general observation that assessing the energy savings associated with industrial utility systems such as compressed air and large refrigeration or other industrial process systems is difficult even for experienced reviewers when there is no measurement and verification data upon which to base energy savings calculations. Many of these systems are complex with several interactive components. Load profiles are often difficult to estimate, and in many cases are directly related to production outputs that may be difficult to quantify over long periods of time. Most of the industrial process retrofits share at least some of these characteristics. Measurement and verification requirements were relaxed in the 2002 program, resulting in a higher level of uncertainty for this group of projects.

- **Limited Estimation of kW Peak Demand Savings**. The PY2002 SPC program did not require and track peak coincident demand savings, although estimates were included in a number of applications. Estimating peak coincident demand kW reduction is generally more complex than estimating annual energy savings. Accurate estimation of demand reduction usually requires that data must be collected and evaluated on an hourly basis. If quantifying demand reduction is important, as we believe it is given the peak demand-related resource importance of energy efficiency programs, more rigorous and systematic estimation of peak demand impacts (both in-program and through the evaluation process) should be considered.

ES.3 SUMMARY OF RECOMMENDATIONS

As a result of the findings above and the realization rate and net-to-gross analyses, we developed a set of recommendations aimed at helping to improve the resource reliability of the program, while trying to remain sensitive to the need to keep the program implementation process from becoming overly complex or difficult (as was the concern in the early years of the program). These recommendations are discussed in Chapter 6 of this report and are summarized below:

- **Consider Targeted Increases in the Level of Technical Documentation**. We recognize the importance of keeping the application process and forms from being overly complex and costly to navigate, a key recommendation from the early program year evaluations. At the same time, it is important that the application documentation not be over-simplified. In particular, large complex projects should require more significant levels of site-specific application data than do other types of projects.

- **Consider a Stronger Application Affidavit Statement Regarding Savings Assumptions**. Included in the current affidavit is a release of liability for injury, violation of law, energy savings shortfall, performance and qualifications of project sponsor, and agreement to permit inspection and measurement of the project. The utilities should consider an additional affidavit statement in the application concerning customer/sponsor-supplied information on operating hours and characteristics of equipment described in the application. This might eliminate or reduce gaming in the information provided by the project sponsors.

- **Further Standardize the Review Approach and Documentation Requirements for Recurring Complex Projects**. The utilities have made efforts to standardize savings estimates for measures addressed by the SPC calculator and provide guidance for complex measures such as compressed air, large refrigeration projects, and the like. However, it appears that additional effort may be needed to increase the consistency of analyses required of applicants and carried out by program reviewers for these types of projects. This would include a more detailed and rigorous requirement for the supporting documentation and certain types of measurement.

- **Consider Providing or Requiring More Technical Support for Applicants for Complex Projects**. It may be beneficial to offer or require technical consultant assistance to participants to prepare the required documentation for complex projects, particularly for initial submittals that do not meet the level of increased requirements recommended above.

- **Improve Reviewer Documentation**. Require that reviewer calculations, which document the approved savings upon which the incentive is paid, be attached to the installation report. In some cases we found that documentation of energy savings was obvious for the approved application, but not for the final approved incentive which is usually based on the installation report. The basis of the incentive paid to the participant should be well documented and easy to ascertain with the project file.

- **Consider Increasing Conservatism for Calculated Path Savings Estimates; Increasing Measurement for Large Complex Projects; and Increasing the Incentive Premium for Measured Projects**. As discussed in Section 5, when the SPC program was shifted from a primarily measurement-based to primarily calculation-based program, the SPC Program managers acknowledged and recognized the limitations of calculations for custom projects but intended that the program err strongly on the conservative side for these projects. The expected result of choosing to err strongly on the conservative side would be realization rates greater than 1.0 for calculated savings projects. Because the estimated ex post realization rate is moderately below 1.0 the program may not be adequately implementing the program managers' intended conservative philosophy for the calculated savings projects. The program should consider making more conservative assumptions for the calculated projects. The program should also consider utilizing measurement more often for the largest and most complex projects (or having this function performed by the evaluation team). If calculated savings are made more conservative, consideration should also be given to increasing the payment difference between the calculated and measured projects.

- **Increase Pre-Installation Measurement for Very Large Projects with Highly Uncertain Baseline Conditions**. Savings cannot be reliably estimated for some types of projects on purely an ex post basis. Pre-installation measurements can significantly improve savings estimates for projects such as complex compressed air and industrial process retrofits. The program includes pre-inspection for all projects but only very limited amounts of pre-measurement. Consideration should be given to increasing the amount of pre-measurement for large, complex measures that cannot otherwise be reliably quantified with only ex post data. Pre-installation measurement can be challenging in practice and burdensome to applicants. Care should be taken in this effort; in some cases, applicant installation schedules and other constraints may outweigh pre-measurement in importance. Either the program implementation or the evaluation team could perform these selected pre-measurements.

- **Consider Independent Review of the SPC Calculator**. The SPC calculator was used for at least one measure in 40 percent of the applications reviewed. Considering its wide use, it seems prudent to have an independent or peer group evaluation of the SPC calculator; if such a review has not recently been performed.

- **Consider Additional Programmatic Efforts to Reduce Free Ridership**. Suggestions for reducing free ridership in the SPC program were developed in the previously published process and market evaluation of the PY2002 SPC Program (Quantum, 2004). They are repeated in this report now that the net-to-gross analysis has been completed. Approaches to consider are discussed in Section 6 of this report and include increasing incentive levels for higher payback measures or emerging technologies, incorporating a payback floor, bonus payments for first-time participants, and allowing and encouraging program administrators to exclude projects that are obvious free riders.

ES.4 CONSIDERATIONS FOR FUTURE SPC IMPACT EVALUATIONS

Because this evaluation is the first ex post impact evaluation of the SPC program, we have developed two suggestions related to the evaluation process itself:

- **Shift Ex Post Impact Evaluations from a Program-Year to a Paid-Year Basis or a Combination of Both.** Many PY2002 projects, particularly larger ones, took more than a year longer than the program installation deadline of June 1, 2003 to complete installation. The long lag between participation and installation year makes it extremely difficult to conduct an ex post impact evaluation based on program year. This PY2002 impact evaluation was delayed several times due to the lack of installed projects in our sample to evaluate.

- **Increase the Scope to Expand Ex Post Measurement**. As discussed in the Introduction to this report, due to budget constraints, the current evaluation was not able to utilize site-specific ex post measurement as much as was desirable. In the future, if reliable ex post realization rates are desired for peak demand as well as energy, increased levels of measurement will be needed. We suggest that either a larger percentage of projects should be required to follow the measurement path in the program or the measurement element of the impact evaluation should be expanded. Future evaluations should also utilize larger sample sizes than that in this study, in particular, to allow estimation of realization rates for the Program by utility.

- **Integrate the Evaluator Early into the Program Process to Enable Pre-Measurement for a Sample of Projects.** If an expanded impact evaluation approach is pursued, it will be important for the evaluation to be integrated into the program implementation process so that pre-installation measurements can be made for large, complex projects and a random sample of other projects.

1. INTRODUCTION

In this report, we present results from a set of evaluation activities focused on California's Nonresidential Standard Performance Contract Program for program year 2002 (PY2002). The PY2002 evaluation scope includes process, market, and impact evaluation components. This report covers only the gross and net impact evaluation objectives. The companion process and market evaluation report dated March 2004 was published separately (see footnote 1). These evaluation activities were preceded and informed by evaluations of the nonresidential SPC program conducted for each of the program years from PY1998 through PY2001. This chapter provides a brief introduction to the SPC Program, the objectives and scope of the evaluation, the approach, and the guide to this report.

1.1 SUMMARY OF THE 2002 SPC PROGRAM REQUIREMENTS

As in previous years, the 2002 SPC Program was administered by Pacific Gas & Electric Company (PG&E), Southern California Edison Company (SCE), and San Diego Gas & Electric Company (SDG&E).

Under the 2002 SPC Program, the program administrators offered fixed-price incentives to project sponsors for kWh energy savings achieved by the installation of energy-efficiency measures. The fixed price per kWh, performance measurement protocols, payment terms, and other operating rules of the program were specified in a standard contract.

To qualify for the SPC, a project must produce a minimum level of energy savings; however, two or more projects may be aggregated to meet this requirement. The program is open to almost any equipment replacement or retrofit project for which the savings can be measured and verified with a useful life of greater than 3 years. A sample of eligible measures includes:

- Replacement of standard fluorescent lighting with high-efficiency fluorescent lighting
- Installation of variable-speed drives on electric motors
- Installation of lighting controls to reduce lighting operating hours
- Replacement of standard-efficiency air conditioning with high-efficiency equipment.

Projects that are not eligible include, but are not limited to:

- Any power generation or co-generation project
- Fuel substitution or fuel-switching projects
- New construction projects
- Any repair or maintenance project.

A number of important milestones must be completed as part of the project approval process. Readers unfamiliar with these milestones and other implementation details should review the program procedure manuals or program web sites for more information.[3]

Differences between 2001 and 2002 Programs

Some changes from the 2001 program were implemented in 2002, including:

- 2002 incentive rates are the same for all customers.
- No peak demand or small customer bonuses were offered in 2002.
- All projects use the calculated savings approach except when the utility determines a need for M&V. A one-time supplemental payment was provided for measured projects to defray the M&V costs.
- Calculated savings projects receive the full incentive after the approval of the installation report. No Operating Report is required.
- Lighting measures may account for no more than 30 percent of a utility's total incentive budget.
- Lighting measures were eligible only as part of a Comprehensive Retrofit (defined as having 20 percent of energy savings from non-lighting replacement measures).

2002 SPC Incentive Structure

With the exception of gas, retrofit incentives were essentially the same in PY2002. The per-unit incentive levels for the 2002 program are shown in Exhibit 1-1. Incentives for gas measures increased from \$0.27/therm in 2000 to \$1.00/therm in 2001, then dropped to \$0.45/therm in PY2002. The financial incentive cannot exceed 50 percent of the project capital cost.

Exhibit 1-1
2002 Program Incentive Levels by Measure Type and Year

Measure Type	Incentive per Unit of Savings
Lighting	\$0.050/kWh
HVAC&R	\$0.14/kWh
Motors/Other	\$0.080/kWh
Gas	\$0.45/therm

[3] Additional programmatic details on the California nonresidential SPC Programs can be found at each utility's web site; PG&E: http://www.pge.com/biz/rebates/spc_contracts/, SCE: http://www.sce.com/spc, SDG&E: http://www.sdge.com/business/specializedincentives.shtml.

1.2 SPC CALCULATOR

The SPC program has developed energy savings estimation software for many measures. The software is available on CD-ROM or can be downloaded on the Internet.[4] The software can be used to complete the details required to file a project application and also to perform estimates of energy savings and financial incentives for the following energy efficiency measures:

- Lighting Replacement
- Lighting Controls
- Air Conditioning Unit Replacement
- Air Conditioning Economizers
- Variable Speed Drives for HVAC Fans
- Cool Roofs
- Variable Speed Drives for Process Applications
- Motor Efficiency Upgrades
- Air Compressors
- Injection Molders
- Dairy Vacuum Pumps
- Gas Boiler Measures

Engineering calculations must be performed for measures not covered by the estimation software. The program requires that engineering calculations be performed using accepted engineering procedures with documentation to support the submitted calculations.

1.3 OBJECTIVES, SCOPE, AND CAVEATS

The PY2002 evaluation focuses on process evaluation, market assessment, and impact evaluation. The primary goal is to provide feedback to program planners and policy makers to help improve the program, as necessary.

This impact evaluation volume provides results on verification, ex post energy savings estimates, and net-to-gross. The previously released process evaluation and market evaluation included: (a) a characterization of participant experiences with the program; (b) an integration and analysis of the utility program tracking data; and (c) an assessment of energy-efficiency related market conditions.

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[4] SPC software may be downloaded from the following web site: http://www.aesc-inc.com/download/SPC/

The primary objective of this impact evaluation is to generate findings and recommendations that will improve program and evaluation planning for PY2005 and beyond - when determining the resource value of the program will be of paramount importance. Specific aspects of this objective include the following:

- Establish a process for conducting ex post evaluation for this program type
- Conduct site-specific ex post savings analyses
- Implement the process for a small but representative sample of sites
- Estimate program savings for the sampled sites
- Extrapolate savings from the sample to the program population
- Caveat the results given evaluation budget limitations for this study
- Develop recommendations for how program savings and evaluation efforts can be improved.

Although the objectives of the impact evaluation are fairly comprehensive, the resources available to conduct it were very limited. As a result, it is critically important for readers and users of this report to understand the scope and limitations of this impact evaluation within the following context:

- The types of projects that are being evaluated in this study are the most complex energy savings projects in the energy efficiency program portfolio, as well as the largest contributors to total savings and overall cost-effectiveness.
- By definition, most of these projects are unique as carried out at each site, which limits the power and accuracy of statistical extrapolation from the samples.
- The total budget available for this impact evaluation was about an order of magnitude smaller than the level of effort expended on California utilities' ex post impact evaluations for similar programs (i.e., custom type projects for large nonresidential customers) in much of the 1990s under the evaluation protocols in place during that period.[5]
- Consequently, the person-hour budgets per site were much less than those typical for these types of projects under the previous evaluation protocols.
- The limited person-hour budgets per site constrained measurement and monitoring activities. (See Section 6 of this report for further discussion.)

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[5] Examples of protocol-era impact evaluations for large, complex projects can be found in PG&E's industrial impact evaluations for 1997 and 1998. See http://www.calmac.org/publications/334ES.pdf and http://www.calmac.org/publications/403ES.pdf. The protocols can be found at http://www.calmac.org/cadmac-protocols.asp.

- The sample sizes used in the current study are significantly smaller than what would have been required under the previous protocols.

- Finally, we note that an ex post impact evaluation was not required for the PY2002 SPC program by the CPUC.[6] The evaluation team voluntarily put forth the plan to conduct this study for reasons further discussed below.

Readers may ask why the evaluation team pursued this effort given the limitations and caveats above. The answer is that the evaluation team believes that it was nonetheless important to begin the process of ex post impact evaluation for the SPC program for PY2002 for the following reasons:

- The resource value of all programs was of obvious increasing importance when the evaluation plan was developed in 2002.

- The evaluation team believed that the California IOUs and CPUC would want to adopt a more rigorous ex post impact evaluation process for PY2004 and beyond.

- The evaluation team believed that even a constrained effort would generate important lessons learned for program managers, planners, evaluators, and policy makers for future program years, when even more resources would be at stake.

- Because SPC projects typically take 6 to 24 months to be installed after acceptance of program applications, the evaluation team believed that waiting until later program years to begin the ex post impact evaluation process would delay the associated learning by far too long.

We believe that the results presented in this report support and justify the decision to conduct the impact portion of the evaluation study despite the constraints.

1.4 GUIDE TO THIS REPORT

A guide to each of the elements included in this final report is provided below:

Main Body

- **Executive Summary**: The Executive Summary provides a very short summary of the impact evaluation results.

- **Introduction** (Chapter 1): The Introduction includes a brief program overview, discussion of the overall objectives and scope of the project, evaluation tasks, and this report guide.

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[6] Note that only a very small number of PY2002-PY2003 utility or non-utility programs included ex post impact evaluation, as this was not a CPUC requirement for those program years.

- **Methods** (Chapter 2): This chapter provides a summary of the methods used in the impact evaluation including a comparison of the proposed sampling plan and the sample of sites completed.

- **Gross Impact Results** (Chapter 3): This chapter provides a summary of the results of the impact evaluation.

- **Net to Gross Results** (Chapter 4): This chapter provides a summary of the results of the net to gross evaluation.

- **Key Issues** (Chapter 5): In this Chapter we discuss some of the more significant issues identified in the impact evaluation that pertain to the reported energy savings from the application review stage through the installation review stage.

- **Recommendations** (Chapter 6): In this chapter, we provide suggestions for program planners and policy makers to consider in helping to improve the program.

Appendices

- **Qualitative Assessment of Ex Ante Calculations and Supporting Material** (Appendix A). This appendix summarizes our qualitative assessment of the quality of the documentation, calculations, and review process.

- **Summary of project paybacks (**Appendix B). This appendix summarizes project paybacks after SPC incentives for the sample.

- **Impact Evaluation Reports** (Appendix C): This appendix includes the individual site level impact evaluation reports. There are 43 reports comprising the impact evaluation for 40 customers.

- **Verification Reports** (Appendix D): This appendix summarizes the verification of the installed energy efficiency projects. In some cases, an SPC application may have covered more than one end use or site. Many of the impact evaluations are focused on one assigned end use only and there is no verification of the other measures or sites covered in that application.

2. METHODS

In this chapter we present the methods used in the impact evaluation. A summary of the sampling plan is provided, followed by an overview of the approach used for the site specific impact evaluations.

2.1 SAMPLING PLAN

In this section, we present the sampling plans for the impact evaluation of the PY2002 SPC program.

A sample of participating SPC customers was selected for primary data collection and downstream verification and engineering analysis. The careful selection of this sample is important to the success of the impact evaluation. The approach requires an intelligent segmentation of all participating customers into strata that are analytically compatible. This is important because the findings from the sampled customers are extrapolated to the remaining participant populations based upon application commonality. For this particular effort, the segments used to leverage results that we considered consisted of a combination of the following: size of project savings, end-use, savings fuel (electric or gas), IOU, and sponsorship type (customer or third-party).

Both the proposed sampling plan and the sample of sites actually completed are presented.

For the impact evaluation, we drew a sample that is proportionally distributed with respect to size of savings, end use, type of sponsorship, and utility. The sample was drawn from customers with active applications as of March 2003. Electricity makes up roughly 90 percent of the savings and incentives for the PY2002 SPC program. Consequently, given budget constraints, it was agreed that the impact evaluation would focus on measuring electricity savings. Thus, the primary sampling variable is electricity savings at the customer level. We determined that three proportional savings strata would be optimal. The strata each represent one-third of program electricity savings. We refer to these as tiers, with Tier 1 being the tier with the largest projects and Tier 3 the smallest.

A second stratification variable used is end use, as defined by the program. The program pays incentives based on whether projects are classified as Lighting, HVAC/R, or Other.[7] Many projects contain measures from more than one end use. The end use with the largest energy (kWh) savings in an application was assigned as the "primary end use" for the sample design. Stratifying on program end use ensures that the sampled mix of projects is representative of the population mix and allows us to calculate realization rates by end use.

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[7] Note that, for payment purposes, "Other" includes industrial process and many controls measures, even controls that apply only to lighting or HVAC/R.

The program population data for the sampling strata are shown in Exhibit 2-1. These figures are based on data received from the utilities in March 2003.[8] As originally proposed, the total size of the sample would be roughly 50 customers. The final sample plan developed had 51 points distributed by size and end use as shown in Exhibit 2-2. The total savings associated with the original sample is shown in Exhibit 2-3. However, the final sample completed was for 40 customers, as shown in Exhibits 2-4. We were unable to complete the original sample plan consisting of 51 customers due to delays caused by a significant number of projects that were not installed in time for the evaluation. We also experienced reluctance on the part of some customers to participate in the impact evaluation, and could not proceed with 2 customers for this reason.

We originally selected all 11 customers from the first strata, which represent those customers with the largest savings, but were able to evaluate only 6 of those customers since 4 customers had not completed their projects and one customer did not cooperate with the evaluation. We randomly sampled from the remaining strata and allocated sample points to maximize confidence and precision on program savings. The energy savings associated with the actual sample completed is shown in Exhibit 2-5. With these 40 points, we were able cover approximately 40 percent of the population savings.

Exhibit 2-1
Electric PY2002 Population Data by Stratum and End Use

		GWh Savings			
kWh Strata	No. of Customers	Lighting	HVAC/R	Other	Total
Tier 1	11	17.5	14.0	46.2	77.7
Tier 2	35	17.9	18.4	44.3	80.5
Tier 3	215	14.3	19.6	46.4	80.3
Total	**261**	49.6	52.1	136.8	238.5

Exhibit 2-2
Original Electric Impact Evaluation Sample Plan – Number of Customers

	End Use			
kWh Strata	Lighting	HVAC/R	Other	Total
Tier 1	7	4	8	11
Tier 2	5	5	10	20
Tier 3	6	7	7	20
Total	**18**	**16**	**25**	**51**

[8] Note that the gross ex ante savings for the SPC program will change over time because savings estimates are sometimes adjusted based on the Project Installation Report and project installations can lag several years after the program-funding year. In addition, some projects will have cancelled since March 2003. As of fall 2004, there were still a number of projects from the 2002 program that had not been installed.

Exhibit 2-3
Original Electric Impact Evaluation Sample Plan – Sampled GWh Savings

	Sample Points	GWh Savings			
kWh Strata	Total (Ltg,HVACR,Other)	Lighting	HVAC/R	Other	Total
Tier 1	11 (7,4,8)	17.5	14.0	46.2	77.7
Tier 2	20 (5,5,10)	9.8	9.5	22.1	41.4
Tier 3	20 (6,7,7)	2.0	1.3	2.6	5.9
Total	51	29.2	24.8	70.9	125.0

Exhibit 2-4
Actual Electric Impact Evaluation Sample Completed – Number of Customers

	End Use			
kWh Strata	Lighting	HVAC/R	Other	Total
Tier 1	2	2	2	6
Tier 2	7	6	7	20
Tier 3	4	6	4	14
Total	**13**	**14**	**13**	**40**

Note: 43 Evaluations were performed representing 40 customers.

Exhibit 2-5
Actual Electric Impact Evaluation Sample Completed – Sampled kWh Savings

	Sample Points	GWh Savings			
kWh Strata	Total (Ltg,HVACR,Other)	Lighting	HVAC/R	Other	Total
Tier 1	6 (2,2,2)	8.3	12.5	31.9	52.7
Tier 2	20 (6,5,9)	13.6	8.9	15.0	37.5
Tier 3	14 (4,6,4)	1.6	1.3	1.6	4.5
Total	40	23.5	22.7	48.5	94.7

Note kWh based on March 2003 Tracking data.

2.2 ESTIMATING EX POST ENERGY SAVINGS

The key steps involved in developing an overall savings estimate for the program are to:

- independently verify reported measure installation records,
- develop ex post estimates of the energy savings for each project in the sample, and
- apply those findings to the full participant population to obtain a complete estimate of program impacts.

Ex post impact experience with custom nonresidential projects shows that program effects cannot be reliably measured through a multi-customer regression analysis of billing data (an approach typically employed in ex post residential analysis and prescriptive commercial programs). In the past, evaluators have found that this is true due to the fact that custom sites are usually also large customers (typically using in excess of millions of kWh per year), and it is difficult to isolate program effects in the billing regression model because of the many site-specific changes that affect energy consumption (in addition to program changes). For this reason, we adopted the approach used in the previous evaluation protocols and primarily relied on application review, on-site data collection, engineering analyses, and limited (mostly spot) measurements to produce ex post gross impact estimates. However, for some projects that had been completed several months before our evaluation, we did use individual customer pre- and post-retrofit billing records to verify calculated impacts.

This study's approach to the impact analysis consists of a distinct set of steps that are listed below and discussed in the subsections that follow. These steps include:

- developing and implementing the sample design,
- obtaining the sample of SPC application files and associated documentation,
- reviewing the applications and preparing the ex post analysis plans,
- conducting the on-site data collection,
- conducting site-specific verification and developing the ex post impact estimates for each site,
- preparing detailed, site-specific documentation for the ex post sample,
- carrying out a quality control review of the ex post impact estimates and implementing any necessary revisions, and
- extrapolating the final ex post estimates for the sample to the remaining applications.

2.3 IMPACT APPROACH OVERVIEW

For the sampled participant sites, the engineering analysis methods used for each evaluation varied from application to application, depending on the measures covered, the availability of additional data, and the application-based calculations submitted. These projects are individually designed and implemented because a diverse mix of end-use technologies and applications is found across the participant population.

A multi-step process was performed, covering verification and engineering-based calculations supporting each application review. The first step was to obtain and review selected application forms and develop site-specific analysis plans and field data collection plans, targeted to gather missing information or verify application information. This step was followed by an on-site audit to complete the data collection for site characteristics, plant and equipment specifications, measure(s) installed and the operation strategy for applicable equipment. Utilizing the information gathered from the application documentation and site visits, we completed an impact evaluation of the energy and demand savings associated with the target end use for each site in the sample. This evaluation was then documented and submitted for quality control review. The final site-specific evaluation results were then extrapolated to the program population using the ratio estimation method referenced below.

Obtain Sample SPC Application Records

Once the sample was drawn, QC submitted a formal data request to each utility for application records, including verification records and transactions. Once those documents were received, the engineer assigned to each application conducted an initial review. This was used to assess the need for additional documentation that could be obtained from the utility or its third-party program implementation contractor.

Review Applications and Prepare Analysis Plans

For each selected application, we performed an in-depth application review to assess the engineering methods, parameters and assumptions used to generate all adjusted ex-ante impact estimates. Application review served to familiarize the assigned engineer with the gross impact approach applied in the ex ante calculations. This also allowed an assessment of the additional data needs that were required to complete each analysis and the likely sources for obtaining those analytic inputs. Data sources included third-party SPC program implementers, EESPs that participated in a given project, and several on-site sources, including interviews completed at the time of the on-site, visual inspection of the systems and equipment, EMS data downloads and spot measurements. In addition, results of the in-program[9] verification efforts were examined.

Each review included a formal analysis plan that was submitted to the impact project manager. This plan outlined the general ex post impact approach (which may or may not differ from the approach used in each SPC application) and identified calculations necessary to complete the evaluation. The analysis plan specified what data was required to be collected during the site visit.

The ex post methods applied varied in complexity from applications that required an entirely new approach, to those that required an independent calculation using the application-based approach, and finally to those that simply required a careful review and verification of the methods and inputs in the ex-ante calculations.

Conduct On-Site Data Collection

On-site audits were completed for 40 of the customers sampled. The engineer assigned to each job called to set up an appointment with the customer. During the on-site audit, data identified in the analysis plan was collected, including monitoring records (such as instantaneous spot watt measurements for chillers or other installed equipment, measured condensate temperatures, data from chiller logs, and energy management system (EMS) downloads), equipment nameplate data, system operation sequences and operating schedules, and, of course, a careful description of the baseline condition being modeled.

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[9] We use the term "in-program" to differentiate measurement and other activities conducted by the program administrators and their technical support contractors as opposed to related activities conducted by the evaluation team.

The on-site audit consisted of a combination of interviewing and taking measurements when appropriate and possible. During the interview, the QC team engineer met with a building representative who is knowledgeable about the site's equipment and operation, and asked a series of questions regarding such matters as operating schedules, location of equipment, and equipment operating practices. Following this interview, the engineer made a series of detailed observations and measurements of the building and equipment.

Conduct Site-Specific Verification and and Developing the Ex Post Impact Calculations

The application-based estimates of demand and energy impacts were examined and revised as necessary, based on the on-site data, application information, third-party implementer records and billing data when a billing analysis was used.

Calculations were performed at a variety of levels of complexity using methods that include bin models, application of ASHRAE methods and algorithms, and other specialized algorithms and models. In many instances ex post impact estimates were derived by utilizing a different approach from that used in the ex ante calculations. This is especially true for the Process and HVAC end uses. In other cases, the same methodology was employed but with data inputs that were based on findings from our site visits.

During the site visit, the engineer also verified that the proposed measures had been installed as detailed in the SPC application. In many cases this verification was limited to the specific measure or end use being evaluated. Detailed verification sheets for each site are included in Appendix B.

Site-Specific Analysis Documentation

Documentation is provided in Appendix A for each site included in the impact analysis. The documentation for each site includes the following elements:

- Measure Description
- Summary of Program Impact Calculations
- Comments on Program Impact Calculations
- Description of the Impact Evaluation Process
- Impact Evaluation Results
- Supporting Documentation

Quality Control Review

Two levels of quality control review were implemented for this impact evaluation. The first level of quality control occurred within the impact evaluation team. All sites were assigned to a lead senior engineer who conducted the initial impact estimates. Each site was then reviewed by a second senior engineer who did not work on the site directly. This peer-level review focused on the quality and clarity of the documentation and consistency and validity of the estimation methods. The second level of quality control occurred by submitting the draft site reports to the utilities and their SPC technical support contractors for review. This review was important because it sometimes revealed gaps in the project documentation files received by the Quantum team that were important to calculation of the realization rate (e.g., in a few cases, the ex ante values had changed since we had originally received them or more detailed data was received that was not included in the original files).

Estimate Impacts for Participant Population

Based on these 40 customers, engineering-based realization rates were derived at the strata and program end use levels (i.e., for the cells in the sampling matrix). The realization rate is defined as the ratio of ex post-to-ex ante impact. These realization rates are applied back to the remaining participant population by applying the realization rates from the sample to the population within each cell of the sampling matrix. The realization rates within a sampling cell are weighted by the size of the savings for each customer in the sampled cell. The realization rates are weighted across the sampling cells based on the ratio of the total savings for the population of participants in the cell to the entire program savings.[10]

[10] The overall program realization rate and confidence interval utilize the ratio-estimation methods documented in Chapter 13 – Sampling, page 358, of the TecMKT Works, 2004. *2002 Evaluation Framework Study*, prepared by TecMKT Works for Southern California Edison Company, June. http://www.calmac.org/publications/California_Evaluation_Framework_June_2004.pdf. In addition, the CPUC is currently undertaking a series of workshops to develop new evaluation protocols.

3. GROSS IMPACT RESULTS

In this chapter we present and discuss the overall results of the gross impact analysis. The results are first summarized on an unweighted basis by program end use (process/other, lighting, and HVAC). Anonymous site-specific results are included in summary tables. We then present weighted results for the entire program. Detailed site-specific project descriptions, ex ante methods, ex post methods, and ex post results are provided in Appendices A and B. We also provide a qualitative assessment of the level of documentation supporting the SPC ex ante calculations.

A description of the stages of program documentation is provided to facilitate understanding the references to these stages that follow. There are three stages of the project documented in the SPC application. These are briefly described as follows:

- **Application Submission**: The customer or project sponsor submits the SPC application and supporting savings calculations and documentation to the SPC Program administrator.

- **Application Review**: The SPC application is reviewed and savings calculations are adjusted, if necessary, and accepted by the SPC program administrator. An incentive offer is formalized at this stage.

- **Installation Report**: Following the installation, the SPC reviewer performs a site inspection to verify the installation and make adjustments, if necessary, to the energy and demand savings claim. The financial incentive is quantified and paid to the customer based on this assessment. In some cases the SPC program administrator required measurement (commonly referred to in the Program as "Measurement and Verification" or "M&V") of the savings for the project. In these cases, the financial incentive was based on the results of the measurement.

3.1 EX ANTE, EX POST UNWEIGHTED RESULTS BY END USE

In this subsection, we provide the following for each program end use:[11]

- summary of ex ante savings for sampled sites,

- summary of ex post savings estimates and gross realization rates for each sampled site, and

- weighted ex post realization rates.[12]

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[11] As noted in the sampling section, many projects contain measures from more than one end use. The end use with the largest energy savings in an application was assigned as the "primary end use" for assigning customers to the sampling cells.

Note that references to project savings and incentive payments for the sampled sites are based on the information the evaluation engineers obtained from the physical program files. In some cases these data may not match the data in the program tracking systems obtained from the utilities in March 2003 (which is the basis for the tables in Chapter 2 and the realization rates). Much of this difference is likely due to the fact that program files were obtained after the March 2003 data cut.

In a few cases we have set the realization rates to "NA". Realization rates noted as "NA" indicate that the realization rate was not evaluated (such as for therms where there are no gas savings), or that the evaluation was inconclusive. Inconclusive results include projects where we did not have enough time or resources to conclusively evaluate a project. This occurred a few times and generally because of project complexity and data uncertainties that only extensive pre- and post-monitoring would have been able to resolve.

Also note that in the individual end use subsections that follow we present only the *unweighted* average realization rates. Because each end use is made up of multiple sampling cells (which include project size as well as end use), *weighting is addressed separately from the end use discussion and is covered in Section 3.2*.

Process End Use

Sixteen projects classified under the process end use were evaluated in the sample. The energy savings and demand reduction approved at the *application review stage* for this end use in the sample were 44,329,104 kWh, 9,949 kW and 55,984 therms. A total financial incentive of $1,484,518 was offered for these projects.

A single site, Site 2, dominates the process end use group. This site accounts for 27,179,804 kWh of the ex ante savings for the process end use. Based on savings data in the sampled SPC applications, this equates to 81 percent of savings for the Tier 1 process cell in the sample, 61 percent of the process savings across all three tiers of the sample, 20 percent of all process savings for the program population, and 11 percent of the entire program savings. A $165,000 incentive was offered for this project.[13]

The revised energy savings approved by the program administrators as part of the *Installation Report* for the process end use were 47,393,894 kWh, 9,094 kW and 55,984 therms. A total incentive of $1,487,979 was paid for these projects.

Energy savings from the program Installation Report, this impact evaluation, and associated realization rates are shown in Exhibit 3-1 for the process end use sample. The realization rates for the kWh energy savings range widely from 0.38 to 1.56. The lowest kWh realization rate

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[12] Realization rates are developed for each site and the program as a whole and are defined as the ratio of program ex ante savings divided by the ex post savings estimated by the evaluation team.

[13] The incentive was capped at this figure because it is 50 percent of the project's cost, an order of magnitude below what would be calculated based on the $0.08 per kWh saved incentive for the process end use.

(0.38) and negative gas savings were estimated for the largest site, Site 2.[14] As discussed further in Section 3.2, which discusses overall program savings, the effect of this site on the *weighted* average realization rate is very significant.

The unweighted average realization rate for the process energy savings is 0.92. The realization rates for the demand kW range from 0.06 to 1.06.[15] The unweighted average realization rate for the process demand savings is 0.78.

A few of the other site-specific findings of interest for the process sample include the following:

- Site 9's kWh realization rate is 0.55. We found that the VFD's in this project were operating at a much higher speed than expected in the ex ante calculations but that there were also kW reductions that were not claimed ex ante.

- Site 12's kWh realization rate is 1.5. We found that the reviewer did not allow savings associated with turning off one compressor because they felt it was mostly associated with fixing leaks in the compressed air system. However, the demand kW realization rate was 0.06 because the majority of the compressed air system does not operate during peak demand hours.

- Site 13's kWh realization rate is low (0.38) because the reduction in compressed air demand was found to be substantially less than estimated in the Ex ante calculations.

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[14] Site 2 involves an industrial process modification that includes the installation of natural gas fired equipment, which contributes strongly to the reduction in electric energy. The program did not account for the increase in natural gas usage at the site, which the evaluation team estimates was in excess of 800,000 therms annually. Because the study scope and sampling design did not include development of a program-level realization for gas savings, the increase in gas usage associated with Site 2 is not accounted for in the program-level results presented in Section 3.2. Other issues related to this site are discussed in Section 5 of this report.

[15] The core objective of this impact evaluation was to develop realization rates for annual energy savings; realization rates for peak demand were a secondary objective given the study scope. This was because developing defensible realization rates for peak demand usually requires more extensive sub-metering to determine peak coincidence. Many of the peak kW realization rates are shown as "N/A" in the following tables because, absent the use of longer term sub-metering, the ex post analysis was unable to determine peak coincidence. In Section 6, we recommend that the scope of future SPC impact evaluations be increased to include increased measurement to support development of peak kW realization rates.

Exhibit 3-1
Summary of Ex Ante and Ex Post Savings
Process End Use

Site	Tier	Ex Ante Savings			Ex Post Savings			Realization Rate		
		kW	kWh	therms	kW	kWh	therms	kW	kWh	therms
1	1	748	6,552,480	-	748	6,552,480	-	1.00	1.00	NA
2	1	6,295	27,179,804	-	2,413	10,419,220	(801,999)	0.38	0.38	NA
3	2	-	1,261,472	-	NA	1,971,839	-	NA	1.56	NA
4	2	34	296,795	-	36	315,495	-	1.06	1.06	NA
5	2	441	1,344,010	-	NA	1,171,824	-	NA	0.87	NA
6	2	161	1,392,687	-	161	1,392,687	-	1.00	1.00	NA
7	2	-	1,606,816	49,424	NA	1,212,380	133,343	NA	0.76	2.70
8	2	315	1,984,241	-	315	2,406,814	-	1.00	1.21	NA
9	2	-	1,137,659	-	NA	627,217	-	NA	0.55	NA
10	2	132	1,151,029	-	132	1,151,029	-	1.00	1.00	NA
11	2	154	1,441,615	-	154	1,441,615	-	1.00	1.00	NA
12	2	608	695,462	-	40	1,050,349	-	0.06	1.51	NA
13	3	199	1,004,422	-	95	377,659	-	0.48	0.38	NA
14	3	-	12,068	6,560	NA	12,068	9,646	NA	1.00	1.47
15	3	7	133,900	-	11	92,362	-	0.77	0.63	NA
16	3	-	199,434	-	NA	172,569	-	NA	0.87	NA
Average		568	2,962,118	3,499	411	1,897,975	(41,188)	0.78	0.92	2.09

1. Realization Rates noted as "NA" indicate that the realization rate was not evaluated or that the evaluation was inconclusive.
2. A dash " - " indicates that no savings was claimed.
3. Installation report not available for site 3. Ex ante kWh is based on SPC tracking system data.

Lighting End Use

Thirteen projects classified under the lighting end use were evaluated in the sample. The energy savings approved at the application review stage for this end use was 14,396,364 kWh, 1,939 kW and 0 therms. A total incentive of $703,300 was offered for these projects. Economic data was not available for two of the projects.

The revised energy savings approved by the program administrators as part of the Installation Report for the lighting end use were 19,107,626 kWh, 2,461 kW and 0 therms. A total incentive of $520,261 was paid for these projects.

Energy savings from the program Installation Report, this impact evaluation, and associated realization rates are shown in Exhibit 3-2 for the lighting end use sample. The realization rates for the kWh energy savings range from 0.70 to 1.25. The unweighted average realization rate for the lighting energy savings is 0.94. The realization rates for the demand kW range from 0.38 to 4.90. The unweighted average realization rate for the lighting demand reduction is 1.32.

Site-specific findings of interest for the lighting sample include the following:

- Site 17's kWh realization rate is 1.25. The ex ante calculation applied the same savings estimate to all areas for the lighting control system based on SPC guidelines. We found that the savings associated with the lighting control system were higher because many areas had higher reduction of operating hours than estimated in the ex ante calculations.

- Site 24's kWh realization is 0.86. We found that the lighting control system did not reduce the lighting hours of operation as much as expected in the ex ante calculations. Demand savings were associated with other measures at a site that was not visited. The demand realization rate was set to "NA" since it was not evaluated.

- Site 25's kWh realization rate is 0.7. We found that the lighting hours of operation were not reduced as much as expected in the ex ante calculations. The demand kW realization rate was 4.9. This is primarily because the ex ante calculations did not account for demand savings associated with the lighting controls. We found a 30 percent demand savings for this measure based on 53 days of measurement.

- Site 28 is a large and complex facility. Billing analysis indicated that no savings were realized. We felt that an accurate assessment of savings would require significant time on site. We set the realization rate to "NA" because we felt the evaluation was inconclusive.

Exhibit 3-2
Summary of Ex Ante and Ex Post Savings
Lighting End Use

		Ex Ante Savings			Ex Post Savings			Realization Rate		
Site	Tier	kW	kWh	therms	kW	kWh	therms	kW	kWh	therms
17	1	302	2,848,907	-	314	3,562,423	-	1.04	1.25	NA
18	1	252	845,310	-	252	845,310	-	1.00	1.00	NA
19	1	574	6,207,958	-	544	4,421,786	-	0.95	0.71	NA
20	2	93	920,756	-	93	811,039	-	1.00	0.88	NA
21	2	147	1,639,391	-	147	1,664,846	-	1.00	1.02	NA
22	2	136	1,379,673	-	164	1,302,522	-	1.20	0.94	NA
23	2	290	1,039,687	-	294	932,979	-	1.01	0.90	NA
24	2	208	1,201,354	-	NA	1,027,892	-	NA	0.86	NA
25	2	11	1,248,216	-	55	878,712	-	4.90	0.70	NA
26	3	3	279,484	-	3	268,267	-	1.00	0.96	NA
27	3	302	542,959	-	115	542,959	-	0.38	1.00	NA
28	3	109	826,210	-	NA	NA	-	NA	NA	NA
29	3	34	127,721	-	34	127,721	-	1.00	1.00	NA
Average		189	1,469,817	-	183	1,365,538	-	1.32	0.94	NA

1. Realization Rates noted as "NA" indicate that the realization rate was not evaluated or that the evaluation was inconclusive.
2. A dash " - " indicates that no savings was claimed.

HVAC End Use

Fourteen projects classified under the HVAC end use were evaluated in the sample. The energy savings approved at the application review stage for the HVAC end use were 13,062,784 kWh, 2,299 kW and 0 therms. A total incentive of $1,294,548 was offered for these projects.

The revised energy savings approved by the program administrators as part of the Installation Report for the HVAC end use were 17,180,897 kWh, 2,424 kW and 0 therms. A total incentive of $1,559,197 was paid for these projects.

Energy savings from the program Installation Report, this impact evaluation, and associated realization rates are shown in Exhibit 3-3 for the HVAC end use sample. The realization rates for the kWh energy use range from 0.05 to 1.36. The unweighted average realization rate for the HVAC energy savings is 0.89. The realization rates for the demand kW range from negative 0.62 to 1.30. The unweighted average realization rate for the HVAC demand reduction is 0.74

Site-specific findings of interest for the HVAC sample include the following:

- Site 30's kWh realization rate is 0.68. We re-calculated the energy savings based on the measurement data submitted by the customer and found that the energy savings and demand reductions were less than approved in the installation report. We could not account for the discrepancy. If the ex ante calculations had correctly used the data submitted by the customer the realization rates would have been 1.00 for kWh savings and kW reduction.

- Site 31's realization rates were set to "NA". We have serious reservations about the energy savings claim for this complex refrigeration retrofit project. We identified many discrepancies and irregularities in the application documentation. The resources necessary to resolve these uncertainties and definitively estimate savings were beyond those available for this site.

- Site 33's kWh realization rate was 0.05. We concluded that the energy savings had been significantly over-estimated, and were based on the project sponsor's assumption that a direct digital control system is significantly more efficient than a pneumatic control system.

- Site 37's kWh realization rate was 1.36. We found that the reviewer had substantially (and inappropriately) reduced the calculated savings estimate to match the maximum incentive offered for this project (rather than capping the incentive and keeping the correct kWh in the project file and program database).

- Site 38's realization rates were also set to "NA". We performed a billing analysis for the project, and our results were inconclusive.

Exhibit 3-3
Summary of Ex Ante and Ex Post Savings
HVAC End Use

Site	Tier	Ex Ante Savings			Ex Post Savings			Realization Rate		
		kW	kWh	therms	kW	kWh	therms	kW	kWh	therms
30	1	404	2,761,327	-	236	1,889,360	-	0.58	0.68	NA
31	1	436	5,529,659	-	NA	NA	-	NA	NA	NA
32	1	-	566,820	-	NA	802,995	-	NA	1.42	NA
33	2	-	292,801	-	-	15,843	-	NA	0.05	NA
34	2	-	1,334,761	-	-	1,061,811	-	NA	0.80	NA
35	2	211	1,506,673	-	157	1,190,125	-	0.75	0.79	NA
36	2	145	1,279,542	-	119	1,038,097	-	0.82	0.82	NA
37	2	1,106	2,698,698	-	1,300	3,667,313	-	1.18	1.36	NA
38	3	-	35,090	-	-	NA	-	NA	NA	NA
39	3	3	55,701	-	3	68,705	-	1.30	1.20	NA
40	3	-	99,591	-	-	99,591	-	NA	1.00	NA
41	3	3.7	125,566	-	4.4	150,679	-	1.20	1.20	NA
42	3	-	237,353	-	-	212,720	-	NA	0.90	NA
43	3	116	657,315	-	(73)	321,408	-	-0.62	0.49	NA
Average		173	1,227,207	-	146	876,554	-	0.74	0.89	NA

1. Realization Rates noted as "NA" indicate that the realization rate was not evaluated or that the evaluation was inconclusive.
2. A dash " - " indicates that no savings was claimed.

3.2 OVERALL PROGRAM REALIZATION RATES

The unweighted average kWh realization rates are very consistent across end uses, ranging from 0.89 to 0.94, with an unweighted average value of 0.92 for all end uses. This indicates that the ex ante savings estimates were reasonably conservative on average across projects. However, there was a wide range of realization rates and because of low realization rate for Site 2 and a few other large sites, the overall weighted realization rate for the program is lower than the unweighted average, as discussed below.

To produce the overall program realization rate, the individual realization rates for each of the sample points are weighted by the size of the savings associated with the project and the proportion of the total program savings represented by each sampling cell. The population weights are based on the tracking data obtained in March 2003. The weighting for the overall realization rate was adjusted for two factors. First, because Tier 1 had so few sample points in each end use, Tier 1 and Tier 2 are collapsed by end use for the final weighting. Second, because Site 2 is so large compared to the rest of the sites, representing 10 percent of the population tracking savings, and is a unique process system, Site 2 is treated as its own tier. Site 2 clearly stands out as an extreme outlier in the analysis as shown in Exhibits 3-4 and 3-5, which present the ex ante and ex post savings for the sample with and without Site 2 included. As shown in the exhibits, the correlation between the ex ante and ex post estimates is high without Site 2 included, but quite low when it is included.

Exhibit 3-4
Correlation of Ex Ante and Ex Post Savings (kWh) with Site 2

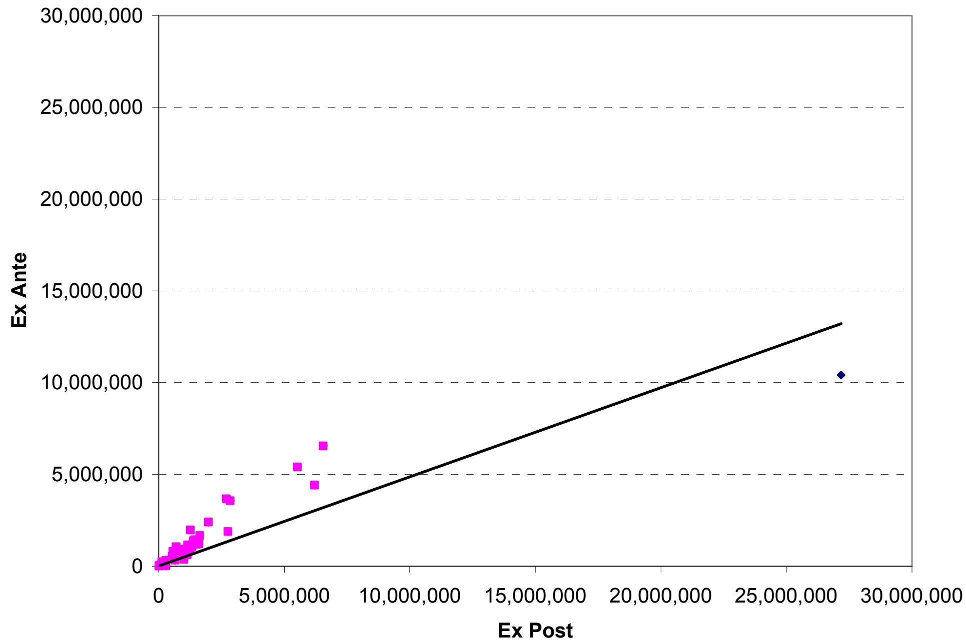
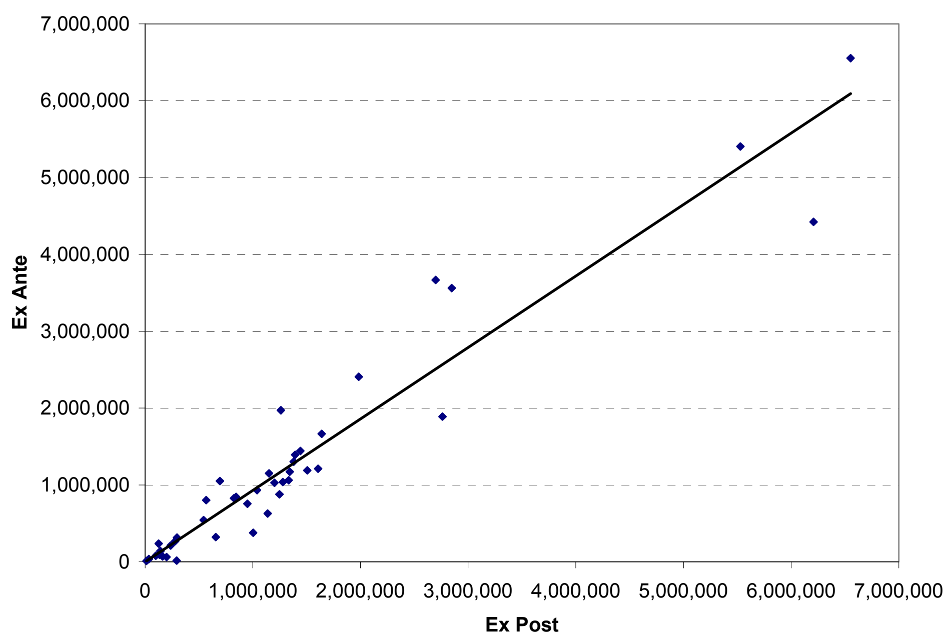


Exhibit 3-5
Correlation of Ex Ante and Ex Post Savings (kWh) without Site 2



The realization rates in the final cells used for the weighting and extrapolation to the program population, as well as the overall weighted program realization rate and the associated confidence interval are show in Exhibit 3-6. Note that the three sites for which the analysis was inconclusive (the "NA" sites discussed in the previous section) are excluded from the calculation of the program realization rate (i.e., they are not defaulted to realization rates of 1.0). The overall weighted realization rate is 0.79. The weighted average realization rate is the primary result of interest since it captures the relative contribution of different sized projects and end uses to overall program savings. The weighted realization rate is lower than the unweighted realization rate because of lower realization rates for Site 2 and the Tier 3 process end use. As discussed in the Findings and Recommendations sections of this report, this underscores the importance of focusing extra analytical resources and attention on the very largest projects in the program. Given that the program recently shifted from a primarily measurement-based program to a program that uses primarily engineering calculations to estimate savings, the fact that there is also uncertainty in the ex post results (see discussion below), and that this is the first impact evaluation feedback for the calculated SPC program model, the overall realization rate is reasonably high.

The 90 percent confidence interval for the 0.79 overall program realization rate is 0.73 to 0.85. Note that the confidence interval does not capture any of the uncertainty in the ex post savings estimate. The confidence interval only captures the effect of the variation in the ex post to ex ante ratio of the sample with a finite population factor correction that reflects the population of program participants. That is, it is as if the ex post values were known precisely without measurement error. This approach used to develop the confidence interval is consistent with the requirements of the CADMAC evaluation protocols (and the methods described the Evaluation Framework Study) and is constrained by the practical limitations associated with aggregating results from complex, site-specific projects that use a variety of estimation approaches.[16] Nonetheless, as discussed in Chapter 1 and elsewhere in this report, it is important to keep in mind that the ex post savings themselves are also estimates that can have considerable uncertainty which is not captured in the reported confidence interval for the program realization rate.[17] It is likely that the confidence interval would be considerably wider if the uncertainty in the ex post estimates could be statistically quantified.

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[16] If statistical methods such as regression analysis were used on every site, it would be possible to calculate a confidence interval around each of the ex post savings estimates and incorporate this uncertainty into the confidence interval for the overall program realization rate. However, statistical methods are not used on all sites and, as a result, only judgmental estimates of uncertainty are available for some cases. With additional resources, statistical methods (including increased monitoring efforts) could be utilized on more sites in future evaluations; however, the site-specific aspects of the SPC program make it unlikely that a complete quantitative roll-up of site-level uncertainty could be achieved. Nonetheless, this is an important issue that should be investigated further in future SPC evaluations, particularly, when additional resources are available for ex post monitoring activities.

[17] For example, the realization rate for Site 2 is based on a regression analysis of the customer's monthly energy consumption and production levels. Even though the regression analysis had a high R-Squared of 0.98, the confidence interval around Site 2's 0.4 electric realization rate was quite wide (approximately 0.1 to 0.7). This is because the savings are only 4 percent of the annual bill for this customer and because the sample size of 17 months of data for the regression is relatively small. The range of uncertainty for this site would probably be much narrower if pre- and post-submetering had been performed rather than having to rely on aggregate electric and gas bills. (Recall that this site also had a negative gas savings, i.e., increase in gas consumption. Incorporation of the negative gas savings into a total energy realization rate for this site produces a total energy realization rate for the site of 0.13, with a 90 percent confidence interval of –0.13 to 0.39.)

Exhibit 3-6
Overall SPC Program Realization Rate and by Tier

Sampling Strata	Lighting	HVAC/R	Process/Other
Tier 0 (Site 02)	--	--	0.38
Tier 1 & 2 Combined	0.89	0.93	1.02
Tier 3	0.99	0.73	0.48

Total Weighted Program Realization Rate	0.79
90 Percent Confidence Interval	0.73 to 0.85

4. FREE RIDERSHIP RESULTS

This section presents the results of estimated free-ridership for the 2002 SPC program. The free ridership data can be used to provide an estimate of the percentage of the immediate, gross first-year savings that would have occurred in the absence of the program. The method used to calculate free ridership is based on self-reported information provided in response to a battery of questions included in telephone surveys conducted with participating customers that address:

- Significance of program incentives on decision to install measures
- Significance of any third-party assistance on decision to install measures
- Likelihood of installing high-efficiency measures in absence of the program
- Estimated time period for installation in absence of the program

In order to develop net-of-free-ridership[18] estimates, customer responses to the battery of questions are converted to numeric values, which we refer to as net-of-free-ridership values (NFRV). Detailed net-of-free-ridership ratios are then calculated for each site included in the analysis. Note that this method has been used extensively as part of previous utility program impact evaluation for programs that require site-specific free ridership and net-to-gross (NTGR) calculations and are consistent with the CADMAC impact evaluation protocols.[19] The results are weighted and adjusted for spillover and self-report bias in order to establish the program NTGR.[20]

General results from the battery of questions used in the free-ridership and net-to-gross analyses are presented in the process and market evaluation report dated March 2004 and published separately, as well as the complete survey instruments.[21]

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[18] Note that we differentiate net-of-free-ridership from net-to-gross. Net-of-free-ridership values account for only free ridership-related effects. Net-to-gross incorporates both free ridership and spillover.

[19] For a discussion of issues related to estimating net-to-gross ratios and free ridership using participant self-reports see *Quality Assurance Guidelines for Statistical, Engineering, and Self-Report Methods for Estimating DSM Impacts*, prepared for the California Demand Side Management Measurement Advisory Committee: The Subcommittee on Modeling Standards for End Use Consumption and Load Impact Models, April 1998. See also CADMAC evaluation protocols at http://www.calmac.org/cadmac-protocols.asp

[20] For more information on the methodology used to adjust for spillover and self-report bias to establish net-to-gross ratios for the SPC program, see XENERGY, 2001. *Improving the Standard Performance Contracting Program: An Examination of the Historical Evidence and Directions for the Future*. Note that although this report recommends a small adjustment for the potential downward bias in the self-report method, it does not recommend that an alternative approach be employed for large nonresidential site evaluations (because alternative methods have more significant limitations for these types of projects).

[21] Quantum, 2004. http://www.calmac.org/publications/2002_SPC_Final_Report.pdf

Methodology Used to Calculate Net Savings

Initial net-of-free-ridership values were assigned on the basis of customer's responses to three questions: the *significance of Program incentives,* the significance of *EESP services* and *likelihood of installing anyway* questions.

Exhibit 4-1 presents the values assigned to the significance of program incentives and EESP services in the 2002 results.[22]

Exhibit 4-1
Assignment of Net-of-Free-Ridership Values for Significance of Program

Significance	Assigned Value	Significance of Incentive (n=36)	Significance of EESP Services (n=21)
Extremely Significant	1.0	31%	39%
Very Significant	0.667	33%	36%
Somewhat Significant	0.333	22%	21%
Insignificant	0.0	14%	4%

We defined the program significance as being equal to the maximum value of the response to questions about the significance of incentives (survey question number PD6c) and significance of EESP services (PD6a). This value was then averaged with the value assigned to the likelihood of installing anyway question (PD7a), as shown in Exhibit 4-2, to create the initial net-of-free-ridership value, called NFRV1.

Exhibit 4-2
Assignment of Net-of-Free-Ridership Values for Likelihood of Installing in Absence of Program

Likelihood of Installing Anyway (PD7a)	Assigned Value	Percent (2002) (n=36)
Definitely Would Not Have Installed	1.0	14%
Probably Would Not Have Installed	0.667	17%
Probably Would Have Installed	0.333	44%
Definitely Would Have Installed	0.0	25%
Don't Know	-	-

Once NFRV1 was determined, each project was examined regarding the level of efficiency or number of measures the customer intended to install in the absence of the program, such as those cases where a customer said they would have installed equipment of lower efficiency or

[22] For the entire battery of questions used in the free-ridership calculations, we allowed multiple responses for those customers who had more than one project under the 2002 NRSPC. In cases where the responses were substantially different by project, the response by project was recorded. As a result, the total number of customer projects used to calculate the preliminary NFRV is 39.

installed high-efficiency equipment at fewer sites (PD8 or PD9a). The adjustment ranged from 0.0 to +0.2. Adjustments were then added to NFRV1 to create the second ratio, called NFRV2.

Next, the issue of deferred free-ridership was considered. Responses to the timing questions (PD8b or PD9b) were translated, using the conversion table in Exhibit 4-3, into NFRV3.

Exhibit 4-3
Forecasted Installation Conversion

Forecasted Installation of Same Equipment (PD8b or PD9b)	Assigned Value	Percent (2002) (n=38)
At the same time	0.0	52%
Six months to one year	0.063	10%
1 to 2 years	0.25	16%
2 to 3 years	0.5	13%
3 to 4 years	0.75	-
4 or more years	1.0	-
Never	1.0	10%
Don't know	-	-

Lastly, NFRV2 and NFRV3 were averaged to create the final NFRV. In addition, all cases of inconsistency or response discrepancy as well as all large projects were reviewed to ensure that the final net-of-free-ridership values were as accurate and reliable as possible. Minor adjustments, if necessary, were made based on other responses in the net-to-gross sequence.

Estimate the 2002 Free Ridership

The preliminary unweighted average net-of-free-ridership value for the 2002 SPC sample is 0.45, representing 39 distinct projects. The range of values calculated across the sampled customers for 2002 is shown in Exhibit 4-4. The free-ridership estimates were then weighted to more accurately reflect the participant population as a whole. The weighting was done to adjust for the effect of the energy savings for different projects and the sampling stratification presented in Section 2; projects with higher kWh savings received heavier weighting, projects with lower kWh savings were weighted less. For the 2002 SPC, the weighted net-of-free-ridership value is also 0.45. The 2002 value is compared to the estimated values from previous evaluations in Exhibit 4-5. As shown in the Exhibit, these estimated net-of-free-ridership values have varied somewhat throughout the history of the program but have generally ranged around 0.5. The lower value for 2002 may be attributable to the fact that the program was subscribed almost immediately by projects that may have been strongly influenced by the 2001 energy crisis. As discussed in our process evaluation report, energy efficiency service providers stated that the fact that the SPC had been fully subscribed early in the program year (for PY2000 through PY2002), led them to de-emphasize its importance in selling projects to customers.[23]

[23] See Quantum 2004 and other previous SPC evaluation reports for discussion of the reasons for free ridership as well as the issues associated with the estimation process.

Exhibit 4-4
Range of Preliminary Net-of-Free-Ridership Values across Sampled Customers/Projects

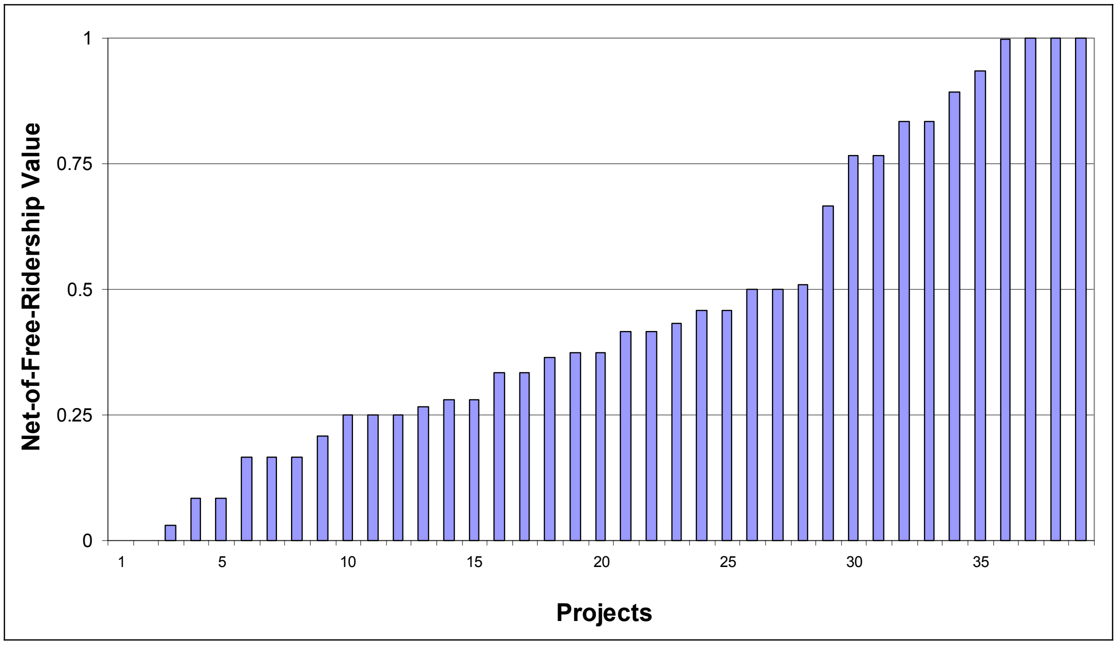

Exhibit 4-5
Net of Free-Ridership Ratios, 1998-2002

(1 – Free Ridership)	1998	1999	2000	2001	2002
Weighted	0.53*	0.51	0.41	0.65	0.45
Unweighted	0.49	0.48	0.46	0.55	0.45

*Weighted by incentives rather than by kWh savings.

Calculate the Net-to-Gross Ratio for the SPC

In order to covert the weighted net-of-free-ridership values into a net-to-gross ratio for the program, we adjusted for self-report bias and spillover. A study conducted by XENERGY on behalf of Southern California Edison examined the historical performance of the Standard Performance Contracting Program over time and recommended these adjustments to correct for biases inherent in the calculation methods used.[24]

[24] XENERGY, 2001b.

- **Self Report Bias.** The study found that there appears to be a downward bias associated with using the self-report approach and recommended a minimum upward adjustment of 0.10 to account for bias in the self-report technique.

- **Spillover.** For purposes of this report, spillover is defined as any additional energy efficiency measures installed as a result of the program, but which did not receive program incentives. The XENERGY study found that spillover has not been fully addressed in past evaluations or in the M&E protocols and recommended a minimum upward adjustment of 0.05 in cases where spillover could not be calculated directly. Note that the 0.05 adjustment was estimated based on answers to questions asked of participants in previous SPC evaluations and only accounts for *participant* spillover. Non-participant spillover has never been estimated for SPC and could be much more significant.

Using the minimum adjustments recommended in the XENERGY report we adjusted the net-of-free-ridership value of 0.45to estimate the net-to-gross ratio the 2002 SPC as shown below:

Weighted Net-of-Free-Ridership Value	0.45
Adjustment to Account for Self-Report Bias	+ 0.10
Adjustment to Account for Spillover	+ 0.05
2002 SPC Net-to-Gross Ratio	**= 0.60**

The estimated 2002 NTGR of 0.6 is somewhat lower than the value of 0.7 adopted by the CPUC in the *Energy Efficiency Policy Manual* but within the range of values estimated for previous program years. As noted above, the value adopted in the policy manual was based on the analysis of the first four years of the program. Given the uncertainty in these estimates and year-to-year fluctuations, we do not believe that the current results warrant a change in the CPUC's adopted value of 0.7 unless another multi-year analysis is conducted that includes results for 2003 through 2005.

5. KEY ISSUES

In this chapter, we present a discussion of some of the cross cutting issues identified in the review of the SPC applications and implementation of the impact evaluation, and we provide recommendations for improvement. We have divided this chapter into three sections. In the historical context section, we remind readers of the history of the SPC program and of the SPC evaluation, and how this history relates to the findings in this PY2002 Impact Evaluation. In the Application Quality section, we discuss issues related to the wide range of quality we found in our review, and we cite examples in the documentation for specific projects. In the Application Review section we offer observations on the review process itself. In the Recommendations section we provide suggestions for program designers and managers to consider that may help to improve the resource reliability of the program.

5.1 NONRESIDENTIAL SPC HISTORICAL CONTEXT

The purpose of this brief section is to put some of the evaluation findings in this report, including those in the remainder of this chapter, into a historical context that recognizes that the program has undergone significant changes throughout its history in response to market and evaluation feedback, as well as to changes in the CPUC's energy efficiency policy goals.

The findings that we present in the remainder of this section and Section 3 point toward the need for some moderate improvements in the rigor of application documentation, review quality, and energy savings estimation. In contrast, in the early years of the program the evaluation findings[25] concluded that application and energy savings measurement requirements were more stringent than necessary to ensure overall ratepayer value.

Over the five-year history of the SPC program, there has been an ongoing issue whether, and to what extent, savings should be measured rather than calculated. Another issue has been the extent of documentation required in application forms. In the first two years of the program, M&V was required on virtually all projects, and application documentation requirements were extremely detailed. However, the time, effort, and cost associated with measuring savings on every project became an issue in the 1998 and 1999 program year evaluations because of concern that measurement census was a conservative but possibly a sub-optimal approach due to its expense and the human resource requirements on the part of both the participants and program administrators. As a result, application documentation requirements were significantly reduced and, in PY2000, the utility program administrators introduced the *calculated* savings path. Under the calculated path, on-site verification of project installation remained a requirement but direct measurement of savings was replaced with engineering calculations made by or approved by the administrators. In PY2000 and PY2001, customers were offered the choice of whether to apply under the calculated path or the M&V path. Even though the M&V path paid a 10 percent incentive premium, most customers chose the calculated path. In PY2002, the calculated path became the default application path, with the

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[25] XENERGY, 1999. *Evaluation of the 1998 Nonresidential Standard Performance Contract Program*. XENERGY, 2001a. *1999 Nonresidential Large SPC Evaluation Study*.

administrators retaining the right to require the M&V path for projects they deemed too complex. For PG&E and SCE, program administrators estimated that roughly 90 percent of 2002 projects were on the calculated path, while for SDG&E the reported figure was roughly 50 percent.

In making these changes, the SPC Program managers acknowledged and recognized the limitations of energy savings calculations based on assumptions for custom projects, but intended that the program err strongly on the conservative side when reviewing, approving, or utilizing such assumptions.

Nonetheless, it does appear to the evaluation team that the program has over-corrected with respect to the extent of its reduction in measurement and energy savings application requirements. Some degree of over-correction is always a risk when programs make significant changes as they seek to improve. The program should be commended for its willingness to make significant changes over the years in response to evaluation findings, participant feedback, and program managers' own experiences running the program. It should also be noted that since this is the first ex post impact evaluation conducted on the SPC program since it changed from a mostly-measured to a mostly-calculated savings program, this is also the first time that the program has received independent feedback on the calculated energy savings estimates and the accompanying application documentation.

5.2 APPLICATION QUALITY ISSUES

This section discusses issues related to the quality of SPC project applications based on review by the evaluation team engineers for the 40 customers in the sample. We found that there are several examples of good documentation supported with credible calculations and a clear definition of the installed measures and their impact in the applications reviewed. At the same time, we also found that there are some sites where the supporting documentation is unclear or even non-existent. Suggestions to address the issues identified in this chapter are contained in the Recommendations chapter of the report.

Wide Range in the Quality of Applications and Supporting Documentation

During the impact evaluation process, we rated the quality of the calculations and documentation supporting the energy and demand savings (see Appendix A). There are numerous examples of applications that are well documented such as Sites 1, 8, 9, 15, and 19, 32, and 37. For these sites, we found clear descriptions of the proposed and installed energy saving measures, a comprehensible presentation of the energy savings calculations, and a verifiable description of the completed installation.

There are, however, some sites where the rationale of the proposed energy savings project is less clear, the supporting documentation poor, and the description of the verified installation difficult to follow. An example site that is in this category is Site 3. Site 3 is a comprehensive refrigeration retrofit project. A description of the proposed retrofit is provided, however, there is little detail on how these modifications will save energy and what process change or system modification will allow the customer to make set point changes proposed in the calculations. We found that the installed system was not what was described in the Application, and there was no update of the energy savings calculations to match the installed system.

We were able to identify several projects sponsored by energy-efficiency service providers (EESP). We found that documentation for these EESP projects was generally of a higher quality level than customer-sponsored applications, though our small sample size limits our ability to draw any conclusion on the mix. These EESP applications were clearer in their descriptions of the energy efficiency measures and were easier to comprehend. This clarity simplifies verification and impact evaluation, and gives a higher level of confidence in the results. Examples are Sites 13, 17, 18, 23, and 27.

Unverified and Undocumented Assumptions Used as Inputs for the Savings Calculations for Many Applications

In a number of cases we found assumptions for the program calculations were unverified and undocumented. Some of this may be attributable to the fact that the program is now based on calculated instead of measured savings and the fact that the program appropriately sought to decrease application costs and paperwork based on findings from the 1998 and 1999 SPC evaluations; however, as we discuss below and in Section 6 of this report, increased documentation of input assumptions for savings estimation is needed, particularly, for larger and more complex sites.

For lighting projects, the hours of operation are input into the SPC calculator. In most cases there is no documentation to substantiate the hours of operation. In some cases (Example Sites 24, 28, 29), customers provide a gross fixture count and do not differentiate hours of operation by area type. For instance, an open office area is likely to have different hours of operation than a conference room or a storage area. Hours of operation for lighting projects should be differentiated by area and specific fixtures should be clearly associated with specific areas.

Another example is compressed air projects. Many compressed air project energy savings calculations are based on an assumed load profile for the air compressors serving the compressed air system. The applicant assumes that compressor "X" will operate "Y" hours at Z% load before the modification, and then bases the calculations on reducing "Y" hours and/or "Z" load. Program savings estimates for these projects are completely based on unverified assumptions that can vary widely from site to site (rules of thumb and averages are typically not reliable for compressed air projects because of the wide range of site-specific variation). An example of this is Site 12. This Site can be contrasted to Sites 6 and 13 where pre-retrofit monitoring of the compressor energy use and load profile forms the basis of the savings calculations. We acknowledge it may not be cost effective to pre-measure all sites, but conducting such measurement on a sample weighted toward the largest projects would be helpful to improving ex post savings estimates.[26]

Some of the refrigeration system and chiller retrofit projects follow a similar pattern. An estimated average annual load point is used for the basis of the calculations. Examples are Sites 3, 36 and 43, where the customer estimated the average annual load upon which the savings calculations were based. There is no measured data to back up this load estimate, nor any discussion on how this load varies throughout the year.

[26] As discussed in the Recommendations section of this report, such pre-measurement could be carried out by an impact evaluation team rather than the program implementers.

