Impact Evaluation of the Non-Residential Custom Program and the Residential Home Improvement Program: FY 2008/09

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Final Report

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EXECUTIVE SUMMARY

The City of Lodi has a number of energy efficiency programs offered through its utility department. This report describes the results of an Evaluation, Measurement, and Verification (EM&V) study for two of Lodi's energy efficiency programs:

- The Commercial Rebate Program
- The Residential Home Improvement Program

This evaluation represents year two of Lodi's EM&V efforts. In year one, the commercial rebate program and the residential appliance efficiency program were evaluated. The commercial rebate program was evaluated again in year two because of its high contribution (~90%) to the total savings accruing from Lodi's energy efficiency programs.

Background

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

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

Objectives

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

- Useful recommendations and feedback to improve the Lodi programs.
- Assessment of conservation program effectiveness.
- Assessment of the quality of the program data for impact evaluation purposes.
- Increased level of confidence in conservation program results through transparent protocols.

Key Findings and Recommendations

The overall conclusion is that the City of Lodi has very well-run residential and commercial DSM programs, and the program offerings to its customers are extensive and comprehensive. However, some improvements in documenting projects are recommended and include:

1. ***Improved documentation of some Commercial Rebate Program lighting installations.*** One of the three lighting retrofits did not include a detailed calculation of savings. This made the project difficult to verify since minimal information on the baseline conditions was available. Since there were many fixtures permanently shut off in the facility, it was difficult to determine if these had been included in the retrofit or if other units were counted in their place. Additionally, the hours used on the application did not appear to match those at the store, but due to the lack of documentation, it was difficult to determine the reason for this discrepancy.

2. ***Improved estimation of equipment usage at one Commercial Rebate Program site***. One of the program participants based savings calculations on rated equipment power. While on-site measurements might not have been practical, some de-rating is almost always required from peak power on production equipment and this should have been allowed for in calculations.

3. ***Improved data on the number of installed radiant barrier units in the Residential Home Improvement Program***. Deemed savings are based on the amount of radiant barrier square footage installed. However, this information was missing from the majority of applications and supporting invoice material for this measure.

Summary of Program Level Measure Realization Rates

Overall, the program realization rates for the two programs evaluated were found to be very close to expected levels. Table EX-1 summarizes the measure realization rates estimated through this evaluation.

Table EX-1: Program Realization Rates for the City of Lodi

Program	Savings Claimed (kWh)	Savings Verified (kWh)	Measure Realization Rate
Commercial Rebate Program	1,033,443	991,983	96%
The Residential Home Improvement Program	24,283	23,385	96%
TOTAL EVALUATED	1,057,726	1,015,323	96%

1 EVALUATION OVERVIEW

1.1 Current Program Offerings

Since 1998, Lodi has spent nearly $7 million on demand-side management rebates and programs designed to increase energy efficiency for the community, resulting in a 14% peak demand reduction and an 11% energy reduction.

Efficiency Program Summaries

Current Residential Customer Programs:

- *Lodi Appliance Rebate Program:* Provides rebates to all customers who purchase an ENERGY STAR ® refrigerator, dishwasher and or front-loading clothes washer.

- *Lodi Energy Efficient Home Improvement Rebate Program:* Provides rebates to customers who install qualifying measures as next described. Rebates are capped at a per customer amount of either $350 per customer, until funds are exhausted, plus an additional $250 allowance for air duct repairs, OR an additional $700 allowance for air duct replacement, if eligible.
    - **HVAC Replacement** - Customers that purchase and install new heating, ventilation and air conditioning (HVAC) with a high efficiency seasonal energy efficiency rating (SEER) can receive a rebate: $175 for a 14+ SEER HVAC unit or 13 SEER rooftop unit with variable speed drive or $275 for installation of an ultra-high efficiency of 17+ SEER HVAC unit. (Requires participation in the HVAC System Performance Test.).
    - **Attic Insulation**- A rebate of $0.15 per square foot is available if customer installs attic insulation up to an R-38 (energy efficiency) value;.
    - **Radiant Barrier/Thermal Shield -** A maximum rebate of $150 for radiant barrier/thermal shield is available.
    - **Wall Insulation** - A rebate of $0.15 per square foot is available if customer installs wall insulation with an R-8 or greater energy efficiency value.
    - **Air Duct Repairs** - A maximum rebate of $250 is available if customer has leaky or damaged air ducts repaired (Requires participation in the HVAC System Performance Test.).
    - **Air Duct Replacement** - A maximum rebate of $700 (Requires participation in the HVAC System Performance Test.).
    - **Whole House Fan** - Install a whole house fan in home and receive a rebate of $100.
    - **Attic Fan** - Install an attic fan and receive a rebate of $40;
    - **Shade Screen/Window Tinting** - Install shade screens or window tinting and receive a rebate of $0.50 per square foot. *Note: the shade screen or window tinting must block at least 70% of the solar heat gain or sun's rays and the shade screens or window tinting must cover (at a minimum) the west and south facing windows of the home.*

- *HVAC System Performance Test:* Provides a rebate for customers who utilize a select list of HVAC contractors capable of performing a high-end duct system performance test (the test measures air flow, air return, and system balance).

Current School (In-Classroom) Programs:

- *Lodi LivingWise Program:* Provides energy efficiency "kits" and manuals to 445 sixth grade students in Lodi schools; the program is designed to teach the students the basics of energy and water conservation.

