Evaluation Measurement and Verification Report for the Local Small Commercial Energy Efficiency & Market Transformation Program #208-02

Prepared for Energx Controls, Inc.

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1. Executive Summary

This report provides the Evaluation, Measurement, and Verification (EM&V) findings for the Energx Controls, Inc. (Energx) Local Small Commercial Energy Efficiency and Market Transformation Program #208-02. The ex ante program goals were to assist hard-to-reach small commercial building owners and businesses to meet the stricter emissions requirement of South Coast Air Quality Management District (SQAMD) Rule 1146 for boilers and water heaters, by providing incentives for installation of 188 low, medium, and high efficiency natural gas boilers in the Southern California Gas Company (SCG) service area. The ex ante program goals, accomplishments, and cost effectiveness are shown in **Table 1.1**.[1] The program exceeded its goals and provided incentives for 219 low, medium and high efficiency boilers at 136 hard-to-reach small commercial customer sites. The program ex ante cost effectiveness was 1.3 for the Total Resource Cost (TRC) test and 2.7 for the Participant test. The EM&V ex post cost effectiveness is 1.8 for the TRC and 3.7 for the participant test. These accomplishments were verified by randomly checking the tracking database with on-site measurements and inspections.

Table 1.1 Ex Ante Goals and Ex Post Accomplishments and Cost Effectiveness

Description	Ex Ante Goal	Ex Post Accomplishment
Low Efficiency Gas Boilers (82 to 84%)	115	184
Medium Efficiency Gas Boilers (85 to 92%)	30	15
High Efficiency Gas Boilers (93 to 97%)	43	20
Total Measures	188	219
Annual Energy Savings (therms/yr)	418,110	362,648
Lifecycle Energy Savings (therms)	5,547,000	7,252,954
Participant Test	2.7	3.7
Participant Test Benefits	$2,471,290	$2,818,132
Participant Test Costs	$908,100	$756,750
Participant Test Net Benefits	$1,563,190	$2,061,632
Total Resource Cost (TRC) Test	1.3	1.8
TRC Test Benefits	$1,632,020	$2,017,327
TRC Test Costs	$1,252,927	$1,152,347
TRC Test Net Benefits	$378,093	$864,980

Ex ante first year therm load impacts are summarized in **Table 1.2**. The first year gross ex ante load impacts for the program are 472,800 therms per year. The ex ante net-to-gross ratio (NTGR) was 0.80 for early replacement low efficiency boilers and 0.95 for medium and high efficiency boilers, and the net ex ante program savings are 418,110 therms per year.[2]

[1] For boilers with input capacities greater than or equal to 500,000 British Thermal Units (Btu) and less than 2,000,000 Btu the deadline is January 1, 2006. Energx offered cash incentives of $1,500 to $7,000 per boiler installation with larger incentives for high efficiency units. Boilers of 2,000,000 Btu input and higher were excluded from the program since they were required to meet SQAMD Rule 1146 by July 1, 2002.

[2] NTGR represents the net program load impact divided by the gross program load impact. The ex ante NTGR was 0.80 for early replacement boilers and 0.95 for high efficiency boilers. The ex post NTGR is 0.96 based on Express Efficiency applicable to nonresidential rebate measures, see *Energy Efficiency Policy Manual*, Version 3, Chapter 4, Table 4.2, page 19, prepared by the California Public Utilities Commission, 2003.

Table 1.2 Ex Ante First Year Natural Gas Load Impacts for the Energx Program

Description	Ex Ante Qty.	Ex Ante Efficiency	Ex Ante Full Load Hours (hrs)	Gross Ex Ante Unit Savings (therm/yr)	Gross Ex Ante Program Savings (therms/yr)	Ex Ante Net-to-Gross Ratio	Ex Ante Net Program Savings (therm/yr)
Low Efficiency 82 to 84%	115	84.5%	2,000	1,800	207,000	0.8	165,600
Med. Efficiency 85 to 92%	30	91.4%	2,000	3,270	98,100	0.95	93,195
High Efficiency 93 to 97%	43	96.0%	2,000	3,900	167,700	0.95	159,315
Total	188			2,515	472,800	0.88	418,110