Lack of Clarity About How a Proposed Project Will Save Energy

Some applications do not contain a clear description of how the proposed retrofit will reduce energy consumption. A clear description would allow for a precise review of the proposed retrofit and the pertinent parameters that require verification to assess the energy savings claim.

For example, the application for Site 33 details the installation of a direct digital control (DDC) system replacing pneumatic controls for an HVAC system. Claims about large increases in energy efficiency are made, but the mechanisms for how the savings were induced by the change are not documented and did not appear to be defensible. We concluded that the claimed savings were almost entirely unfounded.

In another example, in the savings calculations for Site 34, the application documentation assumes that a certain percent reduction in annual energy use is associated with each of several installed retrofit measures. There is no engineering basis for the calculations, just an assumed percent reduction in energy use.

5.3 APPLICATION REVIEW PROCESS ISSUES

Experience Level and Expertise of the Reviewer

Our observation is that there is a wide range in the experience level and expertise of the individuals reviewing the SPC applications at both the application review and installation review stages of the process. This is evident in the reports associated with each stage of the process. Some of the applications have very detailed reports including documented inquiries to the project sponsor requesting more precise information to support the application. Site 37 is an example of well-documented correspondence between the reviewer and the project sponsor.

However, in some cases the reviewers do not appear to have requested even the most basic information that would indicate a general understanding of the proposed project. Site 2 documents an industrial process modification that involves the installation of natural gas-fired equipment reducing the consumption of electric energy (see discussion in Section 3 under the Process end use). There is some documentation accounting for the increase in natural gas usage at the site but it is not included in the ex ante estimates, and ex post results indicate this amount is in excess of 800,000 therms annually. SPC Policy Manual Section 1.4.1 states that fuel-switching measures are ineligible. Although this case may be considered a judgment call, the project looks to the evaluation team like a fuel-switching project.[27]

Sites 12 and 23 contained errors involving three phase power calculations. These errors appear to be the result of carelessness and inadequate quality control. We recognize that the technical support contractors and utility administrators in the review process are working under budget constraints and that there is necessarily a mixture of expertise and experience levels working in the process. Nonetheless, efforts appear to be needed to raise the quality control floor on some

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[27] Note that we are not commenting on whether fuel switching should or should not be included in this program, or other energy efficiency programs for that matter; that question is not within the scope of this evaluation. We are simply noting that analysis of the increase in gas usage associated with the Site 2 project indicates that it appears to be fuel switching, and that the PY2002 program rules do not allow such projects.

applications. This may require improved internal management and oversight such as professional engineer signoff on every application. In addition, additional administrative resources may be needed to ensure that the proper level of engineering expertise is deployed for each project. (See Recommendations section for further discussion.)

Difficulty in Assessing Complex Industrial Process Projects

Related to experience level and expertise of the reviewer is a general observation that assessing the energy savings associated with industrial utility systems such as compressed air and large refrigeration or other industrial process systems is difficult even for experienced reviewers when there is no measurement and verification data upon which to base energy savings calculations.

Many of these systems are complex with several interactive components. Load profiles are often difficult to estimate, and in many cases are directly related to production outputs that may be difficult to quantify over long periods of time. Most of the industrial process retrofits share at least some of these characteristics. Measurement and verification requirements were relaxed in the 2002 program, resulting in a higher level of uncertainty for this group of projects.

As noted previously, we felt for impact evaluation purposes that 38 percent of the process end use sites (Sites 3, 4, 5, 6, 12 and 16) and 50 percent of the HVAC end use sites (Sites 30, 31, 33, 34, 35, 41 and 42) would have benefited from some or better pre-installation measurement. Most lighting end use sites also would benefit from better supporting documentation concerning the hours of operation for the lighting system.

Accurate Assessment of kW Demand Savings Requires Measurement

Estimating demand kW reduction is generally more complex than estimating annual energy savings. Accurate estimation of demand reduction usually requires that data must be collected and evaluated on an hourly basis. Rough estimates of demand reduction require little additional work, but if quantifying demand reduction is important, as we believe it is given the peak demand-related resource importance of energy efficiency programs, a more rigorous approach with a larger evaluation budget is necessary.[28]

Inconsistencies in Reporting Savings

We also noted that there were some inconsistencies in how savings were reported or incentives were set. For example, for Site 37, the approved energy savings were reduced by the reviewer to match the maximum incentive amount offered for the project, thereby under-reporting savings in the tracking system. In contrast, for Site 1, the reviewer approved the calculated savings, while the incentive was capped by the program rule at 50 percent of the capital cost of the project. Our interpretation is that Site 1 was reported in the correct way. Based on our review of the tracking database and analysis of the sampled applications, we believe that most

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[28] The statewide SPC evaluation planned for 2004-2005 provides significantly more resources for impact evaluation as compared to this PY2002 effort. Funding for evaluation of the 2003 SPC was about half of what it was for 2002, as is true for most other 2003 program evaluations.

projects made the adjustment correctly, that is, to the incentives, rather than adjusting the savings to match the payment.

In a limited number of projects we identified some inconsistencies in reporting the savings end use, which forms the basis of the level of the incentive payment. Savings end use is classified by the program administrator for each measure and entered into the tracking database. Sites 3, 4, 30 and 31 are all industrial refrigeration retrofits. Sites 3 and 4 are classified as "Process/other", Sites 30 and 31 are classified as "HVAC".

5.4 CONSTRAINTS AFFECTING THE IMPACT EVALUATION

Depending on the end use, we felt that for almost two-thirds of the sites, the evaluation team would have significantly benefited from the availability of additional time to perform more measurement and analysis. Ten of the 16 process end use sites, 8 of the 13 lighting end use sites and 8 of the 14 HVAC sites were identified as needing more time and resources. The average estimated additional time ranged from 24-36 hours per site, with only minor differences between end uses. The additional time is more than twice that budgeted and deployed for this study (approximately 24 hours per site). The estimated additional time needed is approximately the same as the amount of time per site that PG&E deployed for its protocol-era industrial impact evaluations.

For impact evaluation purposes, we felt that six (38 percent) of the process end use sites (Sites 3, 4, 5, 6, 12 and 16) and seven (50 percent) of the HVAC end use sites (Sites 30, 31, 33, 34, 35, 41 and 42) would have benefited from some or better pre-installation measurement. Most lighting end use sites also would benefit from better supporting documentation concerning the hours of operation for the lighting system.

Exhibit 5-1 summarizes by end use the percent of sites requiring more time for evaluation, the associated average hours required and the percent of sites that would benefit from pre-measurement.

Exhibit 5-1
Additional Hours for Impact Evaluation and
Sites Benefiting From Pre-Measurement

End Use	Impact Evaluation Additional Hours Required		Sites That Would Benefit From Premeasurement
	% Sites	Average Hours	
Process	63%	34	38%
Lighting	62%	26	50%
HVAC	57%	33	50%

Averages are unweighted.

5.5 FREE RIDERSHIP[29]

Estimates of free ridership for the SPC program for PY2002 are moderately high, as were free ridership estimates for most of the previous SPC program years and for industrial programs historically.[30] Of course, it is important to remember that both measuring and trying to reduce free ridership are two of the toughest issues in the energy efficiency field. Readers should recognize that we discuss this topic with the understanding that measuring free ridership is extremely difficult and that results can be highly uncertain. In addition, we recognize that it may be somewhat artificial and misleading to try to measure and isolate free ridership within the context of a single program year. This is because end users are affected not just by an individual program year in which they participate, but also by the effect of previous years of program interventions. Simply put, today's free rider may be yesterday's program-induced market effect.

Despite these uncertainties and difficulties, when public goods funds are limited, as they always will be, it remains important to try to maximize the net rather than the gross effects of program participation using the best available information to do so.

It is important that the free ridership issue be understood in context, not just for the SPC program, but also for all PGC efficiency programs. To appreciate this, we need to consider how free ridership has been addressed historically with respect to CPUC-regulated efficiency programs. Prior to 1998, utility administrators faced incentives and disincentives related to free ridership (and program spillover). Specifically, utility shareholder earnings in this period were tied to *net,* not *gross,* savings. In addition, programs were required to have *net,* not just *gross,* ex post impact evaluations. As a result, administrators saw direct financial consequences from ex post measurements of free ridership and spillover. Although this was not a perfect system, it did provide some direct financial motivation for trying to reduce free ridership.

Since 1998, however, net-to-gross ratios have been used for PGC programs on only an ex ante basis. In addition, neither impact evaluations nor ex post net-to-gross estimation have been required. The post-1998 process has certainly been a simpler one, and one that may have been suited to the context of rapidly changing and uncertain regulatory and market environments. Good program management does include targeting customers who would not have taken the recommended energy efficiency actions in the absence of the program. However, the post-1998 approach does not provide program implementers (utility or non-utility) with any direct financial reward for minimizing free ridership during a particular program year. In our judgment, the CPUC should investigate approaches to providing all program implementers with accurate and timely feedback on freeridership levels, and perhaps with more direct

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[29] This discussion was originally provided in the first PY2002 SPC process and market evaluation report, Quantum Consulting, 2004. It is repeated in this report now that the net-to-gross analysis has been completed.

[30] For example, an analysis of free ridership levels for California efficiency programs in the 1980s estimated an average free-ridership ratio of 0.5 for industrial incentive programs. See, Rufo, Michael, *An Investigation of Commercial and Industrial Utility Demand-Side Management Program Impacts*, Fourth International Energy Program Evaluation: Conservation and Resource Management Conference, Chicago, IL, August 23-25, 1989.

financial incentives to minimize free ridership and maximize net program effects (e.g., including spillover).[31]

The foregoing discussion is provided partly to remind readers that difficult issues associated with free ridership and program market effects (such as spillover) are not limited to the SPC program. Free ridership and market effects have been important issues associated with the SPC program because these issues were designed into each of the evaluations conducted for this program for the entire history of the program to date (Program Years 1998 through 2002). Free ridership, in particular, was estimated in these evaluations not because it was required from a regulatory perspective, but because the evaluation administrators and consultants believed it provided valuable insight that could be helpful to improving the program.[32] This proactive approach, although challenging, proved worthwhile in the long run.[33]

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[31] It is beyond the scope of this evaluation to discuss the variety of possible approaches to this and their associated pros and cons. Some of the issues associated with program evaluation are covered in TecMKT Works, 2004. *2002 Evaluation Framework Study*. In addition, the CPUC is in the process of developing new evaluation protocols.

[32] Note that over this same time period, very few program evaluations, to our knowledge, included formal estimation of free ridership across program years (Savings by Design being one of the exceptions).

[33] For example, the free ridership only net-to-gross ratio of 0.53 from the first evaluation of the SPC in 1998 was adopted by the CPUC as the ex ante net-to-gross ratio for the program, despite caveats in that evaluation that the self-reported method used to estimate free ridership may be biased and that potential spillover benefits were not estimated. An attempt was made to rectify this situation by conducting a multi-year analysis of free ridership that included assessment of the estimation method itself and spillover (see, XENERGY, 2001b). As a result of this expanded effort, the CPUC adopted a revised net-to-gross of 0.70 in the CPUC Energy Efficiency Policy Manual, Version 2, August 2003. Interestingly, most of the other net-to-gross ratios in the current Energy Efficiency Policy Manual have not been updated for five or more years because of the lack of recent studies that address this issue.

6. RECOMMENDATIONS

In this section we present our recommendations based on the results of the impact evaluation, net-to-gross, and related issues.[34] Ultimately the purpose behind these recommendations is to provide the utilities with targeted program enhancements that will lead to improved program performance and increased customer satisfaction.

6.1 APPLICATION QUALITY

Consider Targeted Increases in the Level of Technical Documentation Required, Particularly for the Largest, Most Complex Projects. We recognize the importance of keeping the application process and forms from being overly complex and costly to navigate, a key recommendation from the early program year evaluations. At the same time, it is important that the application documentation not be over-simplified. In particular, large complex projects should require more significant levels of site-specific application data than do other types of projects for several reasons: (a) the projects contribute disproportionately to total program savings; (b) the large incentive payments increase the temptation for gaming or even fraud; (c) measures implemented are often site- or industry-specific; (d) there may be many units in several locations, and (e) savings may be very sensitive to baseline conditions.

The current forms do require applicants to provide backup to support their engineering calculations. As appropriate and necessary, the utilities should increase the depth and quality of backup documentation applicants provide for large and complex projects. In some cases this may also require a detailed description on how a project saves energy for other than straightforward projects such as lighting, motors, and HVAC package units. For many complex projects there is usually some description of proposed system modifications, but we found scant description of how the proposed modifications will, in technical terms, reduce energy consumption. The utilities should also consider requiring a calculation to show savings as a percent of total baseline end use energy. This can serve as a flag for calculations with problems, and could be used to determine when a higher level of scrutiny should apply.

Consider a Stronger Affidavit Statement. Included in the current affidavit is a release of liability for injury, violation of law, energy savings shortfall, performance and qualifications of project sponsor, and agreement to permit inspection and measurement of the project. The utilities should consider an additional affidavit statement in the application concerning customer/sponsor-supplied information on operating hours and characteristics of equipment described in the application, such as, "The information provided in this application is true and accurate to the best of my knowledge." This might eliminate some gaming in the information provided by the project sponsors.

Further Standardize the Review Approach and Documentation Requirements for Recurring Complex Projects. The utilities have made efforts to standardize savings estimates for

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[34] Some of the recommendations presented in the section were developed in Quantum, 2005. *Energy Efficiency Best Practices Study - Large Nonresidential Comprehensive Incentives Programs.* www.eebestpractices.com .

measures addressed by the SPC calculator and provide guidance for complex measures such as compressed air, large refrigeration projects, etc. However, it appears that additional effort may be needed to increase the consistency of analyses required of applicants and carried out by program reviewers for these types of projects. This would include a more detailed and rigorous requirement for the supporting documentation and certain types of measurement (which could be carried out through the program evaluation function, if well coordinated).

Consider Providing or Requiring More Technical Support for Applicants for Complex Projects. It may be beneficial to offer or require technical consultant assistance to participants to prepare the required documentation for complex projects, particularly for initial submittals that do not meet the level of increased requirements recommended above.

6.2 APPLICATION REVIEW AND MEASUREMENT

Improve Reviewer Documentation. Require that reviewer calculations, which document the approved savings upon which the incentive is paid, be attached to the installation report. In some cases we found that documentation of energy savings was available for the approved application, but not for the final approved incentive which is usually based on the installation report. The basis of the incentive paid to the participant should be well documented. It is possible that reviewers have this information but that it is not always making its way clearly into the project application files.

Consider Increasing Conservatism for Calculated Path Savings Estimates; Increasing Measurement for Large Complex Projects; and Increasing the Incentive Premium for Measured Projects. As noted in Section 5, when the SPC program was shifted from a primarily measurement-based to a primarily calculation-based program, the SPC Program managers acknowledged and recognized the limitations of calculations for custom projects but intended that the program err strongly on the conservative side for these projects. The expected result of choosing to err strongly on the conservative side would be realization rates greater than 1.0 for calculated savings projects. However, as shown in Section 3, our estimated ex post realization rate is moderately below 1.0 (primarily because of the effect of lower than average realization rates for the largest site and most complex sites). Thus, the program may not be adequately implementing the program managers' intended conservative philosophy for the calculated savings projects. The program should consider making more conservative assumptions for the calculated projects. The program should also consider utilizing measurement more often for the largest and most complex projects (or having this function performed by the evaluation team). If calculated savings are made more conservative, consideration should also be given to increasing the payment difference between the calculated and measured projects (to provide an incentive for those projects that believe they can prove their savings are greater than would be allowed under the calculated path).

Consider Requiring Senior Engineer Sign Off for Complex Projects. Many SPC projects are very complex, especially in the industrial sector, and should only be handled by experienced, engineers, preferably professional engineers (P.E.). Some projects are of more moderate complexity and may not require a P.E. for lead review but should include a P.E. secondary review and for formal approval and sign off. The signature of the lead senior engineer during the application review could improve accountability for the approved savings. However, there could also be legal, and therefore cost, implications of requiring a P.E. signature ("stamp") because such a requirement could potentially obligate firms and individuals to carry professional design liability insurance.

Increase Pre-Installation Measurement for Very Large Projects with Highly Uncertain Baseline Conditions. Savings cannot be reliably estimated for some types of projects on purely an ex post basis. Pre-inspection and pre-installation measurements can significantly improve savings estimates for projects such as complex compressed air and industrial process retrofits. The program includes pre-inspection for all projects but only very limited amounts of pre-measurement. The amount of pre-measurement should be increased for large, complex measures that cannot otherwise be reliably quantified with only ex post data. Pre-installation measurement can be challenging in practice and burdensome to applicants. Care should be taken in this effort; in some cases, applicant installation schedules and other constraints may outweigh pre-measurement in importance. Either the program implementation or the evaluation team could perform these selected pre-measurements.

Consider Independent Review of the SPC Calculator. The SPC calculator was used for at least one measure in 40 percent of the applications reviewed. Considering its wide use, it seems prudent to have an independent or peer group evaluation of the SPC calculator; if such a review has not recently been performed. This could be done as part of the PY2004-2005 program evaluation. There also may be an opportunity to identify enhancements to the calculator tool that would increase the level of detail associated with the application process.

6.3 FREE RIDERSHIP[35]

Consider Additional Programmatic Efforts to Reduce Free Ridership. Within the context of the background provided in the Issues section of this report, we discuss some specific considerations for ways in which free ridership might be reduced for the SPC program. These suggestions are not offered as panaceas or without recognition that there are practical difficulties associated with each of them. With that in mind, some approaches to consider are discussed below.[36]

One approach to consider is increasing incentives for higher payback measures, particularly for emerging technologies**.** There is a philosophy held by some in the efficiency field that decreasing incentive levels over time is appropriate as a market transformation or exit strategy from a market. This approach was part of the policy environment for the SPC in its early years when the focus of the program was on market transformation.[37] For a specific efficiency technology, such as a T8 lamp, this approach can be effective if carried out with good market intelligence. For a program focused on comprehensive efficiency improvements, such as the SPC, this approach is more problematic and can actually exacerbate free ridership problems,

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[35] These recommendations were originally provided in the first PY2002 SPC evaluation report, Quantum, 2004, when the net-to-gross analysis was preliminary. They are repeated in this report now that the net-to-gross analysis has been completed.

[36] Note that a number of these suggestions were provided in previous SPC program year evaluations (see Section 7 – Sources).

[37] End Use incentives in 1998, in cents per kWh saved, were: Lighting 7.5; HVAC – 21; and Other – 11. In 2002, the values were: Lighting 5; HVAC – 14; and Other – 8.

particularly if the intent is not to exit the market. There is a point at which lowering incentive levels creates a token-level incentive that, although it may provide a halo effect, has limited effect on the financial decision making of end users. We have not concluded that the SPC incentive levels are necessarily at that low a level; however, particularly with lighting, one must consider that the incentives result in a payback reduction of only a half or third of a year, given the fully loaded retail rates end users currently face.

Like most of the free ridership issues discussed herein, this approach poses a dilemma: the CPUC does not want to pay too much for measures that have some risk of otherwise being adopted on their own, but neither should one pay so little that mostly free riders are attracted. For some measures in some market segments, it may be better to pay nothing than to pay a low incentive.[38] On the other hand, there may be some specific types of measures for which a higher incentive is well justified. In particular, we believe that certain emerging technologies, in the early stages of commercialization and with high impact and cost-effectiveness promise, may justify higher incentive levels than the SPC currently offers.[39]

Another approach to consider is a payback floor excluding projects for which the payback time is less than, say, one year. Project-specific investigation of free ridership for the SPC program also indicate that projects with extremely short payback periods are more likely to be free riders, all else being equal. Although it is certainly true that many customers do not adopt attractive efficiency projects with very low paybacks,[40] a payback floor can still be helpful, particularly if it is not set too high and if the administrator is allowed some flexibility in its application (see below). Several program administrators in other parts of the country have used payback floors effectively,[41] although such criteria present project cost verification challenges.

Another possibility is to provide an increased incentive or bonus to end users (not EESPs) that are first time participants in the SPC program. This may help to attract customers that tend to be laggards rather than leaders in their energy efficiency-related investment decisions. Alternatively, incentives could be decreased for projects that individual customers repeat in the program year after year; this would also encourage bigger projects (with larger savings) upfront.

The approaches discussed above are focused on trying to minimize free ridership through indirect programmatic rules and requirements. The advantages of such approaches are that the rules and requirements are codified and apply equally to all customers. Disadvantages of all of

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[38] The SPC does this, for example, with first generation T8 lighting systems, which no longer qualify for incentives.

[39] Automated perimeter dimming systems may be an example of such a case. In addition, there was some discussion and interest expressed in the CPUC's recent workshop on energy efficiency potential on approaches to improving and expanding the relationship between the CPUC's PIER program, the PGC-funded Emerging Technologies program, and other program efforts, such as the SPC.

[40] For example, it is well established that industrial end users often do not invest in compressed air projects with paybacks as low as one year or even less.

[41] For example, National Grid has a 1-year payback floor, while United Illuminating pays less for projects with paybacks of less than 1 year (5 cents per kWh saved) than for those with paybacks over 1 year (10 cents per kWh saved). Wisconsin Power & Light finances projects with bundled paybacks that average 4 or 5 years.

the approaches above are that they are all indirect attempts to minimize free ridership that are based on correlations between project characteristics and free ridership for which there are always exceptions.

Another approach is to allow the program administrators the flexibility to simply exclude projects from the program that they believe have a high probability of being free riders. Administrators in several other jurisdictions have used this; however, these are generally smaller service territories than those found in California.[42] In these cases, the administrator has the flexibility to determine total incentive amounts on a case-by-case basis, including zero incentives. While we do not yet recommend going to case-by-case incentive determination, we do believe consideration should be given to development of a process by which projects considered to be very high likelihood free riders could be excluded from participation. Such a process could require the involvement of an advisory group that includes staff from the CPUC. This would offer protection from claims that such exclusions were unfounded or unfair. Alternatively, or in conjunction with this type of approach, rules could be developed that exclude incentive payments for projects that are driven exclusively by non-energy factors that produce energy savings as a by-product, such as some naturally-occurring improvements in certain industrial processes.[43]

Finally, readers and policy makers should keep in mind that some free ridership is inevitable in energy efficiency programs - indeed in programs of all kinds. The presence of possible free riders should not be considered a reason, in and of itself, to reduce or eliminate program efforts but rather should be seen as something to be managed and minimized.

6.4 IMPACT EVALUATION RECOMMENDATIONS

Because this evaluation is the first independent, ex post impact evaluation of the SPC program, we have developed a few recommendations related to the evaluation process itself. These suggestions are presented below.

Shift Ex Post Impact Evaluations from a Program-Year to a Paid-Year Basis or a Combination of Both. Many PY2002 projects, particularly larger ones, took more than a year longer than the program installation deadline to complete installation. The due date for project installations was originally set for June 1, 2003. In our *PY2002 SPC Process and Market Evaluation* (March 2004) we discussed the implications of these delays on the program. Here we note that the long lag between participation and installation makes it extremely difficult to conduct an ex post impact evaluation based on program year. This PY2002 impact evaluation was delayed several times due to the lack of installed projects in our sample to evaluate. In most of the 1990s, impact evaluations were conducted on a paid year basis. This allowed the evaluation teams to conduct their work without delay since by definition all of the projects in the evaluation population and sample had been installed. The down side of paid-year evaluation is that the

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[42] Quantum, 2005.

[43] A related example is that of an oil pipeline that is expanded to increase revenue-generating throughput but which also results in per unit pumping savings due to reduced friction losses. The revenue-generating benefits of the project completely drive the decision, the energy savings are an unintended and naturally occurring by product of the decision.

projects may come from multiple calendar years and represent a changing mix of approaches over time. For SPC, a combination of paid year and program year may be best in the near term, at least until a significant body of ex post impact results is developed.

Increase the Scope to Expand Ex Post Measurement. As discussed in the Introduction to this report, we do not believe that the available resources for this impact evaluation were adequate given the size and complexity of the program. In particular, the current evaluation was not able to utilize ex post measurement as much as was desirable. In the future, if reliable ex post realization rates are desired for peak demand as well as energy, increased levels of measurement will be needed. In addition, the size of the sample used in the current study is not sufficient. We believe that either a larger percentage of projects should be required to follow the measurement path in the program or the impact evaluation should be expanded. The utilities' filed plan for the *2004-2005 Statewide SPC Measurement and Evaluation Study* proposes a significantly expanded impact evaluation scope. If an expanded impact evaluation approach is pursued, it will be important for the evaluation to be integrated into the program implementation process so that pre-installation measurements can be taken for complex projects.[44]

6.5 SUMMARY

The SPC Program has gone through several changes since its inception in 1998. Significant strides have been made to streamline the application process, standardize the calculation methodology, and simplify the review process and maintain confidence in the savings estimates associated with each application. There are a great number of highly qualified professionals engaged in various aspects of the Program who have worked hard to improve it. In this report, we have identified several important ways that energy savings estimates in this program might be further improved. Most of these changes should be relatively easy to address, resulting in an increase in the certainty of the program's resource value. Reducing free ridership is likely to be a more difficult challenge. These challenges not withstanding, the SPC fulfills a critically important role in the portfolio of nonresidential energy-efficiency programs by supporting complex and comprehensive energy-efficiency projects that offer large, and very cost-effective, energy savings and peak demand reductions that would otherwise not be captured through prescriptive approaches.

[44] The incorporation of evaluation measurement needs during program implementation is being carried in the Self-Generation program evaluation. It is also a planned component of the SDG&E's measurement for its non-residential energy efficiency procurement bidding program. Such an approach would select projects for pre-installation measurement as a function of the probable contribution of each project to the statistical variance associated with the overall estimate of program savings.

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A. QUALITATIVE ASSESSMENT OF EX ANTE CALCULATIONS AND SUPPORTING MATERIAL

As part of the review of project applications necessary to develop the ex post savings estimates for each site, we performed an assessment of (a) the "quality" of the calculations and (b) the "details" supporting the calculations contained in the SPC application. The ratings range from 1 (lowest) to 5 (highest). The purpose of these assessments was simply to ascertain whether there is a wide or narrow range of documentation and technical review quality associated with the SPC applications sampled.

For the process end use, the quality ratings for the calculations ranged from 2 to 4 with an average of 2.7. The detail ratings for the supporting documentation ranged from 1 to 4 with an average of 2.5. We found that unverified assumptions[45] were used in 12 of the 16 applications evaluated in the process sample. The use of unverified assumptions is discussed in more detail in Chapter 5. Measurement was required by the Program at 2 of the 16 process sites. The SPC calculator was used for two of the 16 process end use sites. Both of these sites were VFD applications.

For the lighting end use, the quality ratings ranged from 2 to 4 with an average of 3.1. The detail ratings ranged from 1 to 4 with an average of 2.9. We found that unverified assumptions that were primarily related to lighting hours of operation were used in all 13 applications. Measurement was not required at any site. The SPC calculator was used in 12 of the 13 lighting end use sites.

For the HVAC end use, the quality ratings ranged from 1 to 3 with an average of 2.4. The calculation detail ratings ranged from 1 to 3 with an average of 2.4. We found that unverified assumptions were used in 12 of the 14 HVAC applications. Measurement was by the Program required at two sites. The SPC calculator was used in three of the 14 HVAC end use sites.

Exhibit A-1 below, presents a summary of the results for all end uses. The lighting end use had the highest calculation quality and calculation detail ratings, 3.1 and 2.9, respectively. The process and HVAC end uses were approximately equal with calculation quality and calculation detail ratings of 2.4-2.7. The average rating for all end uses was 2.7 for calculation quality and 2.6 for calculation detail. The SPC calculator was used by participants for at least one measure on approximately 40 percent of the sites. Thirteen percent of the process end use sites, 92 percent of the lighting end use sites and 21 percent of the HVAC end use sites used the SPC calculator.

[45] Unverified assumptions are those that are not supported by documentation such as plant logs, energy management system schedules, manufacturer's performance data, etc. These assumptions are used in the energy savings calculations.

Exhibit A-1
Summary of Qualitative Application Review and Use of Calculator

End Use	Average Calculation Quality Rating	Average Calculation Detail Rating	SPC Calculator Used
Process	2.7	2.5	13%
Lighting	3.1	2.9	92%
HVAC	2.4	2.4	21%
All End Uses	2.7	2.6	40%

Averages are unweighted.

B. SUMMARY OF PROJECT PAYBACKS

Economic data was also calculated and summarized for the sampled projects as part of this evaluation. Cost data in the SPC project files was used for the calculations in this section. Note, however, that the evaluation team did not independently verify these cost data. In addition, no attempt was made to isolate incremental costs (as would be appropriate for replace-on-burnout) from full costs.

As summarized in Exhibit B-1, the simple payback after financial incentive for all end uses at the application review stage ranged from 0.1 to 14.5 years with a median of 2.1 years. The median simple payback after incentive was 1.8 years for the process end use followed by 2.0 years for the HVAC end use and 3.8 years for the lighting end use. Note that the simple paybacks also include measures other than the primary end use for many of the sites.

Process. Economic data was not available for one of the 16 sampled projects. The simple payback before incentive for the remaining 15 projects ranged from 0.2 to 4.6 years with a median of 2.6 years. The simple payback after incentive for these projects ranged from 0.2 to 4.0 years with a median of 1.8 years.

Lighting. Economic data was not available for two of the 13 projects. The simple payback before incentive for these projects ranged from 1.2 to 15.1 years with a median of 4.4 years. The simple payback after incentive for these projects ranged from 0.8 to 14.6 years with a median of 3.8 years. Many of these sites also had other measures installed in addition to lighting efficiency and control retrofits.

HVAC. Economic data was not available for four of the 14 projects. The simple payback before incentive for these projects ranged from 0.8 to 10.0 years with a median of 3.0 years. The simple payback after incentive for these projects ranged from 0.4 to 8.8 years with a median of 2.0 years.

Exhibit B-1
Summary of Simple Paybacks After Incentives

	Simple Payback After Incentive (Years) Application Approved Stage		
End Use	Highest	Lowest	Median
Process	4.0	0.2	1.8
Lighting	14.6	0.8	3.8
HVAC	8.8	0.4	2.0
All End Uses	14.5	0.1	2.1

Averages are unweighted. Incremental costs not isolated.

APPENDIX C – EVALUATION SITE REPORTS

This appendix includes the individual site level impact evaluation reports. The Appendix is organized by the primary end use (Process, Lighting, HVAC) assigned to each Application. There are 43 reports comprising the impact evaluation for 40 customers. Sites are numbered and there are notations concerning the sample cell and tier for each site. Two sample cell types are noted. Sample cell type "O" indicates an original sample point. Sample cell type "A" indicates an additional sample cell. We found it necessary to re-pull sample points because many of the projects in the original sample had not been installed. A more detailed description of the sample cell and tier is included in Chapter 2. Exhibit A shows the site number, tier, primary end use and the utility that administered the application.

Exhibit A
Summary of Selected Site Details

Report #	Tier	SMP	EU	Utility
1	1	O	P	SCE
2	1	O	P	SCE
3	2	O	P	SCE
4	2	O	P	SCE
5	2	O	P	PG&E
6	2	O	P	PG&E
7	2	O	P	SDG&E
8	2	O	P	SCE
9	2	A	P	SDG&E
10	2	O	P	SCE
11	2	O	P	SDG&E
12	2	O	P	SCE
13	3	A	P	PG&E
14	3	O	P	PG&E
15	3	O	P	PG&E
16	3	O	P	SCE
17	2	A	L	SCE
18	1	O	L	SCE
19	1	O	L	SCE
20	2	O	L	SCE
21	2	O	L	SCE
22	2	O	L	SDG&E
23	2	O	L	PG&E
24	2	O	L	SCE
25	2	O	L	SCE
26	3	O	L	SCE
27	3	O	L	SCE
28	3	O	L	SDG&E
29	3	O	L	SCE
30	1	O	H	PG&E
31	1	O	H	PG&E
32	1	O	H	PG&E
33	2	O	H	PG&E
34	2	O	H	SCE
35	2	O	H	SCE
36	2	O	H	PG&E
37	2	O	H	SCE
38	3	O	H	PG&E
39	3	O	H	SCE
40	3	O	H	SCE
41	3	O	H	SCE
42	3	O	H	SCE
43	3	O	H	PG&E

SITE 01 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL   TIER:1   END USE: PROCESS

Measure	Piping Efficiency Upgrade
Site Description	Oil Field Production

Measure Description

Revamp existing oil field injection pumping system. Revise and resize piping to reduce pressure losses and de-stage pumps to reduce discharge pressure.

Summary of Ex Ante Impact Calculations

Using measured baseline flows and pressures, post case flows are estimated using pump manufacturer's performance curves and post case pressures.

Comments on Ex Ante Calculations

Measured base case and post case kW, flows and pressures are used to calculate savings. The total post case flow rate for all three pumps is within 5% of the combined base case flow.

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation, conducting an on-site survey, review of meter data and then computing impacts using the on-site data and the meter data.

Water is continuously (8,760 hrs/yr) injected into the production field to maintain sufficient pressure to cause crude oil to flow towards extraction wells. The baseline system of injection pumps includes 5 multi-stage centrifugal pumps as shown in Table 1. After reviewing injection well pressure and flow requirements, it was determined that changes in piping configuration and injection pressure could more efficiently supply water than the baseline system.

The system of injection pumps is as shown in Table 1.

Table 1
Injection Pump Summary

		Base Case		Post Case	
Pump	hp	Stages	Pressure psig	Stages	Pressure psig
D1	1,500	9	1,500	9	1,500
D2	1,500	9	1,500	9	1,500
D3	1,500	10	2,200	10	2,200
D4	1,750	13	2,500	11	2,200
D5	1,750	13	2,500	9	1,500

The pumps supplying 2,500 psig water were 13-stage pumps driven by 1,750-hp motors. Pumps of this type employ multiple impellers on the same shaft to boost discharge pressure in stages. Based on the manufacturer's performance curves, it was determined that the pumps could be de-staged and used in the 1,500 and 2,200 psig systems and still deliver the necessary volume when run in conjunction with the 2,200 psig system pumps. The de-staged pumps develop significantly less water horsepower and greatly reduce kW demand.

The injection system was converted to a two-pressure system instead of three. This required piping changes and the de-staging of the D4 and D5 pumps. The post-retrofit operation of the 1,500 psig system was expanded to include the use of the D5 pump, and the 2,200 psig system was reconfigured to include the D4 pump. Note that the systems are named by approximate operating pressures to identify each system and actual pressures are higher or lower than these nominal pressures.

Pre- and post-retrofit pressure and flow measurements were obtained from the SCADA monitoring system. These are shown in Table 2. It can be seen that the total post-retrofit injection flow rate is nearly the same as the pre-retrofit volume.

Table 2
Ex Ante Pump Operation

System	1,500 psig	2,200 psig	2,500 psig	Total Flow
Pre-Retrofit gpm	77,500	42,800	77,200	197,500
Post-Retrofit gpm	119,400	87,300	0	206,700

Demand kW for each pump motor was measured and recorded. Demand reduction and annual energy savings were calculated based on annual operation of 8,760 hours. This is shown in Table 3.

Table 3
Ex Ante Project Impacts

	Base Case		Post Case		Savings	
Pump	kWh per Year	kW Demand	kWh per Year	kW Demand	kWh per Year	kW Demand
D1	10,976,280	1,253	10,117,800	1,155	858,480	98
D2	8,654,880	988	8,129,280	928	525,600	60
D3	11,133,960	1,271	11,694,600	1,335	-560,640	-64
D4	11,668,320	1,332	11,571,960	1,321	96,360	11
D5	13,104,960	1,496	7,472,280	853	5,632,680	643
Total	55,538,400	6,340	48,985,920	5,592	6,552,480	748

A site visit was made on August 31, 2004 to verify the installation and to observe ex post operating conditions. The equipment was found to operate as described in the project documents. Ex post pressures, flows and kW demands were observed to be the same as shown in the project documents.

The ex post project impacts were determined to be the same as the ex ante impacts since the system was operating in accordance with the ex ante assumptions and the actual pressures, flows, and kW demands continued to be the same as were used in the ex ante analysis. This is shown in Table 4.

Table 4
Ex Post Project Impacts

	Base Case		Post Case		Savings	
Pump	kWh per Year	kW Demand	kWh per Year	kW Demand	kWh per Year	kW Demand
D1	10,976,280	1,253	10,117,800	1,155	858,480	98
D2	8,654,880	988	8,129,280	928	525,600	60
D3	11,133,960	1,271	11,694,600	1,335	-560,640	-64
D4	11,668,320	1,332	11,571,960	1,321	96,360	11
D5	13,104,960	1,496	7,472,280	853	5,632,680	643
Total	55,538,400	6,340	48,985,920	5,592	6,552,480	748

Scope of Impact Assessment

This customer also received incentives for similar measures at three other facilities.

Additional Notes

The level of M&V employed at this site is probably sufficient to accurately determine the impacts of the installed measure. While not necessarily needed, additional trending of actual flow rates could be justified (as additional M&V for this customer).

Economic Information

File Financial Values	Date	Project Cost	Estimated Customer Annual kWh Savings	Estimated Customer kW Savings	Estimated Customer Annual Therm Savings	Estimated Customer Annual $ Savings @ $0.13/kWh	Incentive	Payback w/o Incentive	Payback w/ Incentive
Tracking System	4/23/2002	$ 700,000.00	6,552,480	748.0	0.0	$ 851,822.40	$ 350,000.00	0.8	0.4
Installation Report Approved Amount	10/7/2003	$ 700,000.00	6,552,480	748.0	0.0	$ 851,822.40	$ 350,000.00	0.8	0.4

This incentive was paid as part of a larger project. Total savings claimed for the project were 10,576,957 kWh/yr and 1,207 kW demand reduction. The overall incentive for entire project capped out at $350,000.

Impact Results

	kW	kWh	Therm
SPC Tracking System or Application	748	6,552,480	0
Adjusted Engineering	748	6,552,480	0
Engineering Realization Rate	1.0	1.0	N/A

Summary of Saving Calculations

	Base Case		Post Case		Savings	
Pump	kWh per Year	kW Demand	kWh per Year	kW Demand	kWh per Year	kW Demand
D1	10,976,280	1,253	10,117,800	1,155	858,480	98
D2	8,654,880	988	8,129,280	928	525,600	60
D3	11,133,960	1,271	11,694,600	1,335	-560,640	-64
D4	11,668,320	1,332	11,571,960	1,321	96,360	11
D5	13,104,960	1,496	7,472,280	853	5,632,680	643
Total	55,538,400	6,340	48,985,920	5,592	6,552,480	748

Where:

$$\text{Total kW Demand}_{\text{Base Case}} = \sum_{i=1}^{i=5} \text{kW Demand}_{\text{Base Case Di}}$$
$$= 1{,}253 \text{ kW} + 988 \text{ kW} + 1{,}271 \text{ kW} + 1{,}332 \text{ kW} + 1{,}496 \text{ kW} = 6{,}340 \text{ kW}$$

$$\text{Total kWh per Year}_{\text{Base Case}} = \text{Total kW Demand}_{\text{Base Case}} \times \text{Annual Operating Hours}_{\text{Post Case}}$$
$$= 6{,}340 \text{ kW} \times 8.760 \text{ hours/year} = 55{,}538{,}400 \text{ kWh/year}$$

and

$$\text{Total kW Demand}_{\text{Post Case}} = \sum_{i=1}^{i=5} \text{kW Demand}_{\text{Post Case Di}}$$
$$= 1{,}155 \text{ kW} + 928 \text{ kW} + 1{,}335 \text{ kW} + 1{,}321 \text{ kW} + 853 \text{ kW} = 5{,}592 \text{ kW}$$

$$\text{Total kWh per Year}_{\text{Post Case}} = \text{Total kW Demand}_{\text{Post Case}} \times \text{Annual Operating Hours}_{\text{Post Case}}$$
$$= 5{,}592 \text{ kW} \times 8{,}760 \text{ hours/year} = 48{,}985{,}920 \text{ kWh/year}$$

$$\text{Total kW Demand Savings} = \text{Total kW Demand}_{\text{Base Case}} - \text{Total kW Demand}_{\text{Post Case}}$$
$$= 6{,}340 \text{ kW} - 5{,}592 \text{ kW} = 748 \text{ kW}$$

$$\text{Total kWh Savings per Year} = \text{Total kWh per year}_{\text{Base Case}} - \text{Total kWh per year}_{\text{Post Case}}$$
$$= 55{,}538{,}400 \text{ kWh/year} - 48{,}985{,}920 \text{ kWh/year} = 6{,}552{,}480 \text{ kWh/year}$$

Inputs to Model

Parameter	Value Reported	Units	Notes
City	Long Beach		
Pre-Retrofit Hours of Operation	8,760	hrs/yr	Operating hrs based on around the clock operation 365 days per year
Pre-Retrofit Demand	6,340	kW	Total measured kW
Post-Retrofit Hours of Operation	8,760	hrs/yr	Operating hrs based on around the clock operation 365 days per year
Pre-Retrofit Demand	5,592	kW	Total measured kW

SITE 02 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER:1 END USE: PROCESS

Measure	Install three new natural gas lances to improve oxygen penetration of slag, reduce furnace thermal losses and decrease electricity required to melt steel.
Site Description	Steel Mill

Measure Description

Installed three new Pyrejet natural gas oxy-fuel lances to replace the hand-held lance used previously. The new lances use natural gas as a carrier gas to help oxygen penetrate foamy slag. In addition the new lances inject gas through the wall of the furnace instead of through an open furnace door as with the hand-held lance. The new lances not only improve the ability of the electrodes to melt the steel, the furnace envelope losses are reduced by keeping the furnace door closed. The combined effect decreases the amount of electricity required to melt the same amount of steel.

Summary of Ex Ante Impact Calculations

Electricity savings were estimated by using an Air Liquide (Pyrejet lance manufacturer) simulation program based on the steel production rates and the energy used per steel melting cycle. The results of the analysis showed that energy consumption could be reduced by approximately 12%. The actual energy savings were estimated from seven-months of bills prior to the measure being installed. The seven months of bills were annualized and multiplied by 10% to estimate savings.

Comments on Ex Ante Calculations

Using a simulation tool based on the production process of the facility can be an effective method for estimating savings. However, the actual assumptions used in the model were not available for review and the estimated savings were based on billing data alone with the model prediction of a 12% reduction. The only other data provided was a manufacturer’s description of the system and how it saves energy.

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation, conducting an on-site survey and then computing impacts using a utility bill analysis. The utility bill analysis determined the relationship between energy consumption (gas and electric) and steel production. The analysis is intended to determine the decrease in electric consumption as well as any increase in gas consumption due to the installation of the measure.

The on-site survey was conducted on September 18, 2003. Information on the retrofit equipment and operating conditions was collected through an interview with the Vice President of operations.

Energy and production data were provided that enabled the development of an equation defining the relationship between energy use and steel production. The typical production schedule for the mill is 24 hours per day, Monday through Friday. During busy periods, the mill may operate 10 day periods with one day down between. Two account numbers were confirmed with bills from the customer.

The energy data were taken from Utility billing data (Electric) and the customer’s internal tracking system (Gas), which was based on the billing data but compiled into fiscal months. These are composed of eight 28-day periods and four 35-day periods in one year. The fiscal periods were compared to actual bills and appeared to be reasonable.

The following two equations were used to estimate baseline energy consumption for each billing period:

- Baseline MWh = 38.36 MWh x Days + 0.5950 MWh x Tons Steel
- Baseline Therms = 1,427.1 Therms x Days + 1.3263 Therms x Tons Steel

The R^2 for the MWh equation was 0.942 showing a strong relationship. The R^2 for the gas consumption equation was 0.813, which shows a strong relationship, but less correlation than with electricity. Post-Installation production data were collected and inserted in the regression equation to estimate the baseline energy consumption. Post-Installation energy consumption was then subtracted from the baseline energy to estimate savings. Since only nine months of post-installation utility data were available for the analysis, the results were multiplied by 133% to estimate annual savings.

The analysis results showed that the energy savings did not appear until August 2003. At the on-site survey, two reasons were provided to account for this delay.

- In the summer of 2002, around the time the measure was installed, the existing 65 MVa transformer was replaced with a new 100 MVa transformer. This was done to decrease the melt time of the steel from approximately 80 minutes to less than 60 minutes. During several months of commissioning the new transformer, the Pyrejet lances were disabled.
- Commissioning the new Pyrejet lances took longer than initially expected and continued through August 2003. By the end of August 2003 the new system was considered to be properly commissioned and a majority of the savings are now being achieved.

Savings were analyzed from August 2003 through April 2004 and savings were less than half of the ex ante estimate. Gas usage also increased by over 800,000 therms.

Scope of Impact Assessment

The full project, involving one site and one measure, was reviewed for reasonableness and the savings analyzed through utility bill analysis. The site survey occurred on September 19, 2003.

Additional Notes

Reviewing the savings through utility bill analysis is appropriate for this measure because the size of the equipment and savings prohibit any other forms of measurement. Also, since only a fraction of the savings is required to meet the incentive costs, a more accurate method is not necessary.

Because of the extended period of measure commissioning, the savings could not be estimated until additional data were available. An updated savings estimate was provided on September 7, 2004.

An attempt was made to estimate demand reduction through utility bill analysis, but the results were inconclusive. Therefore, the kW savings were decreased by the same amount as the energy savings.

Impact Results

	KW	KWh	Therm
SPC Tracking System or Application	6,295	27,179,804	0
Adjusted Engineering	2,413	10,419,220	(801,999)
Engineering Realization Rate	38%	38%	N/A

Table 1. Baseline Electric and Natural Gas Billing Data and Production Data

Period Start	Period End	Monthly Electricity (MWh)	Period Start	Period End	Monthly Gas (Therms)	Production
8/30/2001	9/28/2001	19,270	9/4/2001	10/1/2001	75,763	30,305
9/29/2001	10/30/2001	22,086	10/2/2001	11/5/2001	91,356	37,441
10/31/2001	11/30/2001	16,115	11/6/2001	12/3/2001	75,181	25,747
12/1/2001	1/2/2002	24,371	12/4/2001	12/31/2001	83,770	34,246
1/3/2002	1/31/2002	22,193	1/1/2002	2/4/2002	106,920	43,267
2/1/2002	3/4/2002	26,046	2/5/2002	3/4/2002	80,770	35,283
3/5/2002	4/2/2002	30,015	3/5/2002	4/1/2002	103,420	47,974
4/3/2002	5/1/2002	29,358	4/2/2002	5/6/2002	130,520	55,962
5/2/2002	5/31/2002	20,296	5/7/2002	6/3/2002	85,320	27,108
		209,750			833,020	337,333

(1) Period Start and End for electricity is based on SCE billing data
(2) Period Start and End for gas and production is based on Customer internal data

Table 2. Estimated Energy Savings Through Utility Bill Analysis

Month, Year	Production (Tons)	Baseline Energy (MWh)	Post-Install Energy (MWh)	Energy Savings (MWh)
August, 2003	53,721	32,887	32,845	42
September, 2003	45,929	28,749	27,033	1,716
October, 2003	49,380	30,433	30,856	(423)
November, 2003	40,608	25,404	25,037	367
December, 2003	45,360	28,306	27,091	1,215
January, 2004	47,783	29,546	29,719	(173)
February, 2004	46,107	28,550	26,823	1,727
March, 2004	34,126	21,771	19,331	2,440
April, 2004	46,484	28,533	27,610	923
Total	409,498	254,179	246,345	7,834

Table 3. Estimated Energy Savings Through Utility Bill Analysis

Month, Year	Production (Tons)	Baseline Energy (Therms)	Post-Install Energy (Therms)	Energy Savings (Therms)
August, 2003	53,721	115,488	132,626	(17,138)
September, 2003	45,929	103,727	184,484	(80,757)
October, 2003	49,380	109,731	203,007	(93,276)
November, 2003	40,608	96,670	146,630	(49,960)
December, 2003	45,360	104,399	181,637	(77,238)
January, 2004	47,783	107,613	170,597	(62,984)
February, 2004	46,107	102,536	173,364	(70,828)
March, 2004	34,126	89,501	157,983	(68,482)
April, 2004	46,484	104,462	186,806	(82,344)
Total	409,498	934,127	1,537,134	(603,007)

SITE 03 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER:2 END USE: PROCESS

Measure	Refrigeration reconfiguration and added controls
Site Description	Food Processing Plant

Measure Description

Ammonia refrigeration system upgrades including: Installation of a sophisticated refrigeration control system, compressor reconfiguration, segregation of loads based on temperature requirements, and addition of a second refrigerant accumulator to improve load management by increasing the compressor suction pressure.

Summary of Ex Ante Impact Calculations

Ex ante calculations are based on compressor energy required at existing suction and discharge pressures vs. compressor energy required at proposed suction and discharge pressures.

The compressor suction pressure, condensing pressure, load profile and total system capacity were verified during the site visits. The compressor efficiency (bhp/ton) was obtained from manufacturer data for each compressor model. The refrigeration system operating hours were assumed to be 8,760 hrs/year, which is reasonable for a food processing facility. The total system capacity was verified to be 1,134 tons. The average system load was estimated at approximately 62% of the total system capacity, or 700 tons on average The cooling requirements of the facility did not change after the upgrade, and so the total post-installation average capacity is assumed as 700 tons. The baseline energy usage is based on the current compressor suction pressure of 25 psig, which was verified during the pre installation site inspection. The post-installation energy usage is calculated based on the proposed compressor suction pressures, which is 35 psig for 400-tons out of the total 700-ton load, and 45 psig for 300 tons. The compressors operating at a lower suction pressure will provide cooling for the equipment that operates at a lower temperature (such as the ice builders and water chillers) while the higher suction pressure compressors will save energy by providing cooling for equipment that operates at a higher temperature such as the storage silos.

Comments on Ex Ante Calculations

The project was very complex and it is difficult to precisely estimate the savings. The plant load profile, in tons, was estimated based on equipment specifications and operator assumptions. Measured data was not available. Lack of measured data is the most significant factor that affects the accuracy of the savings calculations. Based on the lack of better data, the 700-ton average annual plant load profile is considered acceptable.

The documentation in the file was incomplete. Many preliminary designs were proposed and savings estimates presented. However, the final project, as installed was never documented.

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation, conducting an on-site survey and then computing impacts using the on-site data.

The on-site survey was conducted on November 12th, 2003. The project manager was very cooperative and provided a complete explanation of the completed project. Technical data was obtained from the new refrigeration control system.

The pre-retrofit refrigeration was provided by two compressor rooms- East and West. Both systems operated at a suction pressure of 25 psig. (12°F) and a discharge pressure of 135 psig. The refrigeration system operated at 25 psig because three ice builders in the plant required the low temperature to build ice. Other loads in the plant, such as pasteurization, product refrigeration, air conditioning, cold boxes, etc., only require 32°F to 40°F. This can be achieved with suction pressures of 33 to 42 psig Increasing the suction pressure at a specific discharge pressure decreases the compression ratio of the compressors and uses less energy.

By reconfiguring the refrigeration compressors and adding a second suction accumulator the plant is able to operate with two different suction pressures to serve the low and high temperature requirements. The low-pressure side now operates with a setpoint of 33 psig and the high side with a setpoint of 42 psig. The increase from 25 psig to 33 psig is now possible because there is reduced load on the low side system with all the high side demands now on a separate suction. Segregation of the loads is what allows them to raise the suction pressure(s). The load on the low side was reduced, but I cannot verify this or determine why with confidence. My guess is that the reduction in capacity of the refrigerant is less because there are not loads prior to the ice builders. There may also be more volume of refrigerant (lbs.) available in the low-side now that a second accumulator was added. The discharge pressure has also been reduced from 135 psig to 111 psig. Condensing temperature does not float. VSDs on the evaporative condensers maintain 111 psig.

Prior to the new refrigeration configuration being implemented, auto-purgers were installed to reduce the discharge pressure of the system. The system was operating at 10 psi above the theoretical pressure temperature curve for ammonia. Auto-purgers were installed to reduce the discharge pressure. This project was rebated under a separate SPC project. The auto-purgers reduced the pressure 9 psi. Therefore, the baseline for this project should be the system operating with a discharge pressure of 126 (135 psig – 9 psi). This will avoid double counting of savings between this project and the other project at this site, which provided a rebate for the autopurgers.

A graphical representation of the new refrigeration system is shown below. Two suction accumulators are shown- Low Stage Suction (LSS) and the High Stage Suction (HSS).

The LSS includes two compressors- one 16-cylinder and one 12-cylinder. The HSS operates with two 16-cylinder and one 12-cylinder compressor. Two additional compressors can be operated on the high side, but have not been needed.

The new capacity of the system at 111 psig discharge is:

LSS at 33 psig = 387 tons
HSS at 42 psig = 747 tons
Total Refrigeration Capacity = 1,134 tons

The ex ante load profile for the refrigeration plant was estimated as an annual average of 700-tons. We were unable to obtain measured data to support the estimated average annual load. We have accepted the average annual load used in the ex ante analysis because no better data is available. The load at the time of the evaluation visit was obtained from the refrigeration control system. Based on the number of cylinders loaded and the rating of the machines. Although only an instantaneous observation, it did indicate a base load on the system. Ambient conditions were cool and humid (55°F, ~90%RH) and the system load was 166-tons on the Low side and 204-tons on the high side (370 total tons).

The load split between the high and low side in the ex ante was LSS= 300-tons and the HSS= 400-tons. Based on the observed loads at the site visit and the total capacity of the high and low sides, it is more reasonable to split the load 250-tons LSS and 450-tons HSS. This is based on the observed load split and the operating engineers estimate. The facilities engineer stated that his best estimate was that the average 700-tons was still reasonable but that the split was more likely 250-tons on the LSS and 450-tons on the HSS.

The base energy consumption was calculated based on the adjusted load split and the compressor efficiencies at 25 psig suction and 126 psig discharge.

Based on the same load profile, since the refrigeration central plant reconfiguration did not affect the food processing load, the savings are calculated using the operating conditions of 111 psig discharge and 33 psig and 42 psig suction pressures.

The total energy savings are then calculated using an average motor efficiency of 92% and operating time of 8,760 hours per year.

Scope of Impact Assessment

This project and another project for auto purgers on the refrigeration system were assessed.

Additional Notes

The level of M&V employed at this site is not sufficient to estimate the annual savings with precision. The annual load profile, in tons of refrigeration, determines the magnitude of the savings. Within the scope and budget of this evaluation, measure data to support the estimated load profile was not obtainable. An additional 25-35 hours of engineering time would be required and possibly the use of a significant amount of metering equipment.

Economic Information

File Financial Values	Date	Project Cost	Estimated Customer Annual kWh Savings	Estimated Customer kW Savings	Estimated Customer Annual Therm Savings	Estimated Customer Annual $ Savings @ $0.13/kWh	Incentive	Payback w/o Incentive	Payback w/ Incentive
Application Estimate	04/29/2002	$ 450,000	600,000	250	0.0	$ 78,000	$84,000	5.8	4.7
Resubmittal	08/16/2002	$ 450,000	1,500,000	N/A	0.0	$ 195,000	$210,000	2.3	1.2
Application Approved	10/28/2002	$ 450,000	1,261,472	N/A	0.0	$ 163,991	$100,918	2.7	2.1
2002 SPC Installation Report	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Impact Results

	kW	kWh	Therm
SPC Tracking System	0	1,261,472	0
Installation Report	N/A	N/A	0
Adjusted Engineering	225	1,971,839	0
Realization Rate	-	1.56	

Figure 1
New Refrigeration System

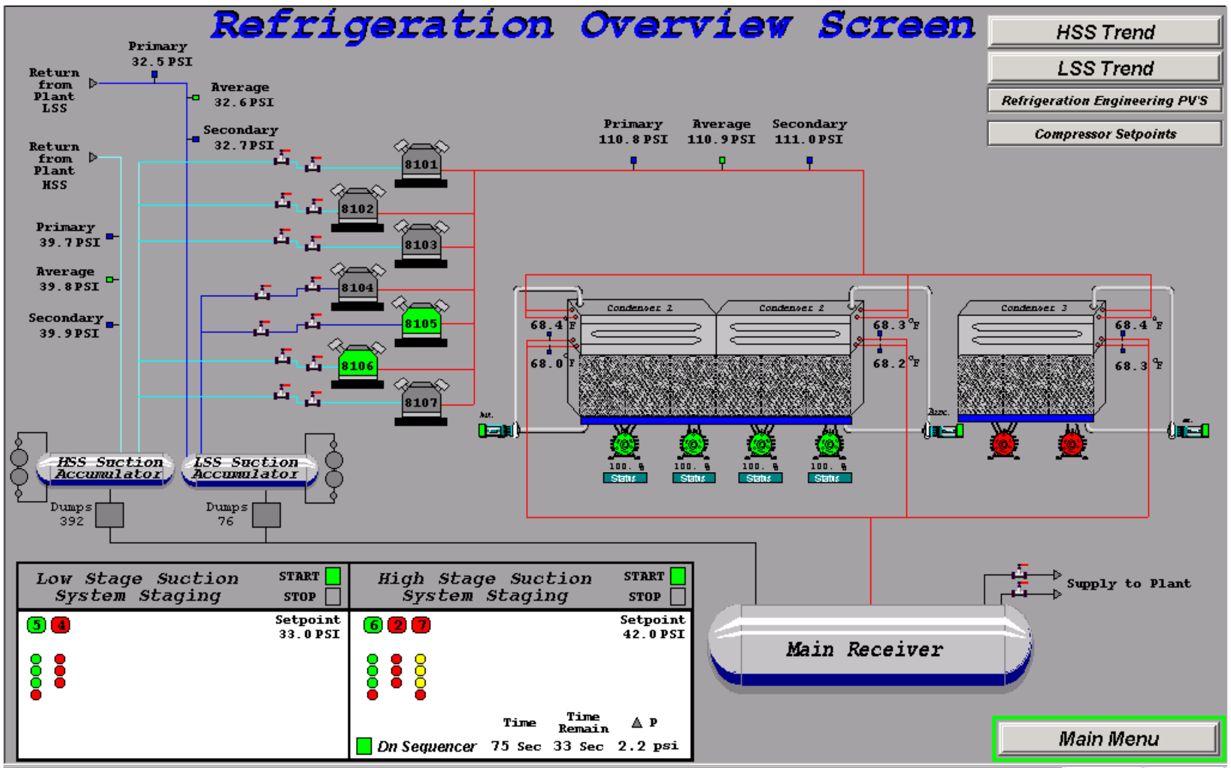


Table 1
Vilter Compressor Specifications @ 126 psig Discharge

Manuf Data @ 126 psia						
Compressor Model	448		4412		4416	
Suction psig	tons	bhp	tons	bhp	tons	bhp
24	83.1	85.2	124.6	125.4	166.1	165.4

Table 2
Baseline Brake-Horsepower Requirement

Ammonia System Calculations

Average Annual System Tonnage	700
Discharge Pressure (psia)	126
System Require BHP	706

EAST COMPRESSOR ROOM		WEST COMPRESSOR ROOM	
Suction Pressure (psig)	25	Suction Pressure (psig)	25
Discharge Pressure (psia)	126	Discharge Pressure (psia)	126
Average Required Capacity (tons)	250	Average Required Capacity (tons)	450
Required Bhp	252	Required Bhp	455
Compressor (model 448)		Compressor (model 448)	
Quantity	1	Quantity	5
Capacity (tons)	77.10	Capacity (tons)	288.2
% of Capacity	14%	% of Capacity	48%
Required Tons	35.7	Required Tons	217.4
Bhp/ton	1.03	Bhp/ton	1.03
Required Bhp	36.65	Required Bhp	223.01
Compressor (model 4412)		Compressor (model 4412)	
Quantity	3	Quantity	0
Capacity (tons)	308.30	Capacity (tons)	0.00
% of Capacity	57%	% of Capacity	
Required Tons	142.8	Required Tons	0.00
Bhp/ton	1.01	Bhp/ton	0.00
Required Bhp	143.75	Required Bhp	
Compressor (model 4416)		Compressor (model 4416)	
Quantity	1	Quantity	2
Capacity (tons)	154.20	Capacity (tons)	308.40
% of Capacity	29%	% of Capacity	52%
Required Tons	71.4	Required Tons	232.6
Bhp/ton	1.00	Bhp/ton	1.00
Required Bhp	71.12	Required Bhp	231.57

Table 3
Vilter Compressor Specifications @ 111 psig Discharge

Manuf Data @ 111 psig						
Compressor Model	**448**		**4412**		**4416**	
Suction psig	**tons**	**bhp**	**tons**	**bhp**	**tons**	**bhp**
24						
28						
33			165.82	117.36	221.16	155.04
39						
42			203.58	109.39	271.54	144.38

Table 4
New Brake-Horsepower Requirement

Ammonia System Calculations

Average Annual System Tonnage	700
Discharge Pressure (psia)	111
System Require BHP	428

LOW STAGE SUCTION (LSS ACCUMULATOR)	
Suction Pressure (psig)	33
Discharge Pressure (psia)	111
Average Required Capacity (tons)	250
Required Bhp	181.07
Compressor 8105 (model 4416)	
Capacity (tons)	214.35
%load	100%
Full Load Bhp	155.04
Required Bhp	155.04
Compressor 8104 (model 4412)	
Capacity (tons)	160.73
%load	0.22
Full Load Bhp	117.36
Required Bhp	26.03

HIGH STAGE SUCTION (HSS ACCUMULATOR)	
Suction Pressure (psig)	42
Discharge Pressure (psia)	111
Average Required Capacity (tons)	450
Required Bhp	247.43
Compressor 8102 (model 4412)	
Capacity (tons)	197.81
%load	100%
Full Load Bhp	109.39
Required Bhp	109.39
Compressor 8106 (model 4416)	
Capacity (tons)	263.78
%load	0.96
Full Load Bhp	144.38
Required Bhp	138.04
Compressor 8107 (model 4416)	
Capacity (tons)	263.78
%load	0.00
Full Load Bhp	144.38
Required Bhp	0.00

Table 5
Total Energy Savings

NEW SYSTEM		
	Total Bhp	428.50
	Avg. Motor Eff.	0.92
	System kW	347.5
	Hours per year	8760
	kWh per year	3,043,720
OLD SYSTEM		
	Total Bhp	706.10
	Avg. Motor Eff.	0.92
	System kW	572.6
	Hours per year	8760
	kWh per year	5,015,559
SAVINGS	Average kW	225.1
	kWh per year	1,971,839

SITE 04 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER:2 END USE: PROCESS

Measure	Installation of Auto Purger on refrigeration system
Site Description	Food Processing Plant

Measure Description

An auto-purging system was installed on the ammonia refrigeration system. Purging the refrigeration lines is required to remove non-condensable gases. This is typically air vapor trapped in the system. Non-condensable gases require the system to operate with a higher head pressure than required. To achieve a higher head pressure the compressors must work harder and therefore consume more energy.

Summary of Ex Ante Impact Calculations

The ex ante calculations were performed using an equation provided by the vendor. The equation estimates the percent of total compressor work that is due to the excess pressure from non-condensable gasses. The percent of work is equal to the excess pressure divided by the total pressure rise of the system.

The excess pressure, as measured by the customer, was 10 psi. The excess pressure is determined by measuring the liquid temperature leaving the condenser and comparing that to the theoretical condensing temperature for that pressure. For example, if the condensing pressure is 163.7 psig, the condensing temperature should be 84 degrees. If the condensing temperature is actually 77 degrees, that would correspond to a condensing pressure of 145.4 psig. The excess pressure due to non-condensable gasses is 18.3 psi (163.7 psig minus 145.4 psig).

The ex ante savings were calculated as shown in the following equation. The calculation inputs are described below.

kWh Savings = (P_e/P_d)*kW/ton*Avg. Annual Tons*Hours/yr.
kWh Savings = 10/115.7 * 0.56 * 700 * 8,760 = 296,795

Where:

P_e = Excess Head Pressure (psi)
P_d = Discharge Head Pressure (psia)
kW/ton = Estimated compressor efficiency
Avg. Annual Tons = Estimated average annual tons of refrigeration
Hours/yr. = Annual hours of operation at avg. tons.

Comments on Ex Ante Calculations

The ex ante calculations are based on measured values of the excess pressure and the head pressure. The other values in the equation are estimated. The average annual tons was estimated for another SPC application (# 63) and was used in this application. The compressor efficiency (kW/ton) was estimated from generic compressor literature by the vendor. Both of these values affect the results proportionally. At the time of the ex ante calculations these were reasonable values. The compressor efficiency was modified in the evaluation calculation when more operating information was available.

Evaluation Process

The evaluation process consisted of verifying the auto-purgers and re-calculating the savings. Some of the inputs to the calculation were modified with values collected during the on-site visit. In particular, the compressor efficiency and the discharge pressure differed from the ex ante.

The evaluation savings calculation is shown below. Following the calculation is an explanation of the inputs.

The total energy savings are then calculated using an average motor efficiency of 92% and operating time of 8,760 hours per year.

Scope of Impact Assessment

This project and another project for major refrigeration system modifications were assessed.

Additional Notes

The level of M&V employed at this site is not sufficient to estimate the annual savings with precision. The annual load profile, in tons of refrigeration, determines the magnitude of the savings. Within the scope and budget of this evaluation, measured data to support the estimated load profile was not obtainable. An additional 25-35 hours of engineering time would be required and possibly the use of a significant amount of metering equipment.

Economic Information

File Financial Values	Date	Project Cost	Estimated Customer Annual kWh Savings	Estimated Customer kW Savings	Estimated Customer Annual Therm Savings	Estimated Customer Annual $ Savings @ $0.13/kWh	Incentive	Payback w/o Incentive	Payback w/ Incentive
Application Estimate	05/06/2002	$ 75,000	296,795	34	0.0	$ 38,583	$41,580	1.9	0.9
2002 SPC Installation Report	09/20/2004	$ 75,000	296,795	34	0.0	$ 38,583	$41,580	1.9	0.9

Impact Results

	kW	kWh	Therm
SPC Tracking System	34.0	297,000	0
Installation Report	34.0	297,000	0
Adjusted Engineering	36.0	315,495	0
Realization Rate	1.06	1.06	NA

Table 6
Vilter Compressor Specifications @ 135 psig Discharge

Manuf Data @ 135 psig						
Compressor Model	448		4412		4416	
Suction psig	tons	bhp	tons	bhp	tons	bhp
24	80.9	88.2	121.3	129.8	161.8	171.2

Table 7
Baseline Brake-Horsepower Requirement

Ammonia System Calculations

Average Annual System Tonnage	700
Discharge Pressure (psig)	135
System Require BHP	751

EAST COMPRESSOR ROOM	
Suction Pressure (psig)	25
Discharge Pressure (psig)	135
Average Required Capacity (tons)	250
Required Bhp	267
Compressor (model 448)	
Quantity	1
Capacity (tons)	77.10
% of Capacity	14%
Required Tons	35.7
Bhp/ton	1.09
Required Bhp	38.94
Compressor (model 4412)	
Quantity	3
Capacity (tons)	308.30
% of Capacity	57%
Required Tons	142.8
Bhp/ton	1.07
Required Bhp	152.85
Compressor (model 4416)	
Quantity	1
Capacity (tons)	154.20
% of Capacity	29%
Required Tons	71.4
Bhp/ton	1.06
Required Bhp	75.59

WEST COMPRESSOR ROOM	
Suction Pressure (psig)	25
Discharge Pressure (psig)	135
Average Required Capacity (tons)	450
Required Bhp	483
Compressor (model 448)	
Quantity	5
Capacity (tons)	288.2
% of Capacity	48%
Required Tons	217.4
Bhp/ton	1.09
Required Bhp	237.00
Compressor (model 4412)	
Quantity	0
Capacity (tons)	0.00
% of Capacity	
Required Tons	0.00
Bhp/ton	0.00
Required Bhp	
Compressor (model 4416)	
Quantity	2
Capacity (tons)	308.40
% of Capacity	52%
Required Tons	232.6
Bhp/ton	1.06
Required Bhp	246.13

Table 8
Vilter Compressor Specifications @ 126 psig Discharge

Manuf Data @ 125 psia						
Compressor Model	448		4412		4416	
Suction psig	tons	bhp	tons	bhp	tons	bhp
24	83.1	85.2	124.6	125.4	166.1	165.4

Table 9
New Brake-Horsepower Requirement

Ammonia System Calculations

Average Annual System Tonnage	700
Discharge Pressure (psig)	126
System Require BHP	706

EAST COMPRESSOR ROOM		**WEST COMPRESSOR ROOM**	
Suction Pressure (psig)	25	Suction Pressure (psig)	25
Discharge Pressure (psig)	126	Discharge Pressure (psig)	126
Average Required Capacity (tons)	250	Average Required Capacity (tons)	450
Required Bhp	252	Required Bhp	455
Compressor (model 448)		Compressor (model 448)	
Quantity	1	Quantity	5
Capacity (tons)	77.10	Capacity (tons)	288.2
% of Capacity	14%	% of Capacity	48%
Required Tons	35.7	Required Tons	217.4
Bhp/ton	1.03	Bhp/ton	1.03
Required Bhp	36.65	Required Bhp	223.01
Compressor (model 4412)		Compressor (model 4412)	
Quantity	3	Quantity	0
Capacity (tons)	308.30	Capacity (tons)	0.00
% of Capacity	57%	% of Capacity	
Required Tons	142.8	Required Tons	0.00
Bhp/ton	1.01	Bhp/ton	0.00
Required Bhp	143.75	Required Bhp	
Compressor (model 4416)		Compressor (model 4416)	
Quantity	1	Quantity	2
Capacity (tons)	154.20	Capacity (tons)	308.40
% of Capacity	29%	% of Capacity	52%
Required Tons	71.4	Required Tons	232.6
Bhp/ton	1.00	Bhp/ton	1.00
Required Bhp	71.12	Required Bhp	231.57

Table 10
Total Energy Savings

NEW SYSTEM		
	Total Bhp	706.10
	Avg. Motor Eff.	0.92
	System kW	572.6
	Hours per year	8,760
	kWh per year	5,015,559
OLD SYSTEM		
	Total Bhp	750.51
	Avg. Motor Eff.	0.92
	System kW	608.6
	Hours per year	8,760
	kWh per year	5,331,055
SAVINGS	Average kW	36.0
	kWh per year	315,495

SITE 05 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER:2 END USE: PROCESS

Measure	System modifications
Site Description	Sand Mining & Processing Plant

Measure Description

This is a complex project involving installation of new pumps, removal of pumps/motors, relocation of existing pumps, modification of existing pumps and installation of a VFD on one pump.

Summary of Ex Ante Impact Calculations

Horsepower ratings and estimated hours of operation for each motor were used to calculate demand and annual consumption for the pre- and post retrofit periods. Annual production data were also provided to normalize the energy savings to production output.

According to the application, the project involves the removal of 7 motors (for a reduction of 910 hp), the addition of 2 motors (for an increase of 500 hp), and the addition of a VFD to one motor (resulting in an "effective" capacity reduction of 150 hp). All told, the net capacity reduction is 560 hp.

The reviewer noted that the calculations submitted in the application did not account for motor loading or efficiency and concluded that motor loading and efficiency would be approximately equal, and therefore canceling in the Ex-Ante impact motor power calculations.

The calculations were used to estimate an incentive value, which was verified by a utility bill and sand production analysis. The utility bill and sand production analysis compares a year of post-retrofit utility bills and sand production data to baseline data.