- *Lodi Solar Schoolhouse Program:* Provides teacher mini-grants and teacher training regarding solar/renewable energy resources; also via this program, sponsors various solar fairs and events at individual schools.

Current Low-Income Residential Programs:

- *Lodi C.A.R.E. Package Program:* Provides grants to very low-income customers in need of assistance paying their electric utility account; the program coordination/customer screening is performed by the Lodi Salvation Army. In order to secure a grant payment, customers must consent to in an in-home energy audit.

Current Commercial/Industrial Customer Programs:

- *Lodi Energy Audit Program:* Lodi offers on-line and on-site residential energy audits as well as on-site small commercial customer energy audits.

- *Commercial (G-1 & G-2) Rebate Program:* Provides rebates for small and medium-sized commercial customers who install designated energy efficiency measures, such as attic insulation, window tinting/shade screens, programmable thermostats, ceiling fans, appliances, high efficiency lighting retrofits, and maintenance of refrigeration/HVAC equipment.

- *Lodi Commercial/Industrial (G-3 to I-1) Rebate Program:* Provides rebates of up to $12,500 to large commercial and industrial customers; the rebate is for pumps/motors, process equipment improvements, building envelope improvements, HVAC/chiller replacements, and high efficiency lighting retrofits.

1.2 Evaluation Priorities

In the 2009 program year, it is estimated that over 90% of Lodi's net annual energy savings will come from non-residential energy efficiency program. Nearly 95% of the energy savings from non-residential projects is expected to be from lighting measures. Because of these high savings estimates, the non-residential energy efficiency program has the highest priority for receiving an independent impact evaluation.

2 IMPACT EVALUATION OF THE COMMERCIAL REBATE PROGRAM

In order to comply with state requirements, municipal utilities in California require independent verification of their energy efficiency incentive programs. The objective of the evaluation of the City of Lodi Electric Utility Commercial Rebate program is to determine if the savings for the program are in line with those claimed through rebate applications. The methodology and activities used in the impact evaluation are discussed below.

2.1 Impact Evaluation Methodology Overview

The methodologies employed to measure and verify energy savings attributed to the Commercial Rebate Program included the following activities:

1. Completed measure installation verifications.
    a. Developed a sample for field verification activities.
    b. Conducted field verification activities and observations, which could include the installation of data logging equipment, if appropriate.
    c. Reviewed applications and supporting documentation provided to the City of Lodi Electric Utility.
    d. Developed adjusted measure savings values based on field activities and data reviews.
2. Provided conclusions and recommendations for City of Lodi Electric Utility Commercial Rebate Program.

These activities are discussed in detail in the following sections. Additional detailed information may be found in the appendices.

2.2 Measure Installation Verification

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

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

2.2.1 Installation Verification Sample

The Program had only five commercial installations during the 2009 program year. All five of these were included for onsite verification. Three of the five sites reviewed installed lighting retrofit measures. One of the remaining two sites installed a compressed air measure and the other installed more efficient injection molding equipment.

Table 2-1 details the verification results of the energy efficient installations and savings sampled that occurred under the Commercial Rebate Program for the City of Lodi Electric Utility.

Table 2-1. Verified Program Installations and Savings

Customer	Retrofit Measures	kW	kWh
Site 1	retrofit T-8 to reduced wattage and number	13.9	121,825
Site 2	T-12 and T-8 to reduced wattage T-8	17.5	110,299
Site 3	T-12 to T-8, more efficient T-8, reduced lamps, pulse start metal halide, and LED exit signs	19.0	150,182
Site 4	Replace hydraulic injection molding equipment with new all electric units	47	90,504
Site 5	Install two VFD air compressors	149	424,263
Program Total		246.6	894,267

Lighting retrofits, compressed air, and production equipment made up roughly equal portions of claimed program savings. However, as Table 2-2 shows, verified savings for the production equipment retrofit were a significantly smaller fraction of program savings than had been predicted.

Table 2-2. Distribution of Non-Residential Program Savings by Project Type

Project Category	Claimed Savings (kWh)	% of Claimed	Verified Savings (kWh)	% of Verified
Compressed air	388,200	38%	424,263	42.8%
Lighting	364,443	35%	382,306	38.5%
Production equipment	280,000	27%	185,414	18.7%
Total program savings	1,032,643	100%	991,983	100%

The Utility provided Summit Blue with application documentation for all five projects. Particular attention was paid to reviewing these documents and supplementing this work with select field measurements in reviewing the program.

Due to the relatively modest participant population of this Program, the evaluation team concluded that it would be cost effective and appropriate to verify all five projects as part of this review. The evaluation of the lighting retrofits involved an IPMVP Option A approach, involving engineering calculations and site interviews. The other two projects employed IPMVP Option B as well, involving field measurements as

well as engineering calculations and site interviews. The overall impact evaluation adhered to Chapter 6 of the California Energy Efficiency Policy Manual.[1]

In some cases deemed values were compared to calculated savings values. Only some of the implemented measures had standard deemed values available. These are considered an acceptable alternative to calculated values for CEC verification. T-12 to T-8 retrofits, incandescent exit sign replacement with LED units, delamping, and wall mounted occupancy sensors have standard deemed savings values. In each case, these results were compared to the calculated values. No deemed values were available for retrofitting 32 watt T-8 lamps with 28 watt lamps or installation of pulse start metal halide fixtures, so calculated values were combined with the available deemed savings for comparison to claimed and calculated savings. All three lighting projects showed greater savings than the deemed values so no deemed values were used in calculating program savings. Neither of the non-lighting projects had deemed savings available for comparison.