Ex post first year therm load impacts are summarized in **Table 1.3**. The ex post first year gross therm load impacts are 377,758 ± 43,023 therms per year at the 90 percent confidence level. The ex post NTGR is 0.96, and the first-year ex post net program savings are 362,648 ± 41,302 therm per year at the 90 percent confidence level. The first year ex post net realization rate for therm savings is 0.87 ± 0.10. The first year net realization rate is less than one due to ex post full load operating hours and ex post measured efficiencies being less than ex ante values. Ex post field measured efficiencies are lower than rated efficiencies due to markedly different inlet and outlet temperature conditions compared to the ANSI Z21.13-2000 test conditions under which boilers are rated. Another reason for the reduced efficiency might be due to the performance of randomly selected boilers in the field compared to manufacturer test results which are done for a selected sample of manufactured boilers. Field measured efficiencies might also be lower due to piping insulation, buried versus unburied piping and weather conditions that affect annual operating efficiency, and fuel consumption of the boilers. In-situ field measurements of old boilers were performed and the pre-retrofit combustion efficiency values were in the 75% range and generally consistent with the ex ante pre-retrofit efficiency values.

Table 1.3 Ex Post First Year Natural Gas Load Impacts for the Energx Program

Description	Ex Post Qty.	Ex Post Efficiency	Ex Post Full Load Hours (hrs)	Gross Ex Post Ante Unit Savings (therm/yr)	Gross Ex Post Program Savings (therms/yr)	Ex Post Net-to-Gross Ratio	Ex Post Net Program Savings (therm/yr)	Ex Post Net Realization Rate
Low Efficiency 82 to 84%	184	81.2%	1,869	1,512	278,208	0.96	267,080	1.61
Med. Efficiency 85 to 92%	15	80.9%	1,971	1,858	27,870	0.96	26,755	0.29
High Efficiency 93 to 97%	20	87.3%	1,850	3,584	71,680	0.96	68,813	0.43
Total	219			1,725	377,758	0.96	362,648	0.87

Lifecycle therm savings are summarized in **Table 1.4**. The ex-ante net lifecycle savings are 5,547,000 therms. The EM&V study ex-post net lifecycle savings are 7,252,954 ± 328,611 therms. The ex-post net lifecycle therm realization rate is 1.31 ± 0.06. The lifecycle net realization rate is greater than one due to the ex post NTGR and effective useful life (EUL) being greater than ex ante values.[3]

[3] Ex post 0.96 NTGR and 20 year EUL are based on Express Efficiency applicable to nonresidential rebate measures, see *Energy Efficiency Policy Manual*, Version 3, Chapter 4, Tables 4.1 and 4.2, prepared by the California Public Utilities Commission, 2003.

Table 1.4 Lifecycle Natural Gas Load Impacts for the Energx Program

Measure	Net Ex Ante Program Savings (therm/yr)	Ex Ante Effective Useful Life (EUL)	Net Ex Ante Lifecycle Program Savings (therm)	Net Ex Post Program Savings (therm/yr)	Ex Post Effective Useful Life (EUL)	Ex Post Net Lifecycle Program Savings (therm)	Ex Post Net Realization Rate
Low Efficiency 82 to 84%	165,600	3	496,800	267,080	20	5,341,594	10.75
Med. Efficiency 85 to 92%	93,195	20	1,863,900	26,755	20	535,104	0.29
High Efficiency 93 to 97%	159,315	20	3,186,300	68,813	20	1,376,256	0.43
Total	418,110		5,547,000	362,648		7,252,954	1.31

Participant and non-participant process surveys were used to obtain general feedback and suggestions. Survey results indicate 92 percent of participants were satisfied with the program based on random interviews with 40 participants. Most participants expressed appreciation for courteous Energx staff. Process survey responses indicated significant demand for the program with 100 percent of participants indicating that they think all businesses would benefit from the program. Non-participants were allowed to give multiple answers as to why they did not participate in the program. Non-participant survey results indicate that 45 percent didn't know about the Energx program, 35 percent said that they are waiting for the SCAQMD deadline of January 1, 2006 to replace their boilers, 20 percent said that they didn't have the money to replace their boilers, and 20 percent indicated that their existing boilers didn't need replacing. Forty-five percent of the non-participants surveyed indicated that better advertising would have helped. Process survey results, on-site inspections, and field measurements were used to guide the overall process evaluation in terms of investigating operational characteristics of the program and developing specific recommendations to help make the program more cost effective, efficient and operationally effective. The process recommendations are as follows.