Comments on Ex Ante Calculations

The calculation did not include any information on motor loading or the sequence in which the motors would run over a 24-hour period. This makes the demand reduction estimate difficult to verify.

Evaluation Process

The Evaluation process consisted of a review of the SPC application form and supporting documentation, an on-site survey, and engineering analysis using on-site collected data.

The on-site survey was carried out on January 22, 2004 in Byron. Information on the retrofit equipment and operating conditions was collected during a walk through the Plant and an interview with the Plant Manager and Safety Engineer.

Removal and replacement of motors were visually verified. Two discrepancies were noted between the equipment ratings recorded in PG&E application review process and during the site visit.

PU-004 had been recorded as 75 HP, but it was found to be 40 HP. The Plant Safety Engineer confirmed that PU-004 has a 40 HP motor.
PU-039 was recorded as 270 HP, but was found to be 300 HP.

Accepting all other assumptions of operating hours for equipment from the Ex Ante Analysis, these changes reduce the savings impact from 1,344,010 kWh and 441 kW to 1,171,824 kWh and 392 kW.

The Ex-Ante impact calculations did not account for motor loading or efficiency. The calculations were used to estimate an incentive value, which was verified by a utility bill and sand production analysis. The utility bill and sand production analysis compares a year of post-retrofit utility bills and sand production data to baseline data.
The plant operates on the basis of demand for sand and has no regular shifts or operating hours. This makes it difficult to calculate operating hours for any given year. For this reason impact calculations are normalized to sand production.

The pre-retrofit data from 2000 is shown below:

Annual Sand Production	392,255 Tons
Annual Electricity Consumption	8,313,388 kWh/yr
Electricity per Ton of sand	21.19 kWh/Ton-sand

No values for billed demand were included, so peak demand reduction cannot be verified by this method.

Achieving the ex-post savings estimate of 1,344,010 kWh equates to reducing the energy per unit of sand to 17.73 kWh/ton-sand.. According to the PIR, the installation was completed in April 2003 and the first month of data indicated that estimated savings was achieved.

04/03- 05/03 Sand Production	35,615 Tons
04/03-05/03 Electricity Consumption	631,295kWh
Electricity per Ton of sand	17.73 kWh/Ton-sand

Correcting the Ex-Ante Analysis for the field verified motor capacities (changing PU-004 and PU-039 as noted above) results in an estimated savings of 1,171,824 kWh. This increases the estimated post-retrofit normalized usage from 17.73 kWh/ton-sand to 18.21 kWh/ton-sand. The corrected Ex-Ante estimate is shown in the Table below:

Annual Sand Production	392,255 Tons
Annual Electricity Consumption	7,141,564 kWh/yr
Electricity per Ton of sand	18.21kWh/Ton-sand

The plant manager provided post retrofit utility bill and sand production data from May 03 to April 04. The data is summarized in the table below

05/03- 04/04 Sand Production	415,690 Tons
04/28/03-05/23/03Electricity Consumption	7,547,316 kWh
Electricity per Ton of sand	18.15 kWh/Ton-sand

The result is within 0.3% of the Ex-Post Impact calculation of 18.21 kWh/Ton-sand and supports the adjusted engineering results.

Additional Notes

Although the Ex-post demand reduction calculation uses the method laid out in the program application and reduces the ex-ante estimate of 441 kW to 392 kW, it is possible for the demand reduction to be less. Since plant operation depends on demand for sand, it is conceivable that all pumps may run during electric peak demand hours. If pre- and post-retrofit demand data were provided, they could be normalized to production in the same manner as energy consumption to verify the demand reduction estimate. However, this would require the use of peak hour production data for the noon to 6 pm period, which the participant did not have. /Also, demand data were not included in the program application and were not supplied subsequently by the Customer. Without demand kW and detailed production data, kW demand impact is not verifiable and the engineering realization rate has been set to not applicable (NA) for peak demand kW.

The scope of this evaluation is deemed to be adequate. Given the fact that reasonable results were derived using ex ante methods and successfully triangulated using bills, no further analysis is considered necessary.

Impact Results

	KW	KWh	Therm
SPC Application Calculations	441	1,344,010	NA
Adjusted Engineering	392	1,171,824	NA
Engineering Realization Rate	NA	0.87	NA

Economic Information

Description	Date	Project Cost	Estimated Demand Savings, kW	Estimated Energy Savings, kWh	Estimated Gas Savings, therms	Estimated Annual Cost Savings ($0.13/kWh), $	SPC Incentive, $	Simple Payback w/ incentive, yrs	Simple Payback w/o incentive, yrs
Application Submitted Amount	4/4/2002	$701,400	656	2,103,282	0	$273,427	$168,262.00	1.95	2.57
Application Approved Amount	6/14/2002	$701,400	441	1,344,010	0	$174,721	$107,520.80	3.40	4.01
Installation Approved Amount	7/7/2003	$701,400	441	1,344,010	0	$174,721	$107,520.80	3.40	4.01
SPC Program Review	5/12/2004	$701,400	392	1,171,824	0	$152,337	$93,745.92	3.99	4.60

SITE 06 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL   TIER:2   END USE: PROCESS

Measure	Compressor Pad Modification
Site Description	Beverage Can Manufacturer

Measure Description

The project involves modifications to the compressed air distribution system, installation of a larger storage tank, and installation of a new control system.

Summary of Ex Ante Impact Calculations

Pressure and current were logged for each compressor for various periods of time over a 2 month period generally occurring between September and November 2002. The average of these loading measurements and an assumed 8,760 annual hours of operation were used to generate pre-retrofit demand and consumption estimates. Proposed loading estimates and 8,760 hours of operation were used to generate a post-retrofit demand and consumption estimate. These estimates indicated a demand reduction of 161 kW and energy savings of **1,407,919 kWh**.

The reviewer modified the submitted calculations by decreasing annual operating hours to **8,688 since the plant shuts down for 3 days per year**. This resulted in a reduction in the savings estimate to **1,392,687 kWh**, representing about 6% savings based on the 2002 annual consumption of the entire facility.

	Energy	Demand
	kWh	*kW*
Savings estimate	1,392,687	161
2002 (pre-retrofit)	24,250,904	3,248
2003 (post-retrofit)	24,452,944	3,264
Percent Savings	5.74%	4.96%

Comments on Ex Ante Calculations

This project utilized pre-retrofit trend logging and measurement to determine the annualized baseline energy use. Engineering calculations were used to predict the ex ante savings based on the load profile determined in the pre-retrofit analysis. The analysis did not include a discussion of how the demand on the compressors would vary depending on the plant operation and production rate, but implies that the measurement period utilized in the calculations are representative of annualized operation.

The plant engineer tracks production daily. Based on this information the pre-retrofit measurement could have considered production rates. This would have generated a production-normalized baseline. A similar process after the installation and commissioning would provide a more accurate estimate of annual energy savings.

Evaluation Process

The Evaluation process consists of a review of the application form and supporting documentation, conducting an on site survey and verification of impacts using pre- and post-retrofit electric bills and production data collected on-site.

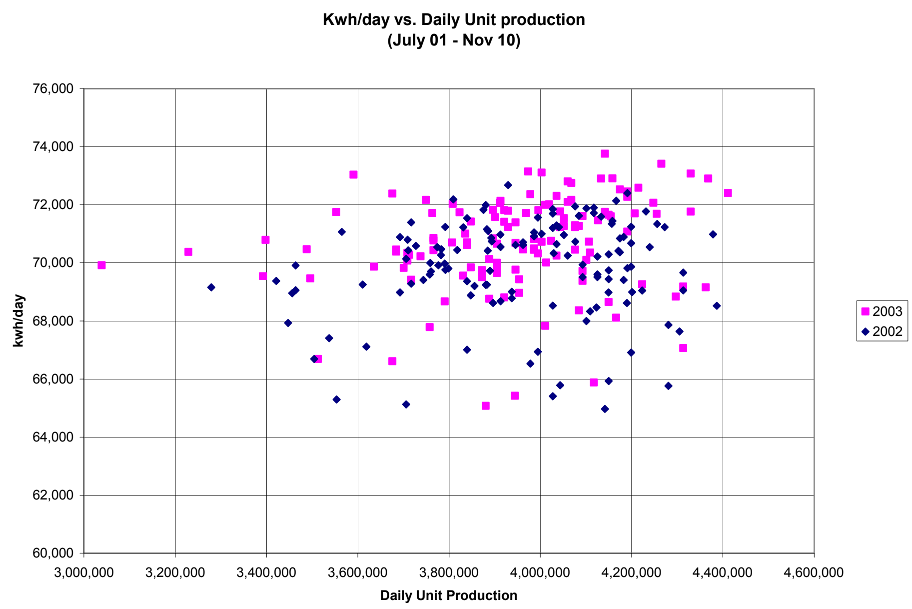
The onsite survey was conducted on November 11, 2003. Information on the retrofit equipment and operating conditions was collected through an interview with the Plant Engineer.

Historic daily production rates and 15-min interval whole-premise kW data were obtained. Daily values of kWh per unit were calculated for July 01 – Nov. 10 2002 and 2003. Due to a lack of pre-retrofit compressor interval electric use data and inadequate evaluation resources for measurement, a billing analysis was deemed appropriate.

Unfortunately, the savings estimates for the measure are fairly minor compared to the overall site energy usage, as shown in the table above..

Current Plant Operation:
The production at the plant decreased by 0.65% in 2003 compared to the same time period in 2002 (Jul, 01- Nov, 10).
A 100hp base-coater, which operated only 5-10 days a month in the pre-retrofit phase, was operating 20-25 days a month from April – Nov 2003. This would register as an increase of **139,320 kWh** in the consumption data for Jul –Nov 2003. Which accounts for 10% of the ex-ante savings estimate. However, the base-coater was running intermittently in the pre-retrofit period, so it is not expected to affect demand.
It took almost six months from Jan-June 2003 to install and commission the compressor pad to the new operating procedures.

Based on these factors, and the noise they induce in the overall energy consumption of the facility, the savings estimate cannot be verified with confidence through utility billing analysis in the limited time available for the evaluation.



The plot above shows energy consumption normalized to production for July 01, to November 10 for 2002 and 2003. The plot shows that consumption in 2003 increased. The base coater accounts for some of this increase (1800 kWh/day) But it is unknown on which days the base coater was working in the pre- or post retrofit periods. The decrease in production in 2003 should result in a decrease in consumption. However that is not the case as seen from the data. There may also be some other changes in the operational procedures at the plant which increased the facilities demand.

Based on the data gathered for the billing analysis, it cannot be determined whether this increase is a result of other changes at the facility. Our approach to evaluating this project did not yield a satisfactory result. We therefore have decided to accept the ex ante analysis since we did not identify anything during our site visit to discount the premise of the calculations provided.

Additional Notes

Improved baseline measurement normalized to post-retrofit production would have assured a more accurate analysis of impacts for this project. Since the ex-ante impact estimates were less than 6% of the facilities annual consumption in 2002, and given the fact that this is a production facility that undergoes many day-to-day and other longer-term changes, M&V is the appropriate choice for such applications. It is rare that a billing analysis approach is able to capture an accurate estimate of savings given a mere 6% savings expectation.

Impact Results

	KW	KWh	Therm
SPC Application Calculations	161	1,392,687	0
Adjusted Engineering	161	1,392,687	0
Engineering Realization Rate	1.0	1.0	NA

Economic Information

Description	Date	Project Cost	Estimated Demand Savings, kW	Estimated Energy Savings, kWh	Estimated Gas Savings, therms	Estimated Annual Cost Savings ($0.13/kWh), $	SPC Incentive, $	Simple Payback w/ incentive, yrs	Simple Payback w/o incentive, yrs
Application Submitted Amount	5/2/02	$123,090	161	1,407,919	0	$183,029	$61,545.00	0.34	0.67
Application Approved Amount	5/21/02	$123,090	161	1,392,687	0	$181,049	$61,545.00	0.34	0.68
Installation Approved Amount	5/7/03	$227,377	161	1,392,687	0	$181,049	$61,545.00	0.92	1.26
SPC Program Review	1/9/03	$227,377	161	1,392,687	0	$181,049	$61,545.00	0.92	1.26

SITE 07 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER: 2 END USE: PROCESS

Measure	Controls
Site Description	Hotel

Measure Description

Guestroom controls were installed in this 1,050 room hotel. The controls setback temperatures when the guestroom is unoccupied, the balcony door is open, or the room is unrented. The control is occupancy sensor based thermostat. All of the thermostats are networked to communicate with the hotel's server. This allows even greater temperature setbacks when rooms are unrented.

Summary of Ex Ante Impact Calculations

A bin method was used to predict the energy and therm savings of this project. The calculations are not shown in the file, but they are explained as…"A series of calculations was performed using hotel occupancy data, 30-year average bin weather data for the local area, and temperature setbacks for rented (occupied, unoccupied, night setback), and unrented room status. The bin method compares the relative amount of energy that would be transferred to the guest rooms with and without a guest room control system. The average annual savings was calculated to be 1,606,764 kWh of electricity (12.4% of the total), and 49,333 Therms of gas (11.8% of the total).

The ex ante savings model is shown below.

Comments on Ex Ante Calculations

The ex ante algorithms applied were not shown in the application. The table shown above does not clearly show how the energy and therm savings were calculated. The predicted energy savings of 12.4% of the total property usage most likely seemed reasonable to the application reviewer. The final incentive payment and claimed energy savings would be based on measured data, so the prediction was probably not scrutinized heavily.

Evaluation Process

The vendor of this control product generally has to provide their clients with a solid M&V plan and report. Therefore, the system was designed to measure and store HVAC operational data from each room. The system cumulates runtime of the room HVAC at each of the available settings (typically Off, Low, Med, High Cooling or Heating). Room controls can also be bypassed and let the thermostat revert back to complete manual operation ("reference" mode). The M&V for this project specified that 40 rooms would be set in the reference mode. There are 4 distinct areas, or towers, on the property and 10 rooms from each would be reference rooms. The system automatically rotates which 10 rooms in each tower will be selected as reference rooms. The HVAC runtime measured in the reference rooms is used as the baseline for the energy savings calculation.

Daily runtime data for reference and EMS controlled guestrooms was obtained from the control system (via the vendor). The data is summarized to average daily runtimes (by thermostat setting) for the reference rooms and the controlled rooms. The savings can be determined by multiplying the reduction in runtime by the power consumption of that unit at each setting. Power consumption coefficients are developed for each type of HVAC system. A matrix of the HVAC systems and their power coefficients is shown below.

HVAC Systems Matrix

Area	Main & North Towers	South Tower	Lanai Bldg.	Weighted Avg. kW		Main & North Towers
Type	4-Pipe FCU	2-Pipe FCU	PTAC			4-Pipe FCU
Quantity	602	335	113	1050		602
	kW	kW	kW	kW		Therms
Fan Off	0.000	0.000	0.000	0.000		n/a
Fan Lo	0.069	0.069	0.069	0.069		n/a
Fan Med	0.138	0.138	0.138	0.138		n/a
Fan Hi	0.414	0.414	0.414	0.414		n/a
Cool Off	0.000	0.000	0.000	0.000		n/a
Cool Lo	0.602	0.602	1.190	0.666		n/a
Cool Med	0.738	0.738	1.190	0.787		n/a
Cool Hi	1.081	1.081	1.190	1.092		n/a
Heat Off	0.000	0.000	0.000	0.000		0.000
Heat Lo	0.069	1.569	1.095	1.449		0.197
Heat Med	0.138	1.638	1.095	1.501		0.221
Heat Hi	0.414	1.914	1.095	1.707		0.249
Std_Elec_Off			0	0		n/a
Std_Elec_Lo			3.5	3.5		n/a
Std_Elec_Med			3.5	3.5		n/a
Std_Elec_Hi			3.5	3.5		n/a

The power coefficients were developed from nameplate data obtained during the evaluation site visit, the vendors experience, and engineering judgement. A weighted average power coefficient was calculated for each setting by summing the product of the coefficients and the number of rooms and dividing by the total number of rooms.

The heating power coefficients for the 4-pipe FCUs in the Main and North tower include fan power and therms savings. The FCUs are provided heat from a natural gas fired water boiler. The PTAC units and the 2-pipe FCUs have electric resistance strips for heating.

The evaluation savings are shown below. Peak demand savings were conservatively estimated using the resulting ex post kWh savings divided by 8,760.

Scope of Impact Assessment

This was the only project at the site.

Additional Notes

The level of M&V employed at this site was slightly below what would be required to verify savings with high precision. Obtaining spot power measurements of the various HVAC components would provide more accurate power coefficients and thus improve the savings estimate.

Also, the system to date has not been fully commissioned. They are still working on the communications between the control system network and the hotel's server. Given the troubles, the amount of runtime data stored in the system varied each month. However, data from all seasons was available and we believe that the dataset is a fair representation of the average annual pattern.

Occupancy is not tracked and included in the savings estimate. It is assumed that the randomly chosen reference rooms will have the same occupancy levels as the controlled rooms.

Peak demand savings were not claimed for this project, but they do occur. It is very difficult to measure these savings and therefore the customer chose not to apply for incentive money for peak savings. Data in enough detail to directly measure peak demand savings was not available, but ex post approach applied is a conservative estimate. The current scope of this evaluation does not support the required effort to accurately determine peak demand savings.

Although the energy savings is below the predicted, it is still 9.4% of the total facility usage. This is a reasonable amount of savings to expect from a controls project. The hotel will achieve greater savings when the communications between the control system and the hotel server are commissioned. For many hours they have been unable to reach the second tier of savings. That is, when rooms are unrented they are not currently setback to a higher temperature in the summer.

Economic Information

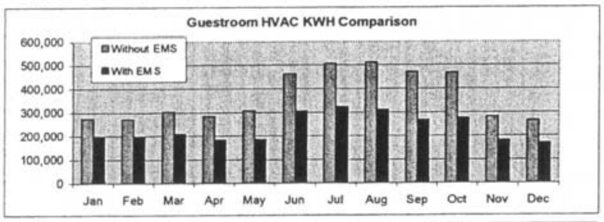
File Financial Values	Date	Project Cost	Estimated Customer Annual kWh Savings	Estimated Customer kW Savings	Estimated Customer Annual Therm Savings	Estimated Customer Annual $ Savings @ $0.08/kWh	Incentive	Payback w/o Incentive	Payback w/ Incentive
Application Estimate	06/30/2002	$ 500,510	1,606,816	0	49,424.0	$ 128,545	$150,786	3.9	2.7
Application Approved	01/09/2003	$ 500,510	1,606,816	0	49,424.0	$ 128,545	$180,943	3.9	2.5
2002 SPC Installation Report	09/29/2003	$ 500,510	1,606,816	0	49,424.0	$ 128,545	$180,943	3.9	2.5

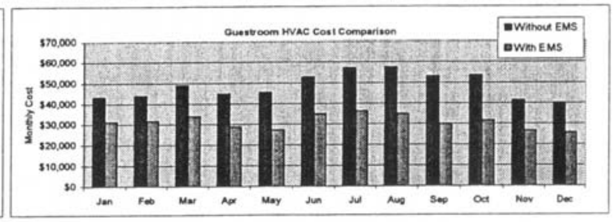
Impact Results

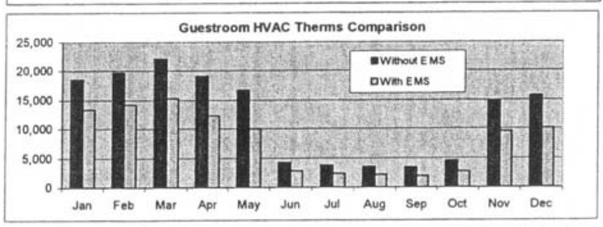
	kW	kWh	Therm
SPC Tracking System	0.0	1,606,816	49,424
Installation Report	0.0	1,606,816	49,424
Adjusted Engineering	138.5	1,213,380	133,343
Engineering Realization Rate	N/A	76%	270%

Ex Ante Savings Model

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Total
Total Elec Usage	1,020,629	1,006,325	1,140,558	1,066,093	1,092,219	1,081,963	1,162,756	1,173,506	1,079,513	1,097,638	1,029,997	980,020	12,931,217
Total Elec Cost	$99,385	$95,097	$108,014	$104,305	$111,854	$132,394	$140,494	$134,880	$126,314	$131,389	$107,139	$95,166	$1,386,431
Guestroom HVAC Elec.	273,604	271,394	302,291	283,529	306,099	463,628	507,595	512,016	472,415	467,570	281,279	263,891	4,405,311
Cost at Blended Rate	$29,335	$29,098	$32,410	$30,399	$32,819	$49,708	$54,422	$54,896	$50,650	$50,131	$30,158	$28,293	$472,319
Total Gas Usage (Therms)	38,558	41,672	46,071	39,656	37,006	30,673	31,164	29,625	28,206	31,506	31,854	32,585	418,576
Total Gas Cost	$26,813	$28,554	$31,430	$27,162	$25,365	$40,329	$28,379	$21,829	$17,917	$20,040	$22,864	$23,537	$314,219
Guestroom Gas Heating (Therms)	18,508	19,651	22,115	19,035	16,673	4,263	3,740	3,556	3,385	4,577	14,877	15,641	146,022
Cost at Blended Rate	$13,894	$14,752	$16,601	$14,290	$12,517	$3,200	$2,808	$2,669	$2,541	$3,436	$11,168	$11,742	$109,617
Guestroom HVAC Cost - No EMS	$43,229	$43,849	$49,012	$44,688	$45,335	$52,908	$57,230	$57,565	$53,192	$53,567	$41,326	$40,035	$581,936
HVAC Cost per room per Day-no EMS	$1.33	$1.49	$1.51	$1.42	$1.39	$1.68	$1.76	$1.77	$1.69	$1.65	$1.31	$1.23	$1.52
Estimated Room HVAC Savings	27.8%	27.8%	30.9%	35.5%	39.8%	34.1%	36.6%	39.4%	43.6%	41.2%	35.8%	35.8%	36.0%
Estimated Savings - Elec (KWH)	75,929	75,475	93,494	100,564	121,883	158,204	185,687	201,744	206,008	192,815	100,567	94,392	1,606,764
Estimated Savings - Elec. ($)	$8,141	$8,092	$10,024	$10,782	$13,068	$16,962	$19,909	$21,630	$22,087	$20,673	$10,782	$10,120	$172,270
Guestroom HVAC Elec-w/EMS	197,675	195,919	208,797	182,965	184,216	305,424	321,908	310,272	266,407	274,755	180,711	169,498	2,798,547
Estimated Savings - Gas (Therm)	5,136	5,465	6,840	6,752	6,639	1,454	1,368	1,401	1,476	1,888	5,319	5,595	49,333
Estimated Savings - Gas ($)	$3,856	$4,102	$5,135	$5,068	$4,984	$1,092	$1,027	$1,052	$1,108	$1,417	$3,993	$4,200	$37,034
Guestroom HVAC Gas-w/EMS	13,372	14,186	15,275	12,284	10,034	2,808	2,372	2,155	1,909	2,690	9,558	10,047	96,689
Guestroom HVAC Cost - w/EMS	$31,232	$31,655	$33,853	$28,838	$27,283	$34,854	$36,294	$34,884	$29,996	$31,477	$26,550	$25,715	$372,632
HVAC Cost per room per Day-w/EMS	$0.96	$1.08	$1.04	$0.92	$0.84	$1.11	$1.12	$1.07	$0.95	$0.97	$0.84	$0.79	$0.97







Note: 2002 data used through May

Number of rooms	1050		
Number of FCUs	1050		
Total Elec Usage (kWh)	12,931,217	$1,386,431	
Estimated Savings - Electricity (kWh)	1,606,764	$172,270	12.4%
Total Gas Usage (Therms)	418,576	$314,219	
Estimated Savings - Gas (Therms)	49,333	$37,034	11.8%
Total Energy Cost		$1,700,650	
Total Estimated Savings		$209,304	12.3%

Evaluation Calculations and Results

	EMS Control		Manual Control						
	Hrs/Day Spent In Mode	% of Day Spent in Mode	Hrs/Day Spent In Mode	% of Day Spent in Mode	% Savings	kW Coeff.	Therm Coeff.	kWh Savings	Therm Savings
Fan_Off	19.516	81.3%	14.393	60.0%	21.3%	0.000	n/a	0	0
Fan_Lo	0.055	0.2%	0.433	1.8%	1.6%	0.069	n/a	10,001	0
Fan_Med	0.005	0.0%	0.102	0.4%	0.4%	0.138	n/a	5,088	0
Fan_Hi	0.210	0.9%	0.828	3.5%	2.6%	0.414	n/a	98,120	0
Cool_Off	0.000	0.0%	0.000	0.0%	0.0%	0.000	n/a	0	0
Cool_Lo	1.570	6.5%	1.528	6.4%	-0.2%	0.666	n/a	-10,666	0
Cool_Med	0.250	1.0%	0.273	1.1%	0.1%	0.787	n/a	6,927	0
Cool_Hi	0.855	3.6%	1.215	5.1%	1.5%	1.092	n/a	150,789	0
Heat_Off	0.000	0.0%	0.000	0.0%	0.0%	0.000	0.000	0	0
Heat_Lo	0.472	2.0%	1.540	6.4%	4.5%	1.449	0.197	253,238	34,419
Heat_Med	0.123	0.5%	0.445	1.9%	1.3%	1.501	0.221	78,929	11,621
Heat_Hi	0.821	3.4%	2.965	12.4%	8.9%	1.707	0.249	598,650	87,304
Elec_Off	0.000	0.0%	0.000	0.0%	0.0%	0.000	n/a	0	0
Elec_Lo	0.000	0.0%	0.000	0.0%	0.0%	3.500	n/a	-6	0
Elec_Med	0.000	0.0%	0.025	0.1%	0.1%	3.500	n/a	3,635	0
Elec_Hi	0.052	0.2%	0.182	0.8%	0.5%	3.500	n/a	18,675	0
								1,213,380	**133,343**

Where:

Hrs/Day Spent in Mode = Measured data from controlled and reference rooms

% of Day Spent in Mode = Hrs/Day Spent in Mode / 24 hrs/day

% Savings = Manual control % of Day- EMS Control % of Day[1]

kWh Savings = (Manual Hrs/Day in Mode – EMS Hrs/Day in Mode) * kW Coeff. * 365 Days/yr * 448 rooms with electric heating

Therm Savings = (Manual Hrs/Day in Mode – EMS Hrs/Day in Mode) * Therm Coeff. * 365 Days/yr * 602 rooms with hot-water heating

[1] Calculation is inverse for "Off" modes.

SITE 08 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER: 2 END USE: PROCESS

Measure	Low Pressure ultraviolet lamps
Site Description	Water Treatment Plant

Measure Description

Replace existing medium pressure ultraviolet lamps with low pressure ultraviolet lamps.

Summary of Ex Ante Impact Calculations

Simple pre- and post-retrofit algorithm using fixture connected loads and hours of operation.

Comments on Ex Ante Calculations

Tracking system savings of 2,720,806 kWh/year vary significantly from file savings due to discrepancies in operating hours used. Installation report finds that hours of operation from plant logs is 6,295 hrs/yr compared to 8,632 hrs/yr used to calculate tracking system savings claim. This reduces savings by factor of 6,295/8,632 to 1,984,241 kWh.

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation, conducting an on-site survey and then computing impacts using the on-site data.

The on-site survey was conducted on October 29, 2003. Information on the retrofit equipment and operating conditions was collected through an inspection of the lamps and through an interview with the Plant General Manager.

The Water District operates this Superfund site to recover potable water for sale from a contaminated underground aquifer. Treatment is accomplished in three steps. Air stripping towers remove volatile organic compounds, ion exchange units provide demineralization, and banks of ultraviolet (UV) lamps provide a final UV oxidation of residual contaminants such as N-nitrosodimethylamine. The District maximizes the throughput of the treatment plant by running 24 hours per day, year round. Continuous treatment is only interrupted when maintenance is required in the stripping and ion exchange processes. From plant operating records for the 12 months previous to the verification visit, the UV system operated 7,636 hours, and the plant treated 956.5 million gallons of water.

Through site observations, interviews with plant staff and review of plant operating logs an understanding of the annual schedule of operation and the true demand for the pre- and post-retrofit lamps was developed.

The post case UV system consists of two parallel trains of lamps arrayed in banks. Each bank is comprised of 4 rows of 16 lamps each or 64 lamps/bank. Each train includes 6 banks of lamps. However, at any one time, 4 banks in each train operate for a total of 8 banks of 64 lamps per bank or 512 lamps.

In order to maintain sufficient levels of UV radiation at all times, it is necessary to keep the lamps clean. Cleaning occurs on a quarterly basis when the active banks are removed from service and the standby banks are activated in each train. Because the intensity of the UV output of the lamps declines over time, it is also necessary to replace each lamp after 8,000 hours of operation. During cleaning and lamp replacement, the spare banks are energized to maintain required levels of radiation in the treated stream. As the newly cleaned or replaced banks are returned to service, there are times when all six banks are energized for short periods.

The pre- retrofit lamps consisted of two trains of 12 banks each. Each bank total 20 kW, and nine banks operated in each train at any one time. Total pre-retrofit kW was

$$\begin{aligned} kW_{pre\text{-}retrofit} &= 18 \text{ banks} \times 20 \text{ kW/bank} \\ &= 360 \text{ kW} \end{aligned}$$

The post-retrofit lamps consist of 512 lamps of 87.5-watts each arrayed in 32 rows for a total of 44.8 kW.

$$\begin{aligned} kW_{post\text{-}retrofit} &= 512 \text{ Lamps} \times 87.5 \text{ W/Lamp} \\ &= 44.8 \text{ kW} \end{aligned}$$

From operating logs, the annual operating hours are 7,636 hours per year for both the pre- and post-retrofit equipment.

	Well Production MG/mo			UV Lamps			
	Well No. 2	Well No. 3	Total	Hrs/mo	kW	kWh/mo	kWh/MG
Oct-02	31.96	64.58	96.54	703	44.8	31,494	326
Nov-02	31.92	60.06	91.98	639	44.8	28,615	311
Dec-02	12.60	23.24	35.84	249	44.8	11,150	311
Jan-03	46.61	16.03	62.64	656	44.8	29,384	469
Feb-03	42.98	0.00	42.98	597	44.8	26,744	622
Mar-03	47.27	0.51	47.78	664	44.8	29,727	622
Apr-03	27.20	44.08	71.28	605	44.8	27,088	380
May-03	20.90	69.87	90.77	630	44.8	28,239	311
Jun-03	30.86	64.84	95.70	665	44.8	29,773	311
Jul-03	34.17	71.55	105.73	734	44.8	32,893	311
Aug-03	35.78	73.76	109.54	761	44.8	34,079	311
Sep-03	34.59	71.16	105.75	734	44.8	32,899	311
Total	396.84	559.68	956.51	7,636		342,085	358

Since ex post operating hours were found to be 7,636 hours per year vs ex ante hours of 6,295 per year, the ex ante analysis was adjusted by the ratio of ex post to ex ante operating hours:

$$\begin{aligned} \text{Ex Post Savings} &= \text{Ex Ante Savings} \times \left[\frac{\text{Ex Post Hours}}{\text{Ex Ante Hours}}\right] \\ &= 1{,}984{,}241 \text{ kWh/year} \times \left[\frac{7{,}636 \text{ Hrs/yr}}{6{,}295 \text{ Hrs/yr}}\right] \\ &= 2{,}406{,}814 \text{ kWh/year} \end{aligned}$$

Scope of Impact Assessment

This was the only measure installed by this customer that received incentives from the program.

Additional Notes

The level of M&V employed at this site is sufficient to accurately determine the impacts of the installed measure. No further M&V is justified for this customer.

Economic Information

File Financial Values	Date	Project Cost	Estimated Customer Annual kWh Savings	Estimated Customer kW Savings	Estimated Customer Annual Therm Savings	Estimated Customer Annual $ Savings @ $0.13/kWh	Incentive	Payback w/o Incentive	Payback w/ Incentive
Application Estimate	4/9/2002	$ 600,000.00	3,795,490	439.7	0.0	$ 493,413.75	$303,629.33	1.2	0.6
2002 SPC Installation Report	4/23/2002	$ 600,000.00	2,720,806	315.2	0.0	$ 353,704.83	$211,792.00	1.7	1.1
2002 NSPC Program Submittal Review	1/2/2003	$ 600,000.00	1,984,241	315.2	0.0	$ 257,951.33	$158,739.27	2.3	1.7

Impact Results

	kW	kWh	Therm
SPC Tracking System or Application	315.2	2,720,806	0
Installation Report	315.2	1,984,241	0
Adjusted Engineering	315.2	2,406,814	
Engineering Realization Rate	1.0	1.21	N/A

Because of the discrepancy between the file and the tracking system, it is assumed that the tracking system data used is outdated and that the actual savings claimed is 1,984,241 kWh per year. This makes the kWh realization rate 1.21.

Results

Base Case						Post Case						Savings	
Base Case Lamps	Banks Qty.	W/Bank	kW	Annual Hours	Annual kWh	Replace-ment Lamps	Banks Qty.	W/Bank	kW	Annual Hours	Annual kWh	kW Saved	Annual kWh Saved
Med Press UV Lamps	18	20,000	360.0	7,636	2,748,899	Low Press UV Lamps	32	1,400	44.80	7,636	342,085	315.2	2,406,814

Where:

$$\text{kW} = \text{Banks Qty.} \times \text{W/Bank} \times 1\ \text{kW/1,000 W}$$

$$\text{Annual kWh} = \text{kW} \times \text{Annual Hours}$$

$$\text{kW Saved} = \text{kW}_{\text{Base Case}} - \text{kW}_{\text{Post Case}}$$

$$\text{Annual kWh Saved} = \text{Annual kW}_{\text{Base Case}} - \text{Annual kW}_{\text{Post Case}}$$

Inputs to Model

Parameter	Value Reported	Units	Notes
Pre-Retrofit Hours of Operation	7,636	hrs/yr	Operating hrs based on plant operating data for previous 12 months.
Pre-Retrofit Lamp Wattage	20,000	Watts	Application
Pre-Retrofit Lighting Bank Count	18		Application. Confirmed in site visit interview.
Post-Retrofit Hours of Operation	7,636	hrs/yr	Operating hrs based on plant operating data for previous 12 months.
Post-Retrofit Lamp Wattage	1,400	VA	Application. Confirmed with visual check of spare lamps at onsite visit.
Post-Retrofit Lighting Bank Count	32		Based on site visit observations.

SITE 09 IMPACT EVALUATION
SAMPLE CELL: ADDITIONAL TIER: 2 END USE: PROCESS

Measure	Variable-speed Drives
Site Description	Amusement Park

Measure Description

Installation of variable-speed drives on ten sand filter pumps and one condenser water pump. As debris builds-up in sand filters the pressure increases and results in more work required from the pumps. Sand filters are back-flushed when build-up becomes excessive. Work performed by the pumps is at a minimum following the back flushing and increases as debris builds-up in the filters. The pumps operate 24/7.

Prior to the installation of VSDs the pumps operated at constant speed and constant power.

Summary of Ex Ante Impact Calculations

Operating kW measurements were obtained from each pump prior to the installation of the VSDs. This serves as the baseline kW and since the pumps operate continually the baseline kWh is the simple product of the kW and 8,760 hours per year.

The savings were developed using the 2002 SPC software. The project sponsor estimated the VSD load profile. The SPC software calculated the savings from the measured baseline and the energy required at the assumed load profile.

Pump	Base kW	Predicted Avg. %RPM	SPC Est. Savings
S1	16.7	65%	87,863
S2	16.7	65%	87,863
S3	16.7	65%	87,863
S4	16.7	65%	87,863
SP8	12.4	65%	63,794
SP9	12.4	65%	63,794
SP10	12.4	65%	63,794
50hp	39.4	60%	244,458
SP1	16.8	65%	87,592
SP2	16.8	65%	87,592
SP3	16.8	65%	87,592
SP4	16.8	65%	87,592
			1,137,660

Comments on Ex Ante Calculations

The savings were estimated based on measured baseline conditions and the energy usage predicted by the SPC software. A key assumption input to the SPC software is the expected operating profile of the VSDs. The percent speed predicted for the condenser water pump was 60% continuously. The filter pumps were estimated to operate with the profile shown below. The weighted average speed of this profile is 65.25%.

Weighted Average Ex Ante Load Profile

% Speed	% of Operating Time
20%	0%
25%	0%
30%	0%
35%	0%
40%	0%
45%	0%
50%	35%
55%	0%
60%	0%
65%	35%
70%	0%
75%	0%
80%	20%
85%	0%
90%	10%
95%	0%
100%	0%

Evaluation Process

Each VSDs has the ability to record cumulative hours of operation and energy (kWh). Readings were obtained on 8/29/03 ("Initial readings") from each drive. A second reading was obtained on 8/25/04, nearly a full year of data. The average operating kW was calculated for the time period. To determine savings, the difference between the average operating kW and the measured baseline kW was multiplied by the annual hours of operation. Most of the data indicated that each pump operates continuously, but a couple of pumps were on between 90%-100% over the past year. The operating hours in the savings calculations adjusted for this slight variation.

Evaluation Data and Savings Calculations

Pump	Base kW	Hours- Initial Read	kWh- Initial Read	Hours- Last Read	kWh- Last Read	Avg. kW	%ON	kWh Saved
S1	16.7	1,558	13,070	10,217	83,593	8.14	100%	74,696
S2	16.7	1,564	12,178	10,219	80,298	7.87	100%	77,052
S3	16.7	1,523	11,990	10,181	80,003	7.86	100%	77,209
S4	16.7	1,559	13,350	10,215	86,575	8.46	100%	71,922
SP8	12.4	2,015	14,831	10,571	79,590	7.57	98%	41,679
SP9	12.4	2,004	16,297	10,605	89,422	8.50	99%	33,805
SP10	12.4	1,981	14,772	10,604	78,864	7.43	99%	43,188
CDW	39.4	1,416	36,935	9,349	267,469	29.06	91%	82,707
SP1	16.8	1,718	26,039	9,972	127,908	12.34	95%	37,103
SP2	16.8	1,719	23,241	10,121	140,951	14.01	97%	23,638
SP3	16.8	1,722	26,540	9,493	143,460	15.05	89%	13,747
SP4	16.8	1,723	15,097	10,358	110,108	11.00	99%	50,472
								627,217

Where:

kWh Savings =(Base kW – Avg. kW) * %On * 8760 hrs./yr.
Avg. kW = (kWh Last Read - kWh Initial Read)/(Hours Last Read – Hours Initial Read)
%On = (Hours Last Read – Hours Initial Read) / Total Hours between Reads (8688 hrs.)

The evaluation findings are significantly lower in energy savings than the ex ante savings. The reason for the discrepancy is that the VSDs are operating at a much higher speed than predicted. As shown above, the weighted average speed of the filter pumps was estimated at 65%. Using the centrifugal affinity laws to back into the average speed of the pumps from the average kW, determined from the metered data, we estimate that the pumps all ran between 78% and 96% speed (average). Therefore, savings are being achieved, but the pumps are not backing down as much as expected.

Ex Ante Predicted Pump Speed (Avg.) and Ex Post Estimated Speed (Avg.)

Pump	Predicted Avg. %RPM	Avg. % RPM
S1	65%	79%
S2	65%	78%
S3	65%	78%
S4	65%	80%
SP8	65%	85%
SP9	65%	88%
SP10	65%	84%
CDW	60%	90%
SP1	65%	90%
SP2	65%	94%
SP3	65%	96%
SP4	65%	87%

Scope of Impact Assessment

It appears from the file that HVAC measures were also incented through the SPC program at this site. However, the evaluation scope was limited to the VSDs.

Additional Notes

The level of M&V employed at this site is sufficient to accurately determine the energy and demand impacts.

Economic Information

File Financial Values	Date	Project Cost	Estimated Customer Annual kWh Savings	Estimated Customer kW Savings	Estimated Customer Annual Therm Savings	Estimated Customer Annual $ Savings @ $0.08/kWh	Incentive	Payback w/o Incentive	Payback w/ Incentive
Application Estimate	04/18/2002	$ 109,716	1,150,513	unk	0.0	$ 92,041	$92,041	1.2	0.2
Application Approved	09/27/2002	$ 109,716	1,137,659	unk	0.0	$ 91,013	$91,013	1.2	0.2
2002 SPC Installation Report	08/19/2003	$ 109,716	1,137,659	unk	0.0	$ 91,013	$91,013	1.2	0.2

Impact Results

	kW	kWh	Therm
SPC Tracking System	unk	1,137,659	0
Installation Report	unk	1,137,659	0
Adjusted Engineering	73.3	627,217	0
Realization Rate	Not Applicable	55%	0

SITE 10 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER:2 END USE: PROCESS

Measure	Variable Frequency Drives on Injection Molding Machines
Site Description	Manufacturing

Measure Description

New variable frequency drives for 9 existing injection molding machines.

Summary of Ex Ante Impact Calculations

The application calculations used an AC watt transducer to graph the power versus run-time of the existing injection molding machines for different parts being made. In order to estimate power savings, a graphical representation of the molding cycle was created and used to estimate the speed of a VFD installed on each machine. The result was an estimated reduction of 21% of energy consumption. Then average production rates were used to estimate annual energy savings.

Comments on Ex Ante Calculations

The energy calculations were based on measured data, production and historical data recorded from past projects. The savings appear reasonable and derived from sound assumptions and data. However, a majority of the data used to estimate savings (power versus time graphs, historical savings data, etc.) were not available for this report. Therefore, the savings were reviewed for reasonableness based on the evaluators experience with this measure.

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation, conducting an on-site survey and then computing impacts using data collected on-site.

The on-site survey was conducted on September 18, 2003. Information on the retrofit equipment and operating conditions was collected through an inspection of the injection molding machines and through an interview with the Plant Engineer. In addition to the spot recordings of the injection molding machines, the plant engineer provided a current production schedule and labor hours.

The typical manufacturing schedule for the facility is 24 hours per day, seven days per week.

Although long-term trended data were not available from the site, production cycles for machine 6, machine 9, and machine 15 were observed. These were compared with the product currently being made and the results extrapolated to the other machines.

- Machine 6 was producing a 30 gallon plastic drum and was observed to oscillate between 99% and 25% speed.
- Machine 9 was producing a 55 gallon drum and was observed to oscillate mostly between 99% and 45% speed.
- Machine 15 was producing a 60 CLRD Tuff Crate and varied between 99%, 65% and 25% speed.

The observed cycles were on machines making larger items and they still appeared to be achieving savings greater than 21%, but since several machines were scheduled off for the entire day, the length of the equipment operating time (8,736 hours) may have been overstated. These two effects mean that the overall energy savings are probably consistent with the proposed savings in the application.

The demand savings were calculated from the average difference between the baseline and post-installation demand of the machines. Since the motors on the machines will operate at full power and speed for small periods during most of their cycles, the demand savings occur from the staggered timing of full power operation. By estimating the demand savings with average demand reduction, the coincident demand of the machines is reasonably accounted for.

Scope of Impact Assessment

The full project, involving one site and one measure (on multiple machines) was reviewed for reasonableness.

Additional Notes

The impact results are based on the savings calculated for the utility's installation Report (IR). This report estimated the savings lower than the application because it was determined at the inspection that only 9 units received a VFD as opposed to the 13 machines submitted.

Originally, the data collected from the application M&V plan was going to be used to verify the energy savings, but this data was not available (through the M&V contractor hired by the participating customer). Therefore, the savings were reviewed for reasonableness based on the data collected at the site visit. The level of M&V employed at site is not sufficient to estimate annual savings with precision.

The analysis of savings at this site would be best accomplished using the short-term metering equipment (loggers) to measure the effect of coincident machine loading (such as the likelihood that machines will run fully loaded at the same time) and post-retrofit average annual motor unloading. To accomplish this would require roughly 40 additional hours of engineering time assuming the site was responsive and retrieved the loggers for the contractor.

Impact Results

	KW	KWh	Therm
SPC Tracking System or Application	131.7	1,151,029	0
Adjusted Engineering	131.7	1,151,029	0
Engineering Realization Rate	100%	100%	N/A

Machine Type	Size	HP	Hours	kW before	kW after	kW Savings	% Savings	Savings per Year	Onsite Observation	Onsite Product	Commetns
#13 HPM	1500	275	8,736	90.4	67.4	23.0	25.4%	200,928		Non-scheduled hours	See Note 1
#15 HPM	1200	210	8,736	125.6	105.6	20.0	15.9%	174,720	oscillated 99%, 65% and 25%	60 CLRD Tuff Crate	See Note 1
#16 Toshiba	950	150	8,736	N/A	N/A	N/A	N/A	N/A			VFD not installed as stated in PIR
#8 Toshiba	720	120	8,736	N/A	N/A	N/A	N/A	N/A			VFD not installed as stated in PIR
#2 HPM	700	125	8,736	45.8	38.7	7.1	15.5%	62,026		55 Gallon Drum	See Note 1
#3 HPM	700	125	8,736	45.8	38.7	7.1	15.5%	62,026		1 Gallon Tearstrip Cover	See Note 1
#4 HPM	700	125	8,736	45.8	38.7	7.1	15.5%	62,026		Non-scheduled hours	See Note 1
#14 HPM	700	125	8,736	45.8	38.7	7.1	15.5%	62,026		5 Gallon Blue Pail	See Note 1
#5 Cincinnati	700	120	8,736	98.9	60.4	38.5	38.9%	336,336		Non-scheduled hours	See Note 1
#12 HPM	600	225	8,736	N/A	N/A	N/A	N/A	N/A			VFD not installed as stated in PIR
#6 HPM	500	85	8,736	27.7	21.5	6.2	22.4%	54,163	oscillated 99% and 25%	30 Gallon Drum	See Note 1
#1 Cincinnati	500	100	8,736	N/A	N/A	N/A	N/A	N/A			VFD not installed as stated in PIR
#9 Hartig	140	150	8,736	43.7	27.7	16.0	36.6%	139,776	oscillated 99% and 45%	55 Gallon Drum	See Note 1
Total				569.5	437.4	132.1		1,154,026			

Notes

(1) The savings estimated in this table were calculated from a hard copy of the original project application. The savings are presented for informational purposes only and do not reflect the actual savings calculations, which were 1,151,029 kWh as shown in the post-installation review form. Refer to the original application for details regarding the original calculation.

SITE 11 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER: 2 END USE: PROCESS

Measure	HVAC System Modifications and Lighting Retrofit
Site Description	Hotel

Measure Description

-Lighting retrofit
-VFDs on chilled water pumps and hot water pumps
-VFDs on HVAC Fans
-VFD on Chiller #2
-Install oversized cooling tower

Summary of Ex Ante Impact Calculations

SPC software was used to generate impact calculations for all measures.
The Chiller VFD retrofit was singled out for M&V, and the application includes a description of the required savings model. The calculation procedures follow Section 3.4.7, Determining Energy Savings: Complex Method of the 2001 LNSPC Manual.

Comments on Ex Ante Calculations

The SPC software allows users to input load profiles for VFD applications on pumps. No supporting documentation was included in the application, describing the method used by the customer to estimate post-retrofit load profiles for hot water and chilled water pumps.

Evaluation Process

The Evaluation process consists of a review of the SPC application form and supporting documentation, an on-site survey, and the completion of a billing analysis.

The on-site survey was performed on November 13, 2003. Information on the retrofit equipment and operating conditions was collected during a walk through the Facility and an interview with the Plant Manager and Safety Engineer.

Installation of VFDs and the new Cooling Tower was visually verified. Trend data were obtained from the plant manager, but only for a post-retrofit period – no pre-retrofit trend data were available. It was determined that due to the interacting affects of all the measures, including a possible heating penalty, an accurate impact analysis will not be possible without comprehensive modeling using building simulation software such as DOE2.1.

Considering the scope and resources of this site-level evaluation, it was determined that a utility bill analysis or a TOU data analysis using pre and post retrofit data should be used to estimate impacts. Unfortunately, attempts to isolate impacts using utility bills are inconclusive. Directionally these results suggest that no more than 50% of the ex ante savings were achieved. But, given weaknesses in the billing-based approach, the conclusion is that we must accept the ex ante estimates.

Additional Notes

Since the measures included are heavily dependent on weather and occupancy, this entire site should have been put through the M&V process, rather than just the chiller.

The ex post evaluation resources were inadequate to estimate impacts for this project with any reasonable level of certainty. Pre- and post-installation monitoring would provide clear evidence of the impacts for this project, requiring an additional 60 hours of labor and the use of metering equipment and building simulation models to develop precise impacts.

Impact Results

	KW	KWh	Therm
SPC Application Calculations	153.8	1,441,615	NA
Adjusted Engineering	153.8	1,441,615	NA
Engineering Realization Rate	1	1	NA

Economic Information

Description	Date	Project Cost	Estimated Demand Savings, kW	Estimated Energy Savings, kWh	Estimated Gas Savings, therms	Estimated Annual Cost Savings ($0.13/kWh), $	SPC Incentive, $	Simple Payback w/ incentive, yrs	Simple Payback w/o incentive, yrs
Application Submitted Amount	4/26/2002	$485,000	228.4	1,494,146	0	$194,239	$126,018.99	1.85	2.50
Application Approved Amount	7/26/2002	$485,000	231.4	1,494,178	0	$194,243	$126,019.10	1.85	2.50
Installation Approved Amount	7/11/2003	$485,000	153.8	1,441,615	0	$187,410	$111,950.31	1.99	2.59
SPC Program Review	11/14/2003	$485,000	153.8	1,441,615	0	$187,410	$111,950.31	1.99	2.59

SITE 12 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER: 2 END USE: PROCESS

Measure	Compressor System Modifications
Site Description	Industrial Manufacturing

Measure Description

Installation of air compressor unloaders, air compressor system modifications including relocation and piping of compressors and installation of air receivers to optimize system efficiency. Lighting efficiency improvements were included with the original application submission. The post installation inspector identified that the lighting installation did not meet the SPC program requirements since first generation T-8 lamps were installed and the program requires second or third generation T-8 lamps. The lighting incentive was disallowed.

Summary of Ex Ante Impact Calculations

This is a complex compressed air plant consisting of three compressed air systems operating in a an industrial environment, providing both plant compressed air and compressed air for laboratory testing.

Compressor Unloader Installation (Lab Air System)
The customer submitted baseline calculations for the compressor unloader installation utilizing field measured current and power factor data and operator supplied information regarding the hours of operation of the system and the expected operation in the post retrofit case. The evaluation centers on compressor #2 and compressor #3. Both compressors are 4,500 HP double acting reciprocating compressors operating at 12 kVA power supply. Compressor #2 had already received the unloader installation and the measure was to install similar unloaders on compressor # 3. The calculations assumed that the compressors operate 10 hours per day, 5 days per week, 50 weeks per year or 2,500 hours annually. Table 1 is a summary of the field measured data and the calculated power used. Power is calculated as follows:

Power (kW) = [Current (Amps) x Voltage x Power factor x square root of 3]/1000

Table 1
Summary of Field Measured Data for Compressor #3 Unloader Installation

	Compressor 2 (with unloaders)				Compressor 3 (without unloaders)			
	Amps	Volts	Power Factor	kW Calculated	Amps	Volts	Power Factor	kW Calculated
Full Load	200	12,000	1.00	4,156.9	NA	NA	NA	NA
75% Load	NA	NA	NA	NA	152	12,000	0.99	3,127.7
50% Load	114	12,000	0.83	1,966.6	NA	NA	NA	NA
Unloaded	77	12,000	0.75	1,200.3	108	12,000	0.86	1,930.5

Note: Measurements were not provided for all load points.

The analysis assumes that the system will operate 2,500 hours annually as noted above, and each compressor will operate 50% of the time or 1,250 hours annually. When operating, each compressor will be unloaded 25% of the time. The reduction in energy consumption is estimated by comparing the calculated power consumption of the two compressors operating in the unloaded mode for the estimated annual hours (25% of 1,250 hours) and assuming that the performance of compressor #3 will be identical to compressor #2 after unloaders are installed (1,200.31 kW vs. 1,930.47 kW).

kWh saved = 1,250 hrs x 25% hours unloaded x (1,930.47 kW-1,200.31 kW) = 228,175 kWh. The small difference between the savings calculated above and the savings accepted in the post installation review report (228,490 kWh) is assumed to be due to rounding error.

No demand kW savings were allowed for this measure.

Compressor Plant Modifications-Lab Air System

Before the retrofit, an auto bleed valve was installed to keep the lab air compressors fully loaded by bleeding off air when the pressure became excessive. In the post retrofit case, the auto bleed valve was removed. The addition of three 62,000 gallon air receivers and modification of the control system to fully load the compressors over a 25 psig pressure range instead of a 8 psig pressure range, significantly reduced cycling of the system and keeps the system operating at a more constant load.

The ex ante analysis assumes that the benefit of this system modification will be realized in the first three hours of the day, six days per week, 50 weeks per year (900 hours annually) before the lab air demand has increased. In the pre retrofit case for this 900 hour period the ex ante calculations assumed that one 4,500 HP compressor would operate fully loaded 50% of the time, 50 % loaded 25% of the time and unloaded 25% of the time. After the retrofit the calculations assume that one 4,500 HP compressor would operate fully loaded 25% of the time, 50 % loaded 50% of the time and unloaded 25% of the time. The savings are summarized in Tables 2 and 3 below.

An error was discovered in the ex ante calculations performed by the installation reviewer for this measure. The ex ante calculations estimate the compressor power consumed at full load, 50 % load and unloaded as follows:

Power (kW) = [Current (Amps) x Voltage x Power factor]/1000

The reviewer neglected to multiply by the square root of 3. The correct equation is:

Power (kW) = [Current (Amps) x Voltage x Power factor x **square root of 3**]/1,000

Annual kWh = Power (kW) x TOU % x hr/day x day/wk x wk/yr

Thus the analysis is off by a factor of 1.73 (square root of 3). This is a significant calculation error. In the calculations, the reviewer also used a power factor of 0.77 for the unloaded compressor. Field measured data indicate that the unloaded power factor is 0.75. This has a minor impact on the calculations.

Table 2
Pre-Retrofit Energy Consumption Lab Air System Ex Ante Uncorrected

	Volts	Amps	PF	kW	% TOU	Hr /day	Day /wk	Wk /yr	Annual kWh
Full Load	12,000	200	1	2,400.0	50%	3	6	50	1,080,000
50% Load	12,000	114	0.83	1135.4	25%	3	6	50	255,474
Un-loaded	12,000	77	0.77	711.5	25%	3	6	50	160,083
Total									**1,495,557**

Table 3
Post-Retrofit Energy Consumption Lab Air System Ex Ante Uncorrected

	Volts	Amps	PF	kW	% TOU	Hr /day	Day /wk	Wk /yr	Annual kWh
Full Load	12,000	200	1	2,400.0	25%	3	6	50	540,000
50% Load	12,000	114	0.83	1135.4	50%	3	6	50	510,948
Un-loaded	12,000	77	0.77	711.5	25%	3	6	50	160,083
Total									**1,211,031**

The annual savings associated with this measure are the post -retrofit annual kWh subtracted from the pre -retrofit annual kWh:

Annual savings kWh = 1,495,557 kWh-1,211,031
Annual savings kWh = 284,526 kWh

No demand kW savings were allowed for this measure.

The corrected calculations for this measure are included in the "Evaluation Process" section below.

<u>Compressor Plant Modifications-Plant Air System</u>
According to the installation report review, energy savings for the plant air system were realized by relocating two 200 HP compressors from Building 4 to Building 10 and re-piping the compressed air system. Prior to the retrofit the plant operator ran a 1,250 HP compressor an average of one hour per day to supplement the two 200 HP compressors during periods of high demand. After the retrofit, the need to operate the 1,250 HP compressor was eliminated. The reviewer assumed that the 1,250 HP operated at 60 % load factor for one hour per day, 6 days per week, 50 weeks per year. After the retrofit the need to operate this compressor was eliminated. Based on unstated assumptions regarding motor efficiency, the 1,250 HP compressor operating at a 60 % load factor is calculated to require 608.2 kW of power. (This equates to approximately a 92% motor efficiency which is not unreasonable)

Energy savings for this measure are shown in Table 4 and were calculated as follows:

kWh saved = HP x load factor x 0.746 kW/HP x annual hours

Table 4
Energy Savings- Plant Air System Modifications

HP	Load Factor	kW	Hr/day	Day/week	Wk/yr	kWh
1,250	0.6	608.2	1	6	50	182,446

608 kW of demand savings were allowed for this measure.

Table 5 is a summary of the savings estimate.

Table 5
Summary of Ex Ante Savings

Measure	Annual kWh Savings	Demand kW Savings
Unloaders on Compressor 3	228,490	0
Modifications-Lab Air	284,526	
Modifications-Plant Air	182,446	608
TOTAL	695,462	608

Comments on Ex Ante Calculations

The Ex Ante savings calculations are based on field measured current, voltage and power factor data for the two 4,500 HP compressors and estimates of power consumption for the 1,250 HP compressor. Additionally, assumptions were made concerning the pre and post retrofit operating hours and percent of time at various loads for each compressor. Much of the information about the plant operating hours and compressor loading was provided by the plant operator based on the operator's experience and observations.

Unfortunately the reviewer incorrectly calculated the savings associated with the modification of the Lab Air system, introducing a large error, to a calculation based on a great number of unverified assumptions.

Because of the complexity of the plant modifications, it may have been difficult to foresee the implications of the plant retrofit when the Ex Ante savings calculations were prepared. No measurement and verification was performed for this project after the retrofit was completed.

The Ex Ante calculations and the program review of the calculations do not capture the complexity of the compressed air system. The application submission does not provide a description of the compressed air system before and after the proposed modifications. During the site visit, discussions with the plant operator revealed that the retrofit affects the operation of three compressed air systems. Recognition of this fact primarily affects the savings associated with the Compressor Plant modifications, since the plant was not operated exactly in the manner inferred in the Ex Ante savings analysis.

Evaluation Process

The evaluation plan consisted of a review of the SPC application and a review of the installation review report and supporting calculations. A visit to the site was made to verify the installation and to gain an accurate understanding of the compressed air system configuration. Additionally we attempted to obtain information supporting the plant air demand profile and compressor performance data used in the savings calculations.

Discussions with the plant operator revealed that the facility had two operating compressed air systems prior to the retrofit and three compressed air systems operating after the retrofit. Two of the post retrofit systems are used for industrial testing and operate at 250-550 psig. The third system is the plant air system operating at 110 psig. Each system is described in detail below.

Lab Test Air System

In the pre-retrofit system, lab test air is provided at 250 psig by two 4,500 HP double acting reciprocating compressors and one 1,250 HP reciprocating compressor piped in parallel. These compressors are located in Building 10. The compressors are controlled by an Ingersoll Rand control system that stages the compressors from unloaded to fully loaded as the system pressure varies by 8 psi. An auto bleed valve was installed to keep the compressors fully loaded by bleeding off air when the pressure became excessive. This prevented the compressors from cycling excessively which is harmful to compressor operation and was causing valves to burn out and require frequent maintenance. The plant operator stated that as much as 45% of a 4,500 HP compressors' capacity was frequently being bled off in this manner.

In the post retrofit system, unloaders are installed on Compressor #3, three receivers with a capacity in excess of 60,000 gallons each are installed. A tee is installed from the 250 psig supply line that goes to the suction of a 300 HP compressor that has the capacity to boost air pressure to 550 psi for special testing requirements. The 300 HP compressor was installed outside of Building 10 for a prior project and was not being used at the time of the retrofit. A tee is also installed from the plant air system (described below) to the suction of the 300 HP booster compressor. A new control system now stages the compressed air system from unloaded to loaded over a 25 psig range providing much greater system stability.

Operating Characteristics Pre and Post Retrofit- Lab Test Air System

Discussions with the plant operator revealed that the operating requirements for the Lab Test Air system vary on a daily basis based on the requirements from various projects being performed at the Lab Test facility. The facility is very conscious about energy costs and does not operate the Lab Test Air System during peak summer tariff hours to avoid peak energy costs. The system operates from 4 AM to noon Monday- Friday, and for 6 hours on Saturday during the summer electric tariff and from 6 AM- 2 PM Monday- Friday and for 6 hours on Saturday during other months. The facility operates 50 weeks per year. Annual operating hours for the Lab Test Air System are estimated to be:

[8 hrs/day x 5 days/week + 6 hours (Saturday)] x 50 weeks/yr. = 2,300 hrs. annually

The plant operator confirmed that normal operation for this system before and after the retrofit includes one of the 4,500 HP compressors operating unloaded 25% of the time and the 1,250 HP compressor operating an average 1 day/week for 6 hours. The 4,500 HP compressors are operated in a lead/lag sequence to equalize run time. Each compressor therefore operates an estimated 1,150 hour annually, unloaded 25 % of the time (287.5 hrs./yr). We have accepted the plant operator’s observations since there is no better information available for the compressor load profile.

Energy Savings- Unloaders on Compressor #3

The energy savings associated with the installation of unloaders for Compressor #3 are calculated based on the methodology and field measured data from the ex ante application submission, with the annual hours of operation adjusted based on information provided by the plant operator during the site visit. We have accepted the plant operator’s estimate for the compressor load profile since we have no better data.

The analysis assumes that the system will operate 2,300 hours annually as noted above, and each compressor will operate 50% of the time or 1,150 hours annually. When operating, each compressor will be unloaded 25% of the time. The reduction in energy consumption is estimated by comparing the calculated power consumption of the two compressors operating in the unloaded mode for the estimated annual hours (25% of 1,150 hours) and assuming that the performance of compressor #3 is identical to compressor #2 after unloaders are installed (1,200.3 kW vs. 1,930.5 kW).

kWh saved = 1,150 hrs x 25% hours unloaded x (1,930.5 kW-1,200.3 kW) = 209,933 kWh

No demand kW savings were calculated for this measure since this system does not operate during summer peak demand hours.

Compressor Plant Modifications-Lab Air System

Before the retrofit, an auto bleed valve was installed to keep the lab air compressors fully loaded by bleeding off air when the pressure became excessive. This prevented the compressors from cycling excessively which is harmful to compressor operation and was causing valves to burn out and require frequent maintenance. The plant operator stated that as much as 45% of a 4,500 HP compressors’ capacity was frequently being bled off in this manner. The bleed off was occurring most frequently in the first three hours of each day, before the Lab Air demand increased sufficiently. In the post retrofit case, the auto bleed valve was removed. The addition of three 62,000 gallon air receivers and modification of the control system to fully load the compressors over a 25 psig pressure range instead of a 8 psig pressure range, significantly reduced cycling of the system and keeps the system operating at a more constant load.

During the site visit, the plant operator confirmed the assumptions in the ex ante analysis. The ex ante analysis assumes that the benefit of this system modification will be realized in the first three hours of the day, six days per week, 50 weeks per year (900 hours annually) before the Lab air demand has increased. In the pre retrofit case for this 900 hour period the ex ante calculations assumed that one 4,500 HP compressor would operate fully loaded 50% of the time, 50 % loaded 25% of the time and unloaded 25% of the time. After the retrofit the calculations assume that one 4,500 HP compressor would operate fully loaded 25% of the time, 50 % loaded 50% of the time and unloaded 25% of the time. The savings are summarized in Tables 6 and 7 below.

Two errors were discovered in the ex ante calculations performed by the installation reviewer for this measure as described above in the “Summary of the

Ex Ante Savings" section of this report.

The equation used for this calculation is:

Power (kW) = [Current (Amps) x Voltage x Power factor x square root of 3]/1,000.

Annual kWh = Power (kW) x TOU % x hr/day x day/wk x wk/yr

The corrected results are shown below in Tables 6 and 7.

Table 6
Pre-Retrofit Energy Consumption Lab Air System

	Volts	Amps	PF	kW	% TOU	Hr /day	Day /wk	Wk /yr	Annual kWh
Full Load	12,000	200	1	**4,156.9**	50%	3	6	50	**1,870,614**
50% Load	12,000	114	0.83	**1,966.6**	25%	3	6	50	**442,493**
Un-loaded	12,000	77	**0.75**	**1,200.3**	25%	3	6	50	**270,070**
Total									**2,583,177**

Table 7
Post-Retrofit Energy Consumption Lab Air System

	Volts	Amps	PF	kW	% TOU	Hr /day	Day /wk	Wk /yr	Annual kWh
Full Load	12,000	200	1	**4,156.9**	25%	3	6	50	**935,307**
50% Load	12,000	114	0.83	**1,966.6**	50%	3	6	50	**884,988**
Un-loaded	12,000	77	**0.75**	**1,200.3**	25%	3	6	50	**270,070**
Total									**2,090,365**

The annual savings associated with this measure are the post -retrofit annual kWh subtracted from the pre -retrofit annual kWh:

Annual savings kWh = 2,583,177 kWh-2,090,365
Annual savings kWh = 492,812 kWh

No demand kW savings were calculated for this measure since this system does not operate during summer peak demand hours.

<u>Compressor Plant Modifications-Plant Air System</u>
In the pre-retrofit case, plant air is provided at 100 psig from Building 4 by two 200 HP compressors. There are also two 200 HP compressors located in Building 10 that can be used to back up the plant air system in the case of a problem with the system in Building 4. The use of the Building 10 compressors was not preferred because the quality of the air from the Building 10 system was not as good as the quality of the air from Building 4. The piping main from Building 4 is 2.5 inches before it joins the distribution main at Building 10 and becomes 6 inches.

In the post retrofit case the two 200 HP air compressors in Building 4 are relocated and piped in parallel with the two 200 HP air compressors in Building

10. New air dryers were installed and the quality of air from this system has improved. The system is now connected to the 6 inch main supply for the facility. A tee from this system is also piped to the suction of the 300 HP booster compressor to provide air for special laboratory testing on an infrequent basis.

Operating Characteristics Pre and Post Retrofit- Plant Air System

Discussions with the plant operator revealed that the plant air system operates continuously (8,760 hours annually).

The plant operator stated that before the retrofit, both 200 HP compressors were required to operate continuously to meet the plant air demand of the facility. Following the retrofit, operation of the second air compressor is not required, the plant air demand can be met with one compressor operating. This is largely due decreased pressure drop due to the increased diameter of the distribution main from 2.5 to 6 inches and repair of leaks performed during the retrofit. We have accepted the plant operator's observations since there is no better information available for the compressor load profile.

Our approach to quantifying the savings for this measure calculates that the effect of the plant air modifications equates to assuming that one 200 HP compressor continuously operating with a 25% load factor and 94% efficient motor has been eliminated with this measure. Demand and energy savings for the modifications to the plant air system are calculated as follows:

Demand Savings kW= (nominal HP/motor efficiency) x load factor x 0.746 kW/HP
Demand Savings kW=(200 HP/0.94 eff) x 0.25 LF x 0.746 kW/HP
Demand Savings kW= 39.7 kW

Annual savings kWh= (nominal HP/motor efficiency) x load factor x 0.746 kW/HP x hours

Annual savings kWh =(200 HP/0.94 eff) x 0.25 LF x 0.746 kW/HP x 8,760 hours
Annual savings kWh = 347,604 kWh

Plant modifications have continued at this facility. An additional 200 HP compressor has been added to the plant air system which is periodically used to supply air to the booster compressor for special testing requirements. Also the installation of a more sophisticated control system is being phased in. Table 8 provides a summary of the Impact evaluation savings calculation results.

Table 8
Summary of Impact Evaluation Savings

Measure	Annual kWh Savings	Demand kW Savings
Unloaders on Compressor 3	209,933	0
Modifications-Lab Air	492,812	0
Modifications-Plant Air	347,604	39.7
TOTAL	1,050,349	39.7

Scope of Impact Assessment

The scope of the impact assessment is for the modifications to the Lab Air and Plant Air compressor systems and the installation of unloaders on one compressor serving the Lab Air system.

Additional Notes

The level of M&V employed at this site was inadequate to provide a high level of confidence in the accuracy of the energy savings. Some field measurements were taken for the Lab Air compressors, but all compressor load information and plant air demand profiles were provided by the plant operator. The plant operator stated that the demand for Lab air is highly variable based on the testing requirements which change on a regular basis. Long term monitoring pre and post retrofit would be required to increase the accuracy of this evaluation. We estimate an additional 64 hours of engineering time and the cost of monitoring equipment rental would be required for this task.

Economic Information

Table 9
Economic Summary of the Project

Description	Date	Project Cost	Estimated Demand Savings, kW	Estimated Energy Savings, kWh	Estimated Gas Savings, therms	Estimated Annual Cost Savings ($0.10/kWh), $	SPC Incentive, $	Simple Payback w/ incentive, yrs	Simple Payback w/o incentive, yrs
Application Submitted Amount		$1,541,431	2,260	4,009,071	0	$400,907	$227,315.00	3.28	3.84
Application Approved Amount	12/31/2002	$1,541,431	2,127	3,365,745	0	$336,575	$194,278.00	4.00	4.58
Installation Approved Amount	4/5/2004	$300,000	608	695,462	0	$69,546	$55,607.00	3.51	4.31
SPC Program Review	9/2/2004	$636,000	40	1,050,349	0	$105,035	$55,607.00	5.53	6.06

Impact Results

Table 10
Realization Rate Calculation

	kW	kWh	Therm
SPC Tracking System	2,127	3,365,745	0
Installation Report	608.2	695,462	0
Adjusted Engineering	39.7	1,050,349	0
Engineering Realization Rate	6.2%	151%	N/A

SITE 13 IMPACT EVALUATION
SAMPLE CELL: ADDITIONAL TIER:3 END USE: PROCESS

Measure	New Control Management System
Site Description	Food Processing Plant

Measure Description

Installation of a new energy management and control system on an existing compressed air system. Converting six individually modulating air compressors to a single point controlled load/unload system where the use of the most efficient compressor is prioritized. This project also includes the reduction in demand by repairing air leaks, eliminating a desiccant dryer that requires a compressed air purge and eliminating demand from unregulated users. Additional of receiver capacity is installed and the air dryers are reconfigured.

Summary of Ex Ante Impact Calculations

The electrical usage of the existing and proposed compressed air systems were calculated with an industry standard software tool "AirMaster+", manufacturer specifications, and compressor information supplied by the customer. The control system vendor also performed measurements and monitoring that was used as a basis for the submitted calculations.

The following equations are used to revise the submitted estimated savings.
<u>Hours of operation</u> from submitted data and validated during pre-installation inspection

WD base = 4,311 hours/year
WD 3^{rd} = 1,733 hours/year
Weekend = 1,620 hours/year

Where:
WD= working day shifts 1 and 2.
WD 3^{rd} = working day shift 3

Energy savings were expected to be realized from the reduction of compressed air demand and the reduction of the system air pressure as well as the optimized staging of compressors to meet system demand. Table 1 shows the expected compressed air demand before and after the retrofit.

Table 1 -Compressed Air Usage

Shift	Existing CFM	CFM Reduced	CFM Proposed
WD Base	2,414	863	1,551
WD 3rd	2,414	863	1,551
Weekend	1,324	-	1,324

<u>Baseline power verifications</u>

% Full-Load Power (modulation) = (100%-%Power at no-load)*(% Capacity) + (% Power at no-load)
% Power at no-load = 68 (from AirMaster)
% Capacity = Avg. acfm/Max acfm (from submitted data and manufacturer specifications)
Calculated kW = Full Load Power * (% Full Load Power)

Compressor #6 is gas powered and is not eligible for incentives but is included to validate airflow.

Table 2 is a summary of the pre-retrofit savings calculation.