2.2.2 Site Verification Activities

Field activities involved two components:

1. Evaluators coordinated with the implementation contractor and primary customer contacts to establish field activity dates and identify site level contacts.
2. While on site, the evaluation team conducted an area-by-area, measure-by-measure audit, noting retrofit count, type, and operating conditions. Interviews were also conducted at the site representative's convenience.

Field evaluation activities were conducted on August 19-20, 2009. It was expected that all planned installations were completed and finalized. A total of five sites were verified. Appendix A provides additional installation details.

2.2.3 Installation Verification Results

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

Site 1 (Safeway)

Site 1 was a grocery store that had installed a lighting retrofit. T-8 fixtures on the sales floor and in refrigerated display cases had been retrofitted with a reduced number of lower wattage T-8 lamp and ballast combinations. The store originally contained standard 32 watt T-8 lamps and ballasts in all the retrofitted fixtures. Specification sheets for the new ballasts and a quote and invoice for the new items were included with the applications, although the invoice did not clearly state the model of the items purchased. Additionally, where lamps were accessible Summit Blue visually verified that they were of the new efficient type. Based on these observations the new units were determined to be installed as expected.

The application indicated 8,760 hours of operation for the store in all areas. Discussions with staff and posted store hours indicated that continuous operation was correct for this store. A detailed count of

[1] Version 2, August 2003

fixtures verified that most were present, as expected, based on the application. Only one three-lamp unit was not located.

The wattages used in the application were similar but not identical to the standard values used in California. This resulted in a slight reduction in verified savings relative to the application. Table 2-3 summarizes the findings.

Table 2-3. Site 1 Installation and Savings

	kW Savings	Annual kWh Savings
Claimed Savings	14.4	125,943
Verified Calculated Savings	13.9	121,825
Using Deemed Savings where Applicable	7.0	46,252
Realization Rate	96.5%	96.7%

Site 2 (Raley's)

Site 2 was also a grocery store that had installed a lighting retrofit. The majority of fixtures were switched from 32 watt T-8 lamps to 28 watt T-8 lamps, although 36 fixtures were retrofitted from five lamp T-12 units to four lamp 28 watt T-8 fixtures. The application indicated 5,800 hours of store operation.

The new 28 watt lamps were present in all fixtures where they could be observed, and so were presumed to be in all installed fixtures. Although the store hours were only 6,205 per year based on posted operation, discussions with management indicated that extended stocking operations resulted in 7,300 hours per year of use for the lights that were switchable. An extensive survey of the facility located 2,871 T-8 lamps as opposed to the 2,881 listed on the application. It is probable that most of these units were tandem wired, and dual lamp fixtures were used for calculations. The removed five lamp T-12 fixtures were assumed to use a two lamp and a three lamp ballast for calculation purposes.

A significant number of the fixtures were permanently turned off, for a total of 616 lamps. Approximately 70 lamps appeared to be on continuously for emergency lighting. The remaining 2,185 lamps and 36 checkout area fixtures counted were turned off outside of operating and stocking hours according to personnel. Operational hours of 7,300 per year were used for calculating energy savings on the fixtures, which were neither on nor off permanently. This is significantly higher than the 5,800 hours listed on the application, which is less than even the store's operating hours. However, the application did not account for the 616 lamps that were never on in estimating savings for this project. Nevertheless, the extended operating hours result in significantly higher savings than listed on the application. Only the T-12 to T-8 conversion and delamp had deemed savings available for comparison. Table 2-4 summarizes the findings.

Table 2-4. Site 2 Installation and Savings

	kW Savings	Annual kWh Savings
Claimed Savings	15.3	88,972
Verified Calculated Savings	17.5	110,299
Using Deemed Savings Where Applicable	16.8	101,749
Realization Rate	-	124%

Site 3 (General Mills Phase II)

Site 3 included a combination of T-12 to T-8 retrofits, replacement of T-8 units with more efficient lamp and ballast combinations, high pressure sodium to pulse start metal halide, and LED exit sign retrofits. In addition, a few room occupancy sensors were installed in offices. It was the largest site of the sample and this was the second phase of lighting retrofits, which have been ongoing at the site. The application to the utility claimed 149,528 kWh of electric savings. Although the retrofit largely matched the description in the application, there were a few issues, most commonly that the fixture wattages were not the standard values used in California.

The site consisted of some 60 buildings, six of which were included in the rebated retrofit. The buildings included in the retrofit included a corporate gym, offices, a boiler room, a cafeteria, labs, and restrooms. Lab and common areas operated from 6,000 to 8,760 hours per year depending on the area and offices were in use around 3,000 hours per year.