- The program implementer designed the program based on manufacturer reported performance data and product literature. Future programs might be based on verified boiler efficiency ratings by measuring combustion efficiency in the field with accurate and calibrated combustion efficiency analyzers according to manufacturers' specifications.
- The program incentive levels were based on feedback from contractors and manufacturers and the program implementation plan (PIP) was revised with increased incentive levels to induce participation. Revised PIP was approved by CPUC Staff. Future programs might consider incentives based on verified efficiencies rather than rated efficiencies (which were found to be overstated especially for high efficiency boilers examined in this study).
- Capture and track rated efficiencies from manufacturers and operational hours based on customer information. Capturing this information in the Energx program tracking database will help make measure savings more accurate.
- Consider including rebates for boiler controllers such as the Energx controllers for water heating applications. This measure is highly cost effective and could be coupled with the boiler rebate program to increase savings, cost effectiveness, and reduce lost opportunities.
- Consider including rebates for Energy Star programmable thermostats for space heating applications, hot water pipe insulation, and lowering hot water temperatures since these measures will increase savings, cost effectiveness, and reduce lost opportunities.

Section 2 describes how the EM&V study addresses the required CPUC Energy Efficiency Policy Manual objectives, including baseline information, energy efficiency measure

information, measurement and verification approach, and the evaluation approach. **Section 2** also includes equations used to develop energy and peak demand savings, sample design, methods used to verify proper installation of measures, and methods used to perform field measurements.

Section 3 provides EM&V study findings including load impact results and process evaluation results regarding what works, what doesn't work, and recommendations to improve the program's services and procedures. **Section 3** also includes measure recommendations to increase savings, achieve greater persistence, and improve customer satisfaction.

Appendix A provides the participant and non-participant survey instruments and the audit data collection form.

2. Required CPUC Objectives and Components

This section discusses how the EM&V study meets the required CPUC objectives and components including baseline information, energy efficiency measure information, measurement and verification approach, and the evaluation approach.

2.1 Baseline Information

Existing studies were used to evaluate baseline and measure-specific energy savings data. Existing baseline data was obtained from prior EM&V studies, the CALIFORNIA MEASUREMENT ADVISORY COMMITTEE (CALMAC, www.calmac.org), and the California Energy Commission (CEC, www.energy.ca.gov). Existing baseline studies for small commercial customers are provided in **Table 2.1**.

Table 2.1 Existing Baseline Studies for Small Commercial Customers

1	*Filing of Southern California Gas Company Requesting Approval of Proposed Energy Efficiency Programs and Budgets as Part of the 2002 Energy Efficiency Program Selection Process Required by Rulemaking 01-08-028,* December 14, 2001.
2	*2001 DEER Update Study, Final Report*, prepared for the California Energy Commission, Contract Number 300-99-008, prepared by XENERGY Inc., Oakland, California, August, 2001.
3	*2002 Energy Efficiency Program Selection R.01-08-028, Energy Efficiency Proposal, Statewide Nonresidential Retrofit Express Efficiency*, Appendix C, References/Workpapers/Data Assumptions, prepared by PG&E, December 2001.
4	*Conservation Potential Study,* prepared for Southern California Gas, prepared by XENERGY, 1992.

Existing baseline Energy Use Intensity (EUI) data for small commercial customers are provided in **Table 2.2**. These data are applicable in the SCG service area where measures are being installed. The baseline EUI values shown in **Table 2.2** are from a 1992 Study, and they will be evaluated to determine if they are appropriate for this study.

Table 2.2 Existing Baseline EUI Data for Small Commercial Customers

End Use	EUI W/ft^2	EUI kWh/yr-ft^2	EUI therm/yr-ft^2	Source
Space Heating			0.0905	SCG Study 4, **Table 2**
Water Heating			0.2435	SCG Study 4, **Table 2**

2.2 Energy Efficiency Measure Information

This section provides energy efficiency measure information including assumptions about important variables and unknowns, especially those affecting energy savings. Deemed energy savings for each measure are provided in **Table 2.3**. The deemed energy savings are based on engineering estimates.

Table 2.3 Deemed Savings for Measures Installed in SCG Service Area

Description	Rebate per MMBtuh	Demand Savings per unit kW	Annual Hours of Operation per unit	Savings per unit kWh	Savings per unit therm	EUL	Ex Ante NTG Ratio	Units
Low Efficiency 82 to 84%	$2.5	n/a	n/a	n/a	1,800	3	0.80	115
Medium Efficiency 85% to 92%	$4	n/a	n/a	n/a	3,270	20	0.95	30
High Efficiency 93 to 97%	$7	n/a	n/a	n/a	3,900	20	0.95	43

(Per the Revised Workbook, Table A, NTG for Early replacement is 0.80)

2.2.1 Measure Assumptions and Intended Results

Measure assumptions were provided by Energx in their proposal and PIP as shown in **Table 2.4**. The EM&V study assessed ex ante measure assumptions and developed ex post measure assumptions. This was accomplished through the use of engineering and statistical analyses of data collected during the study (i.e., on-site inspections and telephone surveys). Ex post energy savings were developed for each measure using the ex post baseline and measure assumptions determined in the study.