Table 2 Pre –Retrofit Compressor Energy Calculation

Shift	Comp #	acfm	% Capacity	% Power at no load	% Full Load Power	Calculated kW	Measured kW	Hours	Calculated Annual kWh	Measured Annual kWh
WDBase	1	367	0.72	0.68	0.91	94	90	4,311	406,835	387,990
	2	434	0.85	0.68	0.95	99	104	4,311	425,624	448,344
	3	423	0.83	0.68	0.95	98	102	4,311	422,540	439,722
	4	215	0.78	0.68	0.93	45	52	4,311	192,097	224,172
	5	920	0.92	0.68	0.97	165	190	4,311	711,810	819,090
	6	55	0.00	0.00	0.00	0	0	4,000	0	0
WD3rd	1	367	0.72	0.68	0.91	94	93	1,733	163,546	161,169
	2	434	0.85	0.68	0.95	99	82	1,733	171,099	142,106
	3	423	0.83	0.68	0.95	98	86	1,733	169,859	149,038
	4	215	0.78	0.68	0.93	45	52	1,733	77,222	90,116
	5	920	0.92	0.68	0.97	165	190	1,733	286,144	329,270
	6	55	0.00	0.00	0.00	0	0	1,733	0	0
Weekend	1	255	0.50	0.68	0.84	87	86	1,620	141,079	139,320
	2	321	0.63	0.68	0.88	91	102	1,620	148,034	165,240
	3	398	0.78	0.68	0.93	96	81	1,620	156,149	131,220
	4	0	0.00	0.68	0.00	0	52	1,620	0	84,240
	5	350	0.35	0.68	0.79	134	0	1,620	217,415	0
	6	0	0.00	0.00	0.00	0	0	800	0	0
								Totals	3,689,452	3,711,037

Submitted measured values are validated based on the comparison with the estimated values above.

Compressor kWh = 3,711,037
Air dryer usage = 0
Cooling energy kWh = 104,997

Annual baseline kWh = 3,711,037 + 0 + 104,997 = 3,816,034

Total proposed usage (Calculated using submitted data, manufacturers specifications and DOE's compressed air challenge methodologies)

% Full-Load Power (modulation) = (100% - % Power at no load) * (% Capacity) + (% Power at no load)
% Power at no-load = 23 (from submittal data)
% Capacity = Avg. acfm / Max acfm (from submitted data and manufacturers specifications)
Calculated kW = Full Load Power * (% Full Load Power)

Table 3 is a summary of the post-retrofit savings calculation.

Table 3 Post–Retrofit Compressor Energy Calculation

Shift	Comp #	acfm	% Capacity	% Power at Unload	% Full Load Power	Calculated kW	Hours	Calc. Annual kWh
WDBase	1	449	0.88	0.23	0.91	94	4,311	405,775
	2	0	0.00	0.23	0.00	0	0	0
	3	0	0.00	0.23	0.00	0	0	0
	4	96	0.35	0.23	0.50	24	4,311	103,010
	5	1,000	1.00	0.23	1.00	169	4,311	730,511
	6	0	0.00	0.00	0.00	0	0	0
WD3rd	1	400	0.78	0.23	0.83	86	1,733	149,828
	2	102	0.20	0.23	0.38	40	1,733	68,992
	3	0	0.00	0.23	0.00	0	0	0
	4	0	0.00	0.23	0.00	0	0	0
	5	1,000	1.00	0.23	1.00	169	1,733	293,662
	6	0	0.00	0.00	0.00	0	0	0
Weekend	1	510	1.00	0.23	1.00	104	1,620	167,951
	2	510	1.00	0.23	1.00	104	1,620	167,951
	3	306	0.60	0.23	0.69	72	1,620	116,222
	4	0	0.00	0.23	0.00	0	0	0
	5	0	0.00	0.23	0.00	0	0	0
	6	0	0.00	0.00	0.00	0	0	0
							Total	2,203,902

Compressor kWh = 2,203,902
Air dryer usage kWh = 145,180
Cooling energy kWh = 71,275

Annual proposed kWh = 2,203,902+ 145,180 + 71,275 = 2,420,357

Air leakage repair energy savings estimate

kWh = acfm * compressor efficiency (kW/100 acfm) * annual hours
Compressor efficiency = 18.7kW / 100 acfm (from AirMaster+ generic data)
Air leakage repair energy savings = 273 * (18.7 / 100) * 7664 = 391,255 kWh

Incentive savings validation

Estimated annual energy savings = (3,816,034 – 2,420,357) – 391,255 = 1,004,422 kWh
Energy incentive = 1,004,422 kWh * ($0.08/kWh) = $80,353.76

Table 4 is a summary of the Ex Ante savings.

Table 4 Summary of the Ex Ante Savings

kW	kWh
199	1,004,422.00

Comments on Ex Ante Calculations

The Ex Ante calculations were performed using the "AirMaster +" software tool. Inputs to the software tool were based on field measurements performed by the control system vendor and information collected from the facility operator.

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation, conducting an on-site survey and then computing impacts using the on-site data.

The on-site survey was conducted on September 15, 2004. Information on the Honeywell Air Compressor Management System Control was collected and verified by reviewing the control display data. Other information related to the system operating conditions was provided by the Plant Engineer.

All equipment has been installed as indicated in the original application. According to the LED panel on the installed control system, the compressors were operating during the time of the inspection, as anticipated. The additional receiver capacity, refrigerated dryers (ammonia) and the pressure compensating valves have been installed as proposed.

We collected information related to the schedule of operation and system load. We verified that the system is operating at the reduced pressure of approximately 88 psi. However discussions with the plant manager revealed that the expected reduction in compressor air demand has not been realized as was predicted in the calculations and approved by the installation reviewer. The calculations were based on air flow being reduced from 2,414 CFM to 1,551 CFM during the working day base and working day third shifts. (Refer to Table 1) This was expected to occur 6,044 hours per year. (4,311 hours for WD Base and 1,733 hours WD 3rd shift) .

The Plant manager stated that air demand averages 2,100 CFM and varies between 2,000 and 2,200 CFM during these shifts. Table 4 below is a summary of the actual air demand.

Table 4 –Field Verified Compressed Air Usage

Shift	Existing CFM	CFM Reduced	CFM Proposed
WD Base	2,414	314	2,100
WD 3rd	2,414	314	2,100
Weekend	1,324	-	1,324

The Ex Ante calculations were based on solid engineering methodology and estimated a 863 CFM reduction in air demand, but only a 314 CFM reduction has been realized. Unfortunately, evaluating why the air demand reduction was not fully realized is beyond the scope of our work. The energy consumption associated with the difference, 549 CFM, has not been eliminated from the system.

We therefore have adjusted the savings associated with the project by subtracting the energy consumption associated with 549 CFM for 6,044 hours annually from the claimed savings. Assuming 4.2 CFM/BHP and 94% efficient motors, the adjustment is calculated using the following formulae:

kW= CFM x 1 BHP/4.2CFM x 1/0.94 motor eff x 0.746 kW/HP
kWh = kW x Hours

kW = 549 x 1 /4.2 x 1/0.94 x 0.746
kW = 103.7

kWh = 103.7 x 6,044
kWh = 626,763

We have subtracted 103.7 kW and 626,763 kWh from the savings claim. Table 5 is a summary of the Ex Post Savings Analysis.

Table 5- Summary of Ex Post Savings Analysis

kW	kWh
95	377,659

Scope of Impact Assessment

This evaluation is for all measures approved in this application.

Additional Notes

The level of M&V employed at this site was not adequate to provide accurate calculation for energy savings. An additional 40 hours plus the rental of logging equipment would be required to provide a more accurate assessment of the savings for this project.

Impact Results

	kW	kWh	Therm
SPC Tracking System	156	1,194,699	0
Installation Report	199	1,004,422	0
Adjusted Engineering	95	377,659	0
Engineering Realization Rate	48%	38%	N/A

Project Economics

Description	Date	Project Cost	Estimated Demand Savings, kW	Estimated Energy Savings, kWh	Estimated Gas Savings, therms	Estimated Annual Cost Savings ($0.13/kWh) $	SPC Incentive, $	Simple Payback w/ incentive, yrs	Simple Payback w/o incentive, yrs
Application Submitted Amount	6/26/2002	$360,000	156	1,194,699	0	$155,311	$95,576.00	1.70	2.32
Application Approved Amount	6/11/2002	$360,000	199	1,004,422	0	$130,575	$80,354.00	2.14	2.76
Installation Approved Amount	9/25/2003	$360,000	199	1,004,422	0	$130,575	$80,354.00	2.14	2.76
SPC Program Review	9/29/2004	$360,000	95	377,659	0	$49,096	$80,354.00	5.70	7.33

SITE 14 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER: 3 END USE: PROCESS

Measure	Boiler burner control upgrade
Site Description	Food processing facility

Measure Description

Replace steam boiler's combustion control with a programmable AUTOFLAME Model MK6 control system.

Summary of Ex Ante Impact Calculations

Saving calculations were estimated using the utility company representative and the vendor's experience with boilers. The baseline was determined using efficiency parameters for a typical boiler. For the proposed conditions, the manufactures' efficiency specifications were assumed. Electrical savings from the burner fan's new VFD are based on hypothetical fan curves.

Comments on Ex Ante Calculations

The utility calculations used combustion performance tables to determine pre and post retrofit efficiency. The inputs were percentage oxygen on the exhaust gases and stack temperature rise for the pre and post scenarios. Based on our past experience with steam boilers, the baseline efficiency (80.1%) seems a little bit too high. For a similar boiler vintage and type, the common measured efficiency is in the mid-to-high 70s.

Evaluation Process

The Evaluation process comprises reviewing the SPC application form and supporting documentation, conducting an on-site survey and then computing the impacts on results using on-site collected data.

The on-site survey was carried out on October 03, 2003. Information on the retrofit equipment and operating conditions was collected through an inspection of the boiler and through an interview with the Plant Engineer.

The plant utilizes low-pressure steam (55 psig) for process needs. Two 30-years+ boilers provide the steam. Under this program, an antiquated combustion control system, Fireye 26RJ8 Model 6080, was replaced with a new Autoflame MK6 burner management system in one of the two boilers. The existing gas valves and dampers were also replaced with a new fuel servomotor and new gas valves. A VFD was added to control the combustion air fan speed.

Due to the lack of information for the pre–retrofit case, this analysis utilizes the baseline calculations and assumptions provided in the SPC application, titled "Engineering – Calculation Sheet." We believe that this baseline efficiency level of 80.1% results in a conservative ex-ante and ex-post impact estimate.

Pre retrofit boiler conditions:

The pre retrofit boiler efficiency was determined using the variables shown in the table included after this paragraph and the combustion efficiency chart in the SPC application (attachment 1). The pre retrofit efficiency can be read on the intersection of the stack temperature row, 360 ^{o}F, and the percent oxygen column, or 7%. From attachment 1 chart, the value shown for the boiler efficiency is **80.1 %.** The Customer provided the average boiler load, **62.5 %,** and the operating hours, **6,600 hrs/yr**. These values were assumed to be correct and were not verified due to time limitations.

Firing Rate	Existing O_2	[1]Assumed Stack Temperature, °F
High Fire Low Fire	6% 9%	380 340
[2]Average	7%	360

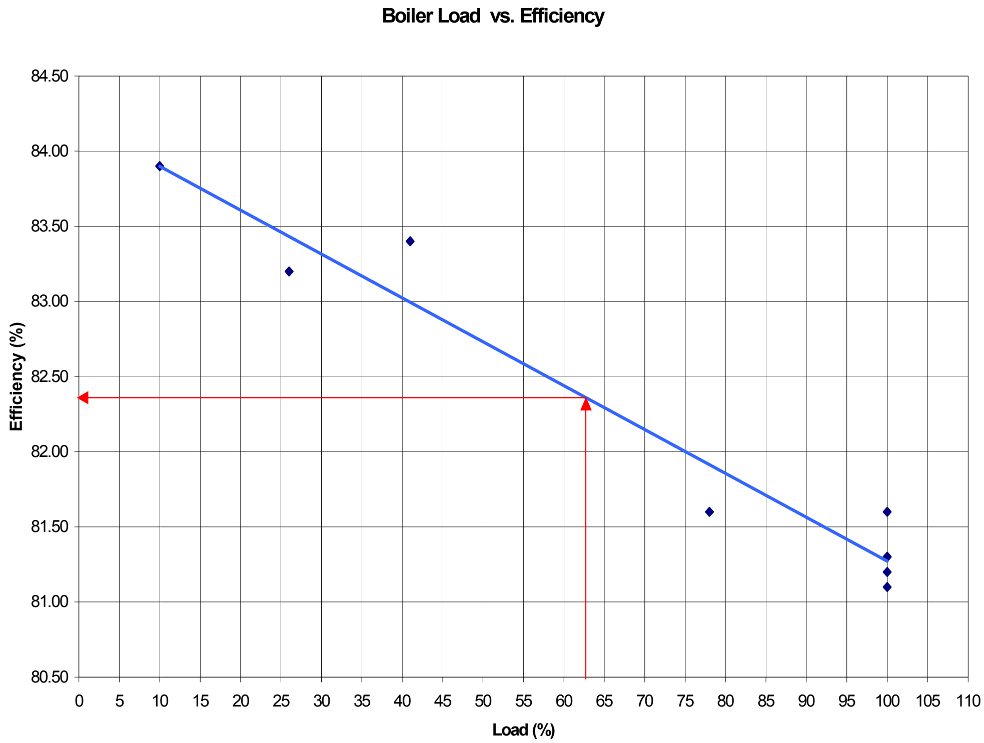
[1]Based on 55 psig operating pressure and 303 °F saturated temperature.

[2]Based on operational conditions between 50 - 100% load.

The post retrofit boiler operating conditions were measured utilizing a Bacharach Combustion Analyzer. It was assumed that this instrument was calibrated and it was not verified. Nine sets of measurements were taken and recorded during a period of 30 min as shown in the following table,

Measured Parameters									
Time	**Loading Rate, %**	% CO2	% Excess Air	CO, ppm	% O2	Stack Temp. °F	**% Efficiency**	Ambient Temp. °F	VFD, Hz
10:32	**10**	9.3	27.6	800	4.3	295	**83.9**	66.6	35.5
10:42	**100**	9.9	17.3	88	3.5	398	**81.6**	73.2	59.6
10:44	**100**	9.8	17.3	71	3.5	411	**81.3**	73.8	59.6
10:46	**100**	9.9	16.1	49	3.5	416	**81.2**	74.3	59.6
10:48	**100**	9.9	17.3	40	3.4	418	**81.3**	74.9	59.6
10:50	**100**	10.0	16.7	38	3.3	423	**81.1**	75.3	59.6
10:52	**78**	9.9	15.5	35	3.1	408	**81.6**	75.3	54.3
10:53	**41**	11.0	6.9	38	1.8	348	**83.4**	75.3	47.0
10:54	**26**	9.3	23.7	115	5.0	324	**83.2**	75.3	44.7

By plotting the boiler-loading rate (assumed to be equivalent to the firing rate) versus the measured boiler efficiency, the post-retrofit boiler efficiency can be determined.



For the average proposed load of 62.5% the measured boiler efficiency is 82.40% as shown on the graph. Therefore, the ex post savings need to be adjusted accordingly,

Ex post savings = Ex ante savings x (Ex Post Improvement %Eff. / Ex Ante Improvement %Eff.)

= 6560 x (1-80.1/82.4) / (1-80.1/81.65) therms / yr

= 9646 therms / yr

Note: The energy savings due to the combustion air fan VFD were considered to be correct. The assumptions used to calculate energy savings by the utility are purely theoretical.

Additional Notes

Pre installation conditions were not recorded nor reported properly. A combustion analyzer could had been used to measure boiler existing combustion efficiency rather than relying on assumptions.

More time and funding were needed to record boiler load under different operating conditions by installing data logging equipment. Boiler annual running time could have also been determined by installing data loggers.

Impact Results

	KW	KWh	Therm
SPC Application Calculations	N/A	12068	6560
Adjusted Engineering	N/A	12068	9646
Engineering Realization Rate	N/A	1.00	1.47

Economic Information

Description	Date	Project Cost	Estimated Demand Savings, kW	Estimated Energy Savings, kWh	Estimated Gas Savings, therms	[1]Estimated Annual Cost Savings, $	SPC Incentive, $	Simple Payback w/ incentive, yrs	Simple Payback w/o incentive, yrs
Application Submitted Amount	7/24/2002	$19,985	0	0	7,922	$4,357.10	$3,565.00	3.77	4.59
Application Approved Amount	10/15/2002	$19,985	0	12,068	6,560	$5,176.84	$3,917.44	3.10	3.86
Installation Approved Amount	7/23/2003	$19,985	0	12,068	6,560	$5,176.84	$3,917.44	3.10	3.86
SPC Program Review	12/11/2003	$19,985	0	12,068	9,646	$6,874.14	$3,917.44	2.34	2.91

[1]Assuming $0.13/kWh and $0.55/therm

SITE 15 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER: 3 END USE: PROCESS

Measure	Compressor station replacement and control
Site Description	High Tech manufacturing facility

Measure Description

The application was for a compressor system modification that included the installation of a 3,000 gallon receiver tank, 2 air dryers, 9 no-loss drains, 2 air knifes, piping modifications, and a process flow controller, resulting in reduced load and reduced air flow.

The actual installation was for two new air compressors, a larger receiver tank, controls, and a dryer. One compressor is base loaded and operates 24 hours per day, seven days per week, and the second meets the variable facility demand through VFD control and operates 24 hours per day, five days per week.

Summary of Ex Ante Impact Calculations

The original calculations were part of a comprehensive compressed air study completed by a professional engineering consultant.

A utility engineer validated the projected savings by running a DOE AIRMaster model. The utility's modeled savings were 3% less than the original submittal and were used to establish the rebate amount.

The facility has two manufacturing lines. One manufacturing line is assumed to operate 24 hours per day, 360 days per year. The other is assumed to operating 24 hours per day, weekdays only, 51 weeks per year. Based on these assumptions the stipulated hours are 6,120 hours for two lines and 2,448 for one line.

The post retrofit savings were estimated based on actual operation data recorded by the utility's installed metering using the formula:

KW Saved = pre installation kW – post installation kW

Pre installation kW was measured at 107 kW for two lines and at 95 kW for one line. Post installation kW was measured at 100 kW for both manufacturing lines and 66 kW when one line is operating.

Energy savings were estimated using the formula:

KWh = kW saved Line 1 X Line 1 Hours + kW saved Line 2 X Line 2 Hours

Comments on Ex Ante Calculations

Three calculation methods were used during the process of completing this project. Each was completed independently and resulted in reasonably consistent savings projections.

The final calculation was based on on-site pre and post installation demand measurements over time. Metering equipment were installed for approximately one week pre and one week post installation. Metering equipment was installed by the utility and then removed after the final calculations were completed.

Pre installation demand was recorded at approximately 107 kW when two lines were operating and at approximately 95 kW when one line was operating. Post installation demand was measured at 100 kW when two lines were operating and at 66 kW when one line was operating. However, the Post Installation Report grants a kW savings of 13.7 kW even though measured demand indicates a reduction of 7 kW.

Two lines were operating during the site visit. The base loaded unit was operating at full load, or 63.7 kW (based on a calculation using nameplate data). The VFD unit was pulling an instantaneous demand of 32.7 kW, for a total demand of 96.4 kW. The demand reading taken during the site visit compares favorably with the 100 kW demand used for calculating the energy savings for the project.

The actual base load compressor operating hours over the last year were about 5,600, falling well short of the stipulated assumption. However, the facility engineering-staff maintain that the lines operate per the stated schedule and any variations are abnormal. We have therefore included two Impact Results Tables to demonstrate the impact of operating hours on the results.

In summary, savings are significantly less (37% less) than the ex ante projections if the savings are based on the base-load compressors hours meter. However, if savings are based on the stipulated hours, which the facility staff indicate are the norm, then the ex post savings are in line with the ex ante savings (4% less).

Evaluation Process

The evaluation process consisted of reviewing the application forms and supporting documentation, conducting an on-site survey, and then computing impacts using the on-site data.

The on-site survey was conducted on July 12, 2004. The customer facility manufactures plastic one-quart screw-cap bottles. The facility operates two extrusion molding lines.

The facility does not have an energy management system that controls or records operational data. Therefore no additional post installation load measurements were available.

Facility operation-staff were interviewed regarding the compressor plant's actual operating conditions, and actual nameplate data was collected for the compressors and dryer. The VFD compressor has a control system that monitored instantaneous data for a number of operating characteristics, including the instantaneous load on the unit. The base load unit also monitors a few operating points including the total operating hours.

Nameplate data was used to calculate the load in the base loaded unit, assuming that it is fully loaded, using the formula:

KW = (Compressor HP + Fan Hp) * .746 / Motor Efficiency = 63.7 kW

The calculated base load was added to the instantaneous kW read from the VFD unit (32.7 kW), resulting in a total kW load at the time of the site visit of 96.4 kW.

Assuming that the air requirements of a single line can be met by the baseload compressor:

KW saved baseload = 95 kW – 63.7 kW = 31.3 kW

KW saved when both lines are operating, which equals the Peak kW Reduction, is:

KW peak saved = 107 kW – 96.4 kW = 10.6

Operating hours were obtained from the run time meter on the base loaded compressor. The unit was installed in July of 2003, approximately one year from the time of the site visit. The compressor has operated 5,597 since installation, which compares poorly with the 8,600 hours stipulated in the original calculation. Based on actual operating hours, and assuming that the operation is proportionally split between one line and two lines, the operating hours of each line is:

1 Line hours = (5,597/8,600) X 24 hrs/day X 2 days/wk X 51 wks/yr = 1,599 hours

2 Lines hours = (5,597/8,600) X 24 hrs/day X 5 days/wk X 51 wks/yr = 3,998 hours

However, the facility-staff maintain that the actual facility operation is more accurately represented by the stipulated hours. If we assume that this is true, then the operating hours are:

1 Line hours = 8,600 X 2 days/wk / 7 days/wk = 2,448 hours

2 Lines hours = 8,600 X 5 days/wk / 7 days/wk = 6,120 hours

Energy savings is calculated using the formula:

Savings = (kW saved X Operating hours) 1 line + (kW saved X Operating hours) 2 lines

Savings for both operating hour scenarios are included in the Impact Results Tables.

Scope of Impact Assessment

The assessment involves the replacement of the compressor station.

Additional Notes

The scope of this project changed over the course of the implementation to meet an additional goal of the end user – to obtain redundancy to eliminate manufacturing down-time resulting from compressor maintenance. The change in the project resulted in lower energy savings and higher installation costs, but the lower economic performance of the project was offset by added manufacturing reliability. Based on the customer's input, the rebate did not influence the customer's decision to implement the project.

The calculations performed during the utility's final review of the project were sufficient to reasonably estimate the energy savings that resulted from the project. Long term M&V could have resulted in more accurate determination of actual demand reduction and, in particular, actual operating hours. However, given the relatively small size of this project, that level of M&V is considered unnecessary.

Economic Information

File Financial Value	Date	Project Cost	Estimated Customer Annual Savings	Estimated Customer kW Saved	Estimated Customer Annual $ Saved @ $0.13 / kWh	Incentive	Payback w/o incentive	Payback w/ incentive
SPC Application Estimate	7/31/2002	$33,664	146,947	13.7	$19,103	$11,756	1.76	1.15
SPC Installation Report	10/16/2003	$50,000	133,900	7	$17,407	$10,712	2.87	2.26
NSPC Program Submittal Review	7/12/2004	$50,000	92,362	10.6	$12,007	$7,389	4.16	3.55

Final Impact Results

Based on Compressor Hours Meter

	KW	KWh	Therm
SPC Tracking System or Application	13.7	146,947	0
Adjusted Engineering	10.6	92,362	
Engineering Realization Rate	0.77	0.63	0

Alternate Impact Results (for Comparison Purposes Only)

Based on Stipulated Hours

	KW	KWh	Therm
SPC Tracking System or Application	13.7	146,947	0
Adjusted Engineering	10.6	141,389	0
Engineering Realization Rate	0.77	0.96	N/A

SITE 16 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER: 3 END USE: PROCESS

Measure	New Air Compressor with VSD control
Site Description	Food Processing Plant

Measure Description

Installation of new air compressor with variable speed control and additional air receiver to allow the compressor to operate at a lower pressure.

Summary of Ex Ante Impact Calculations

The customer submitted savings calculations based on measured data of the pre-retrofit air compressor energy consumption during production hours and non-production hours. This was used to estimate the baseline energy. The proposed system energy was calculated using the new VSD compressor curve and the measured load profile (average cfm) from the existing compressor.

The customer submitted baseline energy consumption calculations are shown in Table 1.

Table 1
Application Baseline Energy Consumption

Manufacturer		Quincy
Model		QSI-740
Rated CFM		740
Rated PSIG		110
Full Load BHP		175
Full Load kW		148.4
Motor Efficiency		88%
Unloaded BHP		43.75
	Production Day	Down Day
Average CFM	550	117
Percentage of Full Load CFM	74%	16%
Percentage of Full Load kW	94%	59%
Average kW	139.1	87.14
Hours per Year	8,134	624
Energy Consumption (kWh/yr.)	1,131,439	54,375
Energy Consumption- Total	1,185,814 kWh/yr.	

The customer submitted energy consumption calculations for the proposed air compressor are shown in Table 2. The calculations are based on the same load profile (cfm and hours) as the baseline but the performance curve of the new compressor at a lower pressure is applied to the profile.

Table 2

Proposed Energy Consumption

Manufacturer		CompAir
Model		L120SR
Rated CFM		701
Rated PSIG		110
Full Load BHP		170
Full Load kW		141.96
Motor Efficiency		84%
Unloaded BHP		N/A
	Production Day	Down Day
Average CFM	550	117
Percentage of Full Load CFM	73%	17%
Percentage of Full Load kW	78%	19%
Average kW	103.6	26.44
Hours per Year	8,134	624
Energy Consumption (kWh/yr.)	842,601	16,498

Energy Consumption- Total	859,099 kWh/yr.

In the application review by SCE's contractor, the baseline was revised to a compressor of "industry standards" rather than the existing compressor. It is stated that the SPC program requires the "industry standard" to be the baseline. The revised baseline is a screw compressor with suction throttle capacity control.

Table 3
Revised Baseline Energy Consumption

Production Days (8,134 Hours/yr)
% Full Load Power= (100%-%Power at no load)*% FL Capacity + %Power at no load
% Full Load Power= (100%-70%)*75%+70% = 92.5%
Base kW= (Package Power)*(airflow capacity/100)*(% Full Load Power)
Base kW= 17.9 kW * (740 acfm/100 acfm) * 92.5% = 122.5 kW
Base kWh/yr.= 122.5 kW * 8,134 Hours = 996,622 kWh/yr.

Down Days (624 Hours/yr)
% Full Load Power= (100%-70%)*15.8%+70% = 74.7%
Base kW= 17.9 kW * (740 acfm/100 acfm) * 74.7% = 98.9 kW
Base kWh/yr.= 98.9 kW * 624 Hours = 61,911 kWh/yr.

Total Baseline Usage
996,622 kWh + 61,911 kWh = 1,058,533 kWh/yr.

The energy consumption for the post-project presented by the customer was accepted by SCE's reviewer. Table 4 provides a summary of the ex ante values.

Table 4
Ex Ante Savings Values

	Customer Submitted	Revised by Reviewer
Base kWh/yr.	1,185,814	1,058,533
New kWh/yr.	859,099	859,099
Energy Savings (kWh)	326,715	199,434
Base kW	139	0
New kW	103	0
Demand Savings (kW)	36	0

Comments on Ex Ante Calculations

There appears to be a couple of errors or calculations that are unclear in the proposed energy savings calculations.

1. The ex ante revised baseline calculation in Table 3 uses the methodology specified by the SPC program. One of the primary variables is the "% Full Load Capacity" (%CFM). The existing compressed air system was measured at 550 cfm at 120 psi. When determining the % Full Load Capacity for the baseline calculation the rated full load capacity of the existing compressor at 110 psi was used. At 120 psi the rated capacity would be lower than the rated capacity at 110 psi. Therefore the % Full Load Capacity would be higher. For example:

   Ex Ante as calculated-

$$\%FullLoadCapacity = \frac{550cfm@120psi}{740cfm@110psi} = 74.3\%$$

The full load cfm at 120 psi for a machine rated at 740 cfm at 110 psi would be approximately 678 cfm. Therefore the % Full Load Capacity of the baseline system should have been:

$$\%FullLoadCapacity = \frac{550cfm@120psi}{678cfm@120psi} = 81\%$$

2. The specifications used to calculate the savings are not for the air compressor that was actually installed. The savings estimates were based on a CompAir L120SR compressor to be installed. The actual compressor installed is an Atlas Copco GA90VSD. While the CompAir unit was satisfactory for estimating the savings during the application process, the specifications and analysis in the SPC installation report should have been updated with the Atlas Copco compressor specifications prior to payment. The CompAir L120SR (172 Horsepower, 128 kW) is a much larger unit than the Atlas Copco GA90VSD (120 HP, 90 kW) that was installed. Using the estimated plant air profile of 550 average cfm on production days the CompAir machine would be approximately 78% capacity. The Altas Copco machine is at 91% capacity at 550 cfm. Using the methodology of the accepted basecase, Table 3, the baseline machine would draw 117 kW at 78% capacity. The Atlas Copco would draw 103.5 kW at 91% capacity.

3. The vendor installed a power meter on the Atlas Copco compressor after it was installed. The monitoring data indicated an average power consumption of 75 kW during a production day. Given this data, the application was paid at the approved amount with the justification that

the measured data was less than the estimated power draw and thus the savings were even greater than the application savings estimates. There was a significant oversight in this process. Based on the manufacture's specifications, the Atlas Copco GA90VSD drawing 75 kW, the air output at 110 psig would have been only 400 cfm. This is significantly less than the baseline cfm. The saving analysis did not normalize the baseline conditions to the measured post-case conditions. At 400 cfm (110 psi), or 57% capacity, the "standard" compressor specified as the baseline would draw 109 kW.

Evaluation Process

The evaluation plan was to obtain data supporting the plant air demand profile to be used in the savings calculations. The air profile is the most important factor to the accuracy of the savings estimation. Based on the air profile, the savings can be calculated using the actual performance curve of the Atlas Copco GA90VSD compressor and a "standard" equivalent screw compressor.

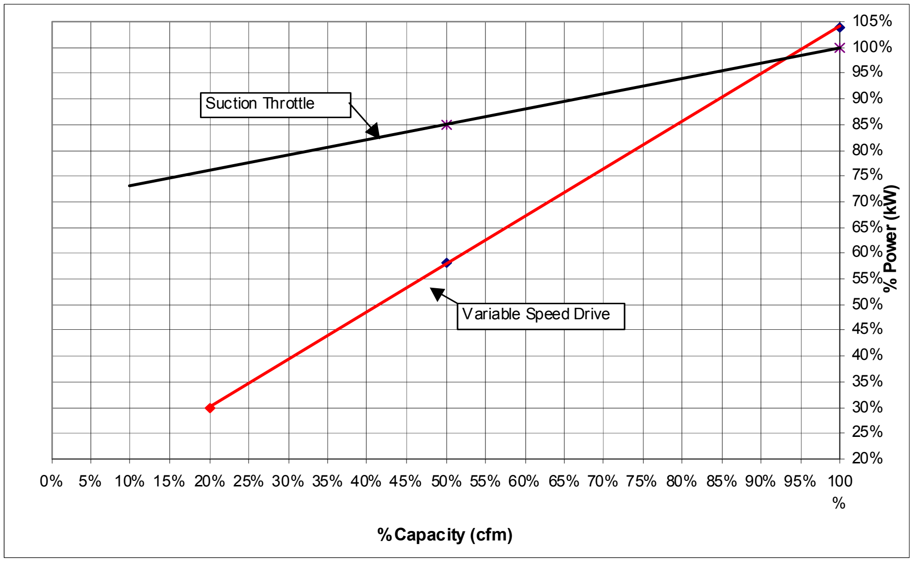
The air profile was obtained from the Atlas Copco's integrated control and monitoring system on-board the unit. The monitoring system trends the operating profile of the variable-speed drive. The information is stored as percent of operation in 20% speed bins. The profile obtained from the units is shown below.

Table 5
Atlas Copco Load Profile

% RPM	% of hrs.
0-20	0%
20-40	0%
40-60	8%
60-80	33%
80-100	59%

Once the load profile is established the savings can be calculated using the performance curves of the "standard" and new air compressors. Per the SPC guidelines and appropriate baseline compressor may be considered as a machine with the same method of capacity control as the existing compressor. Therefore, a machine with inlet throttling is used as the baseline machine. The performance curves of a VSD and inlet throttle controlled machines are shown in Figure 1.

Figure 1
Baseline and New Air Compressor Performance Curves



The baseline energy use is calculated in the same fashion as the ex ante estimate. The evaluation calculation makes the adjustment for the rated full load capacity of the compressor at 120 psi base on a mass flow equation. The rated cfm at 110 psi is 740. The estimated full load at 120 psi is 678 cfm. With that change the baseline energy is calculated as:

Table 3
Revised Baseline Energy Consumption

Production Days (8,134 Hours/yr)

% Full Load Power= (100%-%Power at no load)*% FL Capacity + %Power at no load

% Full Load Power= (100%-70%)*81%+70% = 94.3%

Base kW= (Package Power)*(airflow capacity/100)*(% Full Load Power)

Base kW= 17.9 kW * (678 acfm/100 acfm) * 94.3% = 114.4 kW

Base kWh/yr.= 114.4 kW * 8,134 Hours = 930,890 kWh/yr.

Down Days (624 Hours/yr)

% Full Load Power= (100%-70%)*17%+70% = 75.1%

Base kW= 17.9 kW * (678 acfm/100 acfm) * 75.1% = 91.1 kW

Base kWh/yr.= 91.1 kW * 624 Hours = 56,873 kWh/yr.

Total Baseline Usage:

930,890 kWh + 56,873 kWh = 987,764 kWh/yr.

The energy consumption of the new variable-speed drive compressor is estimating using the load profile (Table 5) and the performance curve of the new compressor. In addition to the more efficient control, further savings are achieved by the addition of another air receiver, which allows the compressor operating pressure to be reduced from 120 psig to 110 psig. An air compressor energy consumption is reduced approximately 1% for every 2% reduction in pressure.

The energy consumption of the new VSD compressor is calculated below in Tables 7.

Table 7
New VSD Compressor @ 110 psig Annual Energy Consumption

% RPM	Avg. % of Full Load	CFM	% of hrs.	Hours/yr	Atlas VSD %FL kW	Atlas VSD kW	kWh
0-20	10%		0%	0			0
20-40	30%		0%	0			0
40-60	50%	303	8%	701	58%	62.4	43,705
60-80	70%	424	33%	2,891	76%	82.3	237,919
80-100	91%	552	59%	5,168	96%	103.2	533,571
Total							**815,194**

The demand savings are estimated assuming that the production days profile of the baseline compressor would occur during the peak period. Subtracted from that demand is the weighted average of the new compressor demand. Peak demand savings are 114.4 kW – 93.1 kW = 21.4 kW.

Table 9
Evaluation Energy and Demand Savings

Energy Savings (kWh)	**172,569**
Weighted Average Demand Savings (kW)	**21.4**

The energy savings are only about 87% of the ex ante estimation. This is primarily due to the non-adjustment of rated full load cfm at 120 psig in the baseline energy consumption calculation.

Scope of Impact Assessment

This project was the only project by this customer that was assessed.

Additional Notes

The level of M&V employed at this site was adequate to provide a high level of accuracy for energy savings. Since the load profile data was not available for the peak period, the average weighted demand (kW) savings was calculated for the savings. To provide accuracy for the peak demand, short-term monitoring would be required. This would add approximately 12 hours of labor plus instrumentation rental.

Economic Information

File Financial Values	Date	Project Cost	Estimated Customer Annual kWh Savings	Estimated Customer kW Savings	Estimated Customer Annual Therm Savings	Estimated Customer Annual $ Savings @ $0.08/kWh	Incentive	Payback w/o Incentive	Payback w/ Incentive
Application Estimate	04/12/2002	$ 62,400	326,715	36	0.0	$ 26,137	$26,137	2.4	1.4
Application Approved	05/09/2002	$ 62,400	199,434	0	0.0	$ 15,955	$15,955	3.9	2.9
2002 SPC Installation Report	09/25/2002	$ 62,400	199,434	0	0.0	$ 15,955	$15,955	3.9	2.9
Evaluation	05/02/2005	$ 62,400	172,569	21	0	$ 13,806	$15,955	4.5	3.4

Impact Results

	kW	kWh	Therm
SPC Tracking System	0	199,434	0
Installation Report	N/A	N/A	0
Adjusted Engineering	21.4	172,569	0
Engineering Realization Rate	N/A	0.87	N/A

SITE 17 IMPACT EVALUATION
SAMPLE CELL: ADDITIONAL   TIER: 2   END USE: LIGHTING

Measure	Lighting Efficiency and Occupancy Controls
Site Description	Distribution Center

Measure Description

Lighting efficiency retrofit with occupancy controls in many areas.

Summary of Ex Ante Impact Calculations

Simple pre- and post-retrofit algorithm using fixture connected loads and hours of operation.

Comments on Ex Ante Calculations

The ex-ante savings were determined by performing a detailed pre and post retrofit lighting fixture inventory and calculating the change in lighting power based on fixture watts published in the SPC Lighting Wattage Tables. Lighting energy use was calculated using estimated hours of operation, and reduction of the base hours for the occupancy sensor installation.

A detailed summary of the estimated pre and post retrofit operating hours for each type of area was provided by the energy services company that developed and managed the project. Estimated annual hours of lighting operation range from 5,200 to 8,760 for the pre retrofit, and from 2,860 to 4,818 for the post retrofit in areas where occupancy sensors are installed.

The calculations performed by the installation reviewer assume that lighting hours of operation are reduced by 45% in areas where occupancy sensors are installed. The reviewer stated that the 45% reduction in operating hours is the value listed in the SPC Program guidelines for warehouse operations.

The application documents approximately 1,800 interior lighting fixtures including 400 watt and 250 watt high bay high pressure sodium fixtures and 400 watt high bay metal halide fixtures converted to four lamp T-5 high output fixtures. There are also two lamp, eight foot high output T-12 fixtures converted to four lamp T-8 fixtures.

Emergency four lamp T-5 fixtures are equipped with occupancy sensors that reduce the fixture to two lamp operation when no occupancy is sensed. Occupancy sensors were installed for all fixtures except those in the Forklift Maintenance area, and the Truck Wash and Truck Shop areas

Pre and post retrofit calculations of lighting loads and energy use were performed using the following formula.

kW = Fixture Watts/1,000 w/kW x Fixture quantity
kWh = kW x Operating hours

Table 1 is a summary of the ex ante lighting savings.

Table 1 Summary of the Ex Ante Lighting Savings

	Total kW	kWh
Lighting Efficiency	302	2,345,487
Lighting Controls	0	503,420
Total	302	2,848,907

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation, conducting an on-site survey and interview with facilities personnel, and re-estimation of the lighting retrofit savings.

Evaluation for the lighting retrofit included a spot check of the fixture counts, lamp type and number of lamps and a verification of occupancy sensor installation for selected areas. Pre and post retrofit operating hours for lighting were reviewed in detail with the facility manager and are discussed below for each area.

Produce Area
The facility manager stated that the produce area is very active from 8 PM to 6 AM daily, with intermittent activity at other times. Due to the long re-strike time of HID lighting, the lights were left on continuously before the T-5 lighting retrofit. Following the retrofit, the facility manager estimates that 100% of the lights are on for 10 hours daily and 50% of the lights are on for the remaining hours since they are controlled by occupancy sensors.

Dry Grocery
The facility manager advised that the dry grocery area is normally occupied from 4 AM to 1 AM on a daily basis. There is very light activity between 10 PM and 1 AM, but lights were required to operate because of safety concerns. Prior to the retrofit, lights were turned off between 1 AM and 4 AM. Following the retrofit, the facility manager estimates that 75% of the lights are on for 18 hours daily and essentially off for the remaining 6 hours since they are controlled by occupancy sensors.

Battery Areas
The facility manager stated that prior to the retrofit, lights were left on continuously in the battery areas. These areas have intermittent occupancy. Following the retrofit, it is estimated that the lights are on less than 25% of the time.

Truck and Forklift Repair and Truck Wash Areas
The truck wash and repair areas are very active at all hours. No occupancy sensors are installed in these areas. These areas are estimated to operate continuously before and after the retrofit.

There are 7 holidays annually, and the facility operates 7 days per week. The facility manager revealed that light levels in the warehouse areas have been reduced by approximately 20 FC in many areas, but are still adequate for the required tasks.

Table 2 is a summary of the pre-retrofit hours of operation for the lighting system. Table 3 is a summary of the post retrofit hours of operation for the lighting system, including the estimated hours of operation reduced by the installation of occupancy sensors.

Emergency four lamp T-5 fixtures are equipped with occupancy sensors that reduce the fixture to two lamp operation when no occupancy is sensed.

Table 2 Summary of Pre-Retrofit Hours of Operation

Area	hr/day	day/wk	wk/yr	Annual Hours
Produce	24	7	51.14	8,592
Dry Grocery	21	7	51.14	7,518
Battery	24	7	52.14	8,760
Truck	24	7	51.14	8,592

Table 3 Summary of Post-Retrofit Hours of Operation

Area	hr/day	% on	Remaining hr/day-% on	day/wk	wk/yr	Annual Hours Operating	Annual Hours Saved
Produce	10	100%	50%	7	51.14	6,086	2,506
Dry Grocery	6	0	75%	7	51.14	4,833	2,685
Battery	24	25%	0	7	52.14	2,190	6,570
Truck	24	100%	0	7	51.14	8,592	0

The fixture quantities and types detailed in the ex ante analysis were spot verified during the site visit. We were able to verify the fixture counts and type for most areas. There was however a lack of clarity about the names given to some areas by the installation reviewer in the lighting survey and we could not reconcile all of the fixture counts. We have accepted the fixture counts provided and have recalculated the energy savings for lighting efficiency and lighting controls based on the hours of operation determined from our interview with the facility manager summarized above in Tables 2 and 3.

Pre and post retrofit calculations of lighting loads and energy use were performed using the following formula.

kW = Fixture Watts/1,000 w/kW x Fixture quantity
kWh = kW x Operating hours

Table 4 is a summary of the impact evaluation lighting savings. Tables 7, 8, and 9 present a summary of the lighting efficiency and controls savings calculations.

Table 4 Summary of the Impact Evaluation Lighting Savings

	Total kW	kWh
Lighting Efficiency	314	2,509,065
Lighting Controls	0	1,053,358
Total	314	3,562,423

Scope of Impact Assessment

The impact assessment scope is for all measures in the SPC application-lighting efficiency and controls.

Additional Notes

The level of M&V employed at this site is not sufficient to accurately determine the impact of the lighting efficiency and controls retrofit. While we have a high confidence in the pre and post retrofit connected kW calculation, we have lower confidence in the hours of operation assumed by the installation reviewer or those determined in our interview with the facility manager. Data logging would be required to accurately estimate the post retrofit operating hours. Data logging would be complicated by the need to access high bay lighting fixtures. An additional 32 hours of engineering time and rental of logging equipment would be required to more accurately assess the impact of the lighting efficiency and controls retrofit.

Economic Information

An economic summary for all measures included in the application is shown in Table 5 below. Table 6 is a summary of the engineering realization rate calculation based on the impact analysis performed in this report.

Table 5 Economic Summary of the Project

Description	Date	Project Cost	Estimated Demand Savings, kW	Estimated Energy Savings, kWh	Estimated Gas Savings, therms	Estimated Annual Cost Savings ($0.10/kWh) $	SPC Incentive, $	Simple Payback w/ incentive, yrs	Simple Payback w/o incentive, yrs
Application Submitted Amount	5/15/2002	$753,999	316	3,085,964	0	$308,596	$154,298.00	1.94	2.44
Application Approved Amount	6/10/2002	$753,999	314	3,001,164	0	$300,116	$150,058.00	2.01	2.51
Installation Approved Amount	1/20/2003	$753,999	302	2,848,907	0	$284,891	$142,445.00	2.15	2.65
SPC Program Review	9/15/2004	$753,999	314	3,562,423	0	$356,242	$142,445.00	1.72	2.12

Impact Results

Table 6 Realization Rate Calculation

	kW	kWh	Therm
Installation Report	302	2,848,907	0
Adjusted Engineering	314	3,562,423	0
Engineering Realization Rate	104%	125%	N/A

Table 7 Pre Retrofit Energy Consumption

Area	Fixture	Quantity	w/fixture	Peak kW	Annual	
					Hours	kWh
Grocery	HPS 400 W	656	465	305.0	7,518	2,293,291
Grocery EM	HPS 400 W	72	465	33.5	8,760	293,285
Grocery	HPS 250 W	464	295	136.9	7,518	1,029,064
Grocery EM	HPS 250 W	50	295	14.8	8,760	129,210
Produce	HPS 400 W	40	465	18.6	8,592	159,811
Produce EM	HPS 400 W	5	465	2.3	8,760	20,367
Produce	MH 400 W	91	458	41.7	8,592	358,097
Produce EM	MH 400 W	9	458	4.1	8,760	36,109
Banana	HPS 400 W	16	465	7.4	8,592	63,924
Produce 35F	HPS 400 W	145	465	67.4	8,592	579,316
Produce 35F EM	HPS 400 W	14	465	6.5	8,760	57,028
Produce 35F	MH 400 W	42	458	19.2	8,592	165,276
Produce 35F EM	MH 400 W	4	458	1.8	8,760	16,048
Produce Battery	8' T12 HO	36	227	8.2	8,760	71,587
Battery	8' T12 HO	96	227	21.8	8,760	190,898
Fork Maint	8' T12 HO	23	227	5.2	8,592	44,859
Fork Maint	4' T12 HO	3	145	0.4	8,592	3,738
Truck Shop	MH 400 W	29	458	13.3	8,592	114,119
Truck Wash	HPS 400 W	10	465	4.7	8,592	39,953
Total		1,805		713		5,665,978

Table 8 Post Retrofit Energy Consumption

Area	Fixture	Quantity	watt/fixture		Annual Hours		Peak kW	kWh
			Occupied	Unoccupied	Occupied	Unoccupied		
Grocery	4 Lamp T-5 HO	656	234	0	4,833	3,927	154	741,885
Grocery EM	4 Lamp T-5 HO	72	234	117	4,833	3,927	17	114,507
Grocery	4 Lamp T-5 HO	464	234	0	4,833	3,927	109	524,748
Grocery EM	4 Lamp T-5 HO	50	234	117	4,833	3,927	12	79,519
Produce	4 Lamp T-5 HO	40	234	0	6,086	2,674	9	56,965
Produce EM	4 Lamp T-5 HO	5	234	117	6,086	2,674	1	8,685
Produce	4 Lamp T-5 HO	91	234	0	6,086	2,674	21	129,595
Produce EM	4 Lamp T-5 HO	9	234	117	6,086	2,674	2	15,633
Banana	Removed	0	0	0	6,086	2,674	-	-
Produce 35 F	4 Lamp T-5 HO	145	234	0	6,086	2,674	34	206,498
Produce 35 F EM	4 Lamp T-5 HO	14	234	117	6,086	2,674	3	24,318
Produce 35 F	4 Lamp T-5 HO	42	234	0	6,086	2,674	10	59,813
Produce 35 F EM	4 Lamp T-5 HO	4	234	117	6,086	2,674	1	6,948
Produce Battery	4 Lamp 4' T-8	36	112	0	2,190	6,570	4	8,830
Battery	4 Lamp 4' T-8	96	112	0	2,190	6,570	11	23,547
Fork Maint	4 Lamp 4' T-8	23	112	0	8,592	168	3	22,133
Fork Maint	2 Lamp 4' T-8	3	59	0	8,592	168	0	1,521
Truck Shop	4 Lamp T-5 HO	29	234	0	8,592	168	7	58,305
Truck Wash	4 Lamp T-5 HO	10	234	0	8,592	168	2	20,105
Total							399	2,103,555

Table 9 Energy Savings Summary

	Savings			
	Efficiency		Controls	
Area	kW	kWh	kWh	Total kWh
Grocery	152	1,139,248	412,158	1,551,406
Grocery EM	17	145,696	33,081	178,777
Grocery	28	212,789	291,527	504,316
Grocery EM	3	26,718	22,973	49,691
Produce	9	79,390	23,456	102,846
Produce EM	1	10,118	1,564	11,682
Produce	20	175,139	53,363	228,502
Produce EM	2	17,660	2,816	20,476
Banana	7	63,924	-	63,924
Produce 35F	33	287,789	85,029	372,818
Produce 35F EM	3	28,330	4,380	32,710
Produce 35F	9	80,834	24,629	105,463
Produce 35F EM	1	7,849	1,251	9,100
Produce Battery	4	36,266	26,490	62,757
Battery	11	96,710	70,641	167,351
Fork Maint	3	22,726	-	22,726
Fork Maint	0	2,217	-	2,217
Truck Shop	6	55,814	-	55,814
Truck Wash	2	19,848	-	19,848
Total	314	2,509,065	1,053,358	3,562,423

SITE 18 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER: 1 END USE: LIGHTING

Measure	Lighting Efficiency and Controls Upgrade
Site Description	College Campus

Measure Description

Replace existing lighting fixtures with high efficiency fixtures in most buildings on a community college campus. Install occupancy sensors to reduce lighting hours in appropriate areas (primarily offices, rest rooms, and break rooms).

Summary of Ex Ante Impact Calculations

Simple pre- and post-retrofit algorithm using fixture connected loads and hours of operation.

Comments on Ex Ante Calculations

Baseline hours of operation vary depending on location of lighting. Ex ante calculation assumed 30% reduction in operating hours due to use of occupancy sensors where installed.

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation, conducting an on-site survey, and then computing impacts using the on-site data.

Buildings throughout the campus share a common construction style. Ceilings are constructed with cast concrete consisting of 3-foot deep recessed cells that resemble an inverted egg-crate. The interior of these cells had 3-foot by 3-foot surface mounted fluorescent fixtures with T12 lamps and electromagnetic ballasts. Many areas in these buildings were remodeled recently incorporating new T-bar suspended ceilings with new 2-foot by 4-foot fluorescent troffer fixtures. These fixtures have T8 lamps and electronic ballasts.

The on-site survey was conducted on September 14, 2004. The campus Library and the Business Education buildings were inspected and a detailed comparison between site observations and the lighting inventories submitted in the installation report were completed during the evaluation process. These two buildings are considered to be representative of the lighting upgrades that were performed throughout the campus.

Information on the retrofit equipment and operating conditions was collected by an inspection of the lamps and through an interview with the campus Director of the Physical Plant.

The pre- retrofit lamps consisted of various sizes and configurations of fluorescent and incandescent fixtures, the majority of which were 4-lamp, 3-foot T-12 fixtures. Most of the T-12 fixtures were replaced with T-8 fixtures with electronic ballasts and many of the incandescent fixtures were replaced with compact fluorescent fixtures. (See Tables 1-4 for all measures)

Only two minor discrepancies were found during the survey that create only minimal adjustments to the ex ante savings estimate. In one case, 9 fixtures were found in a room instead of the claimed 8, and in the other case, 4 two-lamp fixtures in a rest room had been de-lamped to one lamp each.

Discussions with facilities personnel provided data for development of an annual schedule of operation for the pre- and post-retrofit lamps. We found good agreement between actual operation and the hours used in the ex ante analysis. Occupancy sensors were observed in several rooms. Lights in unoccupied spaces were observed off, and came on when the space was entered. The 30% ex ante energy savings associated with the installation of the sensors appears reasonable given what we observed, but this could be further confirmed by logging actual fixture use over time.

It was noted during the site visit that lighting levels were good throughout the campus.

Our spot check revealed that the fixture quantities and hours of operation for the lighting system agreed with those stated in the installation report and the ex ante analysis was accepted without adjustment.

Scope of Impact Assessment

The customer also received incentives for HVAC measures at this campus and lighting and HVAC measures at another campus. The impact evaluation scope is for the lighting efficiency and controls retrofit at this campus only.

Additional Notes

The level of M&V employed at this site is probably sufficient to accurately determine the impacts of the installed measures. Logging of lighting hours of operation may also be justified as additional M&V for this customer. This would require and additional 24 hours plus the rental of logging equipment.

Economic Information

Description	Date	Project Cost	Estimated Demand Savings, kW	Estimated Energy Savings, kWh	Estimated Gas Savings, therms	Estimated Annual Cost Savings ($0.13/kWh) $	SPC Incentive, $	Simple Payback w/ incentive, yrs	Simple Payback w/o incentive, yrs
Application Submitted Amount	5/22/2002	$3,227,386	355	2,644,718	0	$343,813	$182,162.00	8.86	9.39
Application Approved Amount	7/15/2002	$3,227,386	340	2,467,076	0	$320,720	$161,724.00	9.56	10.06
Installation Approved Amount	1/28/2004	$3,227,386	252	845,310	0	$109,890	$42,265.00	28.98	29.37
SPC Program Review	9/23/2004	$3,227,386	252	845,310	0	$109,890	$42,265.00	28.98	29.37

1. Data is for all measures included in the application

Impact Results

	kW	kWh	Therm
SPC Tracking System or Application	252.1	845,310	0
Adjusted Engineering	252.1	845,310	
Engineering Realization Rate	1.0	1.0	N/A

Table 1
Lighting Fixture Savings Summary Whole Campus

PRE-RETROFIT				POST-RETROFIT				SAVINGS		
Fixture Code	Qty	kW	Annual kWh	Fixture Code	Qty	kW	Annual kWh	kW	Efficiency kWh Saved	Controls kWh Saved
F41EE	212	9.12	28,855	F41ILL (G3)	212	6.185	19,758	2.931	9,096	0
F41EIS	372	18.97	70,576	F41ILL/T2-R (G2)	372	9.672	35,980	9.3	34,596	0
F42EE	544	39.17	151,787	F42ILL-R (G2)	544	28.288	109,624	10.88	42,163	8,201
F42ILL (G1)	25	1.48	3,042	F42ILL (G1)	25	1.475	3,042	0	0	913
F42ILL (G1)	3	0.18	1,551	F42ILL-R (G2)	3	0.156	1,367	0.021	184	0
F43EE	13	1.50	7,673	F42ILL (G2)	13	0.767	3,936	0.728	3,736	0
F43EE	12	1.38	3,312	F43ILL-R (G2)	12	0.936	2,246	0.444	1,066	0
F43ILL (G1)	169	15.04	36,195	F43ILL (G1)	169	15.041	36,195	0	0	10,859
F44EE	173	24.91	77,684	F42ILL (G2)	173	10.207	31,829	14.705	45,855	1,359
F44EE	21	3.02	11,249	F42ILL-C (G2)	21	1.659	6,171	1.365	5,078	0
F44EE	324	46.66	166,528	F42ILL-R (G2)	324	16.848	60,135	29.808	106,393	481
F44EE	1,054	151.78	513,308	F42ILL-V (G2)	1,054	83.266	281,606	68.510	231,701	2,911
F44EE	21	3.02	11,249	F43ILL (G2)	21	1.869	6,953	1.155	4,297	0
F44EE	60	8.64	28,149	F43ILL-R (G2)	60	4.68	15,247	3.96	12,902	0
F44EE	19	2.74	9,608	F44ILL (G2)	19	2.128	7,473	0.608	2,135	0
F44EE	171	24.62	88,180	F44ILL-R (G2)	171	17.442	62,461	7.182	25,719	294
F44EE	55	7.92	40,599	F44ILP/H	55	12.87	65,974	-4.95	-25,375	0
F46EE	2	0.43	1,607	F43ILL (G2)	2	0.178	662	0.254	945	0
F46EE	26	5.62	20,892	F43ILL-V (G2)	26	2.912	10,833	2.704	10,059	0
F46EE	13	2.81	16,174	F43ILP/H	13	4.654	26,807	-1.846	-10,633	0
F46EE	13	2.81	16,174	F44ILL-R (G2)	13	1.326	7,638	1.482	8,536	0
F48EE	1	0.29	225	F42ILL (G2)	1	0.059	46	0.229	179	14
F48EE	2	0.58	2,143	F44ILL (G2)	2	0.224	833	0.352	1,309	0
F48EE	49	14.11	55,711	F44ILL-R (G2)	49	4.998	19,731	9.114	35,980	294
F48EE	18	5.18	19,284	F44LL/2 (G2)	18	2.16	8,035	3.024	11,249	0
F48EE	87	25.06	93,208	F46LL (G2)	87	15.834	58,902	9.222	34,306	0
F48EE	6	1.73	6,428	F48ILL (G2)	6	1.344	5,000	0.384	1,428	0
F52ILL	10	0.72	1,803	F42ILL (G2)	10	0.590	1,477	0.130	326	0
F52ILL	3	0.22	22	F42ILL-R (G2)	3	0.156	16	0.060	6	0
F82EHS	12	2.72	10,133	F44LL/2 (G2)	12	1.440	5,357	1.284	4,776	0
F82EVS	3	1.14	570	F44ILL (G2)	3	0.336	168	0.804	402	0
F82EVS	112	42.56	158,323	F46LL (G2)	112	20.384	75,828	22.176	82,495	0
F84EE	2	0.49	241	F82ILL	2	0.218	107	0.274	134	0
F84EHS	1	0.45	227	F44ILL (G2)	1	0.112	56	0.342	171	0
FU2EE	36	2.59	6,221	FU1LL-R	36	0.972	2,333	1.620	3,888	0
FU2EE	82	5.90	21,963	FU2ILL	82	4.838	17,997	1.066	3,966	0
FU2EE	52	3.74	11,059	FU2ILL/T4-R	52	2.652	7,834	1.092	3,226	73
FU2EE	12	0.86	2,074	FU2ILL-R	12	0.624	1,498	0.240	576	0
FU3EE	87	10.01	30,284	FU2ILL	87	5.133	15,537	4.872	14,747	850
I100/1	1	0.10	50	CFT13/2	1	0.031	16	0.069	35	0
I150/1	363	47.13	213,397	CFT32/1-L	363	12.342	56,700	34.788	156,697	0
I200/1	2	0.40	200	F41ILL (G2)	2	0.062	31	0.338	169	0
MH1000/1	26	28.08	104,458	MH1000/1	26	28.080	104,458	0.000	0	41,783
MH1000/1	20	21.60	80,352	MH400/1	20	9.160	34,075	12.440	46,277	0
MH400/1	8	3.66	13,630	MH320PS/1	8	2.920	10,862	0.744	2,768	0
MV100/1	1	0.13	720	MH100/1	1	0.128	737	-0.003	-17	0
MV250/1	23	6.67	24,812	MH175/1	23	4.945	18,395	1.725	6,417	0
N/A	0	0.00	0	F42ILL (G2)	60	3.540	2,761	-3.540	-2,761	0
Total	4,321	597.93	2,161,929		4,381	346	1,244,728	252.087	917,201	68,032

Note: This table was modified during the installation report review, and the savings slightly reduced to 845,310 kWh.

Table 2
Summary of Savings by Building

	Sum of Pre kW per Bldg	Sum of Pre-kWh per Bldg	Sum of Post kW per Bldg	Sum of Post-kWh per Bldg	Sum of kW Saved per Bldg	Sum of Efficiency kWh Saved per Bldg	Sum of Controls kWh Saved per Bldg
BUSINESS EDUCATION	86.37	258,665	55.89	170,940	30.48	87,725	552
CULINARY ARTS BLDG	20.76	59,037	17.65	51,524	3.11	7,514	0
FINE ARTS	98.70	336,004	72.17	248,502	26.53	87,502	3,519
GYMNASIUM	49.36	196,128	48.86	193,802	0.50	2,326	0
GYMNASIUM II	86.61	304,100	63.47	222,287	23.15	81,813	44,190
HUMANITIES	141.70	508,034	123.86	433,450	17.84	74,584	4,372
LIBRARY	80.11	253,219	67.22	214,191	12.89	39,028	2,357
MATH SCIENCE	128.18	440,732	113.30	375,017	14.88	65,715	3,872
PHYSICAL PLANT	2.47	5,946	2.31	5,560	0.16	386	341
SECURITY OFFICE	2.23	8,071	2.23	8,071	0.00	0	624
TECHNICAL EDUCATION I	67.75	246,545	46.82	167,837	20.93	78,708	1,134
TECHNICAL EDUCATION II	77.80	272,876	42.45	142,040	35.35	130,836	2,475
TECHNICAL EDUCTION III	120.41	434,784	87.92	320,269	32.49	114,515	3,552
THEATER ARTS BLDG	88.11	240,178	62.76	124,245	25.35	115,933	0
WOMEN'S LOCKERS & SHOWERS	16.34	59,573	7.91	28,957	8.44	30,616	1,045
Total	1,066.89	3,623,892	814.81	2,706,691	252.09	917,201	68,032

Note: This table was modified during the installation report review, and the savings slightly reduced to 845,310 kWh.

Table 3
Measure Summary for Business Education Building

	Pre-Retrofit						Post Retrofit						Savings		
AREA DESCRIPTION / LOCATION	Fixture Code	Qty	kW per Fixture	kW per Space	Annual Operating Hours	Annual kWh	Fixture Code	Qty	kW per Fixture	kW per Space	Annual Operating Hours	Annual kWh	kW	Efficiency kWh Saved	Controls kWh Saved
Rm 203 Lecture Hall	F41EIS	84	0.05	4.284	3,720	15,936	F41ILL/T2-R (G2)	84	0.026	2.18	3,720	8,124	2.10	7,812	0
Rm B115 Counseling	F42EE	1	0.07	0.072	2,400	173	F42ILL-R (G2)	1	0.052	0.05	2,400	125	0.02	48	0
Rm B115A	F42EE	2	0.07	0.144	2,400	346	F42ILL-R (G2)	2	0.052	0.10	2,400	250	0.04	96	0
Rm B115B	F42EE	2	0.07	0.144	2,400	346	F42ILL-R (G2)	2	0.052	0.10	2,400	250	0.04	96	0
Rm 317A	F42EE	2	0.07	0.144	2,400	346	F42ILL-R (G2)	2	0.052	0.10	2,400	250	0.04	96	0
Rm 319	F42EE	4	0.07	0.288	3,720	1,071	F42ILL-R (G2)	4	0.052	0.21	3,720	774	0.08	298	0
Womens RR	F42EE	5	0.07	0.360	3,720	1,339	F42ILL-R (G2)	5	0.052	0.26	3,720	967	0.10	372	0
Stairwell	F42EE	3	0.07	0.216	8,760	1,892	F42ILL-R (G2)	3	0.052	0.16	8,760	1,367	0.06	526	0
Stairwell #2	F42EE	10	0.07	0.720	8,760	6,307	F42ILL-R (G2)	10	0.052	0.52	8,760	4,555	0.20	1,752	0
Mens RR	F42EE	5	0.07	0.360	3,720	1,339	F42ILL-R (G2)	5	0.052	0.26	3,720	967	0.10	372	290
Rm 214 Office	F43ILL (G1)	2	0.09	0.178	2,400	427	F43ILL (G1)	2	0.089	0.18	2,400	427	0.00	0	128
Rm 310	F43ILL (G1)	2	0.09	0.178	2,504	446	F43ILL (G1)	2	0.089	0.18	2,504	446	0.00	0	134
Rm 206B classrm	F44EE	9	0.14	1.296	2,504	3,245	F42ILL-R (G2)	9	0.052	0.47	2,504	1,172	0.83	2,073	0
Rm 206A classrm	F44EE	12	0.14	1.728	2,504	4,327	F42ILL-R (G2)	12	0.052	0.62	2,504	1,562	1.10	2,764	0
Rm 306 classrm	F44EE	20	0.14	2.880	2,504	7,212	F42ILL-R (G2)	20	0.052	1.04	2,504	2,604	1.84	4,607	0
Office	F44EE	1	0.14	0.144	2,400	346	F42ILL-V (G2)	1	0.079	0.08	2,400	190	0.07	156	0
Rm 318A	F44EE	7	0.14	1.008	1,400	1,411	F42ILL-V (G2)	7	0.079	0.55	1,400	774	0.46	637	0
Rm 318B	F44EE	7	0.14	1.008	1,400	1,411	F42ILL-V (G2)	7	0.079	0.55	1,400	774	0.46	637	0
Rm 313B	F44EE	7	0.14	1.008	1,400	1,411	F42ILL-V (G2)	7	0.079	0.55	1,400	774	0.46	637	0
Hallway	F44EE	2	0.14	0.288	5,760	1,659	F42ILL-V (G2)	2	0.079	0.16	5,760	910	0.13	749	0
Rm 313A	F44EE	7	0.14	1.008	2,504	2,524	F42ILL-V (G2)	7	0.079	0.55	2,504	1,385	0.46	1,139	0
Rm 112A	F44EE	5	0.14	0.720	3,720	2,678	F42ILL-V (G2)	5	0.079	0.40	3,720	1,469	0.33	1,209	0
Lobby	F44EE	4	0.14	0.576	5,760	3,318	F42ILL-V (G2)	4	0.079	0.32	5,760	1,820	0.26	1,498	0
Rm 312	F44EE	12	0.14	1.728	2,504	4,327	F42ILL-V (G2)	12	0.079	0.95	2,504	2,374	0.78	1,953	0
Rm 309	F44EE	12	0.14	1.728	2,504	4,327	F42ILL-V (G2)	12	0.079	0.95	2,504	2,374	0.78	1,953	0
Rm 308	F44EE	12	0.14	1.728	2,504	4,327	F42ILL-V (G2)	12	0.079	0.95	2,504	2,374	0.78	1,953	0
Lobby	F44EE	6	0.14	0.864	5,760	4,977	F42ILL-V (G2)	6	0.079	0.47	5,760	2,730	0.39	2,246	0
Stairwell	F44EE	7	0.14	1.008	5,760	5,806	F42ILL-V (G2)	7	0.079	0.55	5,760	3,185	0.46	2,621	0
Rm 311	F44EE	17	0.14	2.448	2,504	6,130	F42ILL-V (G2)	17	0.079	1.34	2,504	3,363	1.11	2,767	0
Rm 106 Classrm	F44EE	20	0.14	2.880	2,504	7,212	F42ILL-V (G2)	20	0.079	1.58	2,504	3,956	1.30	3,255	0
Rm 112 Computer Rm	F44EE	20	0.14	2.880	2,504	7,212	F42ILL-V (G2)	20	0.079	1.58	2,504	3,956	1.30	3,255	0
Rm 307	F44EE	20	0.14	2.880	2,504	7,212	F42ILL-V (G2)	20	0.079	1.58	2,504	3,956	1.30	3,255	0
Rm 304	F44EE	20	0.14	2.880	2,504	7,212	F42ILL-V (G2)	20	0.079	1.58	2,504	3,956	1.30	3,255	0
Rm 107 Computer Rm	F44EE	21	0.14	3.024	2,504	7,572	F42ILL-V (G2)	21	0.079	1.66	2,504	4,154	1.37	3,418	0
Rm 104 - computer	F44EE	21	0.14	3.024	2,504	7,572	F42ILL-V (G2)	21	0.079	1.66	2,504	4,154	1.37	3,418	0
Rm 108 Computer Rm	F44EE	22	0.14	3.168	2,504	7,933	F42ILL-V (G2)	22	0.079	1.74	2,504	4,352	1.43	3,581	0
Rm 316	F44EE	22	0.14	3.168	2,504	7,933	F42ILL-V (G2)	22	0.079	1.74	2,504	4,352	1.43	3,581	0
Rm 317	F44EE	24	0.14	3.456	2,504	8,654	F42ILL-V (G2)	24	0.079	1.90	2,504	4,748	1.56	3,906	0
Rm 111 Classrm	F44EE	25	0.14	3.600	2,504	9,014	F42ILL-V (G2)	25	0.079	1.98	2,504	4,945	1.63	4,069	0
Rm 319	F44EE	25	0.14	3.600	2,504	9,014	F42ILL-V (G2)	25	0.079	1.98	2,504	4,945	1.63	4,069	0
Lobby	F44EE	20	0.14	2.880	5,760	16,589	F42ILL-V (G2)	20	0.079	1.58	5,760	9,101	1.30	7,488	0
Rm 118	F84EE	1	0.25	0.246	780	192	F82ILL	1	0.109	0.11	780	85	0.14	107	0
Total		530		65.94		192,722		530		35.46		104,997	30.48	87,725	552

Table 4

Measure Summary for Library

	Pre-Retrofit						Post Retrofit						Savings		
AREA DESCRIPTION / LOCATION	Fixture Code	Qty	kW per Fixture	kW per Space	Annual Operating Hours	Annual kWh	Fixture Code	Qty	kW per Fixture	kW per Space	Annual Operating Hours	Annual kWh	kW Saved	Efficiency kWh Saved	Controls kWh Saved
Room 101D	F42ILL (G1)	2	0.059	0.12	2,400	283	F42ILL (G1)	2	0.059	0.12	2,400	283	0.00	0	85
Copy Room	F43ILL (G1)	2	0.089	0.18	2,400	427	F43ILL (G1)	2	0.089	0.18	2,400	427	0.00	0	128
Office (Granthem)	F42ILL (G1)	4	0.059	0.24	2,400	566	F42ILL (G1)	4	0.059	0.24	2,400	566	0.00	0	170
Break Room	F42ILL (G1)	8	0.059	0.47	2,200	1,038	F42ILL (G1)	8	0.059	0.47	2,200	1,038	0.00	0	312
Room 202 storage	F42EE	2	0.072	0.14	780	112	F42ILL-R (G2)	2	0.052	0.10	780	81	0.04	31	0
Room 103 Bursar office	F42EE	1	0.072	0.07	2,400	173	F42ILL-R (G2)	1	0.052	0.05	2,400	125	0.02	48	0
107D	F42EE	1	0.072	0.07	2,400	173	F42ILL-R (G2)	1	0.052	0.05	2,400	125	0.02	48	0
Hallway men's RR	F42EE	1	0.072	0.07	3,720	268	F42ILL-R (G2)	1	0.052	0.05	3,720	193	0.02	74	0
Dean of Admissions office	F44EE	1	0.144	0.14	2,400	346	F44ILL (G2)	1	0.112	0.11	2,400	269	0.03	77	0
Room 218 Director	F42EE	3	0.072	0.22	2,400	518	F42ILL-R (G2)	3	0.052	0.16	2,400	374	0.06	144	0
Women's RR	F42EE	3	0.072	0.22	2,504	541	F42ILL-R (G2)	3	0.052	0.16	2,504	391	0.06	150	0
Men's RR	F42EE	3	0.072	0.22	2,504	541	F42ILL-R (G2)	3	0.052	0.16	2,504	391	0.06	150	0
Room 105 Women's RR	F42EE	3	0.072	0.22	2,504	541	F42ILL-R (G2)	3	0.052	0.16	2,504	391	0.06	150	117
Room 103 Bursar office	FU2EE	3	0.072	0.22	2,400	518	FU2ILL/T4-R	3	0.051	0.15	2,400	367	0.06	151	0
Executive VP	F44EE	2	0.144	0.29	2,400	691	F44ILL (G2)	2	0.112	0.22	2,400	538	0.06	154	0
Room 207	F44EE	1	0.144	0.14	2,400	346	F42ILL-V (G2)	1	0.079	0.08	2,400	190	0.07	156	0
Room 301 office	F44EE	1	0.144	0.14	2,400	346	F42ILL-V (G2)	1	0.079	0.08	2,400	190	0.07	156	0
Room 214 public info	F43EE	2	0.115	0.23	2,400	552	F43ILL-R (G2)	2	0.078	0.16	2,400	374	0.07	178	0
Staff development	F43EE	2	0.115	0.23	2,400	552	F43ILL-R (G2)	2	0.078	0.16	2,400	374	0.07	178	0
Room 306 Women's RR	F42EE	4	0.072	0.29	2,504	721	F42ILL-R (G2)	4	0.052	0.21	2,504	521	0.08	200	0
Room 304 Men's RR	F42EE	4	0.072	0.29	2,504	721	F42ILL-R (G2)	4	0.052	0.21	2,504	521	0.08	200	0
Vice President Ed Support	F44EE	2	0.144	0.29	2,400	691	F44ILL-R (G2)	2	0.102	0.20	2,400	490	0.08	202	0
Room 101C	F44EE	1	0.144	0.14	2,400	346	F42ILL (G2)	1	0.059	0.06	2,400	142	0.09	204	0
Room 206 Women's RR	F42EE	4	0.072	0.29	3,720	1,071	F42ILL-R (G2)	4	0.052	0.21	3,720	774	0.08	298	232
Room 204 Men's RR	F42EE	4	0.072	0.29	3,720	1,071	F42ILL-R (G2)	4	0.052	0.21	3,720	774	0.08	298	232
Registrar office	F44EE	3	0.144	0.43	2,400	1,037	F44ILL-R (G2)	3	0.102	0.31	2,400	734	0.13	302	0
Room 203 conference	F44EE	2	0.144	0.29	2,400	691	F42ILL-V (G2)	2	0.079	0.16	2,400	379	0.13	312	0
Room 309 office	F44EE	2	0.144	0.29	2,400	691	F42ILL-V (G2)	2	0.079	0.16	2,400	379	0.13	312	0
Room 300 office	F44EE	2	0.144	0.29	2,400	691	F42ILL-V (G2)	2	0.079	0.16	2,400	379	0.13	312	114
Room 307 office	F44EE	2	0.144	0.29	2,400	691	F42ILL-V (G2)	2	0.079	0.16	2,400	379	0.13	312	114
Room 215 office	F43EE	4	0.115	0.46	2,400	1,104	F43ILL-R (G2)	4	0.078	0.31	2,400	749	0.15	355	0
Room next to staff devel	F43EE	4	0.115	0.46	2,400	1,104	F43ILL-R (G2)	4	0.078	0.31	2,400	749	0.15	355	0
Dean of Counselling	F44EE	4	0.144	0.58	2,400	1,382	F44ILL-R (G2)	4	0.102	0.41	2,400	979	0.17	403	0
Room 101	F44EE	3	0.144	0.43	2,400	1,037	F42ILL-V (G2)	3	0.079	0.24	2,400	569	0.20	468	171
Foundation Office	F44EE	4	0.144	0.58	2,400	1,382	F42ILL-V (G2)	4	0.079	0.32	2,400	758	0.26	624	0
Room 308 office	F44EE	4	0.144	0.58	2,400	1,382	F42ILL-V (G2)	4	0.079	0.32	2,400	758	0.26	624	0
Room 101A	F44EE	4	0.144	0.58	2,400	1,382	F42ILL-V (G2)	4	0.079	0.32	2,400	758	0.26	624	228
Room 303 office	F44EE	4	0.144	0.58	2,400	1,382	F42ILL-V (G2)	4	0.079	0.32	2,400	758	0.26	624	228
Room 302 office	F44EE	4	0.144	0.58	2,400	1,382	F42ILL-V (G2)	4	0.079	0.32	2,400	758	0.26	624	228
Stacks Area	MV250/1	23	0.290	6.67	3,720	24,812	MH175/1	23	0.215	4.95	3,720	18,395	1.73	6,417	0
Bull pen office area	F44EE	47	0.144	6.77	2,400	16,243	F42ILL-V (G2)	47	0.079	3.71	2,400	8,911	3.06	7,332	0
Stacks area	F44EE	101	0.144	14.54	3,720	54,104	F44ILL-R (G2)	101	0.102	10.30	3,720	38,323	4.24	15,780	0
Total		281		39.58		123,654		281		26.69		84,626	12.89	39,028	2,357

Where:

$$\text{kW per Space} = \text{Qty} \times \text{kW per Fixture}$$

$$\text{Annual kWh} = \text{kW per Space} \times \text{Annual Operating Hours}$$

$$\text{kW Saved} = \text{kW}_{\text{pre-retrofit}} - \text{kW}_{\text{post-retrofit}}$$

$$\text{Efficiency kWh Saved} = \text{kWh}_{\text{pre-retrofit}} - \text{kWh}_{\text{post-retrofit}}$$

$$\text{Controls kWh Saved} = 0.30 \times \text{kWh}_{\text{post-retrofit}}$$

SITE 19 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER: 1 END USE: LIGHTING

Measure	Replace existing metal halide (MH), high pressure sodium (HPS) and T-12 fluorescent lighting without controls, with T-8 and T-5 fluorescent lighting largely controlled with occupancy and daylight sensors.
Site Description	Distribution warehouses

Measure Description

The project covers four distinct locations, each with a similar facility. For each facility, approximately 95% of treated square footage is stock/distribution area and the rest is office area. The stock/distribution area had MH and HPS fixtures that were replaced with T-8's and sensors. The office areas had T-12's that were replaced by T-5's.