Overall, the retrofits fit into several categories:

1. High pressure sodium to pulse start metal halide retrofits
2. T-12 to T-8 retrofits with either ballast and lamp replacement in existing fixtures or complete replacement of fixtures, some with room occupancy sensors
3. Replacement of ballasts of existing T-8 fixtures
4. Replacement of compact fluorescent lamps with newer units
5. Installation of occupancy sensors in offices
6. Exit sign replacement from incandescent, 50 watt, units to LEDs

Pulse start metal halide units were observed to be in use where they were specified, as were T-8 lamps. The T-8 retrofits can be difficult to assess because they can include many different lamp and ballast combinations. It is very difficult to accurately determine which lamp and ballast are used in each location without opening each fixture for detailed examination. However, this is typically not practical, both because of time constraints and because of access difficulties. Several alternative options are available:

1. Discussions with facility personnel can sometimes reveal the type of lamps and ballasts used.

2. Examination of spares kept at the facility can often clarify what types of units are used on site. However, if many different types are in use, this does not always provide adequate information to determine the number of each type of unit.
3. Itemized invoices for the retrofits will typically provide a breakdown of how many of each type of lamp and ballast were purchased, but spares are often included in orders and this does not explain where the units are installed.
4. Retrofit listings will typically list the lamp and ballast description and wattages that can be matched to standard units. However, these lists are not always accurate by the time the final retrofit is implemented and should be compared to invoices and observations for accuracy.

All of the exit signs located within the retrofit areas were LED-based. Since the retrofit plan lists some signs that were already LED and others that were incandescent, Summit Blue has no reason to believe that the count taken prior to the retrofit was not accurate. Additionally, the purchase orders provided to the Program included 17 LED exit signs, although only seven are listed on the retrofit plan. Since manufacturer's data sheets were not provided, standard wattages are used for savings calculations.

Savings due to occupancy sensors was estimated to be 25%, slightly less than the 30% standard for office areas. This was based on discussions with facility personnel. However, due to the minimal number of occupancy sensors in the affected areas, this has only a small effect on savings.

The purchase order provided for this site generally agreed with the retrofit. This may be the result of both the purchase of spare units or units for other projects, but the discrepancy is minimal and the provided invoices indicate, for the most part, that the listed retrofits are basically accurate. Premium ballasts are listed on the invoices, so the descriptions on the retrofit plan are considered accurate.

Table 2-5 shows the total estimated savings for the site.

Table 2-5. Site 3 Installation and Savings

	kW Savings	Annual kWh Savings
Claimed Savings	18.9	149,528
Verified Calculated Savings	19.0	150,182
Using Deemed Savings where Applicable	21.9	127,182
Realization Rate	101%	100%

Site 4 (Quashnick)

Site 4 was a small industrial production facility, producing plastic parts. Three pieces of equipment used for injection molding of plastic parts were replaced with two newer units. The older equipment was partially hydraulic whereas the new units were all electric. Rated equipment power usage was used to estimate savings for the project application.

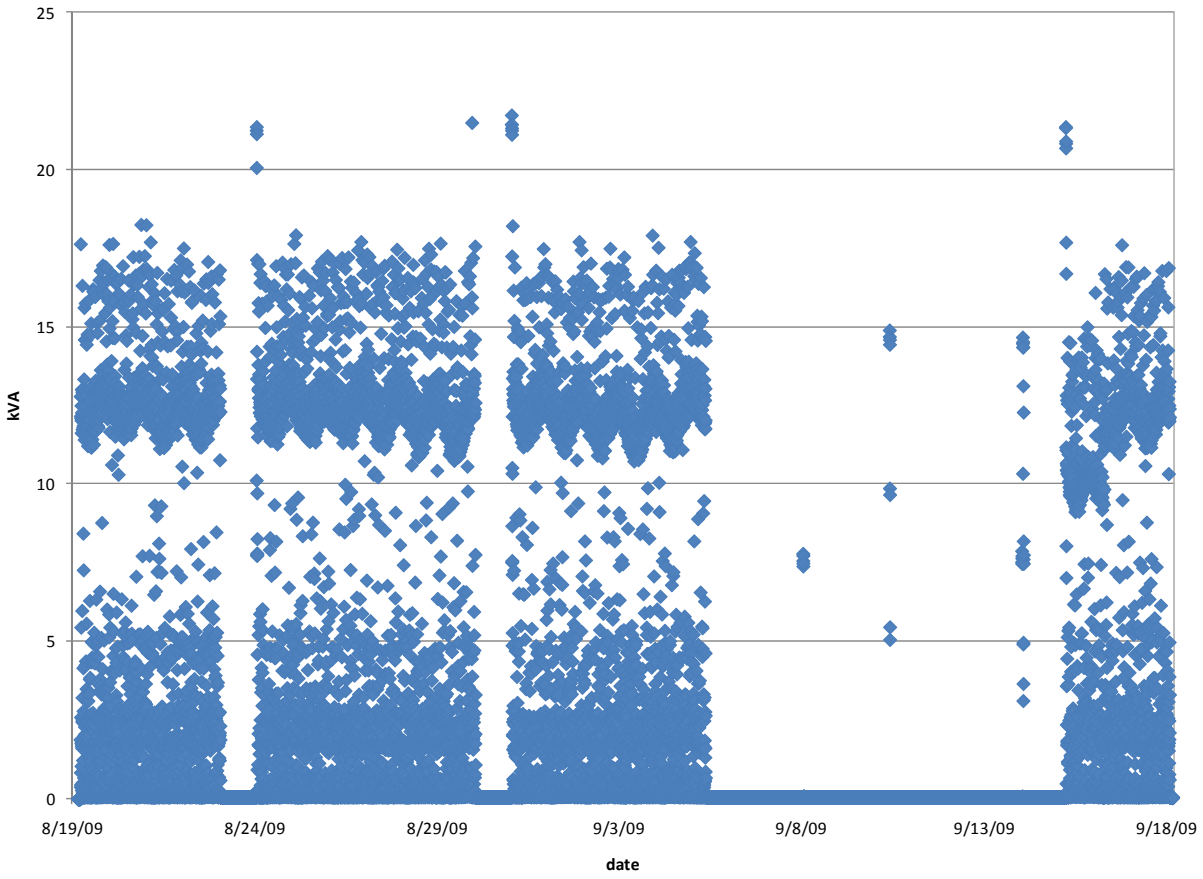
Since the three original units had been removed as part of this project and one of the new units was not operating during the time of this study, due to currently low production, only one unit could be measured to determine actual power usage. The rated power for units is listed below and was used for calculations where measurements were not possible.