Table 2.4 Baseline and Energy Efficiency Measure Assumptions

Description	Baseline Assumption	Measure Assumption	Annual Hours of Operation	Savings Assumption
Low Efficiency 82 to 84%	75% Efficiency	82 to 84% Eff.	2,000	1,800 therm/yr-unit
Med. Efficiency 85 to 92%	75% Efficiency	85% to 92% Eff.	2,000	3,270 therm/yr-unit
High Efficiency 93 to 97%	75% Efficiency	93 to 97% Eff.	2,000	3,900 therm/yr-unit

(Per the Revised workbook, the hours of operation in Table A is 2000 hours/year for all boilers)

The program ex ante and ex post energy savings for Energx Program #208-02 are shown in **Table 2.5**. The lifecycle ex-post net lifecycle therm realization rate is 1.31 ± 0.06. The program ex ante cost effectiveness was 1.3 for the TRC test and 2.7 for the participant test. The EM&V ex-post TRC is 1.8 and the participant test is 3.7. Ex post cost effectiveness is greater than ex ante due to use of incorrect measure life and net to gross ratios (i.e., (i.e., early replacement boiler ex ante EUL was assumed to be 3 instead of 20 years and ex ante net to gross ratios were 0.80 and 0.95 instead of 0.96 for Express Efficiency type measures).

Table 2.5 Ex Ante and Ex Post Load Impacts

Program	Utility	Net kWh/yr	Net kW	Net therm/yr	Net Lifecycle kWh	Net Lifecycle therm
Energx #208 ex ante	SCG	n/a	n/a	418,110	n/a	5,547,000
Energx #208 ex post	SCG	n/a	n/a	362,648	n/a	7,252,954

(Per change order, goal changed to 418,110 therms per year compared to original PIP goal)

2.2.2 Description of Energy Efficiency Measures

This section provides a full description of each energy efficiency measure including assumptions about important variables and unknowns, especially those affecting energy savings. Proper installation of energy efficiency measures was be verified during the on-site inspections.

Early Replacement Boiler 82 to 84% Thermal Efficiency

Early replacement boilers must meet or exceed 82% thermal efficiency and also meet the SCAQMD's Rule 1146. The pre-retrofit boiler has a 75% thermal efficiency. The SCG Statewide program has developed a list of manufacturers that meet this requirement and the same manufacturers' products list was used in this program. Deemed savings are 1,800 therm/yr per boiler.

Market Transformation Boiler 85 to 92% Thermal Efficiency

Market transformation boilers must meet or exceed 85% thermal efficiency and also meet the SCAQMD's Rule 1146. The pre-retrofit boiler has a 75% thermal efficiency. The SCG Statewide program has developed a list of manufacturers that meet this requirement and the same manufacturers' products list was used in this program. Deemed savings are 3,270 therm/yr per boiler.

Market Transformation Boiler 93 to 97% Thermal Efficiency

Market transformation 93 to 97% thermal efficiency boilers must meet or exceed 93% thermal efficiency and also meet the SCAQMD's Rule 1146. The pre-retrofit boiler has a 75% thermal efficiency. The SCG Statewide program has developed a list of manufacturers that meet this requirement and the same manufacturers' products list was used in this program. Deemed savings are 3,900 therm/yr per boiler.

2.3 Measurement and Verification Approach

The measurement and verification approach for the study is based on the *International Performance Measurement & Verification Protocols* (IPMVP) defined **Table 2.6**.[4]