Summary of Ex Ante Impact Calculations

Electricity savings were initially estimated using manufacturers fixture wattages, a count of fixtures from each facility and customer reported operating hours. The program administrator revised the initial estimate by using stipulated wattage values from the program approved wattage table. The revised savings estimate was 3.6% lower than the submitted amount.

Comments on Ex Ante Calculations

Lighting projects under the SPC program are very straight forward as the data and calculations are well defined and documented. Wattage values are stipulated from a well-reviewed table of wattages. The program administrator verified both pre- and post-retrofit fixture counts. Operating hours were self-reported by the applicant, and have the least scrutiny. While the operating hours appear reasonable given the facility schedule of operation, there was no attempt to quantify those hours with monitoring.

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation, conducting an on-site survey and then estimating impacts with the best tool given budget and time constraints. For this project, a two-pronged analysis approach was be used: 1) revising the submitted calculations based on the best available data, and 2) conducting a utility bill analysis.

An on-site survey was conducted on September 18, 2003 at one facility. This is one of four sites that make up the application and this site has the highest savings (51%). Information on the retrofit equipment and operating conditions were collected through an interview with the Maintenance and Facilities Manager for the sites, and visual inspection. This information was then used to develop the evaluation estimate of savings.

During the site survey, a sample of the retrofit fixtures were counted and found to be consistent with the application hours. The biggest discrepancy was found to be the reported operating hours. The application states that the facility operated the lights 24 hours per day, seven days per week prior to the project and reduced the operation using a combination of occupancy and daylight harvesting sensors. During the interview the site contact stated that the facility was only operated five days per week both before and after the retrofit. In addition, the daylight harvesting sensors had been disabled just following their installation due to operational issues. There are no plans to recommission the sensors.

The first calculations to be performed were simply an update of the final, approved calculations for the project. The attached analysis spreadsheet adjusts the savings calculations for the following changes:

- Baseline hours of operation were set to 6,257, which is consistent with 24X5 operation.
- Post installation operating hours were set to baseline operating hours for all calculation rows that used daylight harvesting sensors as the primary means of control.

With these adjustments, the savings were reduced to approximately 60% of the final, or tracking system, savings estimate.

The second approach to estimating the savings involved conducting a regression analysis using billing information and the Metrix software. Since the warehouses are largely unconditioned, lighting is perceived to be a major contributor to the bill.

The analysis was conducted with utility bill data from the five facility meters. Since installation of the measure began in July of 2002, the baseline period for the meters was the year prior to July 1, 2002. In the case of the meter for one of the buildings, the billing data did not go back to the summer of 2001 so the baseline period was chosen as the eight months prior to installation.

The billing data were used with weather from the local area to establish a relationship between energy consumption and cooling degree days (ClgDD). For three of the meters, a statistically valid relationship was established. For cases where a relationship did not exist, the energy consumption appeared to be relatively constant throughout the year. The following equations (rounded to the nearest whole number) were used to estimate the baseline demand and energy consumption for the meters serving the warehouses:

Meter 1

- Baseline kWh = 5,344 kWh / Day + 246 kWh / ClgDD
- Baseline kW = 452 kW + 5 kW / ClgDD / Day

Meter 2

- Baseline kWh = 1,818 kWh / Day + 62 kWh / ClgDD
- Baseline kW = 116 kW + 3 kW / ClgDD / Day

Meter 3

- Baseline kWh = 6,605 kWh / Day + 229 kWh / ClgDD
- Baseline kW = 573 kW

Meter 4

- Baseline kWh = 9,551 kWh / Day
- Baseline kW = 607 kW

Meter 5

- Baseline kWh = 602 kWh / Day
- Baseline kW = 54 kW

Installation was assumed to be completed by the end of August, therefore, the post-installation period began in September of 2002. Based on the available data, the analysis includes the performance through the end of November 2002. Although some of the energy consumption is weather dependent, weather data from 2001 and 2002 show that about 30% of the cooling degree days occur from September through November, therefore, it is reasonable to assume that this would be a typical quarter of savings.

The annualized energy savings were determined by multiplying the quarterly energy savings by four. The annualized demand savings were estimated by taking the average monthly demand savings during the performance quarter. The results of the billing analysis showed the following annualized meter savings:

Meter 1
- Energy Savings (kWh) = 1,249,546 kWh
- Demand Savings (Avg. kW) = 138 kW

Meter 2
- Energy Savings (kWh) = 232,796 kWh
- Demand Savings (Avg. kW) = 33 kW

Meter 3
- Energy Savings (kWh) = 1,370,196 kWh
- Demand Savings (Avg. kW) = 132 kW

Meter 4
- Energy Savings (kWh) = 1,620,560 kWh
- Demand Savings (Avg. kW) = 265 kW

Meter 5
- Energy Savings (kWh) = -51,312 kWh
- Demand Savings (Avg. kW) = -24 kW

Total annual savings for all meters across all sites estimated using the billing data and regression yielded:

- Energy Savings (kWh) = 4,421,786 kWh
- Demand Savings (Avg. kW) = 544 kW

While both methods of estimating savings are reasonable, we believe that the billing regression is better a estimate of the actual savings based on the facility type and the use of observable data.

Scope of Impact Assessment

One of four sites was visited on September 18th, 2003. During that site visit, a sample of the fixtures were counted and verified to be consistent with the application. Billing information for all four sites contributed to the billing regression analysis. Savings were reduced to reflect the actual operating conditions found at the site inspected.

Additional Notes

Reviewing the savings through utility bill analysis is appropriate for this measure because the relative size of the savings to the bill should give a clear indication of the savings. This result, in tandem with the calculated savings produced the final evaluation estimate of savings.

The amount of time allocated to evaluate this site was reasonable and appropriate. Using billing data and a physical verification of the site provide a sound and reasonable analysis of actual savings.

Impact Results

	KW	KWh	Therm
SPC Tracking System or Application (based on the PIR)	573.7	6,207,958	0
Adjusted Engineering	544.0	4,421,786	0
Engineering Realization Rate	0.95	0.71	N/A

POST INSTALLATION - LIGHTING EQUIPMENT SURVEY (LE1)

GENERAL INFORMATION				PRE INSTALLATION						POST INSTALLATION						SAVINGS		
Scope of Work Line Item	Building	Area Description	Usage Group Type	Pre Fixt Number	Pre Fixt. Code	Pre kW/Fixt.	Pre kW/Space	Pre Operating hours	Exist Cont	Post Fixt Number	Post Fixt Code	Post kW/Fixt	Post kW/Space	Post Operating hours	Prop Cont	kW Saved	Efficiency kWh Saved	Controls kWh Saved
1	4100 MISSION	RACK AISLE	AISLES	504	MH400/1	0.458	230.832	6257	NONE	504	F46ILL-V	0.226	113.904	3942	OS/DH	117	460,930	534,376
2	4100 MISSION	OPEN BAY	OPEN	372	MH400/1	0.458	170.376	6257	NONE	372	F46ILL-V	0.226	84.072	6257	DH	86	540,004	0
3	4100 MISSION	OPEN BAY	OPEN	100	MH1000/1	1.080	108.000	6257	NONE	200	F46ILL-V	0.226	45.200	6257	DH	63	392,940	0
4	4100 MISSION	EXTERIOR	EXTERIOR		HPS400/1	0.465	0.000		NONE									
5	1670 CHAMPAGNE	RACK AISLE	AISLES	**208**	MH400/1	0.458	95.264	6257	NONE	222	F46ILL-V	0.226	50.172	3942	OS/DH	45	177,753	220,536
6	1670 CHAMPAGNE	OPEN BAY	OPEN	219	MH400/1	0.458	100.302	6257	NONE	219	F46ILL-V	0.226	49.494	6257	DH	51	317,906	0
7	1670 CHAMPAGNE	EXTERIOR	EXTERIOR		HPS250/1	0.295	0.000		NONE									
8	1670 CHAMPAGNE	EXTERIOR	EXTERIOR		HPS400/1	0.465	0.000		NONE									
9	1670 CHAMPAGNE	EXTERIOR	EXTERIOR		HPS1000/1	1.100	0.000		NONE									
10	NORTH/SOUTH VINTAGE	PICK MODULE	PICK	**1780**	F81EE/T2	0.062	110.360	6257	NONE	2640	F41ILL/T4	0.028	73.920	5241	DT	36	190,982	112,126
11	NORTH/SOUTH VINTAGE	OFFICE	OFFICE	**56**	F43EE	0.115	6.440	6205	NONE	134	F42ILL	0.059	7.906	6205		-1	-9,097	0
12	NORTH/SOUTH VINTAGE	OFFICE	OFFICE	32	F43EE	0.115	3.680	6205	NONE	32	F42ILL	0.059	1.888	6205		2	11,119	0
13	1771 N. VINTAGE	OPEN BAY	OPEN	36	HPS250/1	0.295	10.620	6257	NONE	36	F46ILL	0.175	6.300	6552		4	28,305	-3,133
14	1771 N. VINTAGE	RACK AISLE	AISLES	**107**	HPS250/1	0.295	31.565	6257	NONE	108	F45ILL-V	0.189	20.412	3942	OS/DH	11	43,965	73,073
15	1771 N. VINTAGE	EXTERIOR	EXTERIOR		HPS250/1	0.295	0.000		NONE									
16	1661 S. VINTAGE	RACK AISLE	AISLES	**130**	HPS400/1	0.465	60.450	6257	NONE	150	F46ILL-V	0.226	33.900	3942	OS/DH	27	104,660	139,942
17	1661 S. VINTAGE	OPEN BAY	OPEN	61	HPS400/1	0.465	28.365	6257	NONE	61	F46ILL-V	0.226	13.786	6257	DH	15	91,221	0
18	1661 S. VINTAGE	MEZZANINE	OPEN	62	HPS400/1	0.465	28.830	6257	NONE	62	F43ILL-V	0.112	6.944	6257	DH	22	136,941	0
19	1661 S. VINTAGE	EXTERIOR	EXTERIOR		HPS400/1	0.465	0.000		NONE									
			Total	**3,667.0**			**985.1**			**4,740.0**			**507.9**			**477**	**2,487,628**	**1,076,920**

NOP	0.0%

6257.1429

6257.1

CONTROLS LEGEND:

OS = PIR OCCUPANCY SENSOR
DH = DAYLIGHT HARVESTING
DT = DIGITAL TIMER

SITE 20 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL   TIER: 2   END USE: LIGHTING

Measure	Install high efficiency lighting, lighting controls, high efficiency motors and VFD on chilled water pumps.
Site Description	Paper Manufacturing

Measure Description

This site received a complete lighting retrofit with lighting controls. The site also installed high efficiency motors on the chilled water pumps (2) and the paper blower fan. A VFD was installed to modulate the chilled water pump speed with chilled water demand.

Summary of Ex Ante Impact Calculations

The energy savings for all measures was calculated using the SPC software. The inputs for the lighting savings were fixture wattages and hours of operation. For the high efficiency motor measures, the motor efficiency and the size as well as the hours of operation were used to estimate savings. The VFD measure also used the software calculation templates for a VFD application on a process motor. The calculations assume that except for some of the lighting, all of the equipment operates continuously. The lighting controls measure reduces the hours of operation from 8,760 hours to 4,818 hours in the production areas and from 4,290 hours to 3,003 hours in the offices.

Comments on Ex Ante Calculations

The SPC software provides a general estimate of savings for each of the measures. The controls measure savings appear aggressive and the process motor VFD savings are estimated from a defined user load profile with no additional information required to substantiate the user supplied load profile.

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation, conducting an on-site survey of the facility. The data collected onsite was used to re-estimate savings for the project.

The on-site survey was conducted on January 30, 2004. A walkthrough of the facility showed that most of the lighting was consistent with the types listed in the savings calculations, but the quantity of fixtures that had been retrofit seemed to be much greater than the application showed. It is not clear whether the additional fixtures are part of different SPC applications or the project size increased after the initial application. We attempted to perform a spot check of the fixture quantities installed in certain areas to verify the quantities stated in the application. Unfortunately, the application does not contain a detailed room by room fixture inventory.

Other than fixture quantity, the main difference in the installed fixtures was that we were unable to identify the installation of any of 320-watt pulse start fixtures. In the areas we surveyed, we found that 5-lamp high output T-5 fixtures were installed instead in most of the production areas.

Another difference was that the offices inspected had occupancy sensors for lighting control, but the production areas did not appear to have them. The facility representative stated that the production areas operate continuously and that there were no lighting controls in these areas.   Additionally we observed that all the non-office lights were on at the time of the inspection. One final difference was the chilled water pumps received motors that were slightly more efficient than calculated originally (see below).

The existing 20-hp and 7.5-hp chilled water pump motors were replaced with 92.4% and 91.7% efficient motors, respectively. Two older pump motors were kept as backups. A high efficiency motor (91.7%) was also installed on the blower fan. Finally, a VFD was installed on the chilled water pumps, but it was located inside a motor control panel that could not be opened without shutting down the system. The chilled water pump motors were operating at the time of the inspection, but the paper blower fan motor was not. The blower fan is not on all the time, but is only used periodically and can sometimes be off for days.

The savings for each measure, except the VFD, were recalculated using engineering equations. The energy savings for the high efficiency motors on the chilled water pumps were approximately the same, but the blower fan motor actually runs far fewer hours than estimated so the savings were reduced by 50%.

We elected to accept the high efficiency lighting savings since we were unable to reconcile the differences in the fixture counts. The savings were zero for the production area lighting controls since we observed all lights on in these areas and the facility representative stated that there were no lighting controls for the non office areas. The savings for the VFD measure were not re-calculated based on the data available for this report since these savings were only 3.9% of the total project savings. The results are shown in *Exhibit 1: Measure by Measure Impact Results.*

Scope of Impact Assessment

The assessment addressed application 02-130 only, not the compressed air measures contained in application 02-125. The application 02-130 project includes ten buildings at one site with four different measures installed. The on-site survey focused on the lighting and motor measures in all the buildings. The site survey occurred on January 30th, 2004.

Additional Notes

The level of M&V employed at this site is not sufficient to estimate the annual savings with precision. The savings that result from the analysis are reasonable for a majority of the savings. The savings calculation for chilled water pump VFD, which estimates the motor running at half speed or less for 70% of the hours, appears aggressive, but cannot be adequately verified without several weeks of monitoring, which is not in the budget. Economic information and Impact results are reported for the lighting efficiency and lighting controls portion of the project since the primary end use for this project is lighting.

Economic Information

Economic Summary (Lighting Efficiency and Controls Projects Only)

File Financial Values	Date	Project Cost	Estimated Customer Annual kWh Savings	Estimated Customer kW Savings	Estimated Customer Annual Therm Savings	Estimated Customer Annual $ Savings @ $0.13/kWh	Incentive	Payback w/o Incentive	Payback w/ Incentive
SPC Application	7/23/2002	$ 843,000.00	990,145	80.2	0.0	$ 128,718.85	$49,507.00	6.5	6.2
Installation Report Approved Amount	8/11/2003	$ 843,000.00	920,756	93.0	0.0	$ 119,698.28	$46,037.80	7.0	6.7

Impact Results (Lighting Efficiency and Controls Projects Only)

	KW	KWh	Therm
SPC Installation Report 08/11/03 (Approved Amount)	93	920,756	0
Adjusted Engineering	93	811,039	0
Engineering Realization Rate	100%	88%	N/A

Measure by Measure Impact Results

Measure	Ex Ante		Ex Post		Realization Rate	
	kW	kWh	kW	kWh	kW	kWh
Lighting Controls	-	121,161	-	11,444	-	9%
High Efficiency Lighting	93	799,595	93	799,595	100%	100%
Total	93	920,756	93	811,039	100%	88%

SITE 21 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL   TIER: 2   END USE: LIGHTING

Measure	Lighting and Control
Site Description	Manufacturing Plant

Measure Description

Replace existing metal halide and standard T-12 fluorescent lamps and ballasts with T-8 lamps and electronic ballasts, plus occupancy and daylight harvesting sensors and controls. The building has skylights above the manufacturing and warehouse areas.

Summary of Ex Ante Impact Calculations

Simple pre- and post-retrofit algorithm using fixture connected loads and hours of operation.

Comments on Ex Ante Calculations

Tracking system savings of 1,385,110 kWh/year varies significantly from file savings of 1,639,391 kWh/year due to discrepancies in fixture counts used to calculate tracking system savings claim. Prior to the retrofit, the customer made changes to the facility that altered the lighting system modifications and associated energy savings.

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation, conducting an on-site survey and then computing impacts using the on-site data.

The on-site survey was conducted on December 9, 2003. Information on the retrofit equipment and operating conditions was collected through an inspection of the lamps and controls, and through an interview with the Engineering Manager,. The Engineering Manager stated that they are very pleased with the project. Electric bills were greatly reduced immediately after the work was complete.

The Engineering Manager did mention that at the same time of the lighting retrofit, the manufacturing area was relocated. Some of the operating hours that were originally intended may have since changed.
The facility manufactures 3-ring binders and other kinds of binding materials and devices. The plant normally operates 24 hours a day, 7 days a week. Prior to the retrofit, all of the lights in the manufacturing area operated continuously. Due to the extended plant hours, the office areas also operate extended hours..

Through site observations and the interview with the Engineering Manager, an understanding of the daily and annual schedule of operation and the true hours for the pre- and post-retrofit lamps was developed.

The post case lighting system in the Production-Task Lighting area consists of rows of T-8 lamps, mounted about 10’ above the floor. A photocell that turns off half of these lights on a sunny day. On rare occasions, the photocell is bypassed to allow all lights to operate. The Engineering Manager said that the photocells were very reliable. Everyday the photocell shuts half the lights off 15 to 30 minutes after sunrise, and back on 15 to 30 minutes before sunset. During the site visit it was observed that the lights were all on in this area, with the photocell control in bypass mode. The Plant Engineering Manager restored the system to the automatic mode. There was very little affect on light levels with the lights off.

Adjacent to the Production –Task Lighting area is the high bay manufacturing and “Perma” finished goods pallet storage area. The post case lighting system consists of rows of T-8 lamps, mounted from chains below the high bay ceilings to bring them closer to the floor. These lights are controlled by a photocell that turns off all the lights on a sunny day. During the site visit this area had all the lights off. Light levels were very good under the skylights. The Engineering Manager said this is the usual condition on all but a few rainy days a year.

The post case lighting system in the High Bay Rack Aisles area consists of rows of T-8 lamps, mounted at the ceiling. Motion sensors in each aisle turn on the lights when a forklift enters the aisle, and turns them off after the aisle is vacated. Regularly used material is located at one end of the building, so lights tend to be on more of the time at that end and off more at the other end. The site visit was performed during the busiest time of the day, and it was observed that the lights were off in 12 of the 43 rows. The Engineering Manager said that at night there is 1/3 less activity, so we can surmise that another 7 rows may be off at night.

In the staging area adjacent to the rack aisles, the lights are kept on continuously.

Lights in the office areas have been retrofitted, but no occupancy sensors were added to alter the number of operating hours.
The Engineering Manager stated that lighting operating hours in the high bay and “Perma” areas under the photocells are as follows:
Average photocell off time = 11 hours a day
Number of photocell operation days = 360 days a year
On time = 8,760 hr/yr. – 11 x 360 = 4,800 hr. yr.

In the Production-Task Lighting area, half the lights turn off with the photocells, so the average hours of use are:

50% x 8,760 hr/yr + 50% x 4,800 hr/yr = 6,780 hr/yr.

Average annual lighting hours for fixtures controlled by the occupancy sensors are as follows:

First shift:
8,760 hr/yr. x 1/3 of day x 21 rows on / 43 rows total = 1,426 hr/yr

Second and third shifts:
8,760 hr/yr x 2/3 of day x 14 rows on / 43 rows total = 1,901 hr/yr.

Total average annual hours on in areas controlled by occupancy sensors: 1,426 + 1,901 = 3,327 hr/yr

The following table summarizes the hours:

Usage Group	Space Types Included in Usage Group	Pre-Installlation Operating Hours	Post-Installation Operating Hours
AISLES	HIGH BAY RACK AISLES	8760	3327
OPEN	OPEN BAY STAGING	8760	8760
MANUFACTURING	PROD. TASK LIGHTING	8760	6780
MANUFACTURING	HiIGH BAY PERMA AREA	8760	4800
OFFICE	OFFICE	7488	7488

Ex post operating hours were found to be slightly different for three of the four areas, possibly due to the manufacturing changes. Using the new operating hours, the Ex Post savings comes to 1,664,846 kWh/year compared to the Ex Ante savings of 1,639,391 kWh/year.

The pre and post retrofit fixture connected power provided in the application calculations was accepted.

Scope of Impact Assessment

This was the only measure installed by this customer that received incentives from the SPC program.

Additional Notes

The level of M&V employed at this site is sufficient to accurately determine the impacts of the installed measure. No further M&V is warranted for this customer.

Economic Information

Project costs and payback calculations are not included in the SPC application.

Impact Results

	kW	kWh	Therm
SPC Tracking System or Application	127.8	1,385,110	0
Installation Report	147.2	1,639,391	0
Adjusted Engineering	147.2	1,664,846	
Engineering Realization Rate	1.0	1.02	N/A

Because of the discrepancy between the file and the tracking system, it is assumed that the tracking system data used is outdated and that the actual savings claimed is 1,664,864 kWh per year. This makes the kWh realization rate 1.02.

Results

GENERAL INFORMATION			PRE INSTALLATION						POST INSTALLATION						SAVINGS		
Item	Area Description	Usage Group Type	Fixt Qty	Fixt. Code	kW per Fixt	kW per Group	Op Hours	Control	Fixt Qty	Fixt Code	kW per Fixt	kW per Group	Op Hours	Control	kW Saved	Efficiency kWh Saved	Controls kWh Saved
1	Prod-Task Lighting	MFR	96	F82EHE	0.207	19.872	8,760	NONE	168	F44ILL	0.112	18.816	7,276	DH	1.056	7,683	29,490
2	Breakrooms	MFR	22	F44EE	0.144	3.168	8,760	NONE	22	F42ILL	0.059	1.298	7,276	DH	1.870	13,606	4,701
3	Restrooms	MFR	10	F42EE	0.072	0.720	8,760	NONE	10	F41ILL	0.031	0.310	7,276	DH	0.410	2,983	1,068
4	Warehouse-Aisles	AISLES	243	HPS400/1	0.465	112.995	8,760	NONE	231	F46ILL-V	0.226	52.206	3,796	DH	60.789	230,755	560,907
5	Manufacturing	OPEN	76	MH1000/1	1.080	82.080	8,760	NONE	60	F46ILL-V	0.226	13.560	6,570	OS/DH	68.520	450,176	179,755
6	Warehouse-Staging	OPEN	60	HPS400/1	0.465	27.900	8,760	NONE	67	F46ILL-V	0.226	15.142	6,570	DH	12.758	83,820	61,101
7	Offices	OFFICE	16	F43EE	0.115	1.840	7,488	NONE	16	F42ILL	0.059	0.944	7,488	DH	0.896	6,709	0
8	Offices	OFFICE	14	F43EE	0.115	1.610	7,488	NONE	14	F42ILL	0.059	0.826	7,488	DH	0.784	5,871	0
9	Balemaster	OFFICE	3	F82EE	0.123	0.369	7,488	NONE	3	F43ILL	0.089	0.267	7,488	DT	0.102	764	0
	Total		540			250.6			591			103.4			147.2	802,368	837,023

Base Case				Post Case				Savings	
Base Case Lamps, Control	Fixtures	kW	Annual kWh	Replace-ment Lamps, Control	Fixtures	kW	Annual kWh	kW Saved	Annual kWh Saved
MH, T-12, manual	540	250.6	2,189,995	T-8, daylight and occupancy	762	103.40	525,149	147.2	1,664,846

SITE 22 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER: 2 END USE: LIGHTING

Measure	Lighting and Control
Site Description	Processing Plant

Measure Description

Replace existing metal halide and standard T-12 fluorescent lamps and ballasts with watt-miser T-8 lamps and electronic ballasts. Also, occupancy sensor controls were installed on high-bay fixtures.

Summary of Ex Ante Impact Calculations

Simple pre- and post-retrofit algorithm using fixture connected loads and hours of operation.

Comments on Ex Ante Calculations

The ex-ante savings were determined by obtaining a detailed pre and post lighting inventory and calculating the change in wattage based on fixture wattages published in the SPC documentation. The kilowatt-hours were determined using estimated hours of operation, and reduction of the base hours due to occupancy sensor installation.

For the most part, lighting operates either 24 hours per day, 12 hours per day, or a typical office schedule of 9 hours per day.

The ex-ante lighting analysis is attached to the end of this site report.

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation, conducting an on-site survey and then computing impacts using the on-site data.

The on-site survey was conducted on July 21, 2004. Information on the retrofit equipment and operating conditions was collected through an inspection of the lamps and controls, and through an interview with the facilities engineer.

The evaluation utilized the same spreadsheet analysis that was used in the ex ante analysis. The spreadsheet was updated with values obtained from the site visit. In general, the fixture quantities and types detailed in the ex ante spreadsheet were verified during the evaluation site visit.

There are two significant differences between the ex ante and evaluation analyses.

1. The reduction in operating hours for the high-bay 6-lamp T8 fixtures was estimated to be 50% for most of the workroom floors. The 2nd floor workroom is used during the night for sorting. Prior to the retrofit the fixtures remained on 24 hours. The retrofit included occupancy sensors on each fixture that were supposed to reduce the runtime to 12 hours per day. During the evaluation site visit we observed that most of the lighting was on when it was proposed to be off. Our visit was during the day when the lighting was supposed to be off and all staff was attending a lunch BBQ. During the course of 3 hours of observation an average of less than 15% of the fixtures were ever off. Therefore, it is our judgment that the occupancy sensors are not achieving 50% savings, but

rather about 15%. With this adjustment the savings due to lighting controls is less than 23% of the ex ante claim.

The adjusted hours of operation are shown in bold in the evaluation spreadsheet at the end of this site report.

2. The fixture wattage for the 6-lamp T8 fixtures was listed as 212 watts in the ex ante analysis. The lamps are GE Watt-misers, 30-watts, and the ballasts are GE Ultras. Although 6-lamp fixtures are not specified in manufactures data we found 3-lamp fixtures of this combination of lamp and ballast are rated at 77-watts per fixture. Therefore, we estimate that a 6-lamp fixture would consume approximately 154-watts. This adjustment makes a significant impact on the energy savings achieved through fixture efficiency upgrades.

This adjustment produces an increase in fixture efficiency savings of 21% as compared with the ex ante values.

In summary, the ex ante savings resulting from controls was reduced but this was counterbalanced by an increase in the fixture efficiency savings. The fixture savings are likely to have better persistence than the control savings, so this tradeoff is beneficial in the long run.

Scope of Impact Assessment

It appears from the file that HVAC measures were also incented through the SPC program at this site. However, the evaluation scope was limited to the lighting.

Additional Notes

The level of M&V employed at this site is sufficient to accurately determine the impacts of about 73% of the claimed measure savings (fixture savings only). The additional 27% of the savings is due to lighting controls and significant data logging would be required to accurately estimate the reduction in operating hours. The current budget does not support the level of effort required for the monitoring, estimated to be an additional 20 hours.

Economic Information

File Financial Values	Date	Project Cost	Estimated Customer Annual kWh Savings	Estimated Customer kW Savings	Estimated Customer Annual Therm Savings	Estimated Customer Annual $ Savings @ $0.08/kWh	Incentive	Payback w/o Incentive	Payback w/ Incentive
Application Estimate	12/12/2002	$ 445,000	1,291,197	139	0.0	$ 103,296	$64,560	4.3	3.7
Application Approved	10/24/2003	$ 445,000	1,358,936	169	0.0	$ 108,715	$67,947	4.1	3.5
2002 SPC Installation Report	03/25/2004	$ 445,000	1,379,673	136	0.0	$ 110,374	$68,984	4.0	3.4

Impact Results

	kW	kWh	Therm
SPC Tracking System	162	962,211	0
Installation Report	136	1,379,673	0
Adjusted Engineering	164	1,302,522	0
Engineering Realization Rate	1.20	0.94	N/A

Because of the discrepancy between the file and the tracking system, it is assumed that the tracking system data is outdated and that the actual savings claimed is 1,379,673 kWh per year.

Ex Ante Savings Analysis

Post Fixture Description	Flr	Area Description/ Location	Use Type	Pre Fixt Number	Pre Fixt. Code	Pre W/Fixt.	Pre kW/Space	Pre Operating hours	Pre kWh	Post Fixt Number	Post Fixt Code	Post W/Fixt	Post kW/ Space	Post Operating hours	Post kWh	Prop Cont	kW Saved	Efficiency kWh Saved	Controls kWh Saved
Electronic Ballast and (2) F17 T-8 lamps and Reflector	1&2	Display/315	offices	2	FU2EE	72	0.14	4,000	576	2	F22ILL	33	0.07	4,000	264		0.08	312	0
Electronic Ballast and (3) T-8 Lamps Tandem Wired	All	throughout	offices	51	F43EE	115	5.87	4,000	23,460	51	F43LL	93	4.74	4,000	18,972		1.12	4,488	0
Electronic Ballast and (4) T-8 Lamps Tandem Wired	All	throughout	offices	46	F44EE	144	6.62	4,000	26,496	46	F44ILL	112	5.15	4,000	20,608		1.47	5,888	0
Electronic Ballast and (1) F25 T-8	1	cage	offices	0	F31ES	42	0.00	4,000	0	0	F31LL	24	0.00	4,000	0		0.00	0	0
Electronic Ballast and (1) T-8 Lamp	All	throughout	offices	372	F41EE	43	16.00	4,000	63,984	372	F41ILL	31	11.53	4,000	46,128		4.46	17,856	0
Electronic Ballast and (2) T-8 Lamps	All	throughout	offices	490	F42EE	72	35.28	4,000	141,120	490	F42ILL	59	28.91	4,000	115,640		6.37	25,480	0
Electronic L.P. Ballast and (2) T-8 Lamps and Change Lens	1&2	Vault/ 279	offices	0	F42EE	144	0.00	4,000	0	0	F42ILL	59	0.00	4,000	0		0.00	0	0
Electronic Ballast with (2) 4' T-8 Lamps	2	263	offices	0	F81ES	75	0.00	4,000	0	0	F42ILL	59	0.00	4,000	0		0.00	0	0
Electronic Ballast and (2) T-8 Lamp Tandem Wired	All	throughout	offices	103	F42EE	72	7.42	4,000	29,664	103	F42ILL	59	6.08	4,000	24,308		1.34	5,356	0
H.L. Electronic Ballast with (2) 4' T-8 Lamps	1&2	throughout	offices	10	F82EE	123	1.23	4,000	4,920	10	F44ILL	112	1.12	4,000	4,480		0.11	440	0
Electronic Ballast and (4) T-8 Lamps Tandem Wired	1	Electrical Rm/ Display	offices	0	F44EE	144	0.00	4,000	0	0	F44ILL	112	0.00	4,000	0		0.00	0	0
High to Low Occupancy Sensor	E	Parking Lot	Exterior	0	HPS400/1	465	0.00	4,380	0	0	HPS400/1	279	0.00	2,800	0	HI Low	0.00	0	0
Removal only No Replacement	1	Loading Dock	Exterior Areas	0	MV100/1	125	0.00	4,380	0	0	Removed	0	0.00	0	0		0.00	0	0
Install (12) 4Lamp T-5 HO Fixtures w/ Occupancy Sensors	1&2	Workroom Floor	Exterior Areas	0	Mv100/1-HPS400/1	323	0.00	4,380	0	0	F44ILL-T5HO	234	0.00	2,800	0	OS	0.00	0	0
Install (15) 4Lamp T-5 HO Fixtures w/ Occupancy Sensors	1&2	Workroom Floor	Exterior Areas	0	Mv100/1-HPS400/1	250	0.00	4,380	0	0	F44ILL-T5HO	234	0.00	2,800	0	OS	0.00	0	0
Install (14) 4Lamp T-5 HO Fixtures w/ Sensors	1&2	Workroom Floor	Exterior Areas	0	Mv100/1-HPS400/1	250	0.00	4,380	0	0	F44ILL-T5HO	234	0.00	2,800	0	OS	0.00	0	0
Install 6-Lamp Fixture w/ Occupancy Sensors	2	Workroom Floor	Work Room Floor	27	MH250/1	295	7.97	8,760	69,773	27	46IL-T8	212	5.72	4,818	27,578	OS	2.24	19,631	22,564

Post Fixture Description	Flr	Area Description/ Location	Use Type	Pre Fixt Number	Pre Fixt. Code	Pre W/Fixt.	Pre kW/Space	Pre Operating hours	Pre kWh	Post Fixt Number	Post Fixt Code	Post W/Fixt	Post kW/ Space	Post Operating hours	Post kWh	Prop Cont	kW Saved	Efficiency kWh Saved	Controls kWh Saved
Electronic Timers to switch off Lights	2	Workroom Floor	Work Room Floor	0	F41EE	43	0.00	8,760	0	0	F41EE	43	0.00	4,818	0	OS	0.00	0	0
Electronic Ballast and (1) T-8 Lamp	1&2	Workroom Floor	Work Room Floor	774	F41EE	43	33.28	8,760	291,550	774	F41ILL	31	23.99	8,760	210,187		9.29	81,363	0
Install 6-Lamp Fixture w/ Occupancy Sensors	1&2	Workroom Floor	Work Room Floor	337	MH400/1	458	154.35	8,760	1,352,071	337	46IL-T8	212	71.44	4,818	344,217	OS	82.90	726,222	281,632
(38) Wall and ceiling Ocupancy Sensors	All	throughout	offices	284	F42EE	72	20.45	4,000	81,792	284	F42EE	72	20.45	2,800	57,254	OS	0.00	0	24,538
Install 6-Lamp Fixture w/ Occupancy Sensors	1	Workroom Floor	Work Room Floor	98	MV400/1	455	44.59	4,380	195,304	98	46IL-T8	212	20.78	2,409	50,049	OS	23.81	104,305	40,949
install 4lamp T-5HO Fixtures w/sensors	1	Workroom Floor	Work Room Floor	3	MH250/1	295	0.89	4,380	3,876	3	46IL-T8	212	0.64	2,409	1,532	OS	0.25	1,091	1,254
install 4lamp T-5HO Fixtures w/sensors	1	Workroom Floor	Work Room Floor	11	MV400/1	455	5.01	4,380	21,922	11	46IL-T8	212	2.33	2,409	5,618	OS	2.67	11,708	4,596
install 4lamp T-5HO Fixtures w/sensors	1	Workroom Floor	Work Room Floor	0	HPS400/1	465	0.00	4,380	0	0	46IL-T8	212	0.00	2,409	0	OS	0.00	0	0
				2,608			339.08		2,306,509	2,608			202.95		926,837		136	1,004,139	375,533

Evaluation Savings Analysis

Post Fixture Description	Flr	Area Description/ Location	Use Type	Pre Fixt Number	Pre Fixt. Code	Pre W/Fixt.	Pre kW/Space	Pre Operating hours	Pre kWh	Post Fixt Number	Post Fixt Code	Post W/Fixt	Post kW/Space	Post Operating hours	Post kWh	Prop Cont	kW Saved	Efficiency kWh Saved	Controls kWh Saved
Electronic Ballast and (2) F17 T-8 lamps and Reflector	1&2	Display/315	offices	2	FU2EE	72		0.14	4,000	576	F22ILL	33	0.07	4,000	264		0.08	312	0
Electronic Ballast and (3) T-8 Lamps Tandem Wired	All	throughout	offices	51	F43EE	115		5.87	4,000	23,460	F43LL	93	4.74	4,000	18,972		1.12	4,488	0
Electronic Ballast and (4) T-8 Lamps Tandem Wired	All	throughout	offices	46	F44EE	144		6.62	4,000	26,496	F44ILL	112	5.15	4,000	20,608		1.47	5,888	0
Electronic Ballast and (1) T-8 Lamp	All	throughout	offices	372	F41EE	43		16.00	4,000	63,984	F41ILL	31	11.53	4,000	46,128		4.46	17,856	0
Electronic Ballast and (2) T-8 Lamps	All	throughout	offices	490	F42EE	72		35.28	4,000	141,120	F42ILL	59	28.91	4,000	115,640		6.37	25,480	0
Electronic Ballast and (2) T-8 Lamp Tandem Wired	All	throughout	offices	103	F42EE	72		7.42	4,000	29,664	F42ILL	59	6.08	4,000	24,308		1.34	5,356	0
H.L. Electronic Ballast with (2) 4' T-8 Lamps	1&2	throughout	offices	10	F82EE	123		1.23	4,000	4,920	F44ILL	112	1.12	4,000	4,480		0.11	440	0
High to Low Occupancy Sensor	E	Parking Lot	Exterior	0	HPS400/1	465		0.00	4,380	0	HPS400/1	279	0.00	2,800	0	HI Low	0.00	0	0
Install 6-Lamp Fixture w/ Occupancy Sensors	2	Workroom Floor	Work Room Floor	27	MH250/1	295		7.97	8,760	69,773	46IL-T8	154	4.16	7,446	30,960	OS	3.81	33,349	5,464
Electronic Ballast and (1) T-8 Lamp	1&2	Workroom Floor	Work Room Floor	774	F41EE	43		33.28	8,760	291,550	F41ILL	31	23.99	8,760	210,187		9.29	81,363	0
Install 6-Lamp Fixture w/ Occupancy Sensors	1&2	Workroom Floor	Work Room Floor	337	MH400/1	458		154.35	8,760	1,352,071	46IL-T8	154	51.90	7,446	386,433	OS	102.45	897,444	68,194
(38) Wall and ceiling Ocupancy Sensors	All	throughout	offices	284	F42EE	72		20.45	4,000	81,792	F42EE	72	20.45	4,000	81,792	OS	0.00	0	0
Install 6-Lamp Fixture w/ Occupancy Sensors	1	Workroom Floor	Work Room Floor	98	MV400/1	455		44.59	4,380	195,304	46IL-T8	154	15.09	3,723	56,188	OS	29.50	129,201	9,915
install 4lamp T-5HO Fixtures w/sensors	1	Workroom Floor	Work Room Floor	3	MH250/1	295		0.89	4,380	3,876	46IL-T8	154	0.46	3,723	1,720	OS	0.42	1,853	304
install 4lamp T-5HO Fixtures w/sensors	1	Workroom Floor	Work Room Floor	11	MV400/1	455		5.01	4,380	21,922	46IL-T8	154	1.69	3,723	6,307	OS	3.31	14,502	1,113
				2,608			339.08		2,306,509	2,608			175		1,003,987		164	1,217,533	84,990

SITE 23 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER: 2 END USE: LIGHTING

Measure	Lighting and HVAC
Site Description	Small Government Office

Measure Description

The Customer contracted with an Energy Service Company (ESCO) to complete retrofits and equipment upgrades on a number of end uses, including lighting, boilers, HVAC, pumps, and VFD measures at sixteen different facilities.

Summary of Ex Ante Impact Calculations

Engineering calculations were provided for each of the measures. Savings from each retrofit category were as follows:

Category L (Lighting) – 1,039,687 kWh
Category A (AC&R) – 892,503 kWh
Category O (Other) – 169,801 kWh

Before and after calculations of lighting loads and energy use were performed using the following formula.

KW = Fixture Wattage/1000 X Fixture quantity
KWh = kW X Operating hours

Light fixture watts were based on SPC lighting wattage tables.

Ex ante motor savings were summarized in a table that is reproduced here for reference (no formula was provided):

Table 1

Administration Building

Hp	(e) effy.	(n) effy	New Amps	Hr/yr	Motor kW	kW Saved	kWh Saved
40	93	94.5	47.5	2900	37.846	0.568	1646.3
40	93	94.5	47.5	2900	37.846	0.568	1646.3
10	89.5	91.7	12.1	2900	9.641	0.212	615.1
7.5	88.5	91.7	9.3	2900	7.41	0.237	687.6
7.5	88.5	91.7	9.3	2900	7.41	0.237	687.6
5	87.5	89.5	6.5	2900	5.179	0.104	300.4
5	87.5	89.5	6.5	2900	5.179	0.104	300.4
3	86.5	90.2	4.1	2900	3.267	0.121	350.5

Post retrofit amperages are taken from motor nameplates. Hours of operation are estimated at 2,900.

HVAC savings were calculated using the formulas:

KW Saved = # of Units X Unit Tons X (12/EER1 – 12/EER2)
KWh = kW Saved X Hours (equivalent Full Load hours)

Operating hours and Energy Efficiency Ratings are taken from SPC HVAC Tables.

Comments on Ex Ante Calculations

Several weaknesses in the calculations presented with the application were discovered by the reviewers and corrected in the ex ante calculations. The rationale for additional improvements to the calculation methods are presented in this section, followed by the application of improved ex-post methods in the Evaluation Process section below.

For the lighting end-use, the ex ante approach is acceptable but required several improvements to the inputs, based on data collected on-site. For the motor and HVAC measures, alternative methods are described below and applied in the Evaluation Process section.

<u>Lighting savings:</u> Lighting savings were based on Industry standard calculation methods. SPC lighting wattage tables were used to determine fixture watts. Potential calculation weaknesses are the accuracy of the fixture counts and the accuracy of the operating hours. Fixture counts were verified as reasonably accurate based on the Installation Report Review and the counts made in this review. Fixture counts made during the site visit were 1% higher than the fixture counts used in the ex ante calculations.

<u>Motors:</u> The original motor calculations were based on a comparison of **existing** motors to new high efficiency motors. Based on input from the review team, the calculations were updated to reflect a comparison of the new high efficiency motors to new standard efficiency motors.

Pre-retrofit amperages were not included in the calculation summary Table 1 (above). No formula was provided in the ex ante calculations, but they appear to be based on

KW = Volts X Amps X $\sqrt{Phase}$ X Power Factor

In attempting to recreate the ex ante calculations it becomes apparent that the Power factor was not considered, resulting in an overestimation of kW savings of 14%.

This analysis used the formula kW = Hp X .746 / Eff. Based on the latter formula, ex ante kW saved was overestimated by 10%. Both calculation methods were based on fully loaded motor operation and do not account for the possibility of partial motor loading.

Motor operating hours were estimated at 2,900, and were not substantiated in the project documentation. Based on the Fan system operating schedules in the EMS (collected during the on-site audit), ex ante operating hours were underestimated by 33%.

KWh saved = kW saved X operating hours

Ex Post kWh saved appear to be approximately 19.4% higher than the ex ante calculations.

<u>HVAC:</u> The ex ante calculations were based on an estimate of the **existing** equipment's current EER compared to the actual EER of new equipment. Based on input from the project review team, the calculations were updated to reflect

EER's and Full Load Operating hours from the SPC Program.

The ex ante calculations did not compare favorably with the ex post BIN model calculation. This led to a more detailed analysis of the ex ante assumptions. The ex ante FL hours were assumed to be 1,300. SPC data tables for this climate zone list FL hours of 1,048, which is 19% below the ex ante estimate, and is much more consistent with the ex post calculations. There also seems to be inconsistency in the EERs used in the ax ante calculations and the EERs in the SPC tables. Unfortunately, the scope of this project does not allow for a complete reconciliation of the ex ante and ex post calculations.

The ex post BIN calculation resulted in 38% less savings than the ex ante estimates.

Evaluation Process

In this analysis we repeated the ex ante calculations for the lighting, and used alternative calculation methods for the motor and HVAC measures.

Two of the sixteen facilities were evaluated: the Administration Building and the Public Works building. The Administration building was evaluated for Lighting, HVAC, and energy efficient motors. The HVAC retrofit at the Public Works building differed significantly from the ex ante calculations, so only lighting was evaluated at this facility.

Lighting measures were addressed by counting the number of fixtures in six selected areas in each facility, and validating fixture watts from the SPC wattage tables. Power and energy reduction calculations were identical to those utilized for the ex ante savings estimates.

Lighting watts matched the SPC wattage tables for the Public Works Building, but differ by 1 watt for one of the fixture types at the Administration building. For this reason the results in the ex post kW reductions exceed the ex ante estimates by 2%.

The estimated ex ante operating hours were not substantiated and do not match the operating hours in SPC Table 2. Nearly all the lighting circuits are controlled by manual switches, with the exception of a small number of occupancy sensors in a few rooms. In this analysis we have assumed that the lighting system operation closely matches the HVAC system operation for common areas, is 1,500 hours in conference rooms, and is 2,500 hours in individual offices, resulting in 10% less savings than the ex ante calculations.

<u>Motors</u>: Motor measure installations were validated by collecting nameplate data on a sample of the retrofitted equipment, and collecting operational data from the energy management system.

Ex Post kW was calculated using the formula:

$$KW = Hp \times 0.746 \; / \; e$$

Hp = Horsepower
e = efficiency

Ex post calculations result in 10.0% fewer kW saved than ex ante calculations.

kWh were calculated based on the formula:

kWh = kW X Hours

This analysis used fan operating schedules obtained from the EMS as a basis for determining hours. EMS hours of operation were higher than the ex ante estimates. The resulting kWh savings are 19.4% higher than ex ante estimates.

HVAC: A BIN calculation method using Sacramento weather data was used to validate the HVAC system savings. Savings were calculated to be 38% lower than the ex ante estimates. This led to a review of the original ex ante assumptions. The ex ante calculation was based on EER ratings and "equivalent full load" (FL) operating hours. The ex ante FL hours were 1,300. SPC data tables for this climate zone list FL hours of 1,048, which is 19% below the ex ante estimate, and is much more consistent with the ex post calculations. There also seems to be inconsistency in the EERs used in the ax ante calculations and the EERs in the SPC tables. Unfortunately, the scope of this project does not allow for a complete reconciliation of the ex ante and ex post calculations.

The following table summarizes the results from the ex ante, calculations resulting from updated EER and full load hours, and BIN calculations.

Administration Building

	Original Calc	Based on SPC Tables	% Delta	Based on ex Post Calcs	% Delta
# of Units	2	2			
Tons per unit	70	70			
Original EER	9.55	9.48			
Original kW	175.916	177.215			
Post Retro EER	11.65	11.31			
Post Retro kW	144.206	148.541			
kW Saved	31.7102	28.6741	-9.6%	31.71	0.0%
Equiv Full Load Hours	1300	1048	-19.4%		
kWh Saved	41223.3	30050.4	-27.1%	25,398	-38.4%

Ex ante kW appears to be overestimated 9.6% when compared to the ex ante calculation method with updated EERs. In the BIN calculation we assumed that the EER was the same as the ex ante calculation, thus resulting in the same estimated kW reduction.

Ex ante kWh savings is overestimated by 27.1% when compared to the ex ante calculation method with updated EERs and full load operating hours, and by 38.4% when compared to the BIN calculation using the ex ante EER and Sacramento weather data.

Scope of Impact Assessment

This assessment focused on the lighting portion of the SPC application, but also addressed HVAC and motors retrofits. Other end uses that were part of the project but not addressed here included boilers and VFDs.

Additional Notes

The paperwork in this file is very unorganized. Identifying single facts such as kW reduction resulting from HVAC retrofits is virtually impossible. This is likely due to the comprehensive scope of this project.

It should also be noted that the HVAC retrofit described in the SPC ex ante project was significantly different than the actual installed equipment at the Public Works building.

The time allowed to complete this analysis was appropriate to address the Lighting retrofit. An additional 10 to 20 hours would have allowed for a more comprehensive evaluation of the Project as a whole. We have completed a cursory evaluation of the Motors and HVAC retrofit, but did not address variable frequency drives, boilers, controls, or process changes.

Economic Information

Due to the nature of this project (an ESCO contract) detailed financial data was not available on a measure by measure basis, so a financial analysis of individual lighting, HVAC, and motors measures is not available.

Impact Results

LIGHTING	KW	KWh	Therm
SPC Tracking System or Application	290	1,039,687	
Adjusted Engineering	294	932,979	
Engineering Realization Rate	1.01	0.90	

MOTORS
Administration and Public Works Buildings
Sample ONLY

Motors	kW Saved	kWh Saved	Therm
SPC Tracking Application	1.34	3,898	
Adjusted Engineering	1.21	4,655	
Engineering Realization Rate	0.90	1.19	

HVAC
Administration and Public Works Buildings
Sample ONLY

HVAC	kW Saved	kWh Saved	Therm
SPC Tracking Application	31.71	41,223	
Adjusted Engineering	31.71	25,398	
Engineering Realization Rate	1.00	0.62	

SITE 24 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER: 2 END USE: LIGHTING

Measure	Lighting Control Modifications
Site Description	Defense Contractor-Manufacturing & Testing

Measure Description

Interior and exterior lighting control modifications.

Summary of Ex Ante Impact Calculations

Simple pre- and post-retrofit algorithm using fixture connected loads and hours of operation.

Comments on Ex Ante Calculations

The ex-ante savings were determined by performing a pre and post retrofit lighting fixture inventory and calculating the lighting power based on fixture watts published in the SPC Lighting Wattage Tables. Lighting energy use was calculated with the SPC Estimation Software using the customer's estimated hours of operation for the pre and post retrofit cases.

The estimated pre and post retrofit operating hours for interior and exterior lighting provided by the customer are shown in the SPC calculation spreadsheet. The customer estimated that exterior lighting operated 3,640 hours before the retrofit and 364 hours after the retrofit. Interior lighting was estimated to operate 8,568 hours annually before the retrofit and 3,060 hours after the retrofit. The installation reviewer accepted these estimates.

The application documents approximately 1,550 two lamp T-12 interior lighting fixtures and 73 exterior lighting fixtures. According to the documentation, each exterior lighting fixture has one 1,000 watt and one 400 watt high pressure sodium lamp.

Before the retrofit, interior lights were manually controlled by wall switches. A power line carrier control system was installed for the interior lighting. With this system each light switch is addressable, although many switches are grouped together for scheduling control. The lighting system now operates on a time schedule.

Before the retrofit, the 73 exterior lighting fixtures were controlled by photocells that activated the lights from approximately sunset to sunrise. A new security system has been installed that includes low light cameras which allow surveillance of the secure areas without the exterior lighting operating. Control of the exterior lighting is now manual, and only activated if security personnel have a reason to illuminate an area.

Pre and post retrofit calculations of lighting loads and energy use were performed using the following formula.

kW = Fixture Watts/1,000 w/kW x Fixture quantity
kWh = kW x Operating hours

Table 1 is a summary of the ex ante lighting savings.

Table 1 Summary of the Ex Ante Lighting Savings

	Total kW	Annual kWh
Interior Lighting Controls	0	614,296
Exterior Lighting Controls	0	374,267
Total	-	988,563

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation, conducting an on-site survey and interview with facilities personnel, and re-estimating the lighting retrofit savings.

Evaluation for the lighting retrofit included a spot check of the fixture counts, lamp type and number of lamps and a verification of lighting control installation. Pre and post retrofit operating hours for lighting were reviewed in detail with the facility representative and are discussed below for each area.

Pre and post retrofit calculations of lighting loads and energy use were performed using the following formula.

kW = Fixture Watts/1,000 w/kW x Fixture quantity
kWh = kW x Operating hours

Interior Areas
The interior area affected by the lighting control retrofit has a cafeteria, open offices and private offices. All fixtures have two 34 watt T-12 lamps with magnetic energy saving ballasts. The facility representative stated that private offices account for approximately 20% of the area, open offices 70% of the area, and the cafeteria 10% of the area. Prior to the retrofit lights were controlled by wall switches and were left on continuously in most areas because security personnel did not want the lights off. Janitorial service is performed during working hours because of the sensitive nature of work performed at this facility. According to the SPC lighting calculation spreadsheet, lighting was on 8,568 hours before the retrofit. That equates to lighting being off for 8 days (192 hours) annually.

We believe that a better estimate of interior lighting hours would account for some private office occupants turning off their lights when leaving work. We have revised the annual hours of lighting operation based on the following assumptions.

- 50% of the private office occupants turn their lights off when leaving work. Offices occupied 48.54 weeks/yr.
- The remaining 50% of private offices will turn their lights off during vacations and holidays. (3.6 weeks per year)
- Cafeteria lights are off during holidays (8 days or 1.6 weeks per year)
- Open office lights are on continuously.

Table 2 is a summary of the revised interior lighting hours of operation before the retrofit. A detailed space by space lighting fixture count was not provided in the application. The hours are weighted by percent of total area to generate an annual weighted hours of operation for all interior lights. Based on these assumptions, we estimate the pre retrofit lights operated 7,990 hours annually.

Table 2-Revised Interior Lighting Hours Pre-Retrofit

Area	hr/day	day/wk	wk/yr	Annual Hours	Weight by Area	Weighted Hours
Private Office	8	5	48.54	1,942	10%	194
Private Office	24	7	48.54	8,155	10%	815
Open Office	24	7	52.14	8,760	70%	6,132
Cafeteria	24	7	50.54	8,491	10%	849
Total						7,990

During the site survey we reviewed the lighting control schedule for the power line carrier lighting control system. We were provided the scheduled hours of operation for each group of light switches and the number of switches controlled in each group. There are 17 groups controlling 113 switches. A description of which areas are controlled by each switch was not readily available. All areas operate Monday-Friday, a half day on Saturday, and are scheduled off on Sunday. There is no holiday scheduling implemented at this time.

We have estimated the annual hours of operation for the interior lighting after the retrofit by weighting each group of switches annual hours of operation by the number of switches controlled. Using this method, we have calculated that lights operate 3,717 hours annually after the retrofit. A summary of the estimated weighted post retrofit annual hours of operation is shown in Table 3 below. Exhibit 1 is a copy of the interior lighting schedule for Monday-Friday.

Table 3 Interior Lighting Post Retrofit Hours of Operation

Group	hr/day	% on	day/wk	wk/yr	# of Switches	Annual Hours Operating	Annual Hours Weighted
1	11.25	100%	5.5	52.14	8	3,226	228
6	16	100%	5.5	52.14	9	4,588	365
2	19	100%	5.5	52.14	2	5,449	96
9	12.5	100%	5.5	52.14	9	3,585	286
14	10.5	100%	5.5	52.14	2	3,011	53
12	12	100%	5.5	52.14	7	3,441	213
10	13	100%	5.5	52.14	6	3,728	198
18	13	100%	5.5	52.14	24	3,728	792
7	14	100%	5.5	52.14	4	4,015	142
19	14	100%	5.5	52.14	12	4,015	426
13	14.25	100%	5.5	52.14	2	4,086	72
8	10.5	100%	5.5	52.14	4	3,011	107
11	12.5	100%	5.5	52.14	5	3,585	159
5	10	100%	5.5	52.14	1	2,868	25
4	11	100%	5.5	52.14	6	3,154	167
3	12	100%	5.5	52.14	4	3,441	122
15	13	100%	5.5	52.14	8	3,728	264
Total					113		3,717

The annual energy savings for the interior lighting control system was calculated using the weighted hours of operation for the pre and post retrofit shown in Tables 2 and 3. We have accepted the lighting fixture count shown in the SPC application since no detailed space by space survey was performed, and we have no better information. Table 8 is a summary of the interior and exterior lighting savings calculation.

Exterior Areas

The facility representative verified that there are 73 exterior perimeter security light poles for the facility. All poles have a 1,000 watt high pressure sodium lamp. There are also three 500 watt quartz lamps that are only used for emergencies. Approximately half of the light posts have 400 watt high pressure sodium lamps. The facility representative stated that the 400 watt lamps were disconnected more that 10 years ago to save energy. The SPC lighting calculation appears to erroneously imply that all 73 light posts had 400 watt high pressure sodium lamps and that all were operating prior to the retrofit.

Prior to the retrofit the exterior lights were controlled by photocells that activated the lights from approximately sunset to sunrise daily. We have estimated the annual hours of operation for the lighting system by determining the sunrise and sunset for dates that approximate or equal the autumnal and vernal equinox and the summer and winter solstice for the local area. We then averaged the length of time between sunset and sunrise for these four days to determine the average daily length of night. The result was multiplied by 365 days to estimate the annual hours of operation for the exterior lights before the retrofit. Using this method, we have calculated that lights operated 4,319 hours annually before the retrofit. The calculated daily average hours of operation for the exterior lighting system are shown in Table 4 below:

Table 4 Pre-Retrofit Exterior Lighting Hours of Operation

Date	Sunset	Sunrise	hr/night
21-Mar	18:05	5:54	11.8
21-Jun	20:09	5:40	9.5
21-Sep	18:50	6:40	11.8
21-Dec	16:46	6:56	14.2
Average			11.8

The retrofit included installation of a new security system with low light cameras which allow surveillance of the secure areas without the exterior lighting operating. Control of the exterior lighting is now manual, and only activated if security personnel have a reason to illuminate an area. The lighting is controlled in 4 zones. Security personnel indicate that they rarely turn on the exterior lights and estimate that they are activated less than two hours per week (104.3 hours annually). We have accepted this observation since we have no better information. We calculated the savings for the exterior lighting control modification based on the revised hours of operation.

Table 5 is a summary of the impact evaluation lighting savings. Table 8 presents a summary of the interior and exterior lighting control savings calculations. There are no demand kW savings associated with these measures.

Table 5 Summary of the Impact Evaluation Lighting Savings

	Total kW	Annual kWh
Interior Lighting Controls	0	476,646
Exterior Lighting Controls	0	338,455
Total	-	815,101

Scope of Impact Assessment

The impact assessment scope is for lighting control modifications at one site. The application documents the installation of eight retrofit measures at two sites. Other measures include new rooftop air conditioning units, premium efficiency motors, and lighting efficiency at the site not visited.

Additional Notes

The level of M&V employed at this site is not sufficient to accurately determine the impact of the lighting controls retrofit for the interior lighting. While we have a reasonable level of confidence in the pre and post retrofit connected kW calculation and the post retrofit hours of operation, we have lower confidence in the hours of operation assumed by the installation reviewer or those determined in our interview with the facility representative for the pre retrofit interior lighting calculations.

Data logging would be required to accurately estimate the pre retrofit operating hours for the interior lighting. Data logging would be complicated by the sensitive nature of work performed at this facility and would likely not be allowed due to security concerns. We would therefore recommend that a customer in this type of facility be requested to provide better documentation or in house data logging to increase the accuracy of the savings calculations.

Economic Information

An economic summary for all measures included in the application is shown in Table 6 below. Table 7 is a summary of the engineering realization rate calculation based on the impact analysis performed in this report.

Table 6 Economic Summary of the Project

Description	Date	Project Cost	Estimated Demand Savings, kW	Estimated Energy Savings, kWh	Estimated Gas Savings, therms	Estimated Annual Cost Savings ($0.10/kWh) $	SPC Incentive, $	Simple Payback w/ incentive, yrs	Simple Payback w/o incentive, yrs
Application Submitted Amount	5/9/2002	$949,066	610	2,632,954	0	$263,295	$132,594.00	3.10	3.60
Application Approved Amount	6/25/2002	$949,066	468	2,010,891	0	$201,089	$101,453.00	4.22	4.72
Installation Approved Amount	11/5/2003	$1,119,972	208	1,201,354	0	$120,135	$60,459.00	8.82	9.32
SPC Program Review	9/15/2004	$1,119,972	NA	1,027,892	0	$102,789	$60,459.00	10.31	10.90

Note: Summary shown for all measures at both sites.

Impact Results

Table 7 Realization Rate Calculation

	kW	kWh	Therm
Installation Report	208	1,201,354	0
Adjusted Engineering	NA	1,027,892	0
Engineering Realization Rate	NA	86%	N/A

Neither of the measures evaluated impacts demand kW. Therefore we have set the kW realization rate to NA.

Table 8 Lighting Controls Savings Calculation Summary

Area	Fixture	Quantity	w/fixture	kW	Pre-Retrofit Annual Hours	Pre-Retrofit Annual kWh	Post-Retrofit Annual Hours	Post-Retrofit Annual kWh	Savings Annual kWh
Interior	F/T12/ES	1,549	72	111.5	7,990	891,150	3,717	414,504	476,646
Exterior	1000 W HPS	73	1,100	80.3	4,319	346,829	104	8,374	338,455
Total				192		1,237,979		422,878	815,101

Exhibit 1- Interior Lighting Control Schedule Monday-Friday "On Time"

TIME	ADDRESS	group
03:45-15:00	i2,i3,i4,i5,i6,,i8,i11,i14	1
04:00-20:00	K3,K8,K4,i9,i10,i13,K7,H5,H6	6
04:00-23:00	J6,J7	2
04:30-17:00	F1,H1,H2,H4,H7,H9,H10,H11,H12	9
05:00-16:30	G12	14
05:00-17:00	G4,G5,G6,G7,G8,G9,G10	12
05:00-18:00	F6,F7,G13,G14,G15,G16	10
05:00-18:00	A*,B*,C*,D*,E*	18
05:00-19:00	K9,F2,F5,F8	7
05:00-19:00	L1 THROUGH L12	19
05:00-19:15	G11,I7	13
05:30-16:00	L6,L7,L8,L9	8
05:30-18:00	L4,L5,G1,G2,H3	11
06:00-16:00	K5	5
06:00-17:00	J2,J3,K6,L1,L12,F4	4
06:00-18:00	J8,J9,J11,F3	3
06:00-19:00	H8,J5,J10,J12,K7,K10,K11,K15	15

SITE 25 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL   TIER: 2   END USE: LIGHTING

Measure	High Bay T5 Lighting Conversion
Site Description	Un-Refrigerated Warehouse

Measure Description

Replace existing high pressure sodium lamps with T5 fluorescent lamps. Install occupancy sensors to minimize lighting hours.

Summary of Ex Ante Impact Calculations

Simple pre- and post-retrofit algorithm using fixture connected loads and hours of operation.

Comments on Ex Ante Calculations

Ex ante calculation assumed 60% reduction in run time due to use of occupancy sensors. Baseline hours of operation equal to 8,760 hours per year.

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation, conducting an on-site survey, review of meter data and then computing impacts using the on-site data and the meter data.

The on-site survey was conducted on October 30, 2003. Information on the retrofit equipment and operating conditions was collected through an inspection of the lamps and through an interview with the Plant Engineer. Lighting loggers were deployed throughout the warehouse.

Discussions provided data for development of an annual schedule of operation for the pre- and post-retrofit lamps. Occupancy sensors were set to operate the lights during occupancy and had a 2 minute time delay for shut off following non-occupancy. The pre- retrofit lamps consisted of 780 250-watt high pressure sodium lamps. The post-retrofit lamps consist of 312 6-lamp T-5 fluorescent fixtures and 468 4-lamp T-5 fluorescent fixtures. All post-retrofit fixtures were equipped with infrared occupancy sensors.

It was noted during the site visit that lighting levels were generally low in the warehouse, even with the increased lumens from the new fixtures as compared to the old fixtures.

Examination of available meter interval data shows a significant decrease in electrical usage since the installation of the new lighting in every month as shown in Figure 1.

Other than lighting, the only significant electrical loads in the unconditioned warehouse are two conveyor motors, and battery chargers for the forklifts. The customer also occupies a 4-story office building at this site that is supplied by the same meter as the warehouse. That building is air conditioned and represents the most variable load next to the warehouse lighting. Figure 2 compares the pre-retrofit and post retrofit meter data averaged for each hour of the day for the nine months previous to the installation and the year since the installation. It is clear that something has caused a measurable change in demand. The warehouse is not air conditioned. Only the neighboring office building is air conditioned. Therefore there are no interactive effects with the lighting. The customer attributes all of the change to the new lighting. Assuming the operation of the warehouse and the office building are substantially the same in the post-retrofit period as in the pre-retrofit period, savings averaged 103 kW for each hour.

Figure 1

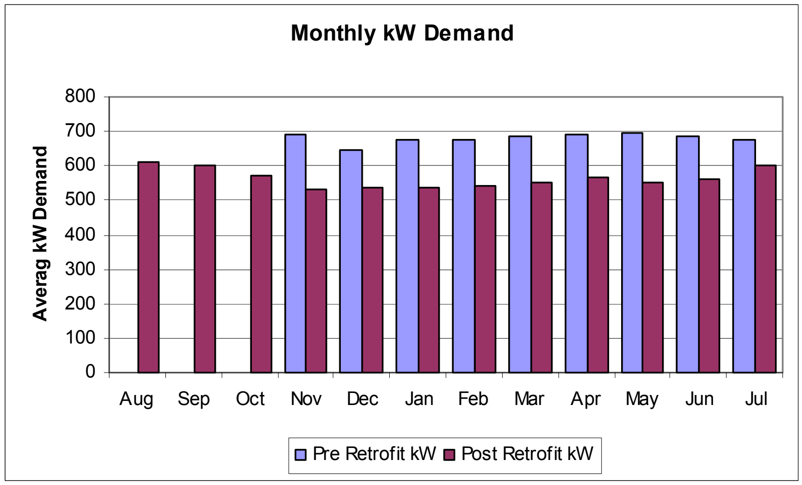
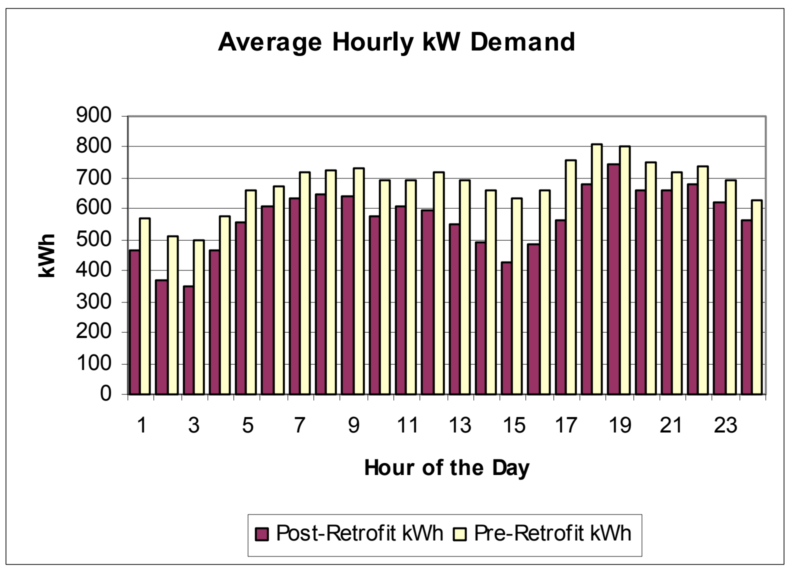


Figure 2

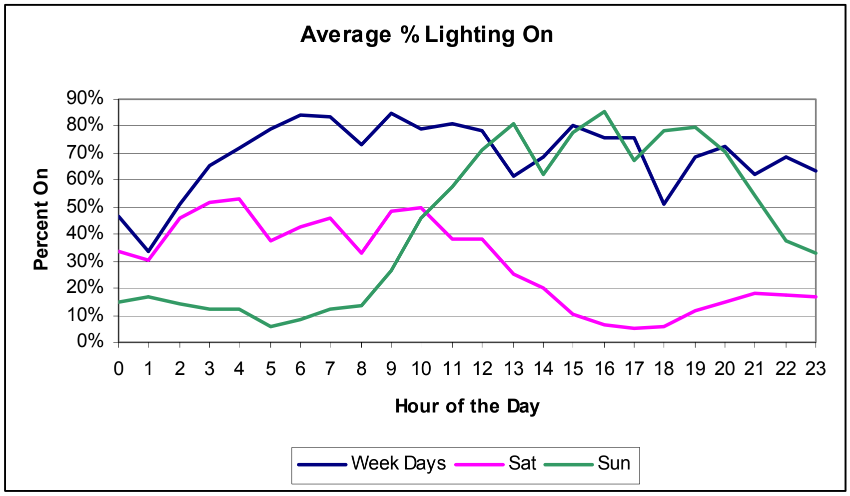


Lighting loggers were set out in the warehouse for 53 days to measure actual operation of the overhead lights. It was found that the lights were actually on 59.6% of the time over all compared to the expected 40%. On weekdays, lights were on 69.2% of the time, while on weekends, lights were on 36.3% of the time. It should be noted that during the observation period, warehouse activity was substantially higher than normal due to the effects of an area-wide grocery workers strike. The site contact reported that weekend shifts had been added to keep up with the added deliveries to non-struck independent grocers.