Table 2-6. Site 4 Equipment Rated Power

Equipment	Component	Rated kW	Cycle Time (seconds)	Parts/ Cycle
Demag Ergotech 50/370-120	Main Unit	30	12	1
	Conair Tempo	8.3		
Van Dorn 50	main unit (2 total)	24.9 (ea)	44	2
	AEC Thermal Controller Pump	0.75		
	AEC Thermal Controller Heater	9		
Nissei NEX 2000	Heater	10.6	12	1
	Thermal Controller	0.75		
	Motor	18.5		
	Thermal Controller Heater	9		
Baseline total		136.7		
Nissei FNX 140	Heater	13.1	34.8	4
	Motor	7.5		
	Advantage Temperature Controller	5.3		
Nissei FNX 110-9E	Heater	7.3	8	2
	Motor	15		
	Conair Tempro Thermal Controller	0.75		
New total		48.95		

As shown in Figure 2-1, below, the power of an injection molder varies significantly during its operation. This is to be expected, as heaters will cycle on and off, and the loading of internal motors will vary during a production cycle. The plot is shown in kVA rather than kW because of variations in power factor, which could not be recorded by the single phase current logger used for recording these data. Spot measurements determined the power factor to be dropping as low as 0.25 and peaking around 0.99. Since the lower power factors corresponded to the lower amperages, presumably mostly the 0.75 kW controller, and higher values were more frequent during the measurement. The 7.3 kW heater should have a power factor of 1.0 and a new 15 kW motor would be expected to have a power factor around 0.9. Because of the variation in loads, an estimated power factor of 0.95 has been used for calculations. This should not introduce significant error into savings estimates relative to the estimates of operation and equipment unavailable for logging.

Figure 2-1. Site 4 Nissei FNX 110 Injection Molder kVA



The unit's rated power of 23.05 kW compares well to the peaks shown on this plot of 21.7 kVA; however, the average operating conditions of 5.2 kVA are only 23% of this value even without reducing by an estimated power factor of 0.95 that gives 5.0 kW, only 22% of the rating. Based on these measurements, all rated powers have been reduced by 75% for energy calculations. This should be a conservative estimate, as some tuning of the new units was still underway during logging and the old hydraulic units may have also run at a higher percentage of rated power. However, since no measurements were available on these units the 75% reduction has been applied to all equipment.

During the logged interval, the system operated approximately 60% of the time. The application assumed 240 days of 24 hour operation per year, or 66% of the time for all units. Although the second unit was not used during the four weeks of logging, the application hours have been accepted for all units since discussions with facility personnel indicated that they were currently at an abnormally low production cycle and that 20 days per month would be more typical.

The new systems also allows for increased production. According to facility personnel, previous production was 2.4 million parts per year and the current production is 3.2 million parts per year, a 33% increase. This is consistent with the available cycle times for part production, which are shown in Table 2-6, above. Based on these cycle times, and the fact that the facility contained two of the Van Dorn 50 systems, the slowest step in part production in the old system would has been reduced from 44 seconds to 34.8 seconds for four parts. This is a 26% reduction in step time, which is reasonably consistent with the 33% production increase. Since neither exact operational hours nor typical idle and loading times are known, the 33% increase in production is estimated to require a 30% increase in operational hours of the old equipment. Combining this with the estimated derated power use gives a baseline power use of 255,902 kWh/year for 3.2 million parts.

Table 2-7 shows the estimated annual savings. No demand savings were listed in the application materials provided to Summit Blue; however, demand savings would be expected and are based on the typical peak of around 75% of rated power.

Table 2-7. Site 4 Installation and Savings

	kW Savings	Annual kWh Savings
Claimed Savings	-	280,000
Verified Calculated Savings	65.8	185,414
Realization Rate	-	66%

The low realization rate at site 4 is due to the use of peak power in all calculations. Equipment rarely runs at peak power as heaters and motors will load and unload as production proceeds. However the production increase and the omission of one of the two Van Dorn 50 units in the application baseline have mitigated the effect of this power derating on the realization rate.

Site 5 (Pacific Coast Producers)

Site 5 was an industrial production facility. The site consisted of four buildings for processing of agricultural products. The site utilizes compressed air for operation of process controls, air tools instrumentation and other uses. The system operates at 101psi. Originally, the site had 3 125 hp air compressors. During normal production months, which make up 6,400 hours per year, one of these compressors operates full time at 80% capacity with a second compressor working as trim when demand for air was high. During peak agricultural months, which make up 2,300 hours per year, demand for air increased such that two or three compressors each running at 20-60% capacity.

The project called for the addition of two smaller air compressors, one 30 hp and one 75 hp, each fitted with variable frequency drives. The proposed arrangement called for use of one 125 hp compressor during normal production, with the 30 hp VFD acting as a trim. The proposal for the peak season was to run one 125 hp compressor with the 70 hp VFD acting as a trim.

Summit Blue personnel fitted each air compressor at the site with a data logger and current transducer to measure energy use. These were left on for several weeks during peak production season and into the beginning of the normal season. Data indicate that the proposed compressor arrangement was not in use. This is typical of new arrangements as systems are optimized. It was found that during peak production times, air demands were largely met with one 125 hp compressor operating and frequently the smaller 30 hp VFD compressor was used rather than the proposed 75 hp VFD. At times of very high demand, both VFD compressors were in use with the 125 hp compressor. In total, the peak energy use was higher than predicted in the project documentation, although still lower than the baseline energy use in the project documentation.

Table 2-8. Site 5 Peak Production Months' Savings

	kW Savings	3 month kWh Savings
Peak Claimed Savings	131	87,400
Verified Peak Savings	149	43,874

During the measured normal production period that was measured, the site's air usage was much lower than expected. It is believed that this is not representative usage. Since representative normal production air use was not measured, it was calculated. Project documentation indicates that projected break horse power during normal periods was expected to be 22% of peak times. At such a rate, the air needs of the site could be met through the two VFD drives with use of the larger 125 hp compressor acting as a trim. Indeed the 125 hp compressor was not used during this time and all air demand was met with the two VFD compressors. Such a VFD-only arrangement would have substantial savings over the proposed arrangement, as it does not require the 125 hp compressor to run at low loading. Normal operational energy use is calculated to be double that measured on site.

Table 2-9. Site 5 Normal Production Months' Savings

	kW Savings	9 month kWh Savings
Normal Production Claimed Savings	29	300,800
Verified Normal Production Savings	16.5	380,390

As shown in Table 2-10, Site 5's savings are calculated to be 109% of the application savings. This is entirely due to optimization of the system to run the 125 hp compressor only as a trim during normal production months and allow new smaller compressors to meet smaller air requirements. It must be noted and understood that the hours used in these calculates are based on a 3 month peak season. This season is variable from year to year and such a large round number is susceptible to a significant error.

Table 2-10. Site 5 Installation and Savings

	Normal production kW Savings	Peak Season kW Savings	Annual kWh Savings
Claimed Savings	29	131	388,200
Verified Calculated Savings	16.5	149	424,263
Realization Rate	57%	114%	109%

2.3 Overall Site Observations

There were several problems with the applications, although overall the Lodi program reporting has improved significantly since the last program year:

1. *Inadequate documentation, particularly at Site 2.* One of the three lighting retrofits did not include a detailed calculation of savings. This made the project difficult to verify since minimal information on the baseline conditions was available. Since there were many fixtures permanently shut off in the facility, it was difficult to determine if these had been included in the retrofit or if other units were counted in their place. Additionally, the hours used on the application did not appear to match those at the store, but due to the lack of documentation, it was difficult to determine the reason for this discrepancy.

2. *Overestimation of equipment usage at Site 4.* Site 4 based savings calculations on rated equipment power. While onsite measurements might not have been practical, some derating is usually required from peak power on production equipment and this should have been allowed for in calculations.
3. *Air compressor operation different from expected at Site 5.* This is not uncommon as air compressors are frequently adjusted to changing operating conditions or optimized after they are installed.
4. *Minor discrepancies in wattages compared to California standard usage*. Vendors are often unaware of the standard wattages used in California, which results in misreporting values, by a few percent. This is a fairly common problem, but does not seriously affect savings for this program.

2.4 Analysis

The final program records submitted by the implementation contractor to the City of Lodi Electric Utility were analyzed for accuracy and consistency and to ensure that the underlying assumptions were reasonable. The key documents analyzed included the following:

- The project applications provided to the program for each site
- The invoices provided to the utility
- Any analyses performed prior to purchasing process-related equipment

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

1. The measure savings assumptions were calculated to be representative of the Program installations.
2. The participant facility operating schedule at Site 2 required some changes relative to estimates used on the applications. It would be advisable to explicitly request operating hours as part of the application rather than relying on vendor estimates in the calculations.
3. Itemized purchase orders should be required for applications, along with a list of the final retrofit plan. This issue has improved since the 2008 review, but still needs improvement.
4. Field measurements are highly recommended for custom equipment due to the potentially large possibility for misestimating usage as seen at Site 4.
5. Overall, the program has done a good job of estimating savings, but non-standard projects such as the one at Site 4 should require more detailed savings estimates in the future.

2.5 Impact Evaluation Results

Table 2-11 provides the savings reported in the final installation review documents submitted for the Program and the verified gross savings. The recommended adjustments are attributable to revised savings estimates for a combination of operational hours, fixture wattages, and adjustments to equipment usage based on measured values. Four of the five sites had measure realization rates near or higher than 100%. The exception was Site 4, which had an energy realization rate of 32%. This was primarily due overestimation of production equipment loading.

Overall, the program level realization rates were good. For demand, the program realization rate was 1.37 and for energy, it was 0.87.