The general measured hourly lighting profiles are shown in Figure 3 for each day of the week. It can be seen that weekend lighting profiles are different than weekday profiles and that overall, the lights are on about 60% of the time and off 40% of the time.

At the summer peak hour, between 3 and 4 pm on weekdays, the lights were measured to be on 80.1% of the time.

Figure 3



The ex ante analysis was adjusted for the verified operating schedule and wattage.

To compute the energy impacts, the following assumptions were used:

- Pre-retrofit hours of operation were 8,760/year. Pre-retrofit wattage was 295 watts per lamp x 780 lamps = 230.1 kW and annual kWh usage was 230.1 kW x 8760 hrs/yr = 2,015,676 kWh/yr.
- Based on lighting logger data, post-retrofit hours of operation are 5,191 hrs/year. Post-retrofit wattage was 351 watts per 6-lamp fixture x 312 fixtures + 234 watts per 4-lamp fixture x 468 fixtures = 219 kW, and annual kWh usage is 219 kW x 5,191 hrs/yr = 1,136,964 kWh/yr
- The resulting annual kWh savings is 2,015,676 – 1,136,964 = 878,712 kWh/yr.

Summer peak impacts were estimated by subtracting post-retrofit from pre-retrofit connected load, with an adjustment for the average measured post-retrofit percent on of 80.1%. Peak kW savings is 230.1 kW – (219 kW x 80.1%) = 54.7 kW.

Scope of Impact Assessment

This customer also received incentives for a refrigeration control measure at another site.

Additional Notes

The level of M&V employed at this site is probably sufficient to accurately determine the impacts of the installed measure. Additional logging of actual lighting schedules may also be justified as additional M&V is for this customer.

Economic Information

File Financial Values	Date	Project Cost	Estimated Customer Annual kWh Savings	Estimated Customer kW Savings	Estimated Customer Annual Therm Savings	Estimated Customer Annual $ Savings @ $0.13/kWh	Incentive	Payback w/o Incentive	Payback w/ Incentive
Application Estimate	4/9/2002	$ 357,842.00	1,214,052	0	0.0	$ 157,826.76	$60,702.60	2.3	1.9
2002 SPC Installation Report	4/23/2002	$ 357,842.00	1,248,216	11.076	0.0	$ 162,268.08	$62,410.80	2.2	1.8

Impact Results

	KW	KWh	Therm
SPC Tracking System or Application	11.1	1,248,216	0
Adjusted Engineering	54.7	878,712	0
Engineering Realization Rate	4.9	0.70	N/A

Results

Interval Metering Data Analysis

Pre Retrofit kW

Hour	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Grand Total
0				652	548	587	590	615	534	528	535	516	567
1				578	481	500	509	531	498	505	507	491	511
2				524	468	482	494	510	497	510	514	507	500
3				510	473	485	496	518	638	670	672	696	574
4				660	580	639	632	635	689	685	687	711	658
5				675	596	666	629	637	722	713	711	733	676
6				722	662	720	680	681	739	752	733	756	716
7				699	675	720	696	714	758	767	744	766	727
8				712	687	739	714	724	755	770	739	760	734
9				714	686	733	720	733	674	670	650	640	691
10				617	651	657	632	651	741	775	747	741	691
11				734	708	724	754	762	745	722	685	652	720
12				745	698	717	716	737	710	694	644	605	696
13				718	687	664	676	701	679	667	602	563	662
14				670	675	634	643	666	639	635	583	544	632
15				625	642	600	605	628	741	776	680	669	663
16				776	740	759	764	765	801	791	707	687	755
17				815	772	792	800	796	790	827	846	825	807
18				803	755	798	815	808	794	804	837	824	804
19				784	749	791	809	809	709	693	731	712	754
20				675	645	667	681	700	728	771	782	791	716
21				753	681	750	745	743	718	731	760	759	738
22				719	654	716	722	704	671	668	703	684	693
23				665	597	650	663	657	597	590	620	609	627
Grand Total		0	0	689	646	675	674	684	690	696	684	677	680

Post Retrofit kW

Hour	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Grand Total
0	544	453	443	494	459	480	499	512	437	402	386	434	462
1	431	383	356	367	358	362	356	383	343	328	318	356	362
2	423	370	347	316	311	317	310	315	342	338	338	384	343
3	563	555	515	336	318	325	325	325	541	532	526	599	456
4	578	576	555	504	517	502	506	508	597	553	553	630	549
5	676	617	614	525	550	533	547	542	654	647	647	703	605
6	658	639	653	582	623	619	611	631	645	630	628	684	634
7	666	659	657	599	610	638	630	615	656	644	637	698	642
8	655	651	640	616	626	652	651	637	644	621	613	683	641
9	588	531	534	608	614	627	634	619	542	537	533	579	579
10	690	681	627	492	498	512	507	514	657	654	659	703	600
11	602	626	546	628	624	640	653	635	573	505	533	561	593
12	658	617	493	538	508	512	518	521	530	534	554	554	545
13	561	521	456	523	489	482	484	523	459	461	456	460	490
14	472	456	398	444	453	419	422	456	388	392	397	411	426
15	562	583	519	386	408	368	381	384	499	515	536	568	476
16	593	622	575	513	514	497	526	521	572	557	584	610	557
17	746	780	737	572	590	557	571	572	705	697	738	781	671
18	738	796	790	709	723	711	727	742	730	689	724	772	738
19	618	661	652	700	730	714	720	740	606	554	595	619	659
20	712	752	708	548	583	554	562	582	684	680	718	741	652
21	684	707	700	645	659	642	666	694	674	650	667	700	674
22	618	622	620	600	614	622	636	651	607	584	602	624	617
23	613	580	540	532	528	554	571	578	563	524	552	557	558
Grand Total	610	602	570	532	538	535	542	550	569	551	562	600	564

$$
\begin{aligned}
\text{Annual kWh Savings} &= \text{Annual kWh}_{\text{pre-retrofit}} - \text{Annual kWh}_{\text{post-retrofit}} \\
&= \left(\text{Grand Total kW}_{\text{pre-retrofit}} - \text{Grand Total}_{\text{post-retrofit}}\right) \times 8{,}760 \text{ hrs.yr} \\
&= \left(680 \text{ kW} - 564 \text{ kW}\right) \times 8{,}760 \text{ hrs/yr} \\
&= 1{,}016{,}148 \text{ kWh/year}
\end{aligned}
$$

Logger Data Results

Percent On by Day Type

Hour of the Day	Week Days	Week Ends	All Days
0	46.63%	24.28%	39.88%
1	33.99%	23.49%	30.82%
2	51.40%	29.82%	44.88%
3	65.60%	32.16%	55.51%
4	72.18%	32.56%	60.22%
5	78.83%	21.44%	61.51%
6	83.98%	25.65%	66.37%
7	83.65%	29.27%	67.23%
8	72.91%	23.37%	57.95%
9	84.59%	37.60%	70.41%
10	78.90%	47.90%	69.60%
11	80.92%	47.93%	71.03%
12	78.07%	54.59%	70.99%
13	61.64%	53.09%	59.05%
14	68.55%	41.06%	60.26%
15	80.07%	43.88%	69.14%
16	76.08%	45.97%	66.99%
17	75.83%	36.37%	63.92%
18	51.02%	42.06%	48.31%
19	68.73%	45.71%	61.78%
20	72.36%	42.98%	63.49%
21	62.22%	36.43%	54.43%
22	68.82%	27.61%	56.38%
23	63.22%	24.87%	51.64%
Grand Total	69.19%	36.25%	59.26%

Percent On by Day of the Week

Hour of the Day	Mon	Tue	Wed	Thur	Fri	Sat	Sun	All Days
0	22.41%	67.29%	63.68%	38.49%	44.96%	33.40%	15.15%	39.88%
1	20.06%	43.12%	44.09%	32.99%	31.97%	30.18%	16.80%	30.82%
2	40.59%	73.40%	60.68%	52.83%	33.57%	45.67%	13.97%	44.88%
3	61.56%	76.90%	80.98%	63.89%	47.80%	51.88%	12.43%	55.51%
4	76.18%	79.66%	80.13%	72.15%	54.72%	52.92%	12.19%	60.22%
5	85.61%	83.78%	81.11%	74.57%	69.47%	37.34%	5.53%	61.51%
6	84.60%	83.32%	85.65%	78.82%	87.01%	42.91%	8.39%	66.37%
7	87.25%	83.34%	86.05%	75.77%	85.10%	45.94%	12.60%	67.23%
8	73.72%	63.76%	71.97%	61.89%	90.56%	33.01%	13.72%	57.95%
9	88.34%	85.65%	85.98%	71.79%	89.90%	48.38%	26.83%	70.41%
10	85.60%	80.18%	83.23%	75.30%	70.46%	49.55%	46.26%	69.60%
11	80.39%	83.52%	78.70%	75.09%	86.18%	38.14%	57.72%	71.03%
12	85.05%	79.02%	67.57%	70.18%	87.79%	38.00%	71.18%	70.99%
13	66.54%	62.89%	48.16%	54.29%	75.19%	24.96%	81.21%	59.05%
14	61.72%	67.01%	73.40%	69.79%	70.39%	20.03%	62.09%	60.26%
15	88.65%	83.36%	87.82%	80.91%	62.06%	10.08%	77.69%	69.14%
16	82.40%	85.13%	83.05%	78.18%	54.42%	6.53%	85.42%	66.99%
17	82.33%	84.01%	85.91%	76.55%	53.46%	5.37%	67.37%	63.92%
18	57.23%	54.06%	53.49%	48.97%	42.80%	6.00%	78.12%	48.31%
19	74.89%	79.63%	78.05%	69.57%	44.80%	11.97%	79.45%	61.78%
20	78.49%	83.85%	84.62%	75.55%	43.00%	15.07%	70.89%	63.49%
21	67.00%	71.56%	65.45%	67.58%	41.65%	18.40%	54.46%	54.43%
22	79.06%	81.22%	73.71%	76.63%	36.91%	17.39%	37.83%	56.38%
23	79.50%	79.42%	57.38%	65.96%	37.16%	16.78%	32.95%	51.64%
Grand Total	70.99%	75.63%	73.37%	67.25%	60.06%	29.16%	43.34%	59.26%

$$\begin{aligned}\text{Pre-Retrofit Demand kW}_{\text{Peak}} &= (\text{Pre} - \text{Retrofit Fixture Wattage} \times \text{Pre-Retrofit Fixture Count}) \times (\text{Percent On})/(1{,}000\ \text{W/kW})\\ &= 295\text{W/Fixture} \times 780\ \text{Fixtures} \times 1.00/(1{,}000\ \text{W/kW})\\ &= 230.1\text{kW}\end{aligned}$$

$$\begin{aligned}\text{Post-Retrofit Demand kW}_{\text{Peak}} &= (\text{Post} - \text{Retrofit Fixture Wattage} \times \text{Post-Retrofit Fixture Count}) \times (\text{Percent On})/(1{,}000\ \text{W/kW})\\ &= (468\ \text{W/Fixture} \times 234\ \text{Fixtures} + 351\ \text{W/Fixture} \times 312\ \text{Fixtures}) \times 0.801/(1{,}000\ \text{W/kW})\\ &= 175.4\ \text{kW}\end{aligned}$$

$$\begin{aligned}\text{Peak kW Savings} &= \text{Pre-Retrofit Demand kW}_{\text{Peak}} - \text{Post-Retrofit Demand kW}_{\text{Peak}}\\ &= 230.1\ \text{kW} - 175.4\ \text{kW}\\ &= 54.7\ \text{kW}\end{aligned}$$

$$\begin{aligned}\text{Pre-Retrofit Annual Energy Usage} &= \text{Pre} - \text{Retrofit Demand kW} \times \text{Pre} - \text{Retrofit Hours of Operation}\\ &= 231\text{kW} \times 8{,}760\ \text{hrs/yr}\\ &= 2{,}015{,}676\ \text{kWh/yr}\end{aligned}$$

$$\begin{aligned}\text{Post-Retrofit Annual Energy Usage} &= \text{Post} - \text{Retrofit Demand kW} \times \text{Post} - \text{Retrofit Hours of Operation}\\ &= 219\ \text{kW} \times 5{,}191\text{hrs/yr}\\ &= 1{,}136{,}964\ \text{kWh/yr}\end{aligned}$$

$$\begin{aligned}\text{Annual kWh Savings} &= \text{Pre} - \text{Retrofit Annual Energy Usage} - \text{Post-Retrofit Annual Energy Usage}\\ &= 2{,}015{,}676\ \text{kWh/yr} - 1{,}136{,}964\ \text{kWh/yr}\\ &= 878{,}712\ \text{kWh/yr}\end{aligned}$$

Inputs to Model

Parameter	Value Reported	Units	Notes
City	Baldwin Park		
Climate Zone			
Pre-Retrofit Hours of Operation	8,760	hrs/yr	Operating hrs based on continuous operation
Pre-Retrofit Fixture Wattage	295	Watts	Application
Pre-Retrofit Fixture Count	780		Application
Percent On	80.1%		Average during peak hours
Post-Retrofit Hours of Operation	5,191	hrs/yr	Operating hrs based on 2 months' logger data
Post-Retrofit Fixture Wattage	234	Watts	Application
Post-Retrofit Fixture Count	468		Application
Post-Retrofit Fixture Wattage	351	Watts	Application
Post-Retrofit Fixture Count	312		Application

SITE 26 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER:3 END USE: LIGHTING

Measure	Install EMS lighting controls and HVAC fan motor variable speed drives.
Site Description	Pharmaceutical manufacturing facility

Measure Description

This project involves 6 variable speed drives installed on four air handling units and new lighting controls in four areas of the facility.

Summary of Ex Ante Impact Calculations

The submitted lighting measure savings used the Engineering Calculation Method. However, the submitted application did not include a description of the lighting calculation methodology nor did it include fixture count and codes. The project reviewer recalculated the lighting savings by estimating the lighting demand based on the building layout and *Title 24 Allowed Lighting Power* – Complete Building Method.

The submitted HVAC measure savings also used the Engineering Calculation Method. Inputs for the HVAC savings calculations were HP, conversion factor and annual operating hours. The project reviewer determined that an incorrect conversion factor was used and that the baseline demand did not take into account the motor load factor. The reviewer recalculated the HVAC savings based on new baseline demand for each of the six fan motors (from his onsite survey) and the EPA Quickfan software tool.

Comments on Ex Ante Calculations

The submitted lighting measure was incomplete and only provided lighting impacts that were unsubstantiated. The reviewer's attempt at estimating an actual lighting demand based on square footage and Title 24 was a slight improvement. However, neither method used actual fixture counts and types to get an accurate lighting demand. The lighting savings was simply a rough approximation based on square footage and Title 24 allowed lighting levels.

Evaluation Process

The evaluation process consisted of a review of the application forms and supporting documentation, as well as conducting an on-site survey of the pharmaceutical facility.
The on-site survey was conducted on August 31, 2004. The goal of the inspection was to verify the existence and operation of the installed VFDs and lighting system at the facility. Table 1 (below) lists an inventory of installed VFDs, rated HP, observed status, observed speed, and the observed operating HP. The description and motor HP were obtained from the project application, and the operational parameters that were observed during the inspection.
Table 2 (below) compares the lighting power from the original application, the approved SPC adjusted values, and the verified values from this inspection. The submitted application and approved calculations estimated the lighting demand in each space using Title 24 allowable lighting power densities (LPD) and square footages of each space, not on actual counts and fixture types. The inspector verified the fixture counts in the Precision Industrial room which accounts for largest lighting kW (65% of installed kW) controlled by the EMS, and a partial count of the Industrial Storage area (32% of installed kW). The inspector verified approximately 375 fixtures in the Precision Industrial room. Each fixture contained four 4' – T8 lamps which emitted a bright white light in the area. Based on this, the inspector assumed that these fixtures contain either 2nd or 3rd

generation lamps equipped with high output ballasts. Each fixture has input wattages of 152 W/fixture based on Appendix B – "Fixture Wattages" of the 2004 SPC manual. The total demand verified is 57.0 kW which is approximately 10% less than the approved demand (64.0 kW).
Based on the site visit, all of the variable speed drives that were specified in the application were verified. The fan motor demand readings from each drive were consistent with the Reviewer's findings during his visit. The HVAC hours of operation and the lighting control schedule appear reasonable and consistent with the approved values. However, the lighting system verified suggests that the approved lighting savings are slightly lower than the approved value due to lower total wattage.

Scope of Impact Assessment

100% of the VFD's for the project were verified. Approximately 95% of the installed wattage with new controls was verified.

Additional Notes

The review of this project involved onsite verification of the measures installed. The only discrepancy noted between the project reviewer's approved numbers and the site survey resulted in a small decrease (4%) in total energy savings. This adjustment was due to small differences of the actual wattage in the Industrial Storage and Precision Industrial Room's lighting demand during onsite verification.

The inspector counted seventeen (17) 1,000 W MH fixtures in approximately half of the area in the Industrial Storage space. The approved lighting demand for this space was 32.4 kW which requires that the space have at least 32 of these fixtures. Even though the inspector did not count all the MH fixtures in the space, the approved lighting demand in the Industrial Storage space is deemed reasonable.

The lighting controls installed under this project turn the lighting off during weekend, holiday and nighttime hours; therefore there is no peak demand impact. Based on the accepted savings estimates for the Quickfan tool, the VFD's have a peak savings of 2.6 kW, which is the total peak demand savings for the project. Please note that documentation on the project rounds to the nearest whole number, so 2.6 is listed as 3.0 in the application.

The amount of time and effort to evaluate this project was reasonable. The inspection time was adequate to verify the majority of the equipment installed under the program and reasonably assess operating hours.

Economic Summary Table

File Financial Values	Date	Project Cost	Estimated Customer Annual kWh Savings	Estimated Customer kW Savings	Estimated Customer Annual Therm Savings	Estimated Customer Annual $ Savings @ $0.13/kWh	Incentive	Payback w/o Incentive	Payback w/ Incentive
Tracking System	12/19/2002	$ 47,750.00	279,484	3.0	0.0	$ 36,332.92	$15,236.15	1.3	0.9
Installation Report Approved Amount	2/3/2003	$ 47,750.00	279,484	3.0	0.0	$ 36,332.92	$15,236.15	1.3	0.9

Impact Results for all Measures

	KW	KWh	Therm
SPC Tracking System or Application	2.6	279,484	0
Adjusted Engineering	2.6	268,267	0
Engineering Realization Rate	100%	96%	N/A

Table 1: Verified VFDs

Unit	Motor hp	VFD Status	VFD Speed	Effective VFD hp	Energy Savings (kWh)	Demand Savings (kW)
AHU 1 Supply	20.0 hp	ON	48.1 Hz	6.9 hp	16,203	0.8
AHU 1 Return	7.5 hp	ON	37.4 Hz	1.0 hp	6,824	0.4
AHU 2A Supply	30.0 hp	ON	59.6 Hz	11.9 hp	8,273	0.9
AHU 2B Supply	30.0 hp	ON	60.0 Hz	13.9 hp	6,625	0
AHU 4 Supply[1]	7.5 hp	N/A	N/A	N/A	3,412	0.4
AHU 4 Return[1]	2.0 hp	N/A	N/A	N/A	728	0.1
Total	97 hp	N/A	N/A	N/A	42,065	2.6

Note (1): Motor was observed from a distance, nameplate was inaccessable.

Table 2: Verified Lighting

	Application		Approved (Adjusted 18% lower)			Verified (Based on count)						
Space/Location	kW	Hr reduction /year	kW	Hr reduction /yr	kWh Savings	Verified Fixture Count	Verified Fixture Type	Input Power per Fixture (W)	kW	Hr reductio n/year	kWh Savings	Notes
Industrial Storage	39.6	2612	32.4	2323	75,340	n/a	MH1000/1	1080	34.6	2323	80,283	Approximately 1/2 fixtures verified
Precision Industrial	78.1	2612	64.0	2323	148,588	375	F44ILL/2-V	152	57.0	2323	132,411	375 F44ILL/2-V fixtures
Main Lobby	1.1	2612	0.9	2323	2,093	n/a	n/a	n/a	0.9	2323	2,093	Counts not verified
Electrical Mechanical	6.0	2612	4.9	2323	11,415	n/a	n/a	n/a	4.9	2323	11,415	Counts not verified
	124.8		102.2		237,437				97.4		226,202	

SITE 27 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER: 3 END USE: LIGHTING

Measure	Lighting Efficiency and Occupancy Controls
Site Description	Public School

Measure Description

Campus wide lighting efficiency retrofit with occupancy controls in selected areas. Stadium lighting replacing existing metal halide lamps and ballasts with new metal halide lamps and ballasts. Reduction in the number of stadium lights.

Summary of Ex Ante Impact Calculations

Simple pre- and post-retrofit algorithm using fixture connected loads and hours of operation.

Comments on Ex Ante Calculations

The ex-ante savings were determined by performing a detailed pre and post lighting fixture inventory and calculating the change in lighting power based on fixture watts published in the SPC Lighting Wattage Tables. Lighting energy use was calculated using estimated hours of operation, and reduction of the base hours for occupancy sensor installation.

A detailed usage group summary of estimated pre and post retrofit operating hours was provided by the energy services company that developed and managed the project. Estimated annual hours of lighting operation range from 709 to 8,760 for the pre retrofit, and from 531 to 6,570 for the post retrofit in areas where occupancy sensors are installed.

The application documents approximately 6,800 interior lighting fixtures including many that appear to receive no modification and more than 500 occupancy sensor installations. There were 192- 1,500 watt metal halide stadium lights before the retrofit. After the retrofit, there are 76- 1,500 watt metal halide stadium lights.

Pre and post retrofit calculations of lighting loads and energy use were performed using the following formula.

kW = Fixture Wattage/1000 w/kW x Fixture quantity
kWh = kW x Operating hours

Calculations for the stadium lighting are shown below in Table 1.

Table 1
Summary of the Ex Ante Stadium Lighting Calculations

	Quantity	Fixture Watts	Annual Hours	Total kW	kWh
Pre-retrofit	192	1,610	232	309	71,716
Post-retrofit	76	1,610	232	122	28,388
Savings	116	-	-	187	43,328

Table 2 is a summary of the ex ante lighting savings.

Table 2
Summary of the Ex Ante Lighting Savings

	Total kW	kWh
Stadium	187	43,328
Interior	100	378,623
Total	287	421,951

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation, conducting an on-site survey and interview with facilities personnel, and re-estimation of the lighting retrofit savings.

Evaluation for the interior lighting retrofit included a random spot check of the fixture counts, lamp type and number of lamps and numbers of occupancy sensors for selected buildings. Evaluation for the stadium lighting retrofit was performed by verifying the fixture counts and proposed hours of operation. Pre and post operating hours for interior lighting and Stadium lighting were reviewed with the facility engineers. Facilities personnel generally concurred with the hours of lighting operation proposed for the areas.

The fixture quantities and types detailed in the ex ante analysis were spot verified during the site visit. 20 spaces were surveyed for the interior lighting in four buildings. In every case the lighting fixture counts and numbers of lamps were accurate. Occupancy sensors were installed in every space surveyed where listed in the application submission.

We were not able to verify wiring configurations or ballast type since we did not open up fixtures. A summary of the spaces surveyed for the spot check is shown in Table 7 below. The hours of operation were reviewed with facility representatives, who generally concurred with the estimates provided in the project application. We have accepted the proposed hours of operation shown in the SPC calculation worksheet since we have no better information. The pre and post retrofit proposed hours of operation for the interior lighting are shown in Table 8 below.

The installation report approved savings for the football stadium lighting was based on 76 new metal halide lights being installed to replace the existing 192 metal halide lights. The analysis assumed that the lights operate 232 hours in both the pre and post retrofit cases. The calculations are summarized in Table 3 below:

Table 3
Summary of the Impact Evaluation Stadium Lighting Calculations

	Quantity	Fixture Watts	Annual Hours	Total kW	kWh
Pre-retrofit	192	1,610	232	309	71,716
Post-retrofit	76	1,610	232	122	28,388
Savings	116	-	-	-	43,328

It is unlikely that the Stadium lighting would operate during peak electrical demand periods. Therefore the demand savings are set to zero for this measure.

Table 4 is a summary of the Impact evaluation savings for the retrofit of the stadium lighting and the interior lighting and occupancy sensor installation.

Table 4
Summary of the Impact Evaluation Lighting Savings

	Total kW	kWh
Stadium	0	43,328
Interior	100	378,623
Total	100	421,951

Scope of Impact Assessment

The application file indicates that HVAC measures were also included in the application for this site. However, the evaluation scope was limited to the lighting retrofit.

Additional Notes

The level of M&V employed at this site is sufficient to accurately determine the impact of the Stadium lighting efficiency retrofit. The additional energy savings is from lighting controls and lighting efficiency for interior areas. Significant data logging would be required to accurately estimate the reduction in operating hours. An additional 32 hours of engineering time and rental of logging equipment would be required to more accurately assess the impact of the interior lighting efficiency and controls retrofit.

Economic Information

An economic summary for all measures included in the application is shown in Table 5 below. Table 6 is a summary of the engineering realization rate calculation based on the impact analysis performed in this report.

Table 5
Economic Summary of the Project

Description	Date	Project Cost	Estimated Demand Savings, kW	Estimated Energy Savings, kWh	Estimated Gas Savings, therms	Estimated Annual Cost Savings ($0.10/kWh) $	SPC Incentive, $	Simple Payback w/ incentive, yrs	Simple Payback w/o incentive, yrs
Application Submitted Amount	5/3/2002	$806,237	159	756,652	0	$75,665	$53,971.34	9.94	10.66
Application Approved Amount	7/1/2002	$806,237	155	532,681	0	$53,268	$31,309.00	14.55	15.14
Installation Approved Amount	6/17/2003	$806,237	302	542,959	0	$54,296	$31,309.00	14.27	14.85
SPC Program Review	9/10/2004	$806,237	115	542,959	0	$54,296	$31,309.00	14.27	14.85

Note: Reported values are for the entire project including lighting, HVAC, motors and VSD's

Impact Results

Table 6
Realization Rate Calculation

	kW	kWh	Therm
Installation Report	302	542,959	0
Adjusted Engineering	115	542,959	0
Engineering Realization Rate	38%	100%	N/A

Table 7
Summary of Field Verified Areas

			SPC Documentation			
			Light Fixtures		Controls	Verified
Item	Building	Area	Quantity	Type	Quantity	Yes/No
1	CRC	103	103	F42ILL	2	Yes
2	CRC	209	22	F42ILL	1	Yes
3	CRC	205	10	F42ILL	1	Yes
4	CRC	203	10	F42ILL	1	Yes
5	CRC	201	10	F42ILL	1	Yes
6	Student Ctr.	129	12	F42ILL	0	Yes
7	Student Ctr.	128	12	F42ILL	0	Yes
8	Student Ctr.	Men's RR	6	F42ILL	1	Yes
9	Student Ctr.	131	24	F42ILL	1	Yes
10	Central Plant	Chiller	12	F44ILL	1	Yes
11	Central Plant	Chiller	16	F42ILL	1	Yes
12	Central Plant	Office	2	F42ILL	1	Yes
13	Central Plant	Electric Rm	1	F42ILL	1	Yes
14	Ins. Resource	204	9	F43ILL	1	Yes
15	Ins. Resource	205	9	F43ILL	1	Yes
16	Ins. Resource	206	9	F43ILL	1	Yes
17	Ins. Resource	213	9	F43ILL	1	Yes
18	Ins. Resource	Men's RR	6	F42ILL	1	Yes
19	Ins. Resource	321	2	F42ILL	1	Yes
20	Ins. Resource	322	2	F42ILL	1	Yes
21	Stadium	Field Ltg.	76	MH	0	Yes

Table 8
Pre and Post Retrofit Proposed Hours-Interior Lighting

Usage Group	Space Types Included in Usage Group	Pre-Installlation Operating Hours	Post-Installation Operating Hours
C	Classroom	2468	2468
C-S	Classroom, w/ new sensor	2468	1851
E	Exterior	3800	3800
E-S	Exterior, w/ new sensor	3800	2850
G	Gymnasium	4150	4150
H	24/7	8760	8760
H-S	24/7, w/ new sensor	8760	6570
J	Mechanical	1000	1000
J-S	Mechanical, w/ new sensor	1000	750
L	Whole Library	5200	5200
L-S	Whole Library, w/ new sensor	5200	3900
O	Office	2334	2334
O-S	Office, w/ new sensor	2334	1750.5
P	Public/Common Areas	4400	4400
P-S	Public/Common Areas, w/ new sensor	4400	3300
R	Restroom	8655	8655
R-S	Restroom, w/ new sensor	8655	6491.25
S	Stadium	1500	1500
S-S	Stadium, w/ new sensor	1500	1125
W	Work Rooms	709	709
W-S	Work Rooms, w/ new sensor	709	531.75
Z-S	Work Rooms, w/ new sensor	2800	2100

SITE 28 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER: 3 END USE: LIGHTING

Measure	T-12 to T-8 lighting retrofit, VSDs on Pumps and HVAC Fans.
Site Description	Medical Center

Measure Description

The project involved a lighting retrofit, high efficiency motor retrofit, and VFDs on HVAC supply fans. The lighting retrofit accounts for 80% of the total energy savings.

Summary of Ex Ante Impact Calculations

SPC software was used to calculate savings for all measures.

Comments on Ex Ante Calculations

The utility accepted the submitted calculations to estimate incentives, with only minor corrections.

Evaluation Process

The Evaluation process consists of a review of the application form and supporting documentations, an on site survey, and the completion of a billing analysis.

The on-site survey was conducted on November 13, 2003. Information on the retrofit equipment and operating conditions was collected through an inspection of the retrofitted equipment and through an interview with the facility staff.

It was not possible to verify the presence of VFDs on HVAC fans since they were in restricted access areas.

A sample of lighting fixtures serving different usage groups was verified, as shown in the table below.

Space Name	Usage Group	Fixture Count	Fixture Codes	Standard fixture wattages (W)	area (sqft)	W/sqft
Restroom	RR	1	B32R1	39	36	1.08
Hall	Hall	8	W32CF1	39	336	0.93
Cafeteria	Common	25	T32RF4	118	3600	0.82
Decontamination	Common	12	T32RF3	93	480	2.33
Risk Mgmt	Office	18	T32RF2	59	672	1.58
Pharmacy	Office	61	T32RF4	118	2600	2.77
Office1	Office	2	T32RF3	93	108	1.72
Office2	Office	3	T32RF2r	59	187	0.95
Office3	Office	3	T32RF2	59	187	0.95
Office4	Office	2	T32RF3	93	221	0.84
Office5	Office	4	T32RF3	93	162	2.30
Office6	Office	9	T32RF2	59	266	2.00
Office7	Office	8	T32RF2	59	296	1.59

The original lighting table submitted with the application did not include areas, so we were unable to extrapolate from the sampled retrofit data provided in the table above to either accept or reject the ex-ante savings estimates.

The billing analysis performed suggests near-zero savings for all measures combined, indicating that other activities at this facility have led to increased usage. Ordinarily, for an installation that features T8 lighting equipment, we expect the savings results to be plainly observed in the bills. For this reason we consider the billing analysis to be inconclusive.

Additional Notes

With more time and resources, monitoring would be possible, allowing verification of the lighting measure savings. This might include lighting circuits or alternatively the installation of lighting loggers in different usage groups. In either case, the purpose of this effort would be to more accurately estimate hours of operation for the fixtures installed.

For the VFD measures installed on pumps, pump load profiles and performance could be verified by recording and analyzing power logger data.

To accurately assess impacts for the lighting measures installed would require, at a minimum, an additional 30 hours of analysis and monitoring time. This is a large and complex facility, and the time spent on-site collecting data was inadequate to support the development of end-use models.

Impact Results

	KW	KWh	Therm
PA Calculations	110.3	826,210	N/A
Adjusted Engineering	Inconclusive	Inconclusive	N/A
Engineering Realization Rate	N/A	N/A	N/A

Economic Information

Description	Date	Project Cost	Estimated Demand Savings, kW	Estimated Energy Savings, kWh	Estimated Gas Savings, therms	Estimated Annual Cost Savings ($0.13/kWh), $	SPC Incentive, $	Simple Payback w/ incentive, yrs	Simple Payback w/o incentive, yrs
Application Submitted Amount	7/3/2002	$129,500	109.4	826,069	0	$107,389	$46,322.78	0.77	1.21
Application Approved Amount	7/5/2002	$129,500	110.3	826,210	0	$107,407	$46,162.58	0.78	1.21
Installation Approved Amount	4/11/2003	$129,500	110.3	826,210	0	$107,407	$46,162.58	0.78	1.21
SPC Program Review	1/12/2004	$129,500	110.3	826,210	0	$107,407	$46,162.58	0.78	1.21

SITE 29 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL   TIER: 3   END USE: LIGHTING

Measure	Lighting Efficiency
Site Description	Aerospace Assembly & Testing

Measure Description

Interior lighting efficiency retrofit.

Summary of Ex Ante Impact Calculations

Simple pre and post-retrofit algorithm using fixture connected loads and hours of operation.

Comments on Ex Ante Calculations

The ex-ante savings were determined by performing a pre and post retrofit lighting fixture inventory and calculating the lighting power based on fixture watts published in the SPC Lighting Wattage Tables.

The customer estimated that interior lighting operates 3,000 hours annually before and after the retrofit. The installation reviewer revised this estimate to be 3,744 hours for most fixtures.

The application details provided by the customer document 520 three lamp T-12 lighting fixtures and 108 four lamp T-12 lighting fixtures being converted to 240 two lamp T-8 lighting fixtures and 378 three lamp T-8 lighting fixtures. Apparently implying that 10 fixtures were removed during the retrofit. The reviewer performed a detailed lighting fixture count inventory. The installation report verified the fixture counts and noted that there were some discrepancies concerning the number of lamps installed in some of the retrofit fixtures.

All lights are manually controlled by wall switches. No occupancy sensors were installed.

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation, conducting an on-site survey, interview with facilities personnel, and estimating the lighting retrofit savings.

Evaluation for the lighting retrofit included a spot check of the fixture counts, lamp type and number of lamps. Pre and post retrofit operating hours for lighting were reviewed with the facility representative.

Pre and post retrofit calculations of lighting loads and energy use were performed using the following formula.

kW = Fixture Watts/1,000 w/kW x Fixture quantity
kWh = kW x Operating hours

The interior space affected by the retrofit has a test and assembly area, open offices, private offices, hallways, conference rooms and reception area. All lights are manually controlled by light switches. According to documentation provided by the customer, lighting operates 12 hours daily, Monday-Friday, 50 weeks per year (3,000 hours annually). The customer does not differentiate between space usage when estimating lighting hours of operation. For instance, a conference room will likely have fewer hours of lighting operation than an open office area. The reviewer revised the annual hours of operation to 3,744 for most areas. While we suspect the reviewer's estimate of lighting hours of operation is higher than actual hours, we have no better information and accept the estimate used in the ex ante calculations.

We spot verified fixture counts in some areas of the facility and found that they agreed with the fixture counts shown in the ex ante calculations. Table 1 is a summary of the impact evaluation lighting efficiency savings.

Table 1 Impact Evaluation Savings Summary

Measure	Total kW	Annual kWh
Interior Lighting Efficiency	34	127,721
Total	34	127,721

Scope of Impact Assessment

The impact assessment scope is for the lighting efficiency retrofit. The application also documents the installation of new rooftop air conditioning units that are not evaluated in this report.

Additional Notes

The level of M&V employed at this site is adequate considering the amount of the incentive for this project. The scope of the project submitted in the application was greater than what was completed. The project size was reduced because the customer's management reduced funding for the proposed measures. Measures such as lighting controls were not installed and the scope of the lighting efficiency retrofit was reduced.

The incentive was further reduced by the reviewer because when the project scope was reduced, the lighting efficiency savings exceeded 80% of the total project savings. The SPC program requires that a minimum of 20% of the kWh savings be from measures other than lighting efficiency.

Economic Information

An economic summary for all measures included in the application is shown in Table 2 below. A cost for the installed project was not provided.

Table 2 Economic Summary of the Project

Description	Date	Project Cost	Estimated Demand Savings, kW	Estimated Energy Savings, kWh	Estimated Gas Savings, therms	Estimated Annual Cost Savings ($0.13/kWh) $	SPC Incentive, $	Simple Payback w/ incentive, yrs	Simple Payback w/o incentive, yrs
Application Submitted Amount	7/12/2002	$221,700	10	283,904	0	$36,908	$15,464	5.59	6.01
Application Approved Amount	8/19/2002	$221,700	39	289,258	0	$37,604	$15,731	5.48	5.90
Installation Approved Amount	9/30/2003	NA	34	127,721	0	$16,604	$4,792	NA	NA
SPC Program Review	9/17/2004	NA	34	127,721	0	$16,604	$4,792	NA	NA

Notes:
1. Installed project scope reduced. No project cost update was provided.

Impact Results

Table 3 Realization Rate Calculation

	kW	kWh	Therm
Installation Report	34	127,721	0
Adjusted Engineering	34	127,721	0
Engineering Realization Rate	1.0	1.0	NA

SITE 30 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER: 1 END USE: HVAC

Measure	System Improvements
Site Description	Agricultural Refrigerated Warehouses

Measure Description

- Remove Engine Room 2 serving cooling load in Building 2.
- Re-pipe Engine Room 1 to serve the cooling load in Building 2.
- Replace the electric defrost system in Building 2 with hot gas defrost.
- Install desiccant dehumidifier systems.

The compressors in building 1 are too large for the existing load and are only running 25% loaded. If additional load from building 2 is added to compressors in building 1 they would run at 60% loaded, thus increasing efficiency. Once this is done the 2 compressors and 2 condensers in building 2 can be disconnected and removed.
There are two elements to the savings at this site;

1. Removal of 2 compressors and 2 condensers from building 2.
2. Addition of building 2 load on building 1 compressors. This will allow the compressors to operate at a higher efficiency.

The replacement of electric dehumidifier system with a gas source dehumidifier was deemed to be fuel switching and was disallowed.

Summary of Ex Ante Impact Calculations

Estimated average reduction in demand and 8,000 hours of operation per year were used to generate savings estimates. The original assumptions were refined after request for clarification from the utility. The re-submitted calculations were again found by the utility to be insufficient. The facility engineer agreed to provide readings from existing electric meters on Buildings 1 and 2 in support of baseline estimates. Readings from the same power meters, taken after the retrofit, were compared with the baseline to estimate impacts.

Comments on Ex Ante Calculations

Pre-retrofit consumption data for Building 2 covered a period of 271 days, from 09/27/01 to 06/25/02. Pre-retrofit data for Building 1 covered only a period of 11 days, from 03/14/02 to 03/25/02. The average demand was 1,068 kW for Buildings 1 and 2 combined.
The PIR-based utility calculations showed a post retrofit demand reduction of 345.2 kW, amounting to 2,761,327 kWh per year in impacts. While the final incentive was paid on this kWh amount, the PIR-approved ex-ante estimate is 403 kW. This apparent contradiction goes unexplained in the application review and incentive processing records.

Evaluation Process

The Evaluation process consisted of a review of the SPC application form and supporting documentation, an on-site visit, and engineering analysis to verify impact calculations. The engineering analysis was based on data provided by the site engineer.

The on-site survey was conducted on November 14, 2003. Information on the retrofit equipment and operating conditions was collected during a walk through the warehouse and an interview with the Plant Engineer.

The removal of equipment from Engine Room 2 and re-piping of the refrigeration system to Engine Room 1 were physically verified.

The customer sent electronic files of the recorded consumption data, as detailed in the Calculation Procedure below. From these data, average demand savings were determined to be 236 kW, as compared to the PIR estimate of 404 kW. Using the initial assumption of 8,000 hours of annual operation, the measure produces 1,889,360 kWh annual savings.

Additional Notes

The Evaluation process consisted of a review of the SPC application form and supporting documentation, an on-site visit, and engineering analysis to verify impact calculations. The engineering analysis was based on data provided by the site engineer.

The on-site survey was conducted on November 14, 2003. Information on the retrofit equipment and operating conditions was collected during a walk through the warehouse and an interview with the Plant Engineer.

The removal of equipment from Engine Room 2 and re-piping of the refrigeration system to Engine Room 1 were physically verified.

The customer sent electronic files of the recorded consumption data, as detailed in the Calculation Procedure below. From these data, average demand savings were determined to be 236 kW, as compared to the PIR estimate of 404 kW. Using the initial assumption of 8,000 hours of annual operation, the measure produces 1,889,360 kWh annual savings.

Impact Results

	Average annual KW	KWh	Therm
SPC Calculations	403.7	2,761,327	NA
Adjusted Engineering	236	1,889,360	NA
Engineering Realization Rate	0.58	0.68	NA

Economic Information

Description	Date	Project Cost	Estimated Demand Savings, kW	Estimated Energy Savings, kWh	Estimated Gas Savings, therms	Estimated Annual Cost Savings ($0.13/kWh), $	SPC Incentive, $	Simple Payback w/ incentive, yrs	Simple Payback w/o incentive, yrs
Application Submitted Amount	4/18/2002	$750,000	940	3,715,277	0	$482,986	$520,138.00	0.48	1.55
Application Approved Amount	8/13/2002	$795,000	403.7	3,229,741	0	$419,866	$300,000.00	1.18	1.89
Installation Approved Amount	6/25/2003	$795,000	403.7	2,761,327	0	$358,973	$300,000.00	1.38	2.21
SPC Program Review	5/10/2003	$795,000	236	1,889,360	0	$245,617	$300,000.00	2.02	3.24

Calculations

Evaluation Report

Pre-Retrofit Bldg 1 & 2 Metering Data

$(\text{Bldg. 2 kW})_{pre}$ from Customer's metered data

From	To	Hours	kWh	kW
9/27/01	3/19/02	4,145	2,283,240	551
3/19/02	6/21/02	2,271	1,225,420	540
6/21/02	6/25/02	92	50,790	553
Hourly weighted avg. of 3 readings =				**547**

$(\text{Bldg. 1 kW})_{pre}$ from Customer's metered data

From	To	Hours	kWh	kW
3/14/02	3/15/02	24	14,640	604
3/15/02	3/16/02	24	11,690	482
3/16/02	3/18/02	50	23,410	465
3/18/02	3/19/02	21	12,010	574
3/19/02	3/23/02	93	48,880	525
3/23/02	3/25/02	48	22,430	472
Hourly weighted avg. of 6 readings =				**511**

Post-Retrofit Bldg 1 & 2 Metering Data

$(\text{Bldg. 2 kW})_{post}$ from Customer's metered data

From	To	Hours	kWh	kW
5/3/03	5/9/03	143	21,000	147
5/9/03	5/11/03	58	5,883	101
5/11/03	5/13/03	41	5,707	138
5/13/03	5/19/03	139	18,340	132
5/19/03	5/20/03	24	3,180	132
5/20/03	5/23/03	82	10,843	132
5/23/03	5/27/03	87	10,292	118
5/27/03	6/2/03	145	20,005	138
6/2/03	6/27/03	602	90,567	150
Hourly weighted avg. of 9 readings =				**141**

$(\text{Bldg. 1 kW})_{post}$ from Customer's metered data

From	To	Hours	kWh	kW
5/3/03	5/9/03	143	107,070	749
5/9/03	5/11/03	58	22,840	391
5/11/03	5/13/03	41	31,120	752
5/13/03	5/19/03	139	90,590	653
5/19/03	5/20/03	24	15,350	634
5/20/03	5/23/03	82	51,670	628
5/23/03	5/27/03	87	48,610	558
5/27/03	6/2/03	146	117,250	804
6/2/03	6/27/03	602	416,490	692
Hourly weighted avg. of 9 readings =				**681**

Actual Savings = $\{(\text{Bldg 2 kW + Bldg 1 kW})_{pre} - (\text{Bldg 2 kW + Bldg 1 kW})_{post}\}$*8000 hrs

	kW	hrs/yr	kWh	
$(\text{Max Bldg 2 kW + Max Bldg 1 kW})_{before}$ =	1058	8000	8,463,382	Baseline Usage
$(\text{Max Bldg 2 kW + Max Bldg 1 kW})_{after}$ =	822	8000	6,574,022	Post Retrofit Usage
Demand Reduction =	**236**		**1,889,360**	**Savings**

SITE 31 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER: 1 END USE: HVAC

Measure	System Improvements
Site Description	Agricultural Refrigerated Warehouses

Measure Description

A summary of the pre-retrofit operation was provided by the customer: Engine room K supplied refrigeration to cold room C-4 and Building K. The refrigeration load in Building K is much less than the load in Building C. Cold Room C-4 is 400 feet from Engine Room K. The refrigeration piping between cold room C-4 and engine room K was undersized, creating a calculated 9.7 psi pressure drop and causing both compressors in engine room K to run 98% loaded.

Engine Room D had no compressor or condenser controls which caused the compressors to run unloaded and unmatched to loads. The lack of condenser control was causing higher head pressures, creating efficiency losses. All the piping was undersized creating high-pressure drops across the suction, discharge and pumped liquid lines. This was causing engine room to run at lower suction temperature, which created artificial loads.

To following 4 measures were installed to address the inefficiencies of the pre-retrofit operation

M1-Remove Engine Room K, re-pipe Engine Room D to serve the refrigeration and cooling load in Rooms K & C4
M2-Re-pipe Rooms C 1, 2 & 3 previously served by Engine Room D, as well as Rooms C4 and K (previously served by Engine Room K), to correctly load compressors and reduce pressure drop;
M3-Install condenser piping & controls;
M4-Install compressor controls.

Summary of Ex Ante Impact Calculations

Estimated average reduction in demand and 8,000 hours of operation per year were used to generate savings figures. The original assumptions were refined after request for clarification from the utility. The re-submitted calculations were again found by the utility to be insufficient. The facility engineer agreed to place power loggers in Buildings D and K in support of baseline estimates. Post retrofit data were also collected using the same power loggers. Comments in the PIR indicate that pre- retrofit logger data (average hourly demand kW) was averaged and multiplied by 8,000 hours to estimate annual energy usage (kWh). The same procedure was used for the post retrofit logger data. The post-retrofit result was then subtracted from pre-retrofit result to estimate annual kW and kWh savings.

Comments on Ex Ante Calculations

The pre-retrofit consumption was logged in August 2002, for 2 days for Building D and 2 weeks for Building K. Average demand was calculated for both buildings and multiplied by 8,000 hours to estimate annual baseline consumption.

Post-retrofit consumption was logged for 7 weeks in March through May 2003. The average demand for Buildings D and K was multiplied by 8,000 hours of operation to generate post-retrofit estimates. Savings estimates were calculated by subtracting the post-retrofit usage from the pre-retrofit usage.

The SPC application and PIR do not document the source of the assumed 8,000 hours of operation. The average pre- and post-retrofit kW estimates were calculated as averages of the logger readings.

The PIR calculations showed an energy savings estimate of 5,529,659 kWh which corresponds to an average demand of 691 kW for 8,000 operation hours. For an unknown reason, the project application estimate of 436 kW was approved.

Evaluation Process

The Evaluation process consisted of a review of the SPC application and supporting documentation, an on-site visit, and engineering analysis to verify impact calculations. The engineering analysis was based on data provided by the site engineer.

The on-site visit was conducted on November 14, 2003. Information on the retrofit equipment and operating conditions was collected during a walk through in the warehouse and an interview with the Plant Engineer.

The removal of equipment from Room K and re-piping of loads to Room D were physically verified.

Logger data was received in electronic format for Building D for the pre- and post-retrofit periods. A printout of the pre-retrofit data for building K was attached with the application, but no post retrofit data was provided for Building K. The information submitted did not include original calculation files.

The raw pre- and post-retrofit logger data were used in a bin method to estimate annual energy usage as follows (refer to the Calculation Procedure below).

- Average annual weather data was obtained for the local area from the National Weather Service. The data was sorted in 10 F degree bins, and annual hours were generated for each bin.
- The logger data provided hourly energy measurements (kWh) and were assumed to be representative of average demand kW. The hourly data was paired with hourly weather data for the local area obtained from the National Weather Service and placed in 10 degree F temperature bins
- Regressions were generated correlating weather data and hourly energy use. Using this analysis, average demand kW was extrapolated into the temperature bins for which no logger data was available.
- The resulting demand kW estimates were weighted by the hours in their respective temperature bins and used to estimate average annual demand.
- The average annual demand was multiplied by 8,000 hours of operation to calculate annual energy consumption.

- Pre- and post-retrofit data were calculated and subtracted to estimate savings.

Based on this method of analysis, the engineering estimate of energy savings is 5,403,227 kWh, leading to a realization rate of 0.98.

We have several reservations concerning the quality of the data and the magnitude of the savings calculated by this method.

- In the pre-retrofit situation, building D provides refrigeration and cooling to buildings C1, C2 and C3, while building K provides refrigeration and cooling to buildings C4 and K; the average annual demand for buildings D and K combined is 833 kW.
- In the post-retrofit situation, building D provides cooling to buildings C1, C2, C3, C4 and K; the average annual demand for buildings D and K combined is 158 kW, which is in the same order of magnitude of the pre-retrofit average annual demand of building K only.
- The de-commissioning of two compressors and auxiliaries in building K and the re-routing of loads to building D, along with the re-piping of all buildings are expected to provide savings by generating a more adequate loading of the compressors in building D. However, the raw logger data show that, while before the retrofit all four compressors in building D were loaded, after the retrofit only one is loaded and Building D kW demand has actually decreased by nearly 600 kW (83%)

After discussing the possibility of using billing analysis with the plant engineer we were advised that they do not have electric meters on individual buildings. The meter is for a whole site which has multiple buildings with various processing equipment. The plant engineer did not have a clear idea of what the operating schedule of all equipment might be. For these reasons, we abandoned using utility bill analysis for this project.

Production data was also requested to normalize the load but was not provided.

Additional Notes

A site with the potential magnitude for energy savings shown in this application should have mandatory pre- and post-retrofit monitoring. The monitoring should be conducted either in periods with similar weather patterns, or for extended periods of time, and correlated with production data to generate a good basis for annualized energy usage estimates.

For this site, only two days of pre-retrofit data were recorded for Building D (10 days for building K), in August 2002. The post retrofit data were collected over a relatively longer period of time; however, the period spans March through May 2003, which is relatively mild compared to August 2002. More time and funding should have been dedicated to record the pre- and post-retrofit consumption under similar ambient conditions. We estimate that an additional 64 hours of engineering time plus the cost of logging equipment rental would be required to perform pre and post retrofit measurement and verification for this project.

We have serious reservations about the energy savings analysis for this project due to significant discrepancies in the pre and post retrofit data provided by the customer. Additionally several irregularities were identified that would need to be resolved before a high level of confidence could be placed on the energy savings associated with this project. Because of these anomalies and concerns, we have set the adjusted engineering kW and kWh to realization rates to NA.

Impact Results

	Average annual KW	KWh	Therm
SPC Application Calculations	436	5,529,659	NA
Adjusted Engineering	N/A	N/A	NA
Engineering Realization Rate	N/A	N/A	NA

Economic Information:

Description	Date	Project Cost	Estimated Demand Savings, kW	Estimated Energy Savings, kWh	Estimated Gas Savings, therms	Estimated Annual Cost Savings ($0.13/kWh), $	SPC Incentive, $	Simple Payback w/ incentive, yrs	Simple Payback w/o incentive, yrs
Application Submitted Amount	4/8/2002	$793,000	353	3,093,667	0	$402,177	$433,111.00	0.89	1.97
Application Approved Amount	6/18/2002	$793,000	436	3,491,085	0	$453,841	$300,000.00	1.09	1.75
Installation Approved Amount	6/25/2003	$793,000	436	5,529,659	0	$718,856	$300,000.00	0.69	1.10
SPC Program Review	5/10/2004	$793,000	675	5,403,227	0	$702,419	$300,000.00	0.70	1.13

Calculation Procedure

Evaluation Report

Raw data summary:

Temperature Bin (F)	Building "D" Baseline		Building "K" Baseline		Building "D" Post-Retrofit	
	N Hours	Average kW	N Hours	Average kW	N Hours	Average kW
20 to 30						
30 to 40						
40 to 50					161	96
50 to 60					472	108
60 to 70	10	709	24	120	323	117
70 to 80	21	723	101	124	101	126
80 to 90	19	717	108	139	21	128
90 to 100			81	145		
100 to 110			23	147		

Annualized data summary: (normalized for weather)

Temperature Bin (F)	N Hours by bin for Bakersfield	Average kW			
		Building "D" Baseline	Building "K" Baseline	Building "D" Post-Retrofit	Building "K" Post-Retrofit*
20 to 30	11	696	90	82	
30 to 40	393	700	97	90	
40 to 50	1,205	704	105	99	
50 to 60	1,965	708	112	107	
60 to 70	1,743	712	120	115	
70 to 80	1,590	717	127	123	
80 to 90	1,147	721	135	132	
90 to 100	609	725	142	140	
100 to 110	97	729	150	148	
Annual	8,760	713	120	116	42

* Post-retrofit data for Building K was not provided. This value for annual average kW was back calculated from the PIR results.

Actual Savings = {(Bldg D kW + Bldg K kW)$_{before}$ - (Bldg D kW + Bldg K kW)$_{after}$}*8,000 hrs

	kW	hrs/yr	kWh	
(Bldg D kW + Bldg K kW)$_{before}$ =	833	8,000	6,664,581	Baseline
(Bldg D kW + Bldg K kW)$_{after}$ =	158	8,000	1,261,354	Post Retrofit
Energy Savings =	**675**		**5,403,227**	**Savings**

SITE 32 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL   TIER: 1   END USE: HVAC

Measure	Lighting and Refrigeration Controls
Site Description	Grocery

Measure Description

Install lighting and refrigeration controls at 10 stores. Lighting controls are designed to reduce light levels in a typical facility to 50% during the hours of noon to 6 p.m. and during pre opening hours. In facilities with skylights, the controls will be connected to light sensors, and are controlled based on light levels.

Refrigeration case anti-sweat devices will be controlled based on dewpoint sensors.

Summary of Ex Ante Impact Calculations

Engineering calculations were used to estimate savings for both measures. For lighting, the load is based on a fixture count multiplied by the fixture wattage taken from the SPC standard fixture wattages. Savings are based on reducing the number of operating fixtures by 50% for six hours per day.

KWh Saved = # Fixtures X 50% X 6 Hrs X 0.102 kW/Fixture X 364 days/yr

For refrigeration the load is calculated based on the number of refrigeration cases multiplied by the nameplate amperage of the antisweat device. Energy savings are based on assuming that the anti-sweat devices will be shut off 50% of the time.

KWh Saved = # of Refer Cases X 8760 hrs/Yr X 50% X Refer Case Amperage X Volts

Post installation inspection included the measurement of antisweat device amperage and found consistency between the submittals and the actual measurements. Post installation inspections also found reasonable consistency in light fixture counts and refrigeration case counts.

Comments on Ex Ante Calculations

The ex ante calculations were based on solid engineering practices for the end uses being considered. The lighting loads are based on the SPC lighting tables, and the refrigeration case loads were based on nameplate values and validated through on-site measurements. The quantity of light fixtures and refrigeration cases were based on counts provided by the customer, and validated by pre-field and post installation site visits, and were consistent with on-site counts for this analysis. The site visits also validated that light levels were at 50% at both facilities.

The weakness of the calculation methods is that the savings are based on estimated reductions in operating hours resulting from the installation of control systems.

For the refrigeration cases, the 50% reduction in operating hours is assumed to result from controls that will shut off the anti sweat heaters based on the measurement of dewpoint inside the store. [The measurement of actual reductions of operating hours would be quite time consuming and is beyond the scope of this study, so additional savings validations were not completed.]

For the Lighting System, the savings calculations are based on reducing the number of fixtures that operate by 50% between the hours of noon to 6:00 p.m. The reduction in operating hours is programmed at the corporate level, and is the same for all stores with the new control system.

The actual control sequence, validated by the site visit, is to eliminate the operation of 50% of the fixtures from 8:30 a.m. to 5:00 p.m., which is 2.5 hours per day more than the estimate used in the ex ante calculations, but does not span PG&E's entire "Peak" range as was originally specified. Although no demand savings were allowed in the ex ante calculations, the controls-based lighting use reduction from noon to 5 pm provides demand savings, on average for the on-peak period.

Evaluation Process

The site visits had the following objectives:

- Validate light fixture counts
- Validate 50% light fixture operation
- Validate the lighting control program sequence of operation.

Site visits were completed for two of the ten sites in which the retrofits were completed. Neither of the sites had skylights. Site visits were completed during the hours that 50% of the light fixtures were scheduled to be off.

Fixture counts erred from the Installation Report Inspection by ~ 2%. Fifty percent of all fixtures in both stores were off. The actual control operating range for light reductions was from 8:30 a.m. to 5:00 p.m., which is 42% greater than the noon to 6:00 p.m. range specified in the rebate application or the Installation Report.

KW Saved = # Fixtures X 50% X (5/6 Hrs) X 0.102 kW/Fixture
KWh Saved = # Fixtures X 50% X 8.5 Hrs X 0.102 kW/Fixture X 364 days/yr

The increased operating hours results in energy savings 42% greater than ex ante calculations.

Scope of Impact Assessment

This assessment focused on the lighting portion of the SPC application. The anti-sweat heaters were not evaluated further due to the long term monitoring that would be required.

The evaluation resources applied to this project were appropriate, given the relatively straight-forward estimation approach applied for the lighting end-use and the ability to sample from completed installations.

Estimation of the anti-sweat heaters would have necessitated metering, requiring an additional 20 hours of work.

Economic Information

The following economic summary evaluates only the lighting portion of this project. Project costs are based on a proportion of the installation of 10 sites compared to the estimated cost for 20 sites that was on the original application, assuming that the cost per facility is relatively consistent.

File Financial Value	Date	Project Cost	Estimated Customer Annual Savings	Estimated Customer kW Saved	Estimated Customer Annual $ Saved @ $0.13 / kWh	Incentive	Payback w/o incentive	Payback w/ incentive
SPC Application Estimate	5/20/2002	$207,000	1,115,663	88	$145,036	$55,783	1.43	1.04
SPC Installation Report	12/11/2003	$103,500	566,820	-	$ 73,687	$28,341	1.40	1.02
NSPC Program Submittal Review	7/8/2004	$103,500	802,995	-	$104,389	$40,150	0.99	0.61

Impact Results

10 Facilities
LIGHTING ONLY

	KW	KWh	Therm
SPC Tracking System or Application	-	566,820	
Adjusted Engineering	215.7	802,995	
Engineering Realization Rate	Not Applicable	1.42	

SITE 33 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER: 2 END USE: HVAC

Measure	Install HVAC EMS
Site Description	Commercial Office

Measure Description

Two applications were submitted for the replacement of pneumatic Variable Air Volume (VAV) boxes and controllers with new Direct Digital Control (DDC) VAV boxes and controls.

Summary of Ex Ante Impact Calculations

The customer used the fan affinity laws to estimate savings. The affinity laws state that horsepower is proportional to the cube of the ratio of the volume of air flow. The customer used the formula:

Hp2 = Hp1 (CFM2/CFM1)^3

Horsepower was converted to kW using the formula:

KW = Hp X 0.746

Savings are based on reducing flow from an estimated average of 70% during normal business hours to 25% during “low occupancy hours.”

KW before = 40.1 kW

KW after = 1.9 kW

Low occupancy are the hours between 10 p.m. and 6 a.m. on weekdays, and all hours on the weekends. Low occupancy hours equals:

Hours = ((8 hrs/day X 5 days/wk) + (24 hrs/day X 2 days/wk)) X 52 wks/yr

Hours = 4,576 low occupancy hours

Energy savings = (kW before – kW after) X Hours

Energy savings = (40.1 – 1.9) kW X 4,576 Hours = 178, 809 kWh

Comments on Ex Ante Calculations

The ex ante calculations were based on an incorrect premise. Ex ante calculations assumed that the installation of DDC controlled VAV boxes would result in low occupancy flow changing from 70% of full load to 25% of full load, resulting in a significant kW reduction.

However, the facility already has pneumatically controlled VAV boxes, fan VFDs, and controllers. DDC controllers are only nominally more efficient than pneumatic controllers. Therefore the pre and post retrofit kW during low occupancy hours will be nearly the same. The ex ante calculations assumed that normal occupancy resulted in an average flow rate of 70%, and that the flow rate during low occupancy could be reduced to 25% with the retrofit. Since pneumatic controllers already existed we can assume that the low occupancy flow rate of 25% has already been achieved prior to the retrofit. The site contact verified the assumed low occupancy flow rate of 25%.

For the ex post calculations we have assumed a pre-retrofit low occupancy flow rate 25%. In addition, we have used an affinity exponent that is less than the cube to account for inherent inefficiencies in VFDs and control systems. We also accounted for the fan motor’s efficiency.

The following table summarizes the ex ante pre retrofit conditions as compared to the ex post pre retrofit conditions.

Table 1
Pre-Retrofit Conditions

	Ex ante	Ex post
# of Air Handlers	4	4
AH Hp	40	40
% Load	70%	25%
Assumed Affinity Exponent	3	2.5
Low Occupancy HP	54.9	5.0
Estimated Hp Eff	100%	93%
Low Occupancy kW	40.9	4.0
Night kWh used	187,344	18,353

The pre retrofit fan energy use during low occupancy hours appears to be overestimated by a factor of 10.

The retrofit does result in some energy savings as a result of the installation of the DDC controls and new thermostats that result in operational changes. With the new controls, the fans can be shut off during the majority of low occupancy hours. Therefore, instead of operating at 25% flow, the fans are off. The site contact acknowledged that the savings resulted from the ability to shut the fans off.

Fan operation data was obtained for one “typical” month showing that fans are off 45% of the times, which equates to 3,950 hours per year.

The following table summarizes the post retrofit conditions for the ex ante and ex post calculations.

Table 2 shows that energy savings based on the ex ante premise of reduced air flow overestimates energy savings by a factor of 11.

Table 2
Post-Retrofit Conditions

	Ex ante	Ex post
Estimated Post Retro Fan Load	25%	25%
Assumed Affinity Exponent	3.0	2.5
Post Retro Hp	2.50	5.00
Post Retro kW	1.87	4.01
Low Occupancy hours	4,576	4,576
Hours fan is off	-	3,950
New unoccupied operating hours	4,576	626
Post Retrofit Energy Use - kWh	8,534	2,510
Estimated kW Saved	39.08	-
Estimated kWh Saved	178,809	15,843

Evaluation Process

Both facilities were surveyed for a greater understanding of the before and after operating characteristics, and to validate the size and efficiency of the equipment being controlled. Both facilities utilize packaged Heating, Ventilation, and Air Conditioning systems. The units include Variable Frequency Drives (VFDs) on the fan drive motors.

The retrofit was the replacement of existing VAV boxes with new VAV boxes, replace the existing pneumatic controls with new DDC controls, and the installation of new thermostats. The majority of the effort was focused on understanding the actual before and after operating characteristics.

When the pneumatic controls were in place, the facility temperature for all Zones was 72 °F. As a result, the fans were required to operate 24 hours per day to ensure that the space temperatures were maintained. Due to the reduced load on the facility during low occupancy hours, the fans were able to operate at a reduced flow.

The installation of the DDC controls has allowed the temperature of each zone to be set individually, and to allow for increased temperature rise in many zones during the low occupancy hours. This has allowed the Owner to shut the fans off during low occupancy until the temperature rise in a specific zone demands that the fans operate to provide cooling.

DDC controlled VFDs are not significantly more efficient than pneumatically controlled VFDs. Therefore it can be assumed that the minimum flow during low occupancy hours is the same for the before and after conditions. The pre retrofit calculations have assumed that the minimum air flow was 25% of the full load air flow during low occupancy, and it is therefore assumed to be 25% for the post retrofit conditions.

Herein we used the formulae:

Hp2 = # of Units X Hp1 X (CFM2/CFM1)^$^{\text{(affinity exponent)}}$

KW = Hp X 0.746 / Efficiency

In the ex post calculations we have assumed that the affinity exponent is the cube only in a theoretical "ideal condition". In this calculation we have assumed that the affinity exponent is 2.5 to allow for inherent inefficiencies in the VFDs and control systems. We have also accounted for the efficiency of the fan motors. For one facility, the ex post calculations are as follows:

$Hp2 = 4 \text{ Units} \times 40 \text{ hp } (0.25)^{2.5} = 5.0 \text{ Hp}$

$KW2 = 5 \text{ Hp} \times 0.746 / 0.93 = 4.01 \text{ kW}$

In both the before and after retrofit conditions the low occupancy flow is 25% of full load, therefore there is no reduction of low occupancy load.

The energy savings don't result from a reduction in air flow, but from the ability to shut the fans off completely during the low occupancy hours.

We were able to obtain some trending data from the Owner for one buildings operation during the month of July. The fans were off for an average 45.1% of the year. Assuming that all of the months operate similarly, the new low occupancy hours are:

Hours = 45.1% X 8,760 = 3,950 hours

Energy Savings = 4.01 kW X 3,950 hours = 15,843 kWh

Scope of Impact Assessment

Each facility SPC application was for one energy efficiency measure: the retrofit of pneumatic VAV boxes and controllers with DDC VAV boxes and controllers. Both facilities were surveyed in this evaluation.

The time allotted for this analysis was sufficient to adequately understand the facility's operation, evaluate the energy savings, and complete the results summary.

Economic Information

The following table summarizes the ex ante and ex post economics of the project.

File Financial Value	Date	Project Cost	Estimated Customer Annual Savings	Estimated Peak kW Saved	Estimated Customer Annual $ Saved @ $0.13 / kWh	Incentive	Payback w/o incentive	Payback w/ incentive
SPC Application Estimate	4/9/2002	$360,000	292,801	0	$38,064	$40,992	9.5	8.4
SPC Installation Report	12/8/2003	$360,000	292,801	0	$38,064	$23,424	9.5	8.8
NSPC Program Submittal Review	8/24/2004	$360,000	15,843	-	$2,060	$1,267	174.8	174.2

Impact Results

	KW	KWh	Therm
SPC Tracking System or Application	0.0	292,801	
Adjusted Engineering	0.0	15,843	
Engineering Realization Rate	1.00	0.05	

SITE 34 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER: 2 END USE: HVAC

Measure	Refrigeration Controls
Site Description	Refrigerated Warehouse

Measure Description

Installation of a Logix refrigeration control system.

Summary of Ex Ante Impact Calculations

Calculation based on estimated savings from previous projects of a similar nature performed by the parent company.

Comments on Ex Ante Calculations

Ex ante calculation assumed 7% reduction in run time due to optimal sequencing of compressors. Also assumes 9% efficiency improvement due to running compressors at full load instead of part load. Assumes reduction in fan speed of 28% for condensers. Assumes 10% reduction in evaporator fan usage due to cycling, and 3.2% reduction in compressor use due to improved defrost controls.

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation, conducting an on-site survey and then computing impacts using the on-site data.

The on-site survey was conducted on October 30, 2003. Information on the retrofit equipment and operating conditions was collected through an inspection of the compressors, fans, and controls, and through an interview with the Plant Maintenance Manager.

This site is a refrigerated warehouse handling grocery items for independent grocers. The warehouse is divided into four rooms: a meat freezer, a meat deli, the west freezer, and the east freezer. There is also a refrigerated dock area where trucks load and unload shipments. Refrigeration for each room is provided by a group of compressors dedicated to that room. Controls are set to maintain temperatures based on the products stored in the room. Refrigeration for the meat dock area is provided by the meat freezer compressors. Refrigeration in the rest of the dock area is provided by the east freezer compressors.

On the day of the site visit, it was observed that all of the compressors on site, except one meat deli compressor were shut down. Facility staff explained that this was the common practice to avoid peak and mid-peak demand charges. Time of day schedules in the control system were reviewed to verify this. During summer peak periods, the controls are set to shut down the compressors from 11:00 am to 6:30 pm and lock out the defrost cycle at 10:00 am. During the winter mid-peak, the controls are set to shut down the compressors from 8:00 am to 6:00 pm and lock out the defrost cycle at 7:00 am. According to plant staff, this same schedule was employed manually before the installation of the Logix control system.

The controls were set to sequence the compressors so that no more than one compressor for each room runs at part load. This was not possible before the installation of the Logix system. Before the Logix system was installed, the compressors were started and stopped manually. Consequently, all of the compressors ran regardless of load.

Measurement of compressor motor amps was taken for the compressor that was running on the day of the site visit. It was found that this compressor was at 100% of full load. Motor operating hours were obtained for all compressors, fans and pumps from the Logix system for the 13 months since the system has been operational. Control system settings were verified for defrost control sequencing and evaporator fan cycling.

Defrost cycles are set up based on evaporator run time. In the Meat Deli section, hot gas defrost occurs after 12 hours of evaporator run time while in the meat and west freezer sections, hot gas defrost occurs after 8 hours of accumulated run time. The east freezer section is hot water defrost which also occurs after 8 hours of accumulated run time. In each room, the evaporators are grouped in 4 zones, and each zone is defrosted separately to avoid introducing excessive heat. Before the installation of the Logix controls, defrost cycles were controlled by mechanical timers. The Meat Deli evaporators were scheduled to defrost every 8 hours, and the freezer evaporators were defrosting every 4 hours.

The controls were set to cycle off each evaporator zone for 5 minutes each hour. This was not done before the installation of the Logix system.