Table 2-11. Reported savings, verified and adjusted savings

	Claimed		Verified	
Project	**kW Savings**	**Annual kWh Savings**	**kW Savings**	**Annual kWh Savings**
Site 1	14.4	125,943	13.9	121,825
Site 2	15.3	88,972	17.5	110,299
Site 3	18.9	149,528	19.0	150,182
Site 4	-	280,000	65.8	185,414
Site 5	131	388,200	149	424,263
Total	179.6	1,033,443	265.2	991,983
Program Realization Rates			1.48	0.96

Calculated savings have been used for all of the sites except site 2, where deemed values were used. At the three lighting sites, only some of the fixtures had deemed savings available and since many of the T-12 to T-8 retrofits actually used low output T-8 ballasts, the deemed values underestimated savings. In addition some sites had longer operating hours than the deemed savings use further decreasing the deemed savings.

3 IMPACT EVALUATION OF THE RESIDENTIAL HOME IMPROVEMENT PROGRAM

The Lodi Home Improvement Rebate Program provides rebates to all customers who purchase home weatherization products to improve their homes building envelope. These can include, but are not limited to, wall or attic insulation, radiant barriers, window film, whole house fans, and attic fans. The rebates are available for the following amounts:

- Attic Fan - $40/fan
- Solar Attic Fan - $40/fan
- Whole House Fan - $100/fan
- Shade Screens - $0.50/sq.ft.
- Window Tint - $0.50/sq.ft.
- Radiant Barrier - $150 maximum
- Attic / Wall Insulation - $0.15/sq.ft.
- HVAC >=15 SEER - $175/unit
- HVAC >=17.5 SEER - $225/unit
- Duct Sealing / Repair – up to $200
- Duct Replacement – up to $750

The estimates of energy impact by measure are based on deemed savings. These values are:

- Attic Fan – 160 kWh and 0.032 kW
- Solar Attic Fan – 89 kWh and 0.008 kW
- Whole House Fan – 8 kWh and 0.015 kW
- Shade Screens – 383 kWh and 0.35 kW
- Window Tint – 436 kWh and 0.427 kW
- Radiant Barrier – 42 kWh and 0.079 kW
- Attic Insulation – 134 kWh and 0.166 kW
- Wall Insulation – 265 kWh and 0.219 kW
- HVAC Heat Pump – 14 SEER – 132 kWh and 0.066 kW
- HVAC Heat Pump – 15 SEER – 191 kWh and 0.123 kW
- HVAC Heat Pump – 16 SEER – -31 kWh and 0.173 kW
- Duct Sealing / Repair – 118 kWh and 0.174 kW

3.1 Impact Evaluation Methodology Overview

The impact evaluation for this program was a low cost review of available data and the application of deemed savings estimates to the observed number of weatherization and HVAC improvements. The steps followed included:

1. Obtained a copy of the program tracking spreadsheet.
2. Reviewed the database and determined the number of rebates by improvement type and characteristic.
3. Requested and obtained copies of select rebate vouchers to verify that the vouchers existed and that invoices were attached to each voucher.
4. Estimated the number of weatherization and HVAC improvements and the associated energy savings for program year 2009 by utilizing the data available in the program tracking database, modifying the number of applications based on verification efforts, and utilizing the deemed energy savings per improvement to develop an overall program impact.

3.2 Measure Installation Verification

For this program, measure verification consisted of visual paper verification that weatherization and HVAC improvement applications and invoices are maintained by the City of Lodi. No on-site visits were performed. Given the relatively low levels of energy savings and the high cost of performing on-site visits, a "paper" verification process was deemed appropriate.

The first step in measure verification was to obtain the program tracking spreadsheet. All of the applications "vouchers" have been scanned by City of Lodi staff and entered into an Excel spreadsheet for easy tracking. From this overall list of participants, only a sample was actually verified with paper invoices and vouchers. To adequately achieve a 90/10 confidence with our sample, we reviewed 49 of the 165 participants, using a random number technique to pick the specific participants in the sample.

Once the sample was drawn, we used it to verify program vouchers and invoices. For the most part, the tracking spreadsheet was accurate and sufficiently provided all the necessary information needed to verify savings.

In the review of the sampled vouchers, two issues were addressed. The first was the simple existence of voucher copies with each application form. The second involved the need for more detailed information in the application and vouchers for the radiant barrier measure.

3.2.1 Missing Vouchers

Of the 49 application forms reviewed, vouchers were missing from three. This is a voucher verification rate of 95%. These findings will be used on a measure weighted basis to determine the program realization rate. As shown in Table 3-1, one voucher was missing for a radiant barrier measure implementation, and two were missing for duct repair/sealing measure implementations.

Table 3-1. Number of Missing Vouchers by Measure

Improvement Measure	# of Vouchers
Radiant Barrier – Verified Existing Vouchers	11
Radiant Barrier – Missing Vouchers	1
Duct Repair/Sealing – Verified Existing Vouchers	4
Duct Repair/Sealing – Missing Vouchers	2
TOTAL – Missing Vouchers	3

3.2.2 Radiant Barriers

Radiant Barriers, sometimes called Tech Shields, are placed in attics and roof structures to reflect heat away from the home in the summer and into the home in winter. Savings for these barriers are calculated in terms of hundreds of square feet, but the rebate vouchers and invoices failed to note the square footages for nearly all cases. In fact, we were only able to confidently verify square footage information for six of the 25 sites. Four sites provided a square foot value, and two sites had enough information about size of rolls or sheets used to calculate a reasonable number. We took a three-tiered approach for calculating square footages for all sites with either missing or partial information.

Tier I – Reasonable Square Footage based on Invoice Data

Tier I sites had enough information on the invoice to identify a reasonable square footage. A total of six sites are included. Four of the invoices/vouchers had actual square footage information provided. For Site 1, the invoice identified three rolls of radiant barrier used, and a call to the installing contractor revealed that his rolls are 500 square feet each. Site 2 showed 85 radiant barrier sheets used and identified a sheet at 4x8 feet.

Tier II – Square Footage based on Invoice Data and Contractor

Tier II sites had enough data to infer square footages based on invoice data and similarity of contractors. Five other sites used the same contractor from Tier I who installed radiant barriers in the form of sheets. The number of sheets was listed for these five sites, but not the actual size per sheet. From Site 2 in Tier I, we inferred a similar 4x8 size and calculated the savings accordingly.

Tier III – Average Square Footage

Tier III uses an average square footage from the four sites with actual identified square footages on their corresponding invoices, plus the Sites 1 and 2 from Tier I. The average was 1,820 square feet, which was then applied to the remaining 14 sites to calculate savings.

Table 3-2 summarizes the number of sites within each analysis tier.

Table 3-2. Number of invoices by Analysis Tier for Radiant Barriers

Radiant Barriers	# of Vouchers
Tier I	
Site 1 – Size and Number of Rolls Identified	1
Site 2 – Size and Number of Sheets Identified	1
Sq. Footage Identified	4
Tier II	
Number of Sheets Identified but no Size	5
Tier III	
No Sq. Footage Identified – Average of 1820sqft. used	14
TOTAL	25

It is recommended that square footage information be gathered for Radiant Barriers in all future vouchers and invoices. This will ensure more robust savings calculations.

3.3 Impact Evaluation Results

The estimate of savings from the program for the program year 2009 sample draw was adjusted to reflect the missing rebate vouchers for radiant barriers and duct repairs. Table 3-3 identifies the sampled weatherization and HVAC improvement measures and provides the claimed and verified savings results for each.

Table 3-3. Sampled Energy Savings from the Home Improvement Rebate Program

Weatherization or HVAC Technology	# of Units	Deemed Savings/Unit (kWh)	Deemed Savings/Unit (kW)	Claimed Savings (kWh)	Claimed Savings (kW)	Verification Percentage	Verified Savings (kWh)	Verified Savings (kW)
attic fan	3.0	160	0.302	292.8	0.6	100%	292.8	0.6
solar attic fan	3.0	89	0.008	162.9	0.0	100%	162.9	0.0
whole house fan	13.0	8	0.015	104.0	0.2	100%	104.0	0.2
shade screens	10.5	383	0.35	4,038.0	3.7	100%	4,038.0	3.7
window tint	0.4	436	0.427	170.0	0.2	100%	170.0	0.2
radiant barrier	275.6	42	0.079	926.0	1.7	94%	874.3	1.6
attic insulation	5.7	134	0.166	765.0	0.9	100%	765.0	0.9
wall insulation	1.7	265	0.219	453.2	0.4	100%	453.2	0.4
HVAC 14 SEER	3.0	132	0.066	396.0	0.2	100%	396.0	0.2
duct repairs	4.0	118	0.174	472.0	0.7	50%	236.0	0.3
TOTAL				**7,779.9**	**8.6**		**7,492.1**	**8.1**

The sample provides an overall Program Realization rate that can then be applied to the Total Claimed Savings for the entire list of program participants. Table 3-4 summarizes these overall results.

Table 3-4. Total Claimed and Verified Energy Savings from the Home Improvement Rebate Program

	Total Claimed Savings (kWh)	Total Claimed Savings (kW)	Total Verified Savings (kWh)	Total Verified Savings (kW)
Sample Draw	7,779.9	8.6	7,492.1	8.1
Program Verification Rate:			96.3%	94.8%
Total Program Participants	24,283.2	27.5	**23,385.1**	**26.0**

It is estimated that the program achieved 23,385 kWh and 26 kW of savings.

Appendix A: Commercial Rebate Site Details

Table A-1. Standard Occupancy Sensor Reductions by Area Type

Space Type	% Savings	Space Type	% Savings	Space Type	% Savings
Assembly	45	Industrial	45	Restroom	45
Break room	25	Kitchen	30	Retail	15
Classroom	30	Library	15	Stair	25
Computer Room	35	Lobby	25	Storage	45
Conference	35	Lodging (Guest Rooms)	45	Technical Area	35
Dinning	35	Open Office	15	Warehouses	45
Gymnasium	35	Private Office	30	Other	15
Hallway	25	Process	45	Parking Garage	15
Hospital Room	45	Public Assembly	35		

Source: 2008 NRR-DR Program Procedures Manual, Table 2-1

Table A-2. Deemed Savings for Selected Measures

Category	Measure	Peak kW Savings	Annual kWh Savings
Compact fluorescent	Screw-in 14-26W	0.038	220
Delamping	Delamp 4' lamp	0.040	235
Exit signs	LED replaces incandescent	0.044	366
Occupancy sensors	Occupancy Sensor: Wall Box	0.176	238
T-8 linear fluorescent	T-12 to T-8 4' lamp	0.006	37