The installation of VSD controls on condenser fan motors was verified. However it was noted that the fans were run at full speed to maximize the effect of floating head pressure control. Trends of fan speeds reviewed in the control system showed that the only time that the VSD was used to reduce fan speed was during defrost cycles. There are normally only one or two of these in a 24 hour period. These cycles last 20 minutes. During this time, the fans are shut off to hold the system at a minimum head pressure of 125 psig. The pre-retrofit fans ran at constant speed, 100% of the time.

Discussions with facility staff provided data for determining possible impacts due to control system synergies. No specific measures could be identified, however they did indicate plans to use the controls to create more, smaller defrost zones. This should save energy by reducing the instantaneous heat input to the space that must be removed by the compressors.

The ex ante analysis was adjusted for the verified operating schedule and actual mode of operation. To compute the impacts, the following assumptions were used:

- Pre-retrofit hours of operation and calculated kW demand for the compressors were as shown in the application unless told otherwise by plant staff.

- Measured post-retrofit hours of operation are as recorded by the plant control system.

- kW demand for the compressors are as shown in the application.

- Post-retrofit cooling tower fan speed is 100% except during defrost when it is 0%. This was used to adjust the ex ante calculation.

- Post-retrofit defrost settings and evaporator fan cycling frequencies were obtained from the control system. These actual values were used to adjust the ex ante calculation.

- Savings factors for improved compressor sequencing and floating head pressure control were assumed to be the same as ex ante values. Measurement of compressor kW was not possible because the compressors were not running during the site visit.

- No other specific energy conservation measures were identified. Therefore, control system synergy savings were determined to be 0 kWh per year.

Scope of Impact Assessment

This customer also received incentives for a lighting efficiency and control measure in another application.

Additional Notes

The level of M&V employed at this site is not sufficient to accurately determine the impacts of the improved compressor sequencing and floating head pressure control measures. Without post case measurement of compressor kW we must accept the vendor's estimates of savings.

To improve the overall level of confidence in these conclusions, measurement of actual post case motor loads would be necessary. Since time of day controls are set to avoid running the compressors during daytime peak and part peak pricing periods, monitoring would have to be done at night or on the week end. Spot kW readings for all compressors on the weekend would probably be enough to verify the impacts of this measure. Combined with continuous monitoring of one compressor in each room for a minimum one week period would provide even more confidence on what the true effects of these measures are. This would require additional budget of about 8 hours for this site to conduct the monitoring and analyze the results (assuming the customer would cooperate with week end work).

Economic Information

File Financial Values	Date	Project Cost	Estimated Customer Annual kWh Savings	Estimated Customer kW Savings	Estimated Customer Annual Therm Savings	Estimated Customer Annual $ Savings @ $0.13/kWh	Incentive	Payback w/o Incentive	Payback w/ Incentive
Application Estimate	4/1/2002	$ 247,755.00	1,334,761	0	0.0	$ 173,518.93	$106,780.88	1.4	0.8

Impact Results

	kW	kWh	Therm
SPC Tracking System or Application	0.000	1,334,761	0
Adjusted Engineering	0.000	1,061,811	0
Engineering Realization Rate	N/A	0.80	N/A

Measure	Ex Ante	Ex Post	Realization Rate
Evaporator Fan Cycling	260,228	203,513	0.78
Defrost Optimization	62,023	94,899	1.53
Condenser Fan VSD	111,948	14,812	0.13
Control Synergy	75,875	0	0.00
Improved Compressor Sequencing	375,589	340,931	0.91
Floating Head Control	449,097	407,656	0.91
Total Savings	1,334,761	1,061,811	0.80

Results

Evaporator Fan Cycling

Qty	Description	hp	Total hp	Eff	Total kW	Annual hrs	% Load	Baseline Annual kWh	Cycling Frequency Min	Cycling Duration Min	Post Case Annual kWh	Evaporator Fan Cycling Savings
18	Meat Freezer	3	54	0.89	45.3	5,489	0.95	236,026	60	5	206,523	29,503
24	Meat Deli	0.33	8	0.72	8.3	6,602	0.95	51,984	60	5	45,486	6,498
120	Meat Deli	0.50	60	0.67	66.8	6,602	0.95	418,979	60	5	366,607	52,372
20	East Compr Room	0.75	15	0.75	14.9	3,707	0.95	52,542	60	5	45,974	6,568
3	East Compr Room	0.33	1	0.72	1.0	4,389	0.95	4,320	60	5	3,780	540
8	East Compr Room	0.75	6	0.75	6.0	5,522	0.95	31,308	60	5	27,394	3,913
6	East Compr Room	1	6	0.82	5.5	5,576	0.95	28,913	60	5	25,299	3,614
24	East Compr Room	3	72	0.82	65.5	5,465	0.95	340,075	60	5	297,565	42,509
40	West Compr Room	0.75	30	0.75	29.8	5,587	0.95	158,386	60	5	138,588	19,798
6	West Compr Room	1	6	0.82	5.5	5,587	0.95	28,973	60	5	25,351	3,622
18	West Compr Room	3.00	54	0.82	49.1	5,587	0.95	260,758	60	5	228,163	32,595
4	West Compr Room	1	3	0.75	3.0	5,587	0.95	15,839	60	5	13,859	1,980
							Total	**1,628,103**			**1,424,590**	**203,513**

Where:

$$\text{Total hp} = \text{Qty} \times \text{hp}$$

$$\text{Total kW} = \text{Total hp} \times \frac{0.746\ \text{kW/hp}}{\text{Eff}}$$

$$\text{Annual kWh}_{\text{Baseline}} = \text{Total kW} \times \%\ \text{Load} \times \text{Annual hrs}$$

$$\text{Annual kWh}_{\text{Post Case}} = \text{Annual kWh}_{\text{Baseline}} \times \left[1 - \frac{\text{Cycling Duration}}{\text{Cycling Frequency}}\right] \times 1.5$$

$$\text{Evaporator Fan Cycling Savings} = \text{Annual kWh}_{\text{Baseline}} - \text{Annual kWh}_{\text{Post Case}}$$

Annual operating hours are from Logix run time trend logs. Cycle duration and cycle frequency are from settings in the Logix control system for fan cycling. Factor of 1.5 in post case kWh equation accounts for the refrigeration effect: For every 2-hp of fan power, the equivalent of 1-hp of compressor power must be used to remove the heat produced by the fan motor into the refrigerated space.

VSD Control of Condenser Fans

Location	Qty	hp	Total hp	Eff	Total kW	Post Case Annual hrs	Annual Defrost Hrs	Baseline Annual hrs	% Load	Baseline Annual kWh	VSD Eff	Post Case Annual kWh	Total Annual kWh Savings
Meat Freezer	2	10	20	0.93	16.0	5,806	177	5,983	0.70	67,191	0.98	66,535	656
Meat Deli	1	5	5	0.90	4.1	0	0	3,334	0.95	13,127	0.98	0	13,127
Meat Deli	1	40	40	0.94	31.7	8,177	177	8,354	0.95	251,937	0.98	251,636	301
East Freezer	2	7.5	15	0.91	12.3	5,877	177	6,054	0.50	37,223	0.98	36,873	350
East Freezer	2	7.5	15	0.91	12.3	5,653	177	5,830	0.50	35,846	0.98	35,468	378
									Total	405,324		390,512	14,812

Where:

$$\text{Total hp} = \text{Qty} \times \text{hp}$$

$$\text{Total kW} = \text{Total hp} \times \frac{0.746 \text{ kW/hp}}{\text{Eff}}$$

$$\text{Baseline Annual hrs} = \text{Post Case Annual hrs} + \text{Annual Defrost hrs}$$

$$\text{Annual kWh}_{\text{Baseline}} = \text{Total kW} \times \text{\% Load} \times \text{Baseline Annual hrs}$$

$$\text{Annual kWh}_{\text{Post Case}} = \frac{\text{Total kW} \times \text{\% Load} \times \text{Post Case Annual hrs}}{\text{VSD Eff}}$$

$$\text{Total Annual kWh Savings} = \text{Annual kWh}_{\text{Baseline}} - \text{Annual kWh}_{\text{Post Case}}$$

Baseline fans ran 100% speed, 100% of the time. Post case fans do not run during defrost cycles. Annual post case operating hours are from Logix run time trend logs. Annual defrost hours are the total defrost hours observed in the Logix control system for defrost scheduling.

Improved Sequencing, Floating Head Pressure Control, and Defrost Optimization

		Total		Total	Annual		Baseline	Improved Compressor Sequencing	Floating Head Control	Defrost Control	Total Annual Savings	Post Case
Qty	**Meat Freezer**	hp	Eff	kW	hrs	% Load	Annual kWh	0.07	0.09	40 min/day	kWh	Annual kWh
1	Screw Compressor	250	0.93	200.5	956	0.80	153,320	10,732	12,833	32,792	56,357	96,963
1	Screw Compressor	250	0.93	200.5	5,206	0.80	835,132	58,459	69,901	32,792	161,152	673,980
						Total	988,452	69,192	82,733	65,584	217,509	770,943

		Total		Total	Annual		Baseline	Improved Compressor Sequencing	Floating Head Control	Defrost Control	Total Annual Savings	Post Case
Qty	**Meat Deli**	hp	Eff	kW	hrs	% Load	Annual kWh	0.07	0.09	20 min/day	kWh	Annual kWh
1	Screw Compressor	300	0.95	235.6	2,777	0.80	523,453	36,642	43,813	19,261	99,716	423,738
1	Screw Compressor	150	0.91	123.0	6,492	0.80	638,599	44,702	53,451	10,054	108,206	530,392
						Total	1,162,052	81,344	97,264	29,315	207,922	954,130

		Total		Total	Annual		Baseline	Improved Compressor Sequencing	Floating Head Control	Defrost Control	Total Annual Savings	Post Case
Qty	**East Compr Room**	hp	Eff	kW	hrs	% Load	Annual kWh	0.07	0.09	30 min/day	kWh	Annual kWh
1	Screw Compressor	100	0.936	79.7	2,518	0.80	160,527	11,237	13,436		24,673	135,854
1	Screw Compressor	100	0.936	79.7	4,881	0.80	311,185	21,783	26,046		47,829	263,356
1	Screw Compressor	100	0.936	79.7	5,504	0.80	350,969	24,568	29,376		53,944	297,025
1	Screw Compressor	100	0.936	79.7	4,794	0.80	305,682	21,398	25,586		46,983	258,699
1	Recip Compressor	75	0.94	59.5	4,420	0.80	210,477	14,733	17,617		32,350	178,127
						Total	1,338,841	93,719	112,061	0	205,780	1,133,061

		Total		Total	Annual		Baseline	Improved Compressor Sequencing	Floating Head Control	Defrost Control	Total Annual Savings	Post Case
Qty	**West Compr Room**	hp	Eff	kW	hrs	% Load	Annual kWh	0.07	0.09	30 min/day	kWh	Annual kWh
1	Screw Compressor	100	0.93	80.2	4,942	0.80	317,163	22,201	26,547		48,748	268,415
1	Screw Compressor	100	0.93	80.2	5,649	0.80	362,533	25,377	30,344		55,721	306,812
1	Screw Compressor	100	0.93	80.2	5,747	0.80	368,811	25,817	30,869		56,686	312,125
1	Screw Compressor	75	0.94	59.5	2,847	0.80	135,554	9,489	11,346		20,835	114,719
1	Recip Compressor	75	0.94	59.5	4,138	0.80	197,041	13,793	16,492		30,285	166,756
						Total	1,381,102	96,677	115,598	0	212,275	1,168,827

Total	4,870,447	340,931	407,656	94,899	843,486	4,026,960

Where:

$$\text{Total kW} = \frac{\text{Total hp} \times 0.746\ \text{kW/hp}}{\text{Eff}}$$

$$\text{Annual kWh}_{\text{Baseline}} = \text{Total kW} \times \text{Annual Hours} \times \%\ \text{Load}$$

$$\text{Improved Compressor Sequencing} = \text{Annual kWh}_{\text{Baseline}} \times 0.07$$

$$\text{Floating Head Control} = \text{Annual kWh}_{\text{Baseline}} \times (1 - 0.07) \times 0.09$$

$$\text{Defrost Control}_{\text{Meat Freezer}} = \text{Annual kWh}_{\text{Baseline}} \times (1 - 0.07 - 0.09) \times \frac{40\ \text{min/day} \times 365\ \text{days/year}}{60\ \text{min/hour} \times \text{Annual Hours}}$$

$$\text{Defrost Control}_{\text{Meat Deli}} = \text{Annual kWh}_{\text{Baseline}} \times (1 - 0.07 - 0.09) \times \frac{20\ \text{min/day} \times 365\ \text{days/year}}{60\ \text{min/hour} \times \text{Annual Hours}}$$

$$\text{Total Annual Savings} = \text{Improved Compressor Sequencing} + \text{Floating Head Control} + \text{Defrost Control}$$

Annual operating hours are from Logix run time trend logs. % Load factors could not be confirmed since compressors were not running at the time of the site visit. Saving factor of 7% for improved compressor sequencing could not be confirmed since compressors were not running at the time of the site visit. Saving factor of 9% for floating head control could not be confirmed since compressors were not running at the time of the site visit. Defrost control savings of 40 min/day in the meat freezer based on reduction of an average of two 20-minute defrost cycles per day. Defrost control savings of 20 min/day in the Meat Deli cooler based on reduction of an average of one 20-minute defrost cycle per day.

SITE 35 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL   TIER: 2   END USE: HVAC

Measure	Consolidate all juice chilling onto chillers #4 and #5. Install (3) new high efficiency chillers and raise ammonia evaporation temperature. Install VFD's on condenser fan motors.
Site Description	Food Processing Facility

Measure Description

This site renovated its refrigeration system and combined three of the five existing circuits into a single "main" circuit to meet the refrigeration needs of the plant. In addition, the difference between the condensing and suction pressures on the compressors for the main refrigeration circuit was reduced. VFDs were added to the condenser fan motors. The other two refrigeration circuits were left unmodified and are used to provide additional refrigeration capacity during times of high load.

Summary of Ex Ante Impact Calculations

The savings estimate was based on data collected over a ten day period in March of 2002. The load on the compressors was estimated from the slide gauge position and manufacturer's performance data. In addition, the current draw and power factor of the compressors was measured. During this period the estimated refrigeration load varied from 72 to 490 tons with an average of 201 tons. The estimated compressor power varied from 131 to 461 kW with an average of 332 kW. Facility operation was estimated to be 24 hours per day, 315 days per year equivalent to 7,560 hours annually. This information was used to calculate an average compressor demand and estimate the annual energy consumption. The proposed energy use was estimated by combining the existing refrigeration loads into a single load and calculating the energy use of the compressors needed to meet this load. The proposed system saves energy by reducing the number of compressors required to operate to meet the refrigeration load and by improving the efficiency of the operating compressors.

Compressor performance data for the existing and proposed operating conditions was used for the calculations. The two operating conditions evaluated were 35 psig suction and 136 psig discharge for the existing case, and 45 psig suction and 120 psig discharge for the post-installation case. These operating parameters were used to estimate the energy consumption of the compressors at different loads and then compared to determine the energy savings.

The VFD on the condenser fans was estimated to decrease condenser fan energy use by 50%.

Comments on Ex Ante Calculations

The calculations provide a reasonable estimate of the energy savings assuming that the data collected over a 10 day period is representative of the compressors' annual energy use. No production data or other independent variables were measured or evaluated to support this assumption.

In addition, the energy savings estimate uses the slide gauge readings from each compressor to estimate the total refrigeration load and then proposes the required compressor operation to meet that load. This calculation does not account for the energy use of compressors #1, #6, and #7, that are not on the main refrigeration circuit, but are used to meet various loads.

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation. An on-site survey of the facility was conducted and the recorded information used to calculate the project savings.

The on-site survey was conducted on January 29th, 2004 and focused on the operation of the compressors. A walkthrough of the facility confirmed that juice chilling had been consolidated onto compressors #4 and 5. We also observed that the new chillers were installed. During the site visit we observed that a VFD was installed for the condenser fan motors. The operation of each compressor at the time of the site survey was recorded as follows:

Compressor #1 - operating
Suction pressure: 45.0 psi
Condensing Pressure: 139 psi
Slide Gauge Reading: 33.4%
Slide Gauge Reading: 158.4 amps

Compressors #2 and #3 - operating
Suction pressure: 36.0 psi
Condensing Pressure: 142.9 psi
Slide Gauge Reading: 19.1%
Current: 160.5 amps

Compressor #4 – Down for maintenance

Compressor #5 - operating
Suction pressure: 35.0 psi
Condensing Pressure: 144.7 psi
Slide Gauge Reading: 98%
Current: 182 amps

Compressors #6 and #7 - not operating

The site visit observations indicate that the compressors were operating at the pre-retrofit pressure differential, and although a VFD was installed for the condenser fans, none of the fans were operating. We therefore concluded that the suction and condensing pressure setpoints for the compressors had not changed after the retrofit.

Based on the information recorded at the site survey, the savings for each measure were recalculated in a spreadsheet analysis. For the re-calculated savings, the energy analysis followed the method used in the application (see *Summary of Ex-Ante Calculations* above). The results showed the energy savings for the system consolidation were approximately the same; but the other measure had no savings since the suction and condensing pressure setpoints for the compressors had not changed after the retrofit, and the compressor fan motor VFD was not operating.

Additionally, the demand savings was reduced from 211.0 kW to 157.4 kW. The results are shown in *Exhibit 1: Measure by Measure Impact Results.*

Scope of Impact Assessment

Both measures described in the application were evaluated. The site survey occurred on January 29th, 2004.

Additional Notes

The adjusted engineering savings for this evaluation are based on observations from a single site visit and may not accurately reflect the annual operation of the facility. In particular, the compressor pressure differential may be less at other times of the year.

Economic Information

Economic Summary

File Financial Values	Date	Project Cost	Estimated Customer Annual kWh Savings	Estimated Customer kW Savings	Estimated Customer Annual Therm Savings	Estimated Customer Annual $ Savings @ $0.14/kWh	Incentive	Payback w/o Incentive	Payback w/ Incentive
Installation Report Approved Amount	8/22/2003	$ 370,600.00	1,506,673	211.0	0.0	$ 210,934.22	$185,300.00	1.8	0.9

Impact Results

	KW	KWh	Therm
SPC Installation Report	211.0	1,506,673	0
Adjusted Engineering	157.4	1,190,125	0
Engineering Realization Rate	75.0%	79.0%	N/A

Exhibit 1: Measure by Measure Impact Results

	Project Application		Evaluation Calculation		RR	RR
Measures	kW	kWh	kW	kWh	kW	kWh
Consolidate Refrig System	149.0	1,128,960	157.4	1,190,125	106%	105%
Reduce Pressure Differential	43.0	322,713	0.0	0	-	-
Install VSD's on Condensers	19.0	55,000	0.0	0	-	-
Total	211.0	1,506,673	157.4	1,190,125	74.6%	79.0%

SITE 36 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL   TIER: 2   END USE: HVAC

Measure	High Efficiency Water-Cooled Chiller
Site Description	High Tech manufacturing facility

Measure Description

Replace an existing 1,000 ton constant speed chiller with a new 1,000 ton variable speed chiller. Use the new chiller as the lead chiller in a lead/lag sequence throughout the year

Summary of Ex Ante Impact Calculations

The calculation is a straightforward baseline and post- retrofit comparison of chiller load, multiplied by kW/ton rating of the Title 20 minimum efficiency and new chiller efficiency, multiplied by operating hours

kWh (baseline) = Chiller Load X Chiller kW/Ton (Title 20) X Annual Hours

kWh (post-retrofit) = Chiller Load X Chiller kW/Ton (post-retrofit) X Annual Hours

The SPC Installation Report calculations differed nominally in full load kW and in annual energy use from the SPC Application (533.9 kW vs. 537.2 kW and 4,701,461kWh vs. 4,680,809 kWh, respectively). No documentation was provided to support the full load kW/ton for the new chiller.

Details of ex ante chiller calculations and the assumed values are included below in Table 1.

Comments on Ex Ante Calculations

The ex ante calculations were evaluated for the accuracy of the assumed operating hours, the assumed chiller load, and the appropriateness of the calculation methodology. In summary:

- Facility operating hours are 24 hours per day seven days per week. The new chiller operates as the lead chiller and will likely operate nearly 8,760 hours per year, less maintenance, which is consistent with the calculation methodology. Actual operating hours could not be confirmed through the evaluation process due to lack of measured data.
- The calculation methodology seems to be more appropriate than using a BIN weather calculation model. Sample load curves included in Attachment 1 demonstrate that the load is driven by manufacturing processes and is not weather dependent.
- Facility operating load data was available, but was not used in the ex ante calculations. Based on three months of data provided by the facility staff, the average load on the chiller is 755 tons, and not the 930 tons used in the SPC calculation.
- Chiller operating efficiency curves were not utilized in the calculations. KW/Ton curves are usually available from chiller manufacturers, and considering that the new chiller is a variable flow chiller, this data would have been valuable in calculating accurate estimates of energy savings.

Additional time and effort would have allowed the engineer to collect actual operating load data and to obtain the chiller efficiency curves, resulting in increased ex ante calculation accuracy. It appears that the rebate level was significant enough to warrant this level of effort.

Evaluation Process

The evaluation process consisted of reviewing the application forms and supporting documentation, conducting an on-site survey, and then computing impacts using the on-site data.

The on-site survey was conducted on June 10, 2004. The customer facility is a high tech manufacturing facility that operates 24 hours per day. Facility operation staff were interviewed regarding the chiller plant's operating conditions, data was collected from the chillers, the Energy Management System (EMS) was surveyed to capture instantaneous load data and to determine what historical data might be available. Fifteen minute interval data was requested from facility staff.

The customer provided 15 minute interval data for facility load for approximately three months, March through May. Data is for the chiller plant in total. Data for individual chiller loads was not available. The data was evaluated to identify the percentage of time that the new chiller was operating at full load and to calculate the average lead chiller load during the time period. Sample daily load curves (Attachment 1) were also developed to determine when peak loads occurred and if they were weather dependent.

The chiller plant protocol is to operate the new chiller as the lead chiller up to a plant load of 930 tons. At that point a 150 ton chiller is brought on line. At 1,070 tons a second 150 ton chiller is added, and at 1,210 tons the 150 ton units are shut off and two 1,000 ton chillers are operated up to 1,670 tons. Additional chillers are added as needed if the load increases beyond this point.

Based on the operating protocol, the lead chiller load was calculated for each of the time intervals in the customer provided 15 minute interval data. The load was then averaged. The average load was calculated to be 755 tons in lieu of the 930 assumed for the SPC calculation.

The facility is a 24 hour manufacturing site. An on-site reading of the chillers operating hours since installation was 6,513. It appears from the signature date on the installation report that the installation occurred near 6/23/03, or nearly a year form the date of this review. Based on actual hours of 6,513, the chiller has a 76% operating frequency, However, this can be a result of start-up issues, the fact that the installation report was completed prior to the chiller going on-line, or other operating scenarios, so it is difficult to conclude with confidence that the operating hours are less than 24 hours per day.

More complex energy use calculation methods were considered to validate the SPC calculation method. As mentioned previously, a simple Load X Efficiency X hours formula was used. An alternative would be to use a BIN calculation method that takes into account impact of weather variations on the facility load. Daily Load Curves, Attachment 1, showed peaks in facility load every few hours, which do not correspond to peak daily temperatures. This would minimize the accuracy of using a BIN model calculation method and validates the appropriateness of the SPC calculation method.

The savings calculation method was the same for the ex ante and ex post calculations.

kWh = kW/Ton X Load X Hours

kWh = Annual energy use
kW/Ton = energy efficiency of the chiller (Title 20 minimum and new chiller)
Load = Chiller Load
Hours = Annual Operating Hours

The following impact results were completed using the same calculation method as the application, using the calculated average chiller load of 755 tons in lieu of the original assumption of 930 tons. Note, however, that during the on-site audit, the instantaneous chiller load was 937 tons. Although the ex post calculations are probably more accurate than the original SPC calculations, the accuracy could be improved significantly by using the actual manufacturer operating efficiency curves and applying the actual historical operating data.

It should be noted that at the time of the site visit two 1,000 ton chillers were operating at an instantaneous load of 930 tons, which is not per the programmed protocol. Facility staff were not able to explain this deviation from operating protocol, but it is likely due to the fact that one of the 150 ton chillers was offline for repair, causing the protocol to default to a manual operating mode.

Attempts were made to obtain actual operating efficiency curves from York to account for part load efficiencies, but they were not available at the time this evaluation was completed.

Scope of Impact Assessment

The application is for only one item, the chiller retrofit.

Additional Notes

Chiller specific kW, flow, and temperature data is not captured by the existing EMS. The installation of measurement equipment would allow for accurate measurement of new chiller energy use per ton.

Chiller manufacturer performance data for both the new chiller and the Title 20 minimum chiller would have enabled a more accurate assessment of the energy savings for this measure. The calculation methodology which compares chiller full load efficiencies yields misleading results since the chilled water load is variable and the chillers rarely operate at full load. A more accurate evaluation would utilize the IPLV (integrated part load value kW/ton) or NPLV (non-standard part load value kW/ton) for the calculation. IPLV data is available from the chiller manufacturer and NPLV can be calculated when chiller performance data and a load profile are available.

Additional effort in this review would have allowed for a better understanding of operating hours, for the collection of a full year's worth of chiller load data, and time to obtain the actual post installation chiller operating efficiency curves from the chiller manufacturer. An additional 6 to 10 hours would be required to complete this work.

Economic Information

Ex Ante Payback Estimates

	Date	Project Cost	Estimated Customer Annual Savings	Estimated Customer kW Saved	Estimated Customer Annual $ Saved @ $0.13 / kWh	Incentive	Payback w/o incentive	Payback w/ incentive
SPC Application Estimate	4/8/2002	$354,592	1,279,542	146.2	$166,340	$179,095	2.1	1.1
SPC Installation Report	6/27/2003	$354,592	1,270,018	144.9	$165,102	$177,803	2.1	1.1
NSPC Program Submittal Review	6/10/2004	$354,592	1,038,097	118.6	$134,953	$145,334	2.6	1.6

Impact Results

	KW	KWh	Therm
SPC Tracking System or Application	144.8	1,270,018	0
Adjusted Engineering	118.6	1,038,097	0
Engineering Realization Rate	0.82	0.82	N/A

SPC Application Calculations

	Unit Efficiency (full load kW/ton)	Average Chiller Load (tons)	Average Chiller Electric Load (kW)	Annual Operating Hours	Annual Energy Use or Impact (kWh)
Baseline Unit	0.577	931	537.2	8,752	4,701,461
Replacement Unit	0.42	931	391.0	8,752	3,422,207
Savings			146.2		1,279,254

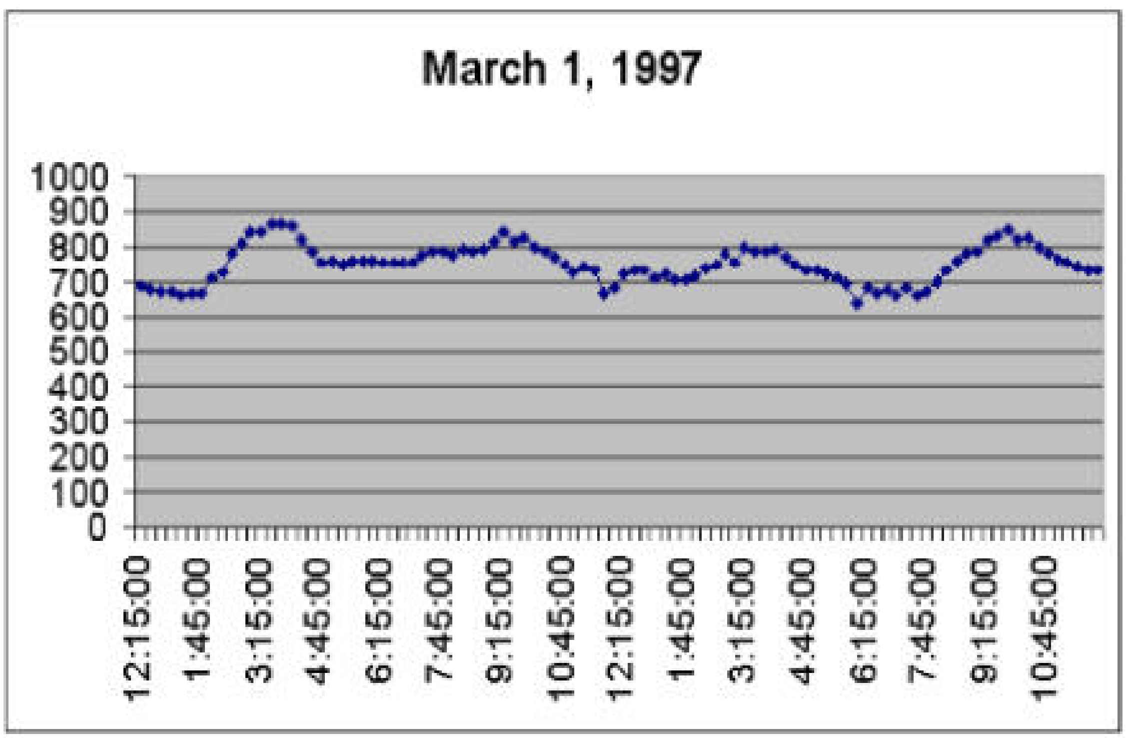
SPC Installation Report Calculations

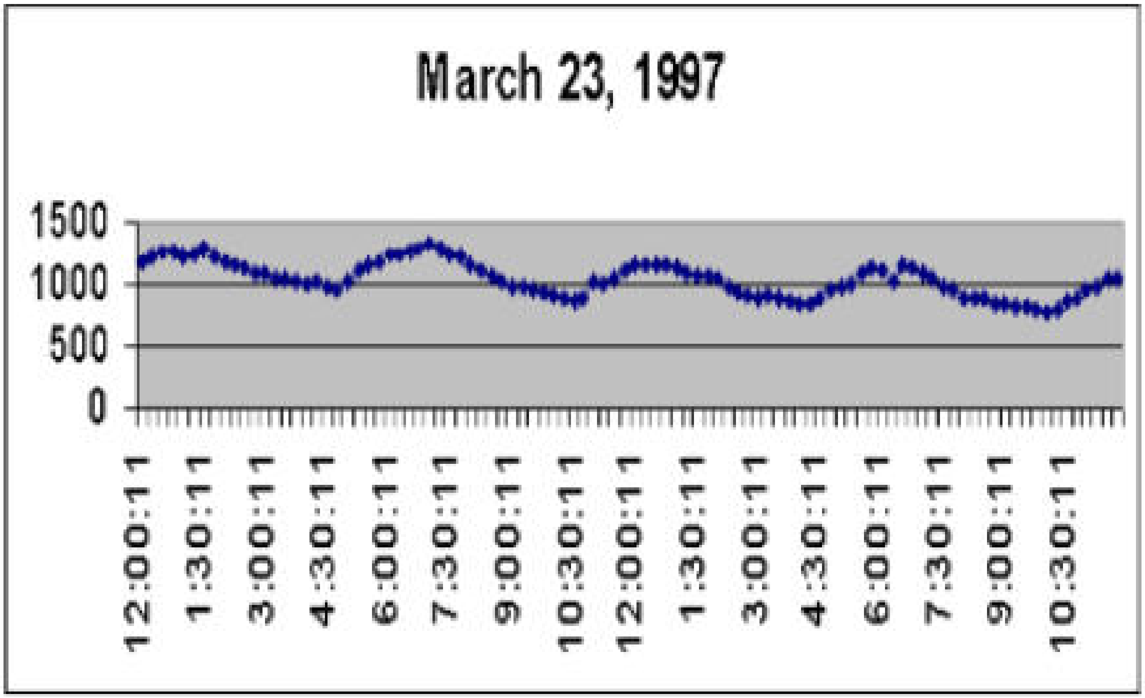
	Unit Efficiency (full load kW/ton)	Average Chiller Load (tons)	Average Chiller Electric Load (kW)	Annual Operating Hours	Annual Energy Use or Impact (kWh)
Baseline Unit	not available	not available	533.9	8,767	4,680,809
Replacement Unit	not available	not available	389.1	8,767	3,410,791
Savings			144.8		1,270,018

Calculations based on Measured Data (ex-post)

	Unit Efficiency (full load kW/ton)	Average Chiller Load (tons)	Average Chiller Electric Load (kW)	Annual Operating Hours	Annual Energy Use or Impact (kWh)
Baseline Unit	0.577	755.5	435.9	8,752	3,815,172
Replacement Unit	0.42	755.5	317.3	8,752	2,777,075
Savings			118.6		1,038,097

Attachment 1
Sample Load Curves

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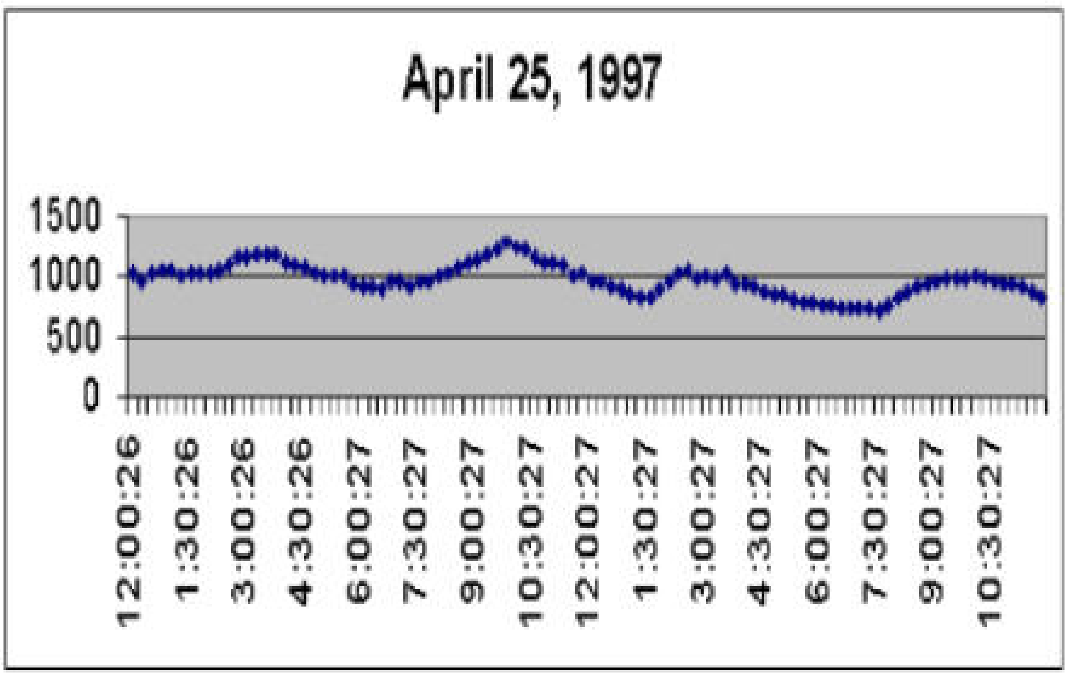
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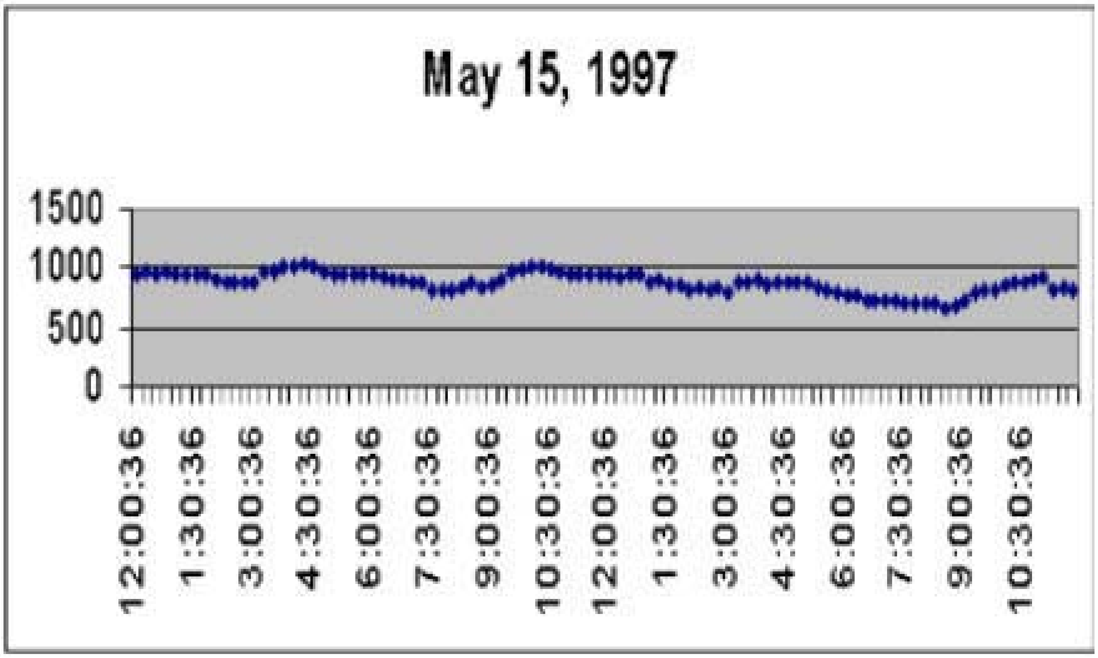
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SITE 37 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER:2 END USE: HVAC

Measure	Comprehensive Mechanical and Controls System Retrofit
Site Description	Commercial Office Complex

Measure Description

Comprehensive mechanical and controls system retrofit including central plant re-piping, chiller VFD, chilled water pump VFD, air handler coil replacement, chilled water storage system modifications, and DDC control system.

Summary of Ex Ante Impact Calculations

DOE 2 model. Base model calibrated to utility bills.

Comments on Ex Ante Calculations

The ex-ante savings were determined by DOE 2 modeling. The project is somewhat complicated by the fact that the mechanical retrofit started in 2001 before the SPC application was approved. This was identified during the pre-installation review, and the customer was required to resubmit the calculations with the recently installed measures included in the building baseline. The customer also provided two separate enhanced case models, one for the HVAC measures and one including the "other" measures since the SPC program incentives are different for each category.

The customer submitted four DOE 2 models briefly described as follows:

1. Calibrated Base Case Model:
This model uses the year 2000 as the base with the equipment and operating strategies used at that time. It uses local weather for that period (year 2000) and is calibrated within SPC required tolerance to the year 2000 utility bills.

2. Base Case Model:
This model is an update of the calibrated base case model which incorporates all the new equipment installed in 2001. This is the baseline for the SPC approved application.

3. HVAC Savings Model:
This model is the base case model with all of the HVAC savings measures included. HVAC savings measures are the re-piping of the central plant to allow series operation of chillers, 1,100 ton chiller retrofit with a VFD and installation of low face velocity, high temperature differential cooling coils.

4. HVAC Plus Other Savings Model:
This model is the base case model with all of the savings measures included. It includes VFD's on pumps and the updated control sequences associated with the installation of the DDC control system. The difference between the results of this model and the "HVAC Savings Model" is the savings predicted by the DOE 2 analysis for the "other" measures.

The energy consumption and resulting savings calculated by the DOE 2 analysis is summarized for each of the models in Table 1 below:

Table 1 Summary of the DOE 2 Model Analysis

			Savings		% of Total Savings	
Model	annual kWh	Peak kW	annual kWh	Peak kW	annual kWh	Peak kW
1. Calibrated Base Case	18,598,127	3,723	-	-	0	0
2. Base Case	17,887,674	3,442	710,453	281	15%	20%
3. HVAC Savings	15,237,050	2,458	2,650,624	984	57%	71%
4. HVAC Plus Other	13,940,088	2,336	1,296,962	122	28%	9%
Total			4,658,039	1,387	100%	100%

The project application was reviewed, and some deficiencies were noted in the DOE 2 model. The reviewer analyzed the impact of the deficiencies and concluded that they had only a small impact on the savings analysis. The application assessed kWh savings were reduced to reflect the maximum incentive of $300,000. Following the completion of construction, the reduced savings levels were approved and the customer was paid a $300,000 incentive. The Ex Ante savings are shown in Table 2 below.

Table 2 Ex Ante Approved Savings

	Savings	
Measure	annual kWh	Peak kW
HVAC Savings	1,401,736	984
HVAC Plus Other	1,296,962	122
Total	2,698,698	1,106

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation, conducting an on site survey, and then estimating impacts using monthly billing regressions that adjust for changes in occupancy and changes in weather.

The facility includes 4 office towers approximately 220,000 ft^2 each, and a central chilled water plant. There are electric meters for each building and the central plant. Occupancy data was received from facilities representatives and billing data from the electric utility. Weather data was obtained from the National Weather Service data base for an airport less than 2 miles from the site. Monthly energy bills were analyzed for the 5 electric meters affected by the retrofit.

The analysis was performed by separating evaluation of the central plant from the evaluation of the buildings and combining the results. This was done because energy use in the central plant is primarily affected by cooling requirements (Cooling Degree-Days) and building energy use is mainly affected by occupancy and heating requirements (Heating Degree-Days). The office towers are heated by electric resistance elements in the air handlers serving each floor.

We elected to evaluate the energy savings for the entire retrofit including the work that was performed in 2001 before the SPC application was approved. This was done so that we could establish a 12 month baseline period before retrofit work started, and also so we could use the DOE 2 modeling to pro rate the savings associated with the SPC approved retrofit measures. We used year 2000 as the base period and performed a regression analysis which relates the monthly energy consumption to weather and occupancy.

The results of this analysis were used to predict the monthly energy consumption for the selected post retrofit period from September 2003- August 2004. This model predicts the energy consumption for the unmodified mechanical system as it was before the retrofit commenced, based on the occupancy and weather for the September 2003- August 2004 period. The predicted energy consumption is subtracted from the actual billed energy consumption, and the result is the savings realized for the entire retrofit project which includes the work performed in 2001.

To estimate the savings associated with the retrofit measures approved in the SPC application, we pro-rated the kWh savings calculated in the regression analysis for the entire project by the ratio of savings attributed to the SPC approved project divided by the savings calculated for the entire project. With reference to the DOE 2 models as numbered in Table 1 above, the ratio based on total predicted kWh and kW is calculated as follows:

(DOE model 2 –DOE model 4)/(DOE model 1 –DOE model 4)

84.7% of the annual kWh and 79.7% of the peak demand savings were predicted by the DOE 2 models to be attributed to measures approved in the SPC calculation. The remainder of the savings, 15.3% of the annual kWh and 20.3% of the peak demand are associated with the retrofit work performed in 2001, before the SPC application was approved.

Table 3 summarizes the percent of savings attributed to each DOE 2 model for the project

Table 3 Percent of Total Savings-DOE 2 Models

	Savings		% of Total Savings	
Model	annual kWh	Peak kW	annual kWh	Peak kW
1. Calibrated Base Case	-	-	0.0%	0.0%
2. Base Case	710,453	281	15.3%	20.3%
3. HVAC Savings	2,650,624	984	56.9%	70.9%
4. HVAC Plus Other	1,296,962	122	27.8%	8.8%
Total	4,658,039	1,387	100.0%	100.0%

The regression evaluation predicts that energy consumption for the 12 month period of September 2003- August 2004 would have been 17,615,436 kWh if the mechanical system had not been modified. Actual billed consumption was 13,265,124 kWh. The difference, 4,350,312 kWh is the savings due to the implementation of all retrofit measures since 2001. 84.3% of 4,350,312 kWh (3,667,313 kWh) is the savings due to the implementation of retrofit measures approved in the SPC calculation. Table 4 is a summary of the results of the evaluation.

Table 4 Ex Post Evaluation Results

	kWh
Predicted kWh for Sep-03 Through Aug-04:	17,615,436
Actual kWh for Sep-03 Through Aug-04:	13,265,124
Total kWh Savings for Sep-03 Through Aug-04:	4,350,312
Savings Attributed to SPC Approved Measures (84.3%)	3,667,313

Figures 1, 2, and 3 are a graphical representation of the analysis results. Tables 9 and 10 below, show the results of the regression analysis. Both models have good R squared values (0.88 and 0.90) indicating a high correlation between energy consumption, occupancy and weather. Additionally, both models have less than 0.1% probability that the relationship established by this analysis is random. This is an indication of a high level of statistical significance.

Due to constraints on the budget allowed for this project we performed a simple utility bill evaluation to determine the peak demand kW savings for the project. The analysis does not use regression analysis. For this analysis we simply subtracted the average maximum peak demand from the years 2002-2004 from the peak demand in the base year (2000) and pro-rated this by the amount of demand savings attributed to the SPC approved measures as calculated by the DOE 2 analysis. Table 5 is a summary of the peak demand for the five electric meters.

Table 5 Summary of Peak Demand

Year	Peak kW
2000	3,799
2001	4,344
2002	2,118
2003	2,042
2004	2,343
Average '02-'04	2,168

We estimate that the peak demand reduction attributed to the entire project is 3,799 kW-2,168 kW = 1,631 kW. Multiplying this by 79.7% (ratio determined from Table 3 above) equates to 1,300 kW attributed to the measures approved in the SPC calculation.

Table 6 is a summary of the impact evaluation savings analysis.

Table 6 Impact Evaluation Savings Summary

Savings	
annual kWh	Peak kW
3,667,313	1,300

Scope of Impact Assessment

The impact assessment scope is for the all measures approved in the SPC application.

Additional Notes

The level of M&V employed at this site is adequate for this project. We were extremely fortunate to obtain occupancy data from the customer for the pre and post retrofit periods. The statistical analysis has high coefficients of correlation and excellent values for statistical significance. We have a high level of confidence in the results of this analysis.

Our analysis is a good validation of the DOE 2 model, which in this case appears to have been constructed to accurately reflect the pre and post retrofit building parameters.

Economic Information

An economic summary for all measures included in the application is shown in Table 7 below. An engineering realization rate calculation is shown in Table 8.

Table 7 Economic Summary of the Project

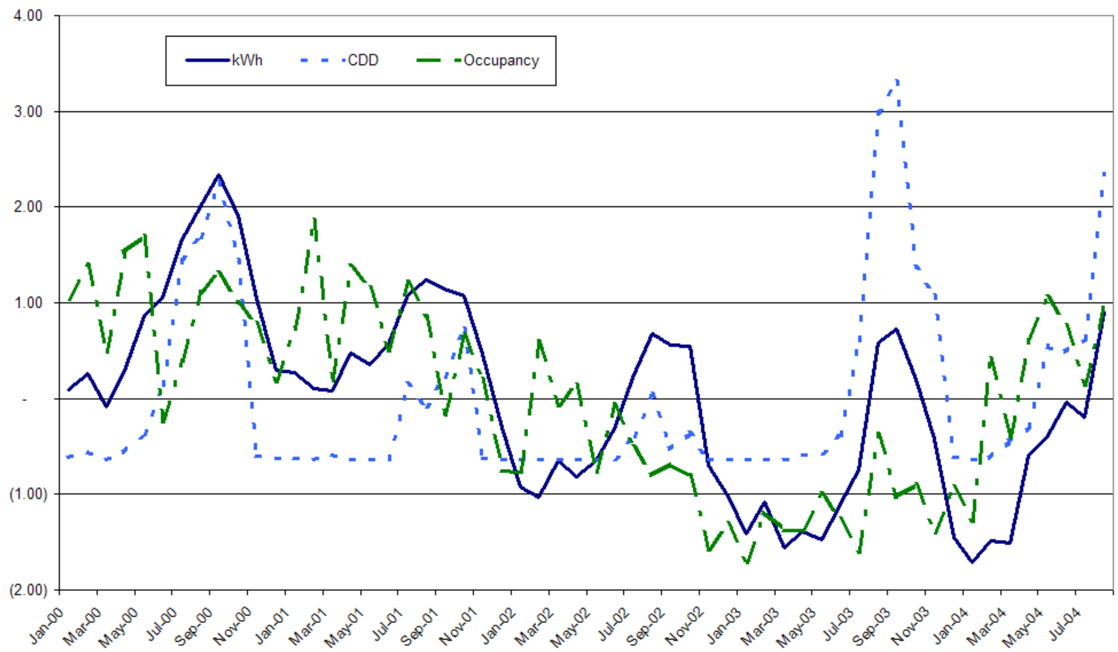
Description	Date	Project Cost	Estimated Demand Savings, kW	Estimated Energy Savings, kWh	Estimated Gas Savings, therms	Estimated Annual Cost Savings ($0.10/kWh) $	SPC Incentive, $	Simple Payback w/ incentive, yrs	Simple Payback w/o incentive, yrs
Application Submitted Amount	4/4/2002	$2,686,000	1,106	3,947,586	0	$394,759	$300,000	6.04	6.80
Application Approved Amount	5/14/2002	$2,686,000	1,106	2,698,698	0	$269,870	$300,000	8.84	9.95
Installation Approved Amount	7/21/2003	$2,686,000	1,106	2,698,698	0	$269,870	$300,000	8.84	9.95
SPC Program Review	9/21/2004	$2,686,000	1,300	3,667,313	0	$366,731	$300,000	6.51	7.32

Impact Results

Table 8 Realization Rate Calculation

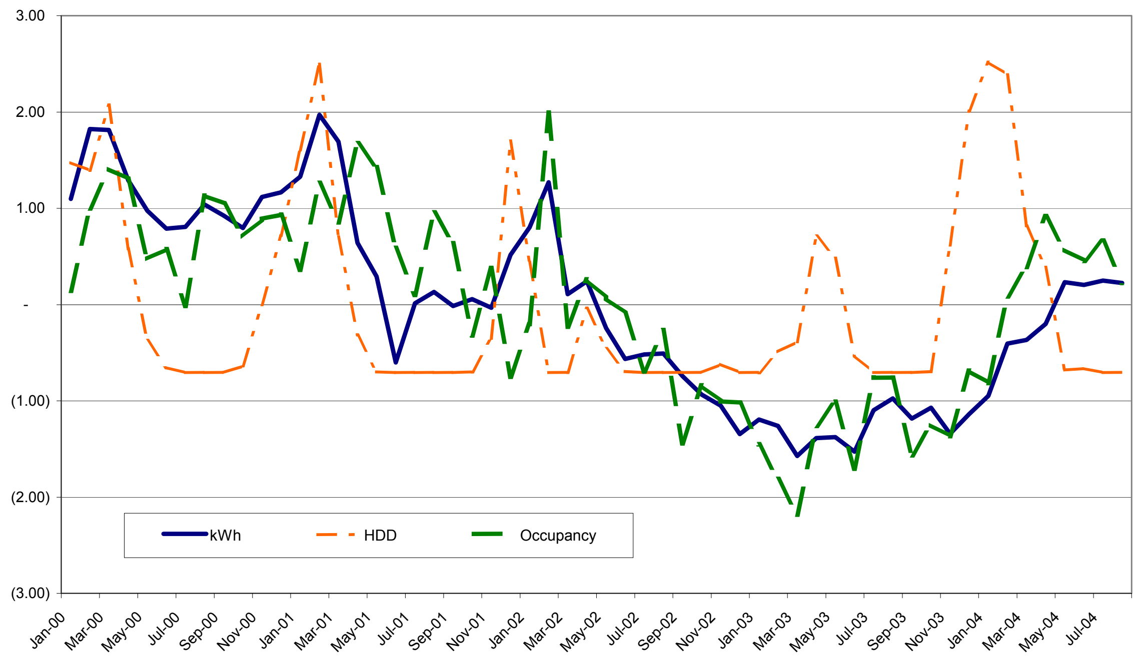
	kW	kWh	Therm
Installation Report	1,106	2,698,698	0
Adjusted Engineering	1,300	3,667,313	0
Engineering Realization Rate	118%	136%	NA

Figure 1- Model Variables (Standardized Values) for Central Plant



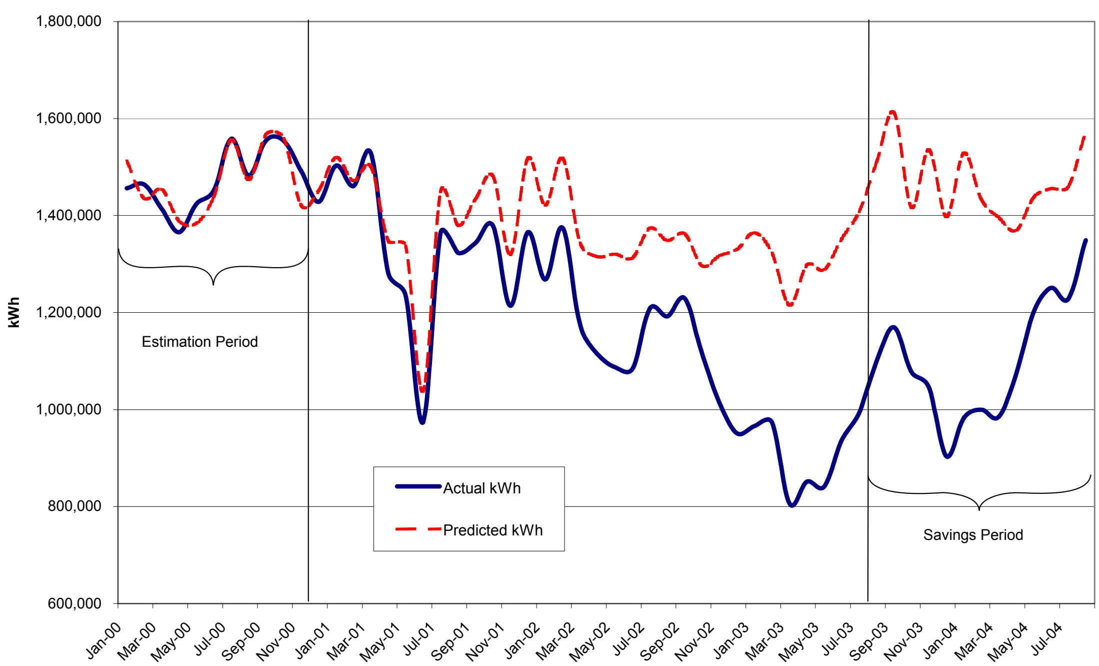
CDD= Cooling Degree Days

Figure 2 -Model Variables (Standardized Values) for Buildings without Central Plant



HDD= Heating Degree Days

Figure 3-Predicted and Actual kWh for Buildings and Central Plant



Predicted kWh is the energy use predicted by the regression model if the mechanical system had not been modified. Actual kWh is the billed energy use.

Table 9 Results of the Regression Analysis-Buildings

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	93992912	18798582	75.69	<.0001
Error	42	10431445	248368		
Corrected Total	47	104424358			

Root MSE	498.36507	R-Square	0.9001
Dependent Mean	9145.42813	Adj R-Sq	0.8882
Coeff Var	5.44934		

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	5506.99946	732.56861	7.52	<.0001
adhdd	1	92.75381	24.57763	3.77	0.0005
adocc	1	975.87018	263.44116	3.7	0.0006
dum18200	1	2476.21863	206.4562	11.99	<.0001
dum18300	1	-1044.16059	204.01328	-5.12	<.0001
dum18400	1	749.61345	225.82396	3.32	0.0019

Table 10 Results of the Regression Analysis-Central Plant

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	75488787	37744393	33.33	<.0001
Error	9	10191429	1132381		
Corrected Total	11	85680216			

Root MSE	1064.13392	R-Square	0.8811
Dependent Mean	11856	Adj R-Sq	0.8546
Coeff Var	8.97525		

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	8664.49975	5467.18084	1.58	0.1475
adcdd	1	946.03042	116.12446	8.15	<.0001
adocc	1	379.94327	1879.75123	0.2	0.8443

SITE 38 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER: 3 END USE: HVAC

Measure	EMS to power on/off room ACs
Site Description	Motel

Measure Description

A new Johnson Controls EMS was installed to control individual guest room ACs when rooms are unoccupied.

Summary of Ex Ante Impact Calculations

Bin data for the local area was used to determine cooling loads per room. Data on historic occupancy rates was used in conjunction with assumptions regarding the percentage of time units are left operational to generate total air conditioning loads. These were then converted to kWh assuming units are loaded 74%.

Comments on Ex Ante Calculations

While the approach used to estimate ex-ante impact estimates is generally found to be acceptable, the assumed 74% AC loading factor is considered high for unoccupied rooms, especially given that this loading reflects 24 hour per day, 365 days per year. A more conservative estimate of AC loading would be more appropriate.

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation, conducting an on site survey, and then estimating impacts using monthly billing regressions that adjust for changes in occupancy and changes in weather.

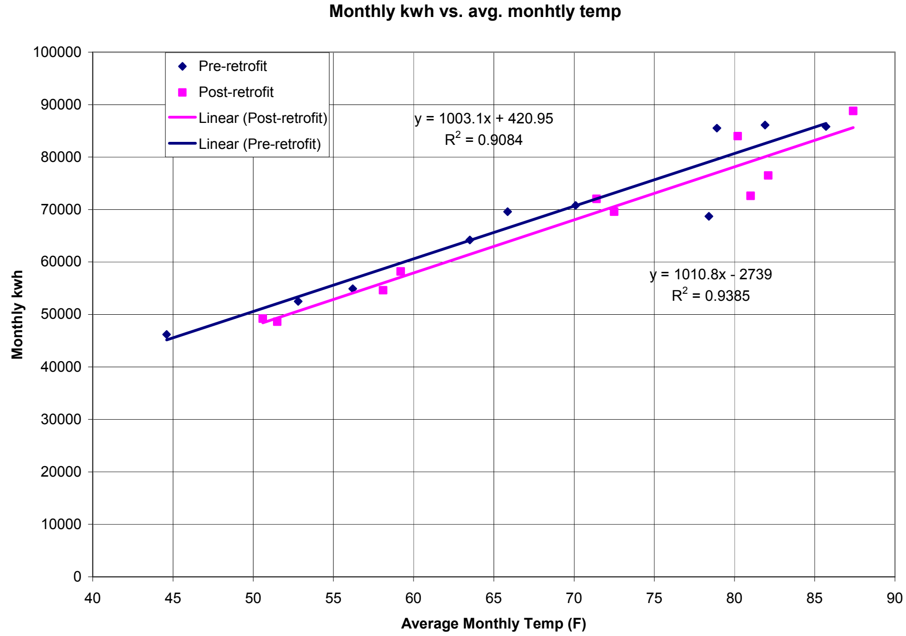
The onsite survey was conducted on November 14, 2003. Information on the retrofit equipment and operating conditions was collected through an inspection of the EMS and through an interview with hotel management.

A spreadsheet was created with the following data:

1. Monthly kWh from utility bills.
2. Average monthly dry bulb temperature for a local airport, obtained from the National Climatic Data Center's online weather data archives.
3. Average monthly occupancy rates, obtained from hotel management.

		Usage	Temp	Occ.		Usage	Temp	Occ.
Month		**KWh**	**F**	**%**		**KWh**	**F**	**%**
Jan	Pre-retrofit (2002)	46200	44.6	75.11	Post-retrofit (2003)	49200	50.6	75.42
Feb		52500	52.8	87.07		48600	51.5	87.97
Mar		54900	56.2	90.29		54600	58.1	87.98
Apr		64200	63.5	88.7		58200	59.2	85.12
May		70800	70.1	79.25		72000	71.4	78.27
Jun		85500	78.9	87.23		84000	80.2	88.04
Jul		85800	85.7	84.72		88800	87.4	79.59
Aug		86100	81.9	91.17		76500	82.1	70.22
Sep		68700	78.4	72.39		72600	81	73.44
Oct		69600	65.86	87.71		69600	72.5	87.1

A simple linear relation between the Monthly energy usage and average dry bulb temperature demonstrates a significant reduction **(21,410 kWh/yr)** in energy usage between the pre & post cases. Although revealing a reduction in usage, this relation does not take into account the affect of occupancy



To address this, a statistical model was created using the pre-retrofit data, with monthly energy usage as a variable dependant on monthly occupancy rates and average monthly dry bulb temperature.

Variable	*Parameter Estimate*	*Standard Error*	*T Value*	*PR > |t|*
Intercept	-32221	17815	-1.81	.1134
Temp	985	97	10.16	<0.0001
Occupancy	401	203	1.98	0.088

The model shows a stronger correlation to temperature than to occupancy. Post retrofit data for occupancy and temperature was input to this model to generate an adjusted baseline, reflecting Jan 2003 to Oct 2003 weather and occupancy. It results in an annual savings estimate of **16,516 kWh**.

Based on the billing analysis, there is a definite indication of reduced consumption, but less than the ex-ante estimate of 35,090. However due to the size of the sample (10 observations of pre & post monthly billing records) and limitations in budget for this evaluation, it was not possible to generate a definite estimate of ex-post energy savings. Therefore we opt to neither accept nor reject the ex-ante estimate of savings, but merely point out, as stated above that the ex-ante AC loading factor of 74% may lead to an overestimation of impact for this particular project.

Additional Notes With more time and resources, a sample of the rooms could be logged to determine actual operational hours for the room ACs. Furthermore, this job could have benefited from the collection of pre-retrofit logger data on the room AC's. Of course pre-retrofit data collection was not possible for this evaluation, taking place after the project was completed.

Impact Results

	KW	KWh	Therm
SPC Application Calculations	0	35,090	0
Adjusted Engineering	0	16,516	0
Engineering Realization Rate	0	NA	0

Economic Information

Description	Date	Project Cost	Estimated Demand Savings, kW	Estimated Energy Savings, kWh	Estimated Gas Savings, therms	Estimated Annual Cost Savings ($0.13/kWh), $	SPC Incentive, $	Simple Payback w/ incentive, yrs	Simple Payback w/o incentive, yrs
Application Submitted Amount	7/17/2002	$40,000	0	35,090	0	$4,562	$4,912.55	7.69	8.77
Application Approved Amount	8/27/2002	$40,000	0	35,090	0	$4,562	$4,912.60	7.69	8.77
Installation Approved Amount	12/13/2002	$40,000	0	35,090	0	$4,562	$4,912.60	7.69	8.77
SPC Program Review	1/8/2004	$40,000	0	35,090	0	$4,562	$4,912.60	7.69	8.77

SITE 39 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER: 3 END USE: HVAC

Measure	Loading Dock Door Seals
Site Description	Refrigerated Warehouse

Measure Description

Revamp existing loading dock door seals. Install new door seals to narrow the gap between seals and truck body.

Summary of Ex Ante Impact Calculations

Simple pre- and post-retrofit algorithm for losses due to leaking seals. Savings based on narrowing the gap at the top of the truck body from 6 inches to 1 inch. Ex ante calculations were based on the algorithm shown in Table 1 at the end of this report. The ex ante calculation used local weather data to determine the average wind speed 6.1 mph and an average dry bulb temperature of 71°F. The ex ante calculations, resulted in 55,700 kWh/yr. and 2.5 peak kW savings.

Comments on Ex Ante Calculations

Assumes EER of 10 for refrigeration equipment. Assumes operation 7.5 hrs/day, 5 days per week, for 50 weeks per year.

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation, conducting an on-site survey, and then computing impacts using the on-site data.

This site is a refrigerated warehouse maintaining frozen food items at –5°F with a system of evaporatively cooled ammonia refrigeration compressors (estimated COP = 3.0). A loading dock area is separate from the freezers. Plastic curtain barriers are installed in the doorways from the freezers into the dock area. The dock areas are maintained at 45°F through a separate set of evaporators from the ammonia system. Some leakage occurs between the freezer section and the loading dock allowing the dock area to drift below 45°F over night. On the morning of the site verification visit, temperatures in the dock area were measured at 37°F.

Trucks are used to transport items to and from the warehouse. The trucks back into the loading dock area through any of 12 doorways to be loaded or unloaded. A rubber seal is installed in each doorway that contacts the sides and top of the truck body to prevent refrigerated air from escaping from the loading dock. To prevent leakage around the bottom of the truck, an insulated ramp is placed in the back opening. When a loading bay is unoccupied, an insulated metal door is closed to prevent the escape of refrigerated air.

The baseline seals allowed a gap of 6″ at the top of the truck body. The retrofit seals were expected to narrow this gap to just 1″. On the day of the site verification visit, the gap was measured to be 1″ in some areas narrowing to 0″ in others. The average gap appeared to be about ¾″. By minimizing the escape of refrigerated air, energy use to refrigerate make-up air is reduced.

Loading and unloading operations occur 5 days per week from 6:00 am to 2:00 pm. At the time of the site verification visit, there were trucks in 11 of the 12 loading bays and the door was closed on the 12th bay. It is therefore reasonable to assume that not all 12 bays are continuously occupied and that one bay is normally unoccupied.

Ex post calculations were based on the same algorithm used in the ex ante calculation, but used hourly average temperatures and wind speeds for each month of the year to determine the average kW for each hour of the weekdays in each month and observed indoor temperatures, hours of operation, and refrigeration system efficiency. Total annual baseline kWh is the sum of the hourly kW results, and annual savings is the difference between the annual baseline kWh and the annual post-retrofit kWh. Average peak kW savings was determined by averaging the kW demand savings for the peak period hours in June, July, August, September, and October. The ex post savings are 68,705 kWh/yr. and 3.2 peak kW.

Differences in savings result from observed differences in ex post operation from those used in the ex ante analysis. Also, using a yearly average in the ex ante calculation masks the variations on peak summer days and results in an average demand that is lower than what actually occurs. Similarly, higher summer time energy use is not accounted for when using a yearly average temperature and wind speed.

Scope of Impact Assessment

This customer also received incentives for similar measures at three other facilities.

Additional Notes

The level of M&V employed at this site is probably sufficient to accurately determine the impacts of the installed measure. Additional trending of actual refrigeration loads may also be justified as additional M&V for this customer.

Economic Information

File Financial Values	Date	Project Cost	Estimated Customer Annual kWh Savings	Estimated Customer kW Savings	Estimated Customer Annual Therm Savings	Estimated Customer Annual $ Savings @ $0.13/kWh	Incentive	Payback w/o Incentive	Payback w/ Incentive
Tracking System	4/23/2002	$ 16,500.00	163,258	2.5	0.0	$ 21,223.54	$7,798.14	0.8	0.4
Installation Report Approved Amount	7/31/2002	$ 16,500.00	163,258	2.5	0.0	$ 21,223.54	$7,798.14	0.8	0.4

Impact Results

	kW	kWh	Therm
SPC Tracking System or Application	2.5	55,700	0
Adjusted Engineering	3.2	68,705	0
Engineering Realization Rate	1.3	1.2	N/A

Table 1
Ex Ante Refrigeration Savings Summary

Descrip.	Door Width ft	Gap ft	Gap Area ft^2	Ave Wind Speed mph	Air Loss cfm	Ave Temp Diff °F	Heat Loss Btu/hr	EER Btu/hr/W	kW	Hrs per Day	Days per Year	Qty.	Annual kWh Used
Base Case	8	0.500	4	6.1	1,718	16	29,683	10	3.0	7.5	250	12	66,787
Post Case	8	0.083	0.66	6.1	285	16	4,927	10	0.5	7.5	250	12	11,087
Savings							24,756		2.5				55,700

Where:

$$\text{Air Loss cfm} = \text{Gap Area ft}^2 \times \text{Ave Wind Speed mph} \times \frac{5{,}280\ \text{ft/mi}}{60\ \text{min/hr}} \times 0.8$$

$$\text{Heat Loss Btu/hr} = \text{Air Loss cfm} \times \text{Ave Temp Diff}\ ^\circ\text{F} \times 1.08$$

$$\text{kW} = \frac{\text{Heat Loss Btu/hr}}{\text{EER Btu/hr/W}} \times 1\ \text{kW}/1{,}000\ \text{W}$$

$$\text{Annual kWh} = \text{kW} \times \text{Hrs per Day} \times \text{Days per Year} \times \text{Qty}$$

Inputs to Model

Parameter	Value Reported	Units	Notes
City	Bloomington		
Climate Zone			
Pre-Retrofit Hours of Operation	1,875	hrs/yr	Operating hrs based on 7.5 hrs/day, 5 days per week for 50 weeks/yr
Pre-Retrofit Indoor Temperature	55	°F	Application
Pre-Retrofit Gap	0.5	ft	Average measured gap
Pre-Retrofit Door Width	8.0	ft	Measured
Number of Doors in Operation	12		Observed
Pre-Retrofit Wind Speed	6.1	mph	Application
Pre-Retrofit Ave. Temp. Diff.	16	°F	Application
Post-Retrofit Hours of Operation	1,875	hrs/yr	Operating hrs based on 7.5 hrs/day, 5 days per week for 50 weeks/yr
Pre-Retrofit Indoor Temperature	55	°F	Observed
Post-Retrofit Gap	0.083	ft	Average measured gap
Post-Retrofit Door Width	8.0	ft	Measured
Number of Doors in Operation	12		Observed
Post-Retrofit Wind Speed	6.1	mph	Application
Post-Retrofit Ave. Temp. Diff.	16	°F	Application

Table 2
Ex Post Weather Data

Average Hourly Dry Bulb Temperature °F

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
6	47.2	47.4	54.7	55.0	60.8	61.2	65.4	64.0	63.9	60.7	49.6	46.3	56.4
7	47.4	47.1	56.0	58.0	63.4	62.7	67.5	66.3	66.0	62.4	49.5	46.5	57.8
8	49.5	49.8	60.0	60.6	66.0	64.4	70.6	69.2	69.0	66.7	53.4	50.1	60.9
9	53.6	53.6	63.7	63.5	68.9	67.2	74.3	73.0	73.1	70.0	56.8	54.0	64.4
10	56.9	56.5	67.5	66.9	72.0	71.3	79.2	77.7	78.1	73.9	60.0	58.0	68.3
11	60.4	59.5	71.6	69.9	75.1	75.0	83.4	81.9	83.1	78.1	63.2	61.7	72.0
12	63.5	61.2	74.3	72.4	77.4	78.2	87.0	85.6	87.1	81.4	65.4	64.0	75.0
13	65.6	62.3	75.6	74.0	79.2	80.6	89.8	88.1	89.5	83.5	66.8	65.8	76.9
Total	60.4	58.5	70.7	69.6	74.8	75.0	83.3	81.7	82.3	77.7	62.4	60.7	71.4

Average Hourly Wind Speed, mph

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
6	2.8	2.8	3.3	2.5	3.1	2.8	1.5	1.8	1.4	2.0	2.2	3.6	2.5
7	3.4	3.9	3.0	2.9	3.6	2.6	1.8	2.0	0.8	1.7	2.4	3.6	2.6
8	3.3	2.6	3.5	3.9	4.1	2.7	2.9	2.5	1.4	1.6	2.2	2.7	2.8
9	3.0	4.9	3.7	3.3	3.8	4.2	3.1	3.3	3.4	2.5	2.5	2.6	3.3
10	3.6	5.0	4.6	5.4	5.0	4.4	3.6	4.8	3.3	3.1	3.1	3.0	4.1
11	4.1	5.8	6.6	6.1	7.2	5.5	6.0	6.3	4.5	4.3	4.0	4.5	5.4
12	5.3	6.8	7.5	7.5	8.0	7.5	7.2	8.3	7.2	5.8	5.1	5.9	6.8
13	5.5	7.2	8.9	8.4	9.5	9.2	9.2	9.2	8.7	7.7	5.5	7.2	8.0
Total	4.7	6.0	6.7	6.8	7.5	7.2	6.8	7.1	6.4	5.5	4.1	4.8	6.1

Table 3
Ex Post Baseline Demand and Annual kWh Usage

Base Case

Door Width	8.0	ft
Gap Width	0.5	ft
Gap Area	4.0	ft^2
Indoor Temp	45.0	°F
EER	9.42	
Hrs/day	8.0	hrs
Days/year	250	days

kW

kW	21	19	23	19	20	22	21	22	21	21	20	21
Hour	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
8	0.2	0.2	1.0	0.8	1.6	1.4	1.0	1.1	0.8	1.0	0.3	0.2
9	0.3	0.3	1.1	1.2	2.1	1.5	1.3	1.4	0.5	1.0	0.3	0.2
10	0.5	0.4	1.7	2.0	2.8	1.7	2.4	2.0	1.1	1.1	0.6	0.4
11	0.8	1.3	2.2	2.0	2.9	3.0	3.0	3.0	3.1	2.0	0.9	0.8
12	1.4	1.8	3.3	3.8	4.4	3.7	4.0	5.0	3.5	2.9	1.5	1.3
13	2.1	2.7	5.6	4.9	7.0	5.3	7.4	7.5	5.6	4.6	2.3	2.4
14	3.1	3.6	7.1	6.6	8.4	8.1	9.7	10.9	9.8	6.8	3.3	3.6
15	3.7	4.0	8.8	7.8	10.5	10.6	13.3	12.8	12.5	9.5	3.9	4.8

kWh

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
8	4	4	24	15	32	32	20	24	17	21	6	3	204
9	5	5	24	23	42	33	28	31	11	21	7	4	233
10	10	7	39	37	56	37	50	44	22	24	12	9	348
11	18	25	51	37	58	67	62	65	64	43	19	16	524
12	29	35	77	73	87	81	84	111	75	61	30	27	769
13	43	51	130	94	140	118	155	166	117	97	47	51	1,208
14	66	68	163	125	168	178	204	240	205	144	66	76	1,703
15	77	76	201	149	210	232	280	281	263	200	77	101	2,148
Grand Total	253	272	709	553	794	777	884	961	775	611	264	287	7,138

Table 4
Ex Post Post-Retrofit Demand and Annual kWh Usage

Post Case		
Door Width	8.0	ft
Gap Width	0.063	ft
Gap Area	0.50	ft^2
Indoor Temp	45.0	°F
EER	9.42	
Hrs/day	8.0	hrs
Days/year	250	days

kW

	21	19	23	19	20	22	21	22	21	21	20	21
Hour	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
8	0.0	0.0	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0
9	0.0	0.0	0.1	0.1	0.3	0.2	0.2	0.2	0.1	0.1	0.0	0.0
10	0.1	0.0	0.2	0.2	0.4	0.2	0.3	0.2	0.1	0.1	0.1	0.1
11	0.1	0.2	0.3	0.2	0.4	0.4	0.4	0.4	0.4	0.3	0.1	0.1
12	0.2	0.2	0.4	0.5	0.5	0.5	0.5	0.6	0.4	0.4	0.2	0.2
13	0.3	0.3	0.7	0.6	0.9	0.7	0.9	0.9	0.7	0.6	0.3	0.3
14	0.4	0.4	0.9	0.8	1.1	1.0	1.2	1.4	1.2	0.9	0.4	0.5
15	0.5	0.5	1.1	1.0	1.3	1.3	1.7	1.6	1.6	1.2	0.5	0.6

kWh

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
8	1	1	3	2	4	4	3	3	2	3	1	0	25
9	1	1	3	3	5	4	3	4	1	3	1	0	29
10	1	1	5	5	7	5	6	5	3	3	1	1	43
11	2	3	6	5	7	8	8	8	8	5	2	2	66
12	4	4	10	9	11	10	11	14	9	8	4	3	96
13	5	6	16	12	17	15	19	21	15	12	6	6	151
14	8	8	20	16	21	22	26	30	26	18	8	9	213
15	10	9	25	19	26	29	35	35	33	25	10	13	269
Grand Total	32	34	89	69	99	97	111	120	97	76	33	36	892

Where for each hour of the day for each month:

$$\text{Air Loss cfm} = \text{Gap Area ft}^2 \times \text{Ave Wind Speed mph} \times \frac{5{,}280\ \text{ft/mi}}{60\ \text{min/hr}} \times 0.8$$

$$\text{Heat Loss Btu/hr} = \text{Air Loss cfm} \times \left(\text{Dry Bulb Temperature }^\circ\text{F - Indoor Temp}^\circ\text{F}\right) \times 1.08$$

$$\text{kW} = \frac{\text{Heat Loss Btu/hr}}{\text{EER Btu/hr/W}} \times 1\ \text{kW/1,000 W}$$

$$\text{Monthly kWh} = \sum_{h=6}^{h=13} \left(\text{kW}_h \times \text{Days per Month}\right)$$

$$\text{EER} = \text{COP} \times \pi$$

Table 5
Average Demand Reduction and Annual kWh Savings

Demand Savings

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
6	0.2	0.2	0.9	0.7	1.4	1.3	0.8	1.0	0.7	0.9	0.3	0.1
7	0.2	0.2	0.9	1.0	1.9	1.3	1.2	1.2	0.5	0.9	0.3	0.2
8	0.4	0.3	1.5	1.7	2.5	1.5	2.1	1.7	0.9	1.0	0.5	0.4
9	0.7	1.2	1.9	1.7	2.5	2.6	2.6	2.6	2.7	1.8	0.8	0.7
10	1.2	1.6	2.9	3.3	3.8	3.2	3.5	4.4	3.1	2.6	1.3	1.1
11	1.8	2.4	4.9	4.3	6.1	4.7	6.5	6.6	4.9	4.1	2.1	2.1
12	2.7	3.1	6.2	5.8	7.4	7.1	8.5	9.5	8.5	6.0	2.9	3.2
13	3.2	3.5	7.7	6.8	9.2	9.2	11.7	11.2	11.0	8.3	3.4	4.2
Ave Peak kW						2.7	3.4	3.5	3.3	2.4		
								Ave On Peak Savings				3.2

kWh Savings/door

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
6	4	4	21	13	28	28	18	21	15	19	6	3	178
7	5	4	21	20	37	29	24	27	10	18	6	3	204
8	9	6	34	33	49	32	44	38	19	21	10	8	304
9	16	22	44	32	51	58	55	57	56	37	16	14	459
10	25	31	67	63	76	71	74	97	65	54	26	23	673
11	38	45	113	82	122	103	135	145	103	85	41	45	1,057
12	58	59	143	110	147	156	179	210	179	126	58	66	1,490
13	68	66	176	130	184	203	245	246	230	175	68	89	1,880
Grand Total	221	238	620	484	695	680	774	841	678	534	231	251	6,246
											Annual kWh Savings		68,705

Where for each hour of the day for each month:

$$\text{kW Demand Reduction}_h = \text{Base Case kW Demand}_h - \text{Post Case kW Demand}_h$$

$$\text{Monthly Ave On Peak Savings} = \frac{\sum_{h=12}^{h=13} \text{kW}_h}{6 \text{ hours}}$$

$$\text{Average On Peak Savings} = \frac{\sum_{m=6}^{m=10} \text{Monthly Ave On Peak Savings}_m \times \text{Peak Days}_m}{\sum \text{Peak Days}}$$

Where Peak Days were:

Peak Months	Jun	Jul	Aug	Sep	Oct	Total
Peak Days	22	21	22	21	3	89

Inputs to Model

Parameter	Value Reported	Units	Notes
City	Bloomington		
Climate Zone			
Pre-Retrofit Hours of Operation	2,000	hrs/yr	Operating hrs based on 8 hrs/day, 5 days per week for 50 weeks/yr
Pre-Retrofit Indoor Temperature	45	°F	Observed
Pre-Retrofit Gap	0.5	ft	Average measured gap
Pre-Retrofit Door Width	8.0	ft	Measured
Number of Doors in Operation	11		Observed
Pre-Retrofit Wind Speed	See Table 2	mph	NOAA Weather Data for Ontario Airport
Pre-Retrofit Ave. Temp. Diff.	See Table 2	°F	NOAA Weather Data for Ontario Airport
Post-Retrofit Hours of Operation	2,000	hrs/yr	Operating hrs based on 8 hrs/day, 5 days per week for 50 weeks/yr
Pre-Retrofit Indoor Temperature	45	°F	Observed
Post-Retrofit Gap	0.063	ft	Average measured gap
Post-Retrofit Door Width	8.0	ft	Measured
Number of Doors in Operation	11		Observed
Post-Retrofit Wind Speed	See Table 2	mph	NOAA Weather Data for Ontario Airport
Post-Retrofit Ave. Temp. Diff.	See Table 2	°F	NOAA Weather Data for Ontario Airport

SITE 40 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER:3 END USE: HVAC

Measure	Install a variable speed drive on an existing 450 ton, constant speed, centrifugal chiller.
Site Description	Large Office Building

Measure Description

The project involved installing a variable speed drive (VSD) and associated controls on an existing 450-ton, constant speed, centrifugal chiller. The chiller rarely operates above 65% load, but was unable to unload effectively. Installation of the VSD increased the efficiency of the unit at part load conditions.

Summary of Ex Ante Impact Calculations

The project was completed under the Calculated Savings Approach using engineering calculations. No Measurement & Verification was required.

The approved calculations are composed of two parts, chiller operating characteristics and chiller annual loading. Chiller kW/ton, both with and without the VSD, come from manufacturers specifications. The chiller annual load profile was developed using an eQUEST simulation. Savings are estimated by calculating the kWh consumed by the chiller with and without the VSD for the load profile and operating hours calculated by the eQUEST simulation.

Comments on Ex Ante Calculations

There are two savings estimates in the documentation. The first estimate is 122,343 kWh and 26.2 kW of savings. While there is documentation to support the chiller performance characteristics, there isn't any documentation to support the load profile or run-time of the chiller plant. The chiller performance data was developed based on a new chiller, operating with and without the VSD. The baseline chiller had a nominal efficiency of 0.554 kW/ton. Title 20 minimum efficiency for chillers exceeding 300 tons capacity is 0.576 kW/ton. With the VSD, the retrofit chiller has a nominal efficiency of 0.569 kW/ton. The program administrator rejected this estimate, with a request for additional supporting data.

The next and approved set of calculations used the output of an eQUEST simulation as the basis for the chiller annual load profile. The simulation output was in a tabular format with annual operating hours provided for each 10 percent of nominal chiller load. Savings were estimated by calculating the kWh consumption of the chiller for each load bin as follows:

- $kWh_{bin} = kW/ton_{bin} * tons_{bin} * annual\ hours_{bin}$

The chiller performance (kW/ton) was provided from chiller manufacturer , tons from the load bin and hours from the eQUEST simulation. While the manufacturers data is presumably based on performance testing, the eQUEST simulation is provided without much detail. The simulation does not include loads greater than 65% of the chillers nominal capacity. Approximately 45% of the savings associated with the project is achieved when the chiller load is under 30% of the nominal capacity.

Evaluation Process

The evaluation process consists of a review of the application form and supporting documentation, conducting an on-site survey and then estimating impacts. For this project, the goal was to verify that the specified equipment was installed and that the assumptions used in the development of the model were reasonable.

A site survey was performed on September 18th, 2003. During that survey, the equipment was inspected and the building operator (applicant) was interviewed. The equipment installation was verified as consistent with what was specified in the application materials. The interview with the facility operator revealed several interesting pieces of information regarding the operation of the chiller:

- Operating Hours: The facility operating hours are 6:00 AM to 6:00 PM M-F during the winter months, 3:00 AM to 6:00 PM M-F during the summer months, 8:00 AM to 5:00 PM Saturdays all year and 8:00 AM to 5:00 PM on Sundays from January through mid-April. These operating hours accommodate the Internal Revenue Service and are increased around the April 15th tax filing deadline.
- The chiller is capacity limited to 65% to reduce demand charges. The chiller cannot go above 65% without a manual override from the operator. The operator stated that the override only occurs during the peak summer days.
- Maximum cooling load, is typically 65% of the nominal chiller capacity.
- System has a water-side economizer installed. This plate and frame heat exchanger, in parallel with the chiller, provides free cooling to the building when outside temperatures are cool enough.

The information we gathered on site confirms the inputs that were used in the eQUEST model used to calculate the ex ante savings. We did not receive the input files for the eQUEST simulation, but documentation included with the application details the inputs and we have accepted the results of the simulation.

Scope of Impact Assessment

The impact assessment covered all of the measures at the site.

Additional Notes

The savings calculations for the application are simple, however, they do appear to be reasonably accurate.

With consideration for the amount of the incentive, the level of M&V employed at this site is probably sufficient to accurately determine the impacts of the installed measure.

Economic Information

Project Economic Summary

Description	Date	Project Cost	Estimated Demand Savings, kW	Estimated Energy Savings, kWh	Estimated Gas Savings, therms	Estimated Annual Cost Savings ($0.13/kWh) $	SPC Incentive, $	Simple Payback w/ incentive, yrs	Simple Payback w/o incentive, yrs
Application Submitted Amount	5/10/2002	$50,235	26	122,343	0	$15,905	$17,128.00	2.08	3.16
Application Approved Amount	7/19/2002	$50,235	-	99,591	0	$12,947	$13,943.00	2.80	3.88
Installation Approved Amount	12/24/2002	$50,235	-	99,591	0	$12,947	$13,943.00	2.80	3.88
SPC Program Review	5/26/2004	$50,235		99,591	0	$12,947	$13,943.00	2.80	3.88

Impact Results

	kW	kWh	Therm
SPC Tracking System or Application	0	99,591	N/A
Adjusted Engineering	0	99,591	N/A
Engineering Realization Rate	NA	100%	N/A

SITE 41 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL   TIER: 3   END USE: HVAC

Measure	Air-Cooled Central Air Conditioner – 60-ton Split System
Site Description	Yogurt Manufacturing Facility

Measure Description

The customer replaced three air conditioning units with one larger capacity unit with economizer capability. The existing three units totaled 44 tons of capacity and did not have working economizer controls. The new unit is 60-ton, 11.0 EER and full economizer controls. Baseline for calculating savings is a 60-ton unit without economizer and an EER rating of 9.5.

The original 5/8/02 application stated a savings of 192,711 kWh/yr. for replacing the old units without working economizer with a new 50-ton 11.0 EER unit with economizer. This estimate was prepared using an "AC&R" software tool. The initial review of the application pointed out that Title 24 calls for economizer control for this size unit and recalculated the savings using SPC software for just the improvement over base case EER. The resulting savings estimate was 9,441 kWh/yr. The application was also reviewed a second time coming up with an estimate of 36,513 kWh savings using eQuest software. The review notes include a statement that eQuest is designed for commercial buildings and does not handle industrial situations well. This review report contained very detailed information about the facility.

The customer pointed out that economizer is not required by Title 24 for this industrial application and asked that their application be reconsidered. The application was then reviewed a third time and an estimate of 125,566 kWh/yr. savings including economizer savings was calculated with the SPC software. This review resulted in the offer of a $17,579.24 incentive.

After installation, the customer submitted an Installation Report, which included an estimated of savings of 125,645 kWh/yr. The estimate was developed using the AC&R module of the SPC software. The Installation Report Review showed that the proposed equipment was installed as specified, except that a 60-ton unit was installed. The incentive payment of $17,579.24 was approved and paid, but the savings estimate was based on the originally proposed 50 ton unit. The reviewer stated that the SPC Program establishes energy savings based on the existing 50 ton usage (although the pre-retrofit capacity is clearly stated as 44 tons).

Summary of Ex Ante Impact Calculations

An SPC software estimate was prepared comparing a baseline 50-ton unit (9.5 EER) without economizer with a new unit of 50-tons with economizer. (Note: The existing three units totaled 44 tons.) This calculation was done based on the two old 12.5 ton units using economizer control, the old 20 ton unit not using economizer control and a new 50 ton unit using economizer control. However, according to file notes and the customer, the economizer was not used on any of the old units.

Comments on Ex Ante Calculations

Tracking system savings of 125,566 kWh/year matches file savings prepared in the installation report. However, the installation report savings was based on an analysis for a 50-ton unit. Actually a 60-ton unit was installed. Also, the air conditioning requirement for plug load alone exceeds 80 tons. So unit savings are more than reported in the installation report, because the year-round cooling needs will be greater than is typical for a commercial building.

The second application review included documentation of the construction of the room that the unit served and the equipment in the room. The plug load consists of 325-hp of equipment, plus lights and personnel. The average electric load comes to 300 kW. Cooling needed for 300 kW of heat gain in a space is:

300 kW x 3,413 Btuh/kW / 12,000 Btuh/ton = 85 tons

Evaluation Process

The evaluation process consisted of a review of the application forms and supporting documentation, conducting an on-site survey and then computing impacts using the on-site data.

The on-site survey was conducted on December 9, 2003. Information on the retrofit equipment and operating conditions was collected through an inspection of the 60-ton unit and through an interview with the installing contractor.

The facility makes yogurt. The area served by the 60-ton unit in the application is the fill room. This is an area where the operators are concerned about contamination of the product. The outside air dampers were kept closed on the three old units because of this concern. The new unit has a HEPA filter; so full economizer capability can be used.

Through site observations, interviews with plant staff and the installing contractor, an understanding of the daily schedule of operation and the true demand for the pre- and post-retrofit air conditioning was developed.

The fill room operates three shifts, 6 days a week. Two shifts are production and one is disinfection. As reported in the Pre-Installation Inspection #2 report, there is 325-hp of equipment operating at a duty cycle of 50%, plus 35 kW of lighting. The average power density comes to 8.5 W/sf. The area is staffed with 10 people at a time. The motor loads included the following equipment:

- (8) Tanks – Agitators
  - (6) @ 20HP
  - (2) @ 25 HP
- (8) Pumps @ 7.5 HP
- (5) Yogurt Fillers @ 5HP
- (10) Blenders @ 5HP
- Misc. – 15HP (Conveyors, etc.)

This approximately 300 kW peak load requires over 80 tons of air conditioning alone:

300 kW x 3,413 Btuh/kW / 12,000 Btuh/ton = 85 tons

Plus there is the solar gain from the roof, gains from personnel, and so on. The facility Energy Manager said that the system does not always maintain the setpoint of 70 all the time, but it does better than the 44 tons of capacity that they had before. The installation contractor also confirmed that comfort conditions would require more than 80 tons, but a compromise in sizing was reached due to budget limitations.

Our site visit has verified that the information supporting the ex ante calculations as provided in the project application is correct, and we feel that the only adjustment required is to adjust the application for the actual installed capacity of the new air conditioning unit. The new unit has a 60-ton nominal capacity versus the 50-ton capacity used in the simulation for the project. Since we determined that even the 60-ton unit is in fact under sized for the application, our simplified approach for this project is to prorate the energy savings and demand reduction based on the ratio of the capacity of the unit actually installed (60 tons) to the capacity of the unit used in the simulation (50 tons). We feel that this simplified approach, though not ideal, yields a more realistic estimate of the savings for this project.

Ex Post Analysis:

Annual kWh savings= (60 tons/50 tons) x 125,566 kWh
Annual kWh savings= 150,679 kWh

Demand Reduction = (60 tons/50 tons) x 3.7 kW kWh
Demand Reduction = 4.4 kW

Scope of Impact Assessment

This was the only measure installed by this customer that received incentives from the program.

Additional Notes

The level of M&V employed at this site is sufficient to accurately determine the impacts of the installed measure. No further evalaution is justified for this customer.

Economic Information

Description	Date	Project Cost	Estimated Demand Savings, kW	Estimated Energy Savings, kWh	Estimated Gas Savings, therms	Estimated Annual Cost Savings ($0.13/kWh), $	SPC Incentive, $	Simple Payback w/ incentive, yrs	Simple Payback w/o incentive, yrs
Installation Approved Amount	1/15/2003	$286,000	3.7	125,566	0	$16,324	$17,579	16.44	17.52
SPC Program Review	4/28/2005	$286,000	4.4	150,679	0	$19,588	$17,579	13.70	14.60

Impact Results

	kW	kWh	Therm
SPC Tracking System	3.7	125,566	0
Installation Report	3.7	125,566	0
Adjusted Engineering	4.4	150,679	0
Engineering Realization Rate	120%	120%	N/A

SITE 42 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER:3 END USE: HVAC

Measure	Install new refrigeration control system with floating suction and floating head pressure control along with variable frequency drives on condenser fans.
Site Description	Refrigerated Warehouse

Measure Description

Installed a new refrigeration control system for the refrigerated warehouse. The refrigeration system consists of two 25-hp low temperature reciprocating compressors, two 60-hp medium temperature reciprocating compressors, and one 125-hp screw compressor for the blast freezer. Heat rejection for the compressors is performed by one evaporative condenser (Evapco: LSCA250).

The new control system controls the suction pressures, condensing pressures, and condenser fan motor speed. The suction pressure is controlled by the refrigerated space temperatures. It floats up when the space temperature decreases and floats down when the space temperature increases. The condensing temperature setpoint also floats based on the wet-bulb temperature and a condenser approach of 25°F. The VFDs on the condenser fans are controlled to maintain the condenser temperature setpoint.

Summary of Ex Ante Impact Calculations

The savings were estimated by using hourly weather data for the local CEC climate zone and the technical data sheets for the compressors. This information was used to estimate the energy use of the compressors at the expected operating conditions.

The baseline compressor energy use was estimated from the compressor technical data sheets and constant operating conditions. The suction temperatures for the low-temperature, mid-temperature and blast freezer compressors were -24°F, 15°F and -40°F, respectively. The condensing temperature for all three systems was 95°F.

The calculations showed the suction temperatures floating with changes in the hourly wet-bulb temperature, which was used to approximate the refrigeration load. The amount the suction pressure was allowed to float was limited based on the system. For the low-temperature and blast freezer compressors, the maximum float was 4° F above the design suction temperature. The medium temperature compressors were allowed to float up to a maximum of 2° F above the design suction temperature. The hourly float was estimated by setting it to zero at the design wetbulb temperature (69°F) and increasing the suction temperature linearly to the maximum float at a wetbulb temperature of 35°F.

The hourly condensing temperatures were estimated by adding the condenser design approach temperature (25° F) to the hourly wet-bulb temperature. The condensing temperature was limited to a minimum of 70° F.

The kW per ton of the compressors at the different suction and condensing temperatures were calculated and subtracted from the baseline kW per ton. The savings were estimated by multiplying the kW per ton by the compressor runtime (25% of the time during low load and 100% during higher loads), which was estimated from discussions with the facility’s refrigeration engineer.

Comments on Ex Ante Calculations

The calculation approach is reasonable. Estimating the refrigeration load is difficult so using the wet-bulb temperature and the lead engineer's estimate of compressor runtime is a reasonable approximation. The hourly suction and condensing temperatures also appear reasonable. In most cases, lowering the condensing temperature will increase condenser fan energy, but setting the maximum reduction in condenser fan speed to 30% and minimizing the condensing temperature at 70° F, makes these savings reasonable.

The only issue concerning the original assumptions involves the independent savings calculations for the floating suction and condensing temperatures. These two measures would operate simultaneously so there is some double dipping of savings in this estimate. However, this is a very small percentage of the savings.

Evaluation Process

The evaluation process consists of a review of the application form, calculations and supporting documentation, conducting an on-site survey and then computing impacts using data available from the sites Human Interface Machine (HIM).

The on-site survey was conducted on September 18, 2003. Information on the retrofit equipment and operating conditions was collected through an interview with the facility maintenance manager.

Although long-term trended data was not available from the site, the current conditions of the refrigeration system were noted and a few weekly profiles observed during the onsite survey. The typical shipping schedule for the warehouse is 14 hours per day, Monday through Friday. However, activity is occurring at the warehouse 24 hours per day seven days per week. The compressor data showed that the suction pressure was floating, but appeared to operating at much lower temperatures than originally estimated. The floating suction temperature at the time of the survey for each of the systems was noted to be:

- Low Temperature Compressors: - 34°F
- Medium Temperature Compressors: - 4.9°F
- Blast Freezer: - 38°F

In addition, to these spot readings daily and weekly trends were documented. The expected range of suction temperatures for the low-temperature, medium-temperature, and blast-freezers were -24°F to -20°F, +15°F to +17°F and -40°F to -36°F, respectively. Of these, only the blast freezer appeared to be in the appropriate range. The low-temperature compressor was operating in a range of -52°F to -32°F and the medium temperature compressor was operating between -14°F to 23°F suction temperature.

The condenser temperature also appeared to float, although at the time of the site survey the ambient wet-bulb temperature was relatively constant at 68°F and the condensing temperature stayed around 94°F to 95°F. The variable frequency drive fluctuated from 14% to 100% during this period. The condenser fan motor was almost always 100% while the blast freezer compressors were operating (8 hours at night).

The average compressor kW during the week of September 1, 2003 to September 7, 2003 was approximately 100 kW without the blast freezer compressors and 175 kW when they were running.

The results show that the blast freezer compressors appear to be operating at higher suction temperatures, but the other compressors are operating at much lower suction temperatures. The lower suction temperatures were confirmed by the lead engineer. The suction temperatures were reduced because the facility discovered that the product was too warm and therefore, required a lower setpoint.

The condenser fans appear to be saving energy and the condensing temperatures also appear to float as described in the application.

At the onsite survey, it was verified that the floating suction and condensing temperatures were operating, although based on on-site collected measurements the suction temperatures were much lower than originally estimated. This was also confirmed from the onsite interview, which established that the suction temperatures had to be lowered because the product was too warm. Based on these results, there is a strong indication that the floating suction temperature measure will not save energy. The other measures appear to have the ability to save the amount of energy originally estimated. Therefore, **the savings associated with the floating suction temperatures have been subtracted from the original savings estimate**, resulting in an ex-post estimate of 212,720 kWh.

Scope of Impact Assessment

The full project, involving one site and three measures, was reviewed for reasonableness. The site survey occurred on September 18, 2003.

Additional Notes

Reviewing the savings through trended data would provide an effective verification analysis; however, data is not currently being trended. Since the onsite personnel are not able to set up trends, a programmer from the controls manufacturer would need to start the trends and collect the data. While that approach was not economically feasible for this evaluation, setting up trends as needed, prior to and after installation, should be a future program consideration for sites equipped with EMCS systems.

Impact Results

	KW	KWh	Therm
SPC Tracking System or Application	N/A	237,353	0
Adjusted Engineering	N/A	212,720	0
Engineering Realization Rate	N/A	89.6%	N/A

SITE 43 IMPACT EVALUATION
SAMPLE CELL: ORIGINAL TIER:3 END USE: HVAC

Measure	Chiller and Cooling Tower Upgrade
Site Description	Food processing facility

Measure Description

Replace three centrifugal chillers with a total capacity of 780 tons with a new 800-ton York unit and an oversized cooling tower to provide low temperature condenser water.

Summary of Ex Ante Impact Calculations

Using actual measured values for chiller efficiency, chiller % load, and chiller kW demand for the period from 08/22/2003 to 10/06/2003, a table of standard values was developed for a typical annual TMY weather data. Two degrees temperature bins were used. A similar table of values was created for the baseline Title 24 chiller. Both tables were used to determine impacts.

Comments on Ex Ante Calculations

The calculation methodology used in this project assumed design conditions; entering condenser water at 69 °F and leaving chilled water at 42 °F, throughout the entire analysis. A simple analysis of the TMY weather data for this location reveals a substantial deviation from these conditions for a considerable part of the year.

Evaluation Process

The Evaluation process comprises reviewing the SPC application form and supporting documentation, conducting an on-site survey and then computing the impacts on results using on-site collected data.

The on-site survey was carried out on November 2003. Information on the retrofit equipment and operating conditions was collected through an inspection of the site and through an interview with the Plant Engineer.

The facility grows mushrooms in a controlled indoor environment. To satisfy the higher than normal internal loads from biomass (mushrooms and compost), low temperature chilled water, 42 °F, is circulated throughout the campus-like complex utilizing a variable volume pumping system. Under this program, three existing chillers with a total capacity of 780 tons were replaced with one 800-ton YORK chiller Model YKFCFDH7-CVE. A new oversized cooling tower, BAC Model 3872A-OM, was installed to take advantage of the energy savings by operating this chiller at low condenser water temperature.

Actual measured data was used to develop relationships between the chiller %-load, chiller efficiency and outdoor temperature conditions (Attachment B, and C). The chiller is available 24/7, 365 day per year. Energy impacts for the post case chiller are based on typical TMY weather data. For the baseline case, a Title 24 (or SPC) chiller performance curve, nominal efficiency, and chiller %load-measured data were used in the bin analysis. The following assumption were used to determined impacts:

Existing chiller efficiency = 0.950 kW/ton
Title 24 nominal chiller efficiency = 0.576 kW/ton (See attachment D)
Design Conditions assumed 42 °F CHWS temperature

Table 1, included at the end of this report, presents measured value for chiller efficiency, chiller %-load, chiller demand, and capacity. These values were obtained by using the customers energy management system for an outdoor temperature range of 53 – 73 °F. For temperatures <53 °F and >73 °F, the %load and kW/ton values were assumed to be equal to their respective low and high limit values. Chiller efficiency at various temperatures were determined from Title 24 performance coefficients (see attach. D) For the pre-retrofit chiller.

Additional Notes

To reflect more accurately the actual chiller operating conditions, more data was needed. This is evident by just looking at the outside air temperature range described in the paragraph above and the TMY temperature bins of table 1. Ideally, one year of 1-hr. intervals should be collected.

Impact Results

	KW	KWh	Therm
SPC Application Calculations	115.5	657,315	NA
Adjusted Engineering	-73	321,408	NA
Engineering Realization Rate	0.00	0.49	NA

Economic Information

Description	Date	Project Cost	Estimated Demand Savings, kW	Estimated Energy Savings, kWh	Estimated Gas Savings, therms	[1]Estimated Annual Cost Savings, $	SPC Incentive, $	Simple Payback w/ incentive, yrs	Simple Payback w/o incentive, yrs
Application Submitted Amount	4/8/2002	$650,000	118	674,169	0	$87,641.97	$94,383.66	6.34	7.42
Application Approved Amount	5/28/2002	$650,000	116	657,315	0	$85,450.95	$92,024.10	6.53	7.61
Installation Approved Amount	6/24/2002	$650,000	116	657,315	0	$85,450.95	$92,024.10	6.53	7.61
SPC Program Review	1/9/2004	$650,000	0	321,408	0	$41,783.04	$92,024.10	13.35	15.56

[1]Assuming $0.13/kWh and $0.55/therm

Table 1. Measured Parameters - Post Retrofit Chiller

Post-Retrofit Chiller	
Nom. Eff.	0.428
Nom. Tons	780
Nom. kW	342

Mid-pts	Outdoor DB Temperature (F)	[1]Operating Hours per Year	% Load on Chiller (Actual)	Tons Output	Efficiency (kW/ton)	Peak Demand (kW)	Annual Energy Use (kWh/yr)
93	92 to 94	1	96.79	755	0.66	498.27	498.27
91	90 to 92	5	96.79	755	0.66	498.27	2,491.37
89	88 to 90	4	96.79	755	0.66	498.27	1,993.10
87	86 to 88	7	96.79	755	0.66	498.27	3,487.92
85	84 to 86	7	96.79	755	0.66	498.27	3,487.92
83	82 to 84	13	96.79	755	0.66	498.27	6,477.57
81	80 to 82	17	96.79	755	0.66	498.27	8,470.67
79	78 to 80	23	96.79	755	0.66	498.27	11,460.32
77	76 to 78	32	96.79	755	0.66	498.27	15,944.80
75	74 to 76	40	96.79	755	0.66	498.27	19,931.00
73	72 to 74	67	96.79	755	0.66	498.21	33,380.29
71	70 to 72	125	96.02	749	0.63	472.96	59,119.42
69	68 to 70	202	93.77	731	0.60	441.13	89,107.74
67	66 to 68	252	90.05	702	0.57	403.66	101,723.10
65	64 to 66	376	84.84	662	0.55	361.50	135,925.68
63	62 to 64	574	78.13	609	0.52	315.60	181,155.65
61	60 to 62	728	69.91	545	0.49	266.92	194,314.38
59	58 to 60	971	60.17	469	0.46	216.41	210,135.68
57	56 to 58	1245	48.91	381	0.43	165.07	205,508.54
55	54 to 56	1075	36.11	282	0.40	113.87	122,406.43
53	52 to 54	998	36.11	282	0.38	105.88	105,663.49
51	50 to 52	791	36.11	282	0.35	97.88	77,420.04
49	48 to 50	443	36.11	282	0.32	89.88	39,815.54
47	46 to 48	306	36.11	282	0.32	89.88	27,502.38
45	44 to 46	208	36.11	282	0.32	89.88	18,694.43
43	42 to 44	154	36.11	282	0.32	89.88	13,841.07
41	40 to 42	63	36.11	282	0.32	89.88	5,662.26
39	38 to 40	25	36.11	282	0.32	89.88	2,246.93
37	36 to 38	4	36.11	282	0.32	89.88	359.51
35	34 to 36	4	36.11	282	0.32	89.88	359.51
	TOTALS	**8760**				**498**	**1,698,585.01**

[1]Actual annual chiller operating hours are 8760 according to maintenance personnel

Table 2. SPC Chiller - Baseline

SPC Baseline Chiller	
Nom. Eff.	0.576
Nom. Tons	780
Nom. kW	449.28

Mid-pts	Outdoor DB Temperature (F)	[1]Operating Hours per Year	% Load on Chiller (Actual)	Tons Output	Efficiency (kW/ton)	Peak Demand (kW)	Annual Energy Use (kWh/yr)
93	92 to 94	1	96.79	755	0.564	425.65	425.65
91	90 to 92	5	96.79	755	0.564	425.65	2,128.25
89	88 to 90	4	96.79	755	0.564	425.65	1,702.60
87	86 to 88	7	96.79	755	0.564	425.65	2,979.55
85	84 to 86	7	96.79	755	0.564	425.65	2,979.55
83	82 to 84	13	96.79	755	0.564	425.65	5,533.44
81	80 to 82	17	96.79	755	0.564	425.65	7,236.04
79	78 to 80	23	96.79	755	0.564	425.65	9,789.93
77	76 to 78	32	96.79	755	0.564	425.65	13,620.78
75	74 to 76	40	96.79	755	0.564	425.65	17,025.97
73	72 to 74	67	96.79	755	0.564	425.66	28,519.30
71	70 to 72	125	96.02	749	0.555	415.73	51,966.73
69	68 to 70	202	93.77	731	0.546	399.46	80,690.65
67	66 to 68	252	90.05	702	0.537	377.37	95,097.23
65	64 to 66	376	84.84	662	0.538	355.97	133,844.19
63	62 to 64	574	78.13	609	0.538	328.04	188,297.32
61	60 to 62	728	69.91	545	0.534	291.03	211,868.46
59	58 to 60	971	60.17	469	0.535	251.01	243,730.53
57	56 to 58	1245	48.91	381	0.540	206.07	256,557.07
55	54 to 56	1075	36.11	282	0.581	163.59	175,856.93
53	52 to 54	998	36.11	282	0.581	163.60	163,271.97
51	50 to 52	791	36.11	282	0.581	163.60	129,406.94
49	48 to 50	443	36.11	282	0.581	163.60	72,474.43
47	46 to 48	306	36.11	282	0.581	163.60	50,061.35
45	44 to 46	208	36.11	282	0.581	163.60	34,028.63
43	42 to 44	154	36.11	282	0.581	163.60	25,194.27
41	40 to 42	63	36.11	282	0.581	163.60	10,306.75
39	38 to 40	25	36.11	282	0.581	163.60	4,089.98
37	36 to 38	4	36.11	282	0.581	163.60	654.40
35	34 to 36	4	36.11	282	0.581	163.60	654.40
	TOTALS	**8760**				**426**	**2,019,993.25**

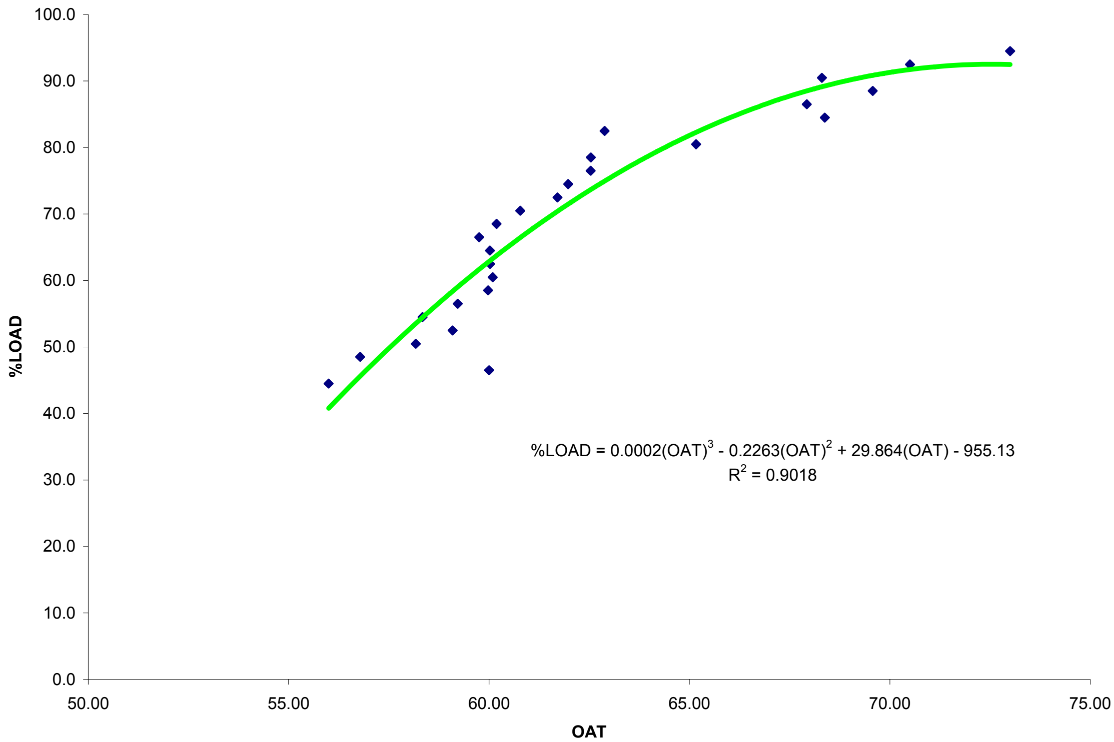
[1]Actual annual chiller operating hours are 8760 according to maintenance personnel

ATTACHMENT A
TITLE 24 MINIMUM EFFICIENCIES FOR CHILLER ABOVE 300 TONS

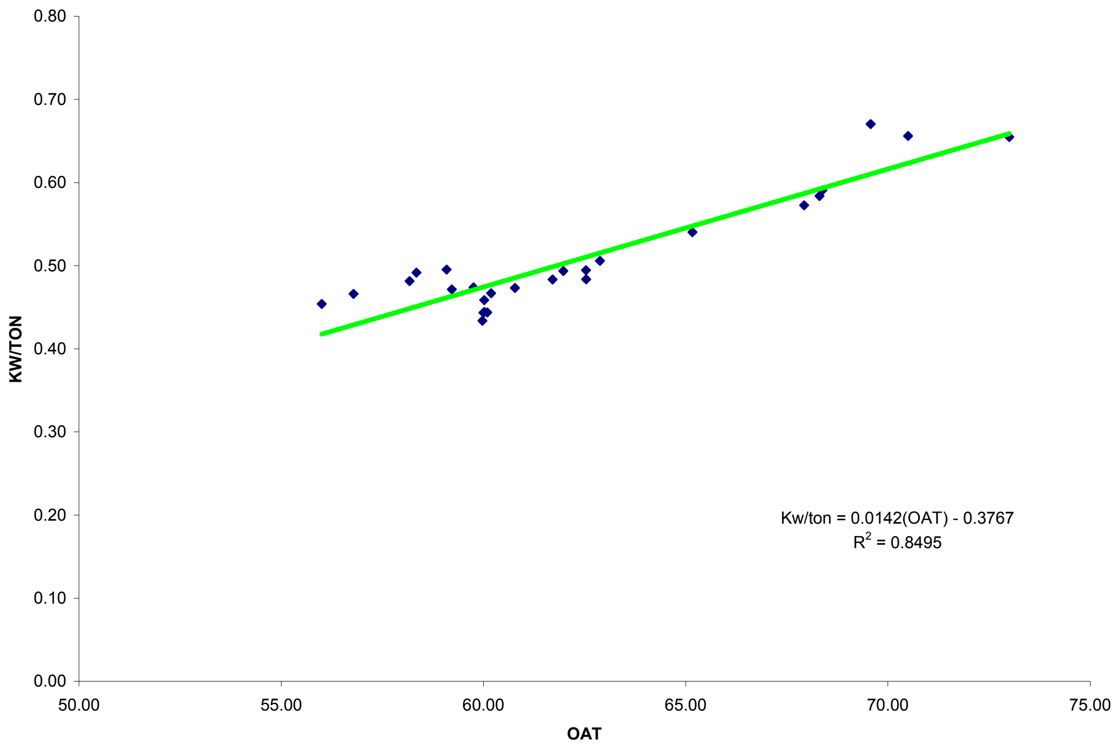
Table C3 – WATER CHILLING PACKAGES – MINIMUM EFFICIENCY REQUIREMENTS (TABLE 1-C3)

Equipment Type	Size Category	Efficiency prior to 10/29/2001	Efficiency as of 10/29/2001	Test Procedure
Air Cooled, With Condenser, Electrically Operated	< 150 Tons	2.70 COP 2.80 IPLV	2.80 COP 2.80 IPLV	ARI 550 or ARI 590 as appropriate
	≥150 Tons	2.50 COP 2.50 IPLV		
Air Cooled, Without Condenser, Electrically Operated	All Capacities	3.10 COP 3.20 IPLV	3.10 COP 3.10 IPLV	
Water Cooled, Electrically Operated, Positive Displacement (Reciprocating)	All Capacities	3.80 COP 3.90 IPLV	4.20 COP 4.65 IPLV	ARI 590
Water Cooled, Electrically Operated, Positive Displacement (Rotary Screw and Scroll)	< 150 Tons	3.80 COP 3.90 IPLV	4.45 COP 4.50 IPLV	ARI 550 or ARI 590 as appropriate
	≥150 Tons and < 300 Tons	4.20 COP 4.50 IPLV	4.90 COP 4.95 IPLV	
	≥300 Tons □	5.20 COP 5.30 IPLV	5.50 COP 5.60 IPLV	
Water Cooled, Electrically Operated, Centrifugal	< 150 Tons	3.80 COP 3.90 IPLV	5.00 COP 5.00 IPLV	ARI 550
	≥150 Tons and < 300 Tons	4.20 COP 4.50 IPLV	5.55 COP 5.55 IPLV	
	≥300 Tons □	5.20 COP 5.30 IPLV	6.10 COP 6.10 IPLV	
Air Cooled Absorption Single Effect	All Capacities	N/A	0.60 COP	ARI 560
Water Cooled Absorption Single Effect	All Capacities	N/A	0.70 COP	
Absorption Double Effect, Indirect-Fired	All Capacities	N/A N/A	1.00 COP 1.05 IPLV	
Absorption Double Effect, Direct-Fired	All Capacities	N/A N/A	1.00 COP 1.00 IPLV	

ATTACHMENT B
RELATIONSHIP BETWEEN ACTUAL CHILLER LOAD AND OUTDOOR TEMPERATURE



ATTACHMENT C
RELATIONSHIP BETWEEN ACTUAL CHILLER EFFICIENCY (kW/TON) AND OUTDOOR TEMPERATURE



ATTACHMENT D
BASELINE CHILLER PERFORMACE CURVES – FROM 2003 SPC MANUAL

Chiller Performance Curves
Chiller Type: **Centrifugal Chiller - Water Cooled**

	a	b	c	d	e	f
Capacity Correction (T_{out}, T_{in})	-0.29861976	0.02996076	-0.00080125	0.01736268	-0.00032606	0.00063139
Part Load Efficiency (PLR)	0.17149273	0.58820208	0.23737257	0.00000000	0.00000000	0.00000000
Temp. Efficiency (T_{out}, T_{in})	0.51777196	-0.00400363	0.00002028	0.00698793	0.00008290	-0.00015467

Nominal Efficiency	**0.576**
Nominal Tons	**780**
Nominal kW	**449.28**

OAT_{db}	Current Data			Calculated Values				Efficiency			Chiller kW
	Tons Output	Condenser Temp	Supply temp	Current Capacity (CAP-FT)	Part Load Ratio	Part Load Adjustment to EIR(EIR-FPLR)	Ambient Adjustment to EIR (EIR-FT)	EIR	COP	kW/Ton	
>74	780	85.0	44.0	741	1.053	1.05	1.00	0.1632	6.13	0.574	447.63
73	755	84.0	44.0	749	1.008	1.01	0.98	0.1604	6.24	0.564	425.67
71	749	83.0	44.0	756	0.991	0.99	0.97	0.1579	6.33	0.555	415.77
69	731	82.0	44.0	763	0.958	0.95	0.95	0.1553	6.44	0.546	399.22
67	702	81.0	44.0	769	0.913	0.91	0.94	0.1528	6.54	0.537	377.16
65	662	79.0	42.0	763	0.868	0.86	0.94	0.1530	6.54	0.538	356.11
63	609	79.0	42.0	763	0.798	0.79	0.94	0.1531	6.53	0.538	327.84
61	545	78.0	42.0	769	0.709	0.71	0.93	0.1518	6.59	0.534	290.88
59	469	77.0	42.0	774	0.606	0.62	0.91	0.1521	6.57	0.535	250.83
57	382	75.0	42.0	783	0.488	0.52	0.89	0.1536	6.51	0.540	206.35
<=55	282	74.0	42.0	786	0.359	0.41	0.88	0.1652	6.05	0.581	163.80

SPC Chiller Performance Curves Coefficients:

Curve	a	b	c	d	e	f
CAP-FT	-0.29861976	0.02996076	-0.00080125	0.01736268	-0.00032606	0.00063139
EIR-FT	0.51777196	-0.00400363	0.00002028	0.00698793	0.00008290	-0.00015467
EIR-FPLR	0.17149273	0.58820208	0.23737257	0.00000000	0.00000000	0.00000000

SITE 01 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Adjustable Speed Drives-Water Services	P			White water transfer pumps, replace recirculation system with VSD				Measure not evaluated.
Motors Project (Process)	P			Grissom Injection Plant piping efficiency upgrade and de-stage injection pump A5				Measure not evaluated.
Motors Project (Process)	P			Freeman Injection plant piping efficiency upgrade and de-stage injection pumps	2	Destaged two 1,750-hp oil field water injection pumps and revised piping to eliminate highest pressure injection pumps.	New piping observed. SCADA system output tracking actual pre- and post-kW.	

SITE 02 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Modified Steel Furnace	P			Insallation of "oxy-fuel lances" to an existing steel furnace	3	New lances inject gas through wall of furnace instead of through open door. This reduces heat loss and improves distribution of gas, which helps the electrodes to melt steel.	Lance connections visually verified on the furnace.	

SITE 03 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Compressor replacement	P			Replace old 150 hp one-stage rotary compressor with new 200 hp compressor with VSD		200 hp compressor with VFD		This project not evaluated.
Ammonia System upgrades	P			suction pressure raised from 25 psi to 35 psi on chillers in east compressor room	1	system reconfiguration and enhanced controls	visually verified and measurements obtained	
Ammonia System upgrades	P			suction pressure raised from 25 psi to 35 psi on chillers in west compressor room	1	system reconfiguration and enhanced controls	visually verified and measurements obtained	
Ammonia System upgrades	P			CLX control system	1	enhanced refrig. control system	visually verified and measurements obtained	

SITE 04 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Auto Purger installation	P			Autopurger on Condenser loop	1	Auto purger system was installed on the ammonia refrigeration system	verbal verification from customer	

SITE 05 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Replace Pumps with higher eff, pumps that utilize VFD and prem. Eff. Motors that will increase mine pumping rate.	P			Pumping system upgrades (pumps and VFD's)			Verified- Nameplate HP was gathered for all pumps	PU-004 was 45hp (not 75hp); PU-39 was 300 hp (not 280 HP)
Revise Tailings /Water supply pumping system	P			Pumping system upgrades (pumps and VFD's)			Not verified- site not visited	

SITE 06 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
AIR COMPRESSOR SYSTEM CHANGE/MODIFY	4-P			Compressor pad modification		New controller; storage and dryer	Verified	

SITE 07 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Controls to HVAC	P			Guestroom EMS system. Room HVAC controlled w/ Occ. Sensor and networked to server	1,050	Guestroom EMS system.	Verified. Observed new EMS system operation.	Installed in 1050 rooms

SITE 08 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
UV Water Treatment	P			replace existing medium pressure UV lamp units with low pressure UV lamp unit	512	low pressure UV lamp unit	Physically Observed	

SITE 09 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
HVAC AFD	H							
HVAC AFD	H							
HVAC AFD	H							
HVAC AFD	H							
VSD for Processes	P			VSD installed on 50 hp "Polar" Condenser Water Pump	1	Yaskawa VSD on Chiller #10 CDW pump	Installed and operating	
VSD for Processes	P			VSDs installed on Alcids filter pumps	3	3 15-hp filter pumps	Installed and operating	
VSD for Processes	P			VSDs installed on "Penguin" filter pumps	4	4 20-hp filter pumps	Installed and operating	
VSD for Processes	P			VSDs installed on "Shark" filter pumps	4	4 20-hp filter pumps	Installed and operating	
Modify Distribution Systems - Whole	P			Install VFD's on circulation pumps.			Physically verified installation of VFD's and associated controls.	
AC&R Cooling Units	H							Measure not evaluated.

SITE 10 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
VFD on injection molding machine	P			VFD on machine #13 HPM	1	275 HP machine	VFD visually verified as being installed	
VFD on injection molding machine	P			VFD on machine #15 HPM	1	210 HP machine	VFD visually verified as being installed	
VFD on injection molding machine	P			VFD on machine #16 Toshiba	1	150 HP machine	Not Installed	Item from original application, but not part of the PIR, so this item should be deleted from verification.
VFD on injection molding machine	P			VFD on machine #8 Toshiba	1	120 HP machine	Not Installed	Item from original application, but not part of the PIR, so this item should be deleted from verification.
VFD on injection molding machine	P			VFD on machine #2 HPM	1	125 HP machine	VFD visually verified as being installed	
VFD on injection molding machine	P			VFD on machine #3 HPM	1	125 HP machine	VFD visually verified as being installed	
VFD on injection molding machine	P			VFD on machine #4 HPM	1	125 HP machine	VFD visually verified as being installed	
VFD on injection molding machine	P			VFD on machine #14 HPM	1	125 HP machine	VFD visually verified as being installed	
VFD on injection molding machine	P			VFD on machine #5 Cincinnati	1	120 HP machine	VFD visually verified as being installed	
VFD on injection molding machine	P			VFD on machine #12 HPM	1	225 HP machine	Not Installed	Item from original application, but not part of the PIR, so this item should be deleted from verification.
VFD on injection molding machine	P			VFD on machine #6 HPM	1	85 HP machine	VFD visually verified as being installed	
VFD on injection molding machine	P			VFD on machine #1 Cincinnati	1	100 HP machine	Not Installed	Item from original application, but not part of the PIR, so this item should be deleted from verification.
VFD on injection molding machine	P			VFD on machine #9 Hartig	1	150 HP machine	VFD visually verified as being installed	

SITE 11 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Chiller VFD	2-H	Install VFD on existing chiller			1	CHLR 2	Verified	M&V approach for this measure verify monitoring is in place
VFD on SF - 1&2 50 HP	3-O			VFD on HVAC supply fans	2		Verified	
Cooling Tower 25 HP	3-O			Install oversize cooling tower	1		Verified	
VSD on CDWP 30 HP	3-O			VSD for condenser water pump	2		Verified	
VSD on CHWP 20 HP	3-O			VSD for chilled water pumps	2		Verified	
VSD on HHWP 15 HP	3-O			VSD for Hot water pumps	2		Verified	
Lighting	1-L		Lighitng retrofit				Verified	

SITE 12 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Indoor System Replacement - Fluorescent	L	Lamp and ballast replacements				NA	NA	Installation reviewer determined installed lamps were first generation T-8's. Entire lighting incentive was disallowed.
Air Compressor System	P			Air compressor system modifications		Two 4,500 HP reciprocating air compressors. Two 200 HP rotary screw air compressors. Three 62,000 gallon air receivers.	The following were physically verified: Installation of unloaders on compressor # 3. Installation of three 62,000 gallon air receivers on the Lab Air system. Relocation of two 200 HP plant air compressors from B4 to B10.	

SITE 13 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
AIR COMPRESSOR SYSTEM CHANGE/MODIFY	P			Install an energy management and control system	1	Air compressors	Verified	M&V approach for this measure verify monitoring is in place

SITE 14 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
VFD on Boiler forced draft fan	**P**			VFD on Forced draft fan for more precise control of airflow into the combustion chamber	1	Danfoss Graham VFD Serial # 013221H262 Material# 175Z7358	Verified	
PROCESS BOILER CHANGE/ADD	4-P			Upgrade burner control on existing boiler for oxygen trimming	1	AutoFlame MK6 Evolution MM/EGA System MM60001	Verified	

SITE 15 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
AIR COMPRESSER SYSTEM CHANGE/MODIFY	P			Compressor pad modification	1	Installled two new compressors	Verified	In lieu of modifying the existing comperssor system, the customer installed a new compressor system and retained the existing one for back up purposes.

SITE 16 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Compressor replacement	P			Replace Old 150 hp compressor with new 150 HP compressor with VSD	1	New Atlas Copco GA90VSD air compressor installed	Visual verification and measurements obtained	

SITE 17 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Indoor System Replacement - Fluorescent	L		Replace 250 W and 400 W metal halide and HPS fixtures with 4 lamp T-5 fixtures. T-8's replaced 8' T-12 HO in selected areas.		Installation report lists more than 1800 fixtures.	4 lamp T-5 Pentron HO fixtures, T-8's in selected areas	Spot checking of selected areas. T-5 and T-8 installed.	Post installation review report lists fixture counts by area. Some areas were not easy to differentiate during the site visit. Facility manager was somewhat confused by area naming.
Occupancy Sensors	L		Install occupancy sensors to control T-5 fixtures in most areas.		Occupancy sensors were not counted.	Occupancy sensors installed for all areas except Truck and Forklift repair, Truck Wash.	Verified that occupancy sensors were installed in most areas.	

SITE 18 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Lighting Controls- EMS	L		Doesn't look like EMS, but rather like lighting replacements for different fixture types		4,321	Campus-Wide lighting upgrade to T-8's and CFL's.	Excellent agreement with ex ante measure list in the two buildings surveyed.	Hours of operation vary by location.
EMS (Space Conditioning)	H	Upgrade EMS, HVAC fan motor VFD, new multi-zone packaged unit						Measure not evaluated.
Lighting Controls- EMS	L							Measure not evaluated.
Motors Project (Process)	P							Measure not evaluated.
Package Units Replacement	H							Measure not evaluated.

SITE 19 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
New lighting fixtures and occupancy/daylighting controls	L		504 F46ILL-V fixtures in rack isle		504	located in distribution warehouse. Sensors mounted to	Counted fixtures, observed controls	Daylighting sensors have been deactivated.
New lighting fixtures and occupancy/daylighting controls	L		Occupancy sensors for 504 F46ILL-V fixtures in rack isle		504	located in distribution warehouse. Sensors mounted to	Counted fixtures, observed controls	Daylighting sensors have been deactivated.
New lighting fixtures and occupancy/daylighting controls	L		Daylighting for 504 F46ILL-V fixtures in rack isle		504	located in distribution warehouse. Sensors mounted to	Counted fixtures, observed controls	Daylighting sensors have been deactivated.
New lighting fixtures and occupancy/daylighting controls	L		372+100 F46ILL-V fixtures in open bay			located in distribution warehouse. Sensors mounted to	Observed Fixtures & controls	Daylighting sensors have been deactivated.
New lighting fixtures and occupancy/daylighting controls	L		Daylighting for 372+100 F46ILL-V fixtures in open bay			located in distribution warehouse. Sensors mounted to	Observed Fixtures & controls	Daylighting sensors have been deactivated.

Measure Description	Target End-Use	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Installation of Occupancy Sensors and Lighting Energy Management System	L		Occupancy sensors for Fluorescent lights in all buildings			117 fixtures in private offices	Several offices inspected and controls found	
Installation of Occupancy Sensors and Lighting Energy Management System	L		Occupancy sensors for HID lights in warehouse			338 fixtures	Did not appear to be installed	
Lighting Retrofit	L		Replacement of Metal Halide with Pulse start Metal halide Lighting			338 fixtures all buildings (1 lamp/fixture)	Fixtures installed were mostly 5-lamp high output T-5 fixtures	
Lighting Retrofit	L		Replacement of T-12 with T8			246 fixtures all buildings (4 lamps/fixture)	Sample of fixtures appeared consistent with application types	
Lighting Retrofit	L		Replacement of T-12 with T8			561 fixtures all buildings (2 lamps/fixture)	Sample of fixtures appeared consistent with application types	
Lighting Retrofit	L		Replacement of Incandescent with Compact Fluorescent			30 fixtures - all buildings	Sample of fixtures appeared consistent with application types	
High eff. Motors	L			Replace Chilled water pump motor P1 with Higher Efficiency Motors		US Electric G29315	Verified US Electric Motor 91.7% efficient	
High eff. Motors	L			Replace Chilled water pump motor P2 with Higher Efficiency Motors		US Electric G74265	Verified US Electric Motor 92.4% eff.	
High eff. Motors	L			Replace Paper blower fan motor with Higher Efficiency Motors		Baldor EM3313T	Verified Baldor Motor 91.7% efficient	
VSD on motor	L			VSD on Main Chilled Water Pump		ABB ACH401601632	Onsite staff said installed	VFD was located inside panel that could not be opened without shutting down process motors

SITE 21 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Lighting Retrofit & Sensors	L		Replace 1000 W MH with T-8 lamps and sensors in manufacturing area		60	New T-8 fixtures with photocell control	Physically observed in operation.	This area is now used for warehouse.
Lighting Retrofit	L		Replace 1000 W MH with T-8 lamps in manufacturing area		168	New T-8 fixtures with photocell control	Physically observed in operation.	These 168 are in the "task" area.
Lighting Retrofit & Sensors	L		Replace 400W HPS with T-8 lamps and sensors in warehouse		402	New T-8 fixtures with photocell control and occupancy sensors	Physically observed in operation.	Warehouse
Lighting Retrofit	L		Replace 400W HPS with T-8 lamps in warehouse		67	New T-8, but run 24 hours.	Physically observed in operation.	Warehouse staging
Lighting Retrofit	L		Replace T12 with T-8 lamps		65	New T-8 fixtures are in place.	Physically observed in operation.	Office areas.

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SITE 22 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Chiller	H							Measure not evaluated.
Upgraded Lighting	L		Installation or T8 fixtures with motion sensors to replace MH and T12 fixtures		2,608		Fixtures and Motion Sensors Verified	
Downsize air Compressor	P							Measure not evaluated.
Lighting Controls	L		Installation or T8 fixtures with motion sensors to replace MH fixtures		476		Fixtures and Motion Sensors Verified	

SITE 23 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
ADD HIGH EFFICIENCY CHILLER	H	HVAC retrofit - plant to single zone, Att. 2 and 3 in application			Two of 16 facilities	replaced air cooled chillers with high efficiency units.	Verified	Of the two facilities evaluated herein, one was designated as an air cooled chiller that would be changed to single zone packaged units. Instead, the actual retrofit was to change the old chiller with a high efficiency air cooled chiller.
HVAC OTHER MOTOR	H	HVAC retrofit - plant to single zone, Att. 2 and 3 in application			Two of 16 facilities	Installed energy efficient motors	Verified	
LIGHTING - OTHER	L		Lighting Retrofits, multiple lamp types		Completed sample counts at two of 16 facilities and extrapolated to entire facilities	T-8 Lighting retrofits	Verified	
NON-PROCESS BOILER CHANGE/ADD	P			Gas savings as part of the plant to single zone retrofit	0		Not Verified	

SITE 24 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Indoor System Replacement - HID	L		Replace metal halide with T5 fixtures in building 902					This site not visited
<75 Ton Chiller	H	Replace a 4 package units of various tonnages with more efficient equipment						This site not visited
Indoor System Modification - Fluorescent	L		Replace 3-lamp fluorescent fixtures with T8 lamps and electronic ballasts					This site not visited
Lighting Controls- EMS	L		Expand EMS system to control additional lights		1,550 2 lamp t-12 fixtures controlled by powerline carrier system.	Powerline carrier system controls cafeteria and office lights in selected areas.	Inspected control system. Viewed lighting schedules for each group of switches.	
Motors Project (Process)	P			Six evaporative cooling units were replaced with units that had premium efficiency motors	SIX	100 HP premium efficiency motors.	Facility representative verified installation.	
Lighting-Install low light cameras, turn off perimeter security Lights	L			Install low light cameras, turn off perimeter security Lights	73- 1,000 watt HPS lights deactivated from automatic control.	Low light security cameras installed. Perimeter security lights now on manual control instead of photocells.	Viewed camera operation from security room. Saw manual switches for perimeter lights. Discussed operation with facility representatives.	

SITE 25 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
New lighting fixtures and occupancy controls	L		468 4-lamp fixtures on 30 ft ceiling		468	4 foot T-5s and occupancy sensors	Physically Observed	
New lighting fixtures and occupancy controls	L		312 6-lamp fixtures on 40 ft ceiling		312	4 foot T-5s and occupancy sensors	Physically Observed	

SITE 26 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Indoor System Modifcation - Fluorescent	L	Lighting controls			102.2 kW	97.4 kW	95% of the installed wattage was verified as part of the evaluation	Lighting fixtures were counted in and total wattage estimated for two out of four spaces in the facility. Verified lighting wattages resulted in a reduction in savings of about 4%.
Variable Speed Drives	P			VFDs on air handler fans	6		6 VSD's were verified on-site	VSD's were observed to be operating over a range of frequencies

SITE 27 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Indoor System Modification - Fluorescent	L		Replace various fixtures with more efficient fixtures		The Install report lists nearly 6,800 fixtures.	Most of the project involves delamping of T-8 fixtures with ballast replacement, some incandescent, metal halide and MV replacements.	Spot Checking of fixture counts and type was performed in selected buildings.	
Occupancy Sensors	L		Install occupancy sensors		The Install report lists 500 sensors.	Occupancy sensors installed in selected areas.	Spot Checking for occupancy sensors was performed in selected buildings.	
Outdoor System Modification	L		Stadium lighting modification		76- 1,500 Watt metal halide Stadium lights.	1,500 watt metal halide Stadium lights.	76 lights were verified installed for the stadium. Lighting watts was verified with facilities personnel.	
Motors Project (Process)	P			Motor conversions	Six premium efficiency motors	One 40 HP-94.5% efficient. Three 30 HP-94.1% efficient. Two 15 HP 92.4% efficient.	Six motors were physically verified.	
Adjustable Speed Drives-Refrigeration	H	Air handler motors			2 VFD's installed.	40 HP VFD installed on AH-3 and 15 HP VFD installed on AH-2. Both are located in the PE Building.	VFD installation physically verified.	
200-600 Ton Chiller	H	Chiller conversion-evaporative condenser added in series with air cooled condenser for two 70 ton Air cooled chillers.			4 Evaporative condensers-one for each compressor.	Chiller conversion-evaporative condenser added in series with air cooled condenser for two 70 ton Air cooled chillers.	Installation of 4 evaporative condensers was physically verified for the air cooled chillers serving Building S.	

SITE 28 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
High Efficiency Motor	4-P			high efficiency motor retrofit		No - equipment in restricted area	Unable to verify- equipment in restricted area	
VSD for HVAC Supply Fans	3-O			VSD on HVAC Supply Fans		No - equipment in restricted area	Unable to verify- equipment in restricted area	
VSD for HVAC Supply Fans	3-O			VSD on HVAC Supply Fans		No - equipment in restricted area	Unable to verify- equipment in restricted area	
Lighting	1-L		Retrofit existing 4008 Fluorescent fixtures, T-12 lamps and magnetic ballast to T-8 and electronic Ballast			Verified - fixtures were examined in a sample of spaces.	spot check of fixtures.	
High Efficiency Motor	4-P			high efficiency motor retrofit		No - equipment in restricted area	Unable to verify- equipment in restricted area	
High Efficiency Motor	4-P			high efficiency motor retrofit		No - equipment in restricted area	Unable to verify- equipment in restricted area	

SITE 29 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Indoor System Replacement - Fluorescent	L		replace T-12 fluorescents with T-8 fluorescents		Did not count all fixtures.	T-8 lamps replaced T-12. Delampling in some areas.	Verified T-8's installed	
Occupancy Sensors	L							Not Installed. Measure removed from Application.
<75 Ton Chiller	H							5 Rooftop Packaged AC units were replaced. Did not verify.

SITE 30 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Remove engine room 2, re-pipe building 2 loads to engine room 1	P			Remove engine room 2, re-pipe building 2 loads to engine room 1			Verified - compressors physically removed from building 2. Pipes connection building 2 to building 1 compressors	
Remove engine room K, cold room piping, condenser piping and controls (VFD's too), and compressor controls	P			Remove engine room K, cold room piping, condenser piping and controls (VFD's too), and compressor controls			Verified - compressors physically removed from engine room K. Pipes connecting Building K to Building C compressors.	

SITE 31 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Remove engine room 2, re-pipe building 2 loads to engine room 1	P			Remove engine room 2, re-pipe building 2 loads to engine room 1			Verified - compressors physically removed from building 2. Pipes connection building 2 to building 1 compressors	
Remove engine room K, cold room piping, condenser piping and controls (VFD's too), and compressor controls	P			Remove engine room K, cold room piping, condenser piping and controls (VFD's too), and compressor controls			Verified - compressors physically removed from engine room K. Pipes connecting Building K to Building C compressors.	

SITE 32 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
LIGHTING CONTROLS	L				Surveyed two of ten completed stores. Counted all fixtures	Lighting control systems	Verified	Only ten sites were installed.
HVAC CONTROLS	H				0	Anti sweat heater controls.	Not Verified	

SITE 33 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
PROCESS OTHER	P			Reset VAV boxes using EMS	1	Installed new thermostats, Digital controllers, and digital VAV boxes	Verified	Two Sites installed
INSTALL HVAC EMS	H	Reset VAV boxes using EMS			1	Installed new thermostats, Digital controllers, and digital VAV boxes	Verified	Two Sites installed

SITE 34 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Refrigeration controls	P			LOGIX Automatic Refrigeration Control system	1	LOGIX Automatic Refrigeration Control system	Physically Observed	
Refrigeration controls	P			VFDs on all 6 condenser fan motors	6	VFDs on all 6 condenser fan motors-total 90 hp	Physically Observed	

SITE 35 IMPACT EVALUATION

Measure Description	Target End-Use	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Refrigeration System Modification	H			consolidate juice chilling on 2 compressors		compressors #4 and #5	Compressors #3, #4, #5 along with their condensers were combined onto a single loop	
Refrigeration System Modification	H			add 3 new high efficiency ammonia plate chiller units		added to single existing chiller with compressor #4 and #5	3 High Efficiency Ammonia Chillers were installed, and a fourth was installed for chiller #2 (compressor #3)	
Refrigeration System Modification	H			raise suction and lower discharge pressures			The suction and discharge temperatures appeared to be able to float, but were at their original temperatures at the site visit.	
Refrigeration System Modification	H			VFD on 3 Condenser Fans			VFDs were installed for the 3 condenser fans, but the condenser fans were not operating at the time of the site audit.	
Refrigeration System Modification	H			VFD on one Compressor			The VFD for the compressor was not installed.	

SITE 36 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
CHANGE/ADD OTHER EQUIPMENT	H	Replace 2-1000 ton chillers			1	Replaced one 1000 ton chiller	Verified	The original application was for the replacement of two, 1,000 ton chillers. The final project was for the replacement of one chiller, and the rebate was paid accordingly.

SITE 37 IMPACT EVALUATION

Measure Description	Target End-Use	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
HVAC system Retrofit	H	Replacement of Coils at AHUs			46	New cooling coils	Installation verified by Building Engineer.	AHU casing modified to accommodate taller and deeper coils. Coils increased chilled water TD and lowered air side PD.
HVAC system Retrofit	H	VFD on Existing Chiller			1	VFD on 1100 ton Carrier chiller	Physically verified.	VFD installed by Carrier. Carrier chiller used to charge TES system off peak.
HVAC system Retrofit	H	Modification Chilled water and TES system piping			NA	New piping and control valves	Installation verified by Building Engineer.	Chilled water piping modified to allow series or parallel operation of chillers.
HVAC system Retrofit	H	VFD on Chilled Water pumps			1	VFD on Chilled water pump for 1100 ton Carrier chiller	Physically verified.	
HVAC system Retrofit	H	Controls Integration with Electric Strip Heaters			Multiple	New DDC controllers to replace drum-type contactors, added capability in EMS	Installation verified by Building Engineer.	50 kW electric heaters in each AHU now controlled in 4 stages by new Siemens Apogee system.
HVAC system Retrofit	H	DDC control for optimal use of HVAC system			NA	Siemens DDC system	Installation verified by Building Engineer.	

SITE 38 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
INSTALL HVAC EMS	2-H	EMS room controls for hotel (when rooms are not occupied)				Twist timer on Room Heat pump	Verified in one room	
INSTALL HVAC EMS	2-H	EMS room controls for hotel (when rooms are not occupied)				Controls interface at Check-in desk	verified- System control was verified by altering the state of the heat pump in one room.	

SITE 39 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Refrigeration	H	Replace dock door seals			12	New door seals narrowed the gap along the top of the trucks, preventing the escape of refrigerated air from the warehouse.	Observed 12 new seals.	Hours of operation from 6:00 am to 2:00 pm, M-F.

SITE 40 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
HVAC	H	VFD added to chiller			1	VFD added to drive train of existing chiller.	Verfiied make, model and operating conditions of chiller w/drive.	

SITE 41 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Rooftop AC retrofit	H	Replace 3 rooftop AC units with single split system			1	Haakon industries Custom Manufactured HVAC system	Physically observed the new unit and its operation	3 small units were replaced with 1 larger unit.

SITE 42 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
New refrigeration control system	H			Opto22 SNAP series controller and I/O modules	1	New Control System w/ workstation and controllers	The new workstation and trend data was reviewed to verify operation	
New refrigeration control system	H			GE Fanuc Touchscreen Operator Interface Terminal	1	New Control System w/ workstation and controllers	The new workstation and trend data was reviewed to verify operation	
New refrigeration control system	H			Dell NT PC with Opto22 FactoryFloor software	1	New VFD for evaporator fan	The new workstation and trend data was reviewed to verify operation. VFD was visibly verified to be installed.	

SITE 43 IMPACT EVALUATION

Measure Description	End-Use Category	HVAC Measure Description	Lighting Measure Description	Process Measure Description	Count	Equipment Description	Installation Verified (Explain)	Notes
Chiller Retrofit	H	Replace 2-300 and 1-150 Ton chillers with New 800 ton chiller			1	York 800 Ton Chiller	Verified	Old chiller still on premises but non-operational. Only used for backup
New Cooling tower for 800 ton chiller	H	Install new Cooling tower capable of providing the 800 Ton Chiller with Low Temp			1	BAC 2 Cell Cooling tower Model# 3872AOM2 Serial#UO2	Verified	New Tower piped exclusively to the 800 Ton chiller. Old towers still present. One in use with smaller 300 Ton chiller, and one removed from loop.