Table 2.6 IPMVP M&V Options

M&V Option	How Savings Are Calculated	Typical Applications
Option A. Partially Measured Retrofit Isolation Savings are determined by partial field measurement of energy use of system(s) to which a measure was applied, separate from facility energy use. Measurements may be either short-term or continuous. Partial measurement means that some but not all parameters may be stipulated, if total impact of possible stipulation errors is not significant to resultant savings. Careful review of measure design and installation will ensure that stipulated values fairly represent the probable actual value.	Engineering calculations using short term or continuous post-retrofit measurements or stipulations.	Boiler pre- and post-retrofit efficiencies are measured and operating hours are based on interviews with occupants or stipulated values.
Option B. Retrofit Isolation Savings are determined by field measurement of the energy use of the systems to which the measure was applied, separate from the energy use of the rest of the facility. Short-term or continuous measurements are taken throughout the post-retrofit period.	Engineering calculations using short term or continuous measurements	Variable speed controls used on a constant speed pump. Electricity use is measured with a kWh meter on pump motor. Metering is performed to verify pre-retrofit constant speed operation and post-retrofit variable speed operation.
Option C. Whole Facility Savings are determined by measuring energy use (and production) at the whole facility level. Short-term or continuous measurements are taken throughout the post-retrofit period. Continuous measurements are based on whole-facility billing data.	Analysis of whole facility utility meter or sub-meter data using techniques from simple comparison to regression analysis or conditional demand analysis.	Energy management program affecting many systems in a building. Utility meters measure energy use for 12-month base year and throughout post-retrofit period.
Option D. Calibrated Simulation Savings are determined through simulation of the energy use of components or the whole facility. Simulation routines must be demonstrated to adequately model actual energy performance measured in the facility. This option usually requires considerable skill in calibrated simulation.	Energy use simulation, calibrated with hourly or monthly utility billing data and/or end-use metering.	Project affecting many systems in a building but where base year data are unavailable. Utility meters measure post-retrofit energy use. Base year energy use is determined by simulation using a model calibrated with post-retrofit utility data.

2.3.1 M&V Approach for Load Impact Evaluation

The M&V approach for the load impact evaluation will involve performing on-site measurement and verification activities for a statistically significant random sample of participating customers. Ex post energy savings were determined using IPMVP Option A (i.e., partially measured retrofit isolation), and Option B (i.e., retrofit isolation). Field measurements of boiler thermal efficiencies were made using a combustion efficiency analyzer and hours of operation were evaluated using motor loggers. The on-site data collection efforts analyzed baseline and measure assumptions by taking measurements and collecting data at customer sites. **Gross ex post savings** for each measure were calculated based on information or measurements collected in the

[4] See *International Performance Measurement & Verification Protocols*, DOE/GO-102000-1132, October 2000.

statistical random sample of on-site inspections and stipulated values. Equations used to estimate ex post savings for each measure and for the program are provided below.

Boiler Savings were calculated based on verification of the make, model, and efficiency. If pre-retrofit efficiency was unavailable then 75% efficiency was assumed. Savings were calculated as follows.

Eq. 1 $$\text{Boiler Savings} = \text{FLH}_{\text{Boiler}} \times \text{MBTUH}_{\text{i}} \times \left[\frac{1-\left(75\%_{\text{pre}}/\eta_{\text{post}}\right)}{100}\right]$$

Where,

$\text{FLH}_{\text{Boiler}}$ = Full Load Hours of operation per year. Ex ante values were stipulated and ex post values were based on billing data and motor logger data.

MBTU_{i} = Boiler input rating in Thousand British Thermal Units per hour,

$75\%_{\text{pre}}$ = Deemed pre-retrofit efficiency for the boiler assumed to be 75%,

η_{post} = Deemed, rated or measured efficiency of post-retrofit boiler (assumed to be to be 83%, 89%, or 95%).

Variability in boiler loads were measured across sampled sites using billing data and motor logger data from on-site surveys.

Gross ex post savings for each measure was calculated based on information or measurements collected in the statistical random sample of on-site inspections, efficiency measurements, billing data, logger data, and engineering analyses. **Sample mean savings estimates** were calculated using **Equation 2**.

Eq. 2 $$\bar{y}_{\text{i}} = \text{Mean Savings} = \frac{1}{n_{\text{i}}}\sum_{j=1}^{n_{\text{i}}} y_{\text{j}}$$

Where,

$\bar{y}_{\text{i}}$ = Mean savings for measure "i" in the sample (i.e., therm/yr).

n_{i} = Number of measures "i" in the sample.

Savings were adjusted based on the proportion of measures, $\hat{p}_{\text{i}}$, found properly installed during verification inspections.

Eq. 3 $$\text{Adjusted savings} = \hat{p}_{\text{i}}\bar{y}_{\text{i}}$$

Where,

$\hat{p}_{\text{i}}$ = $\text{Proportion} = \frac{n_{\text{verified}}}{n_{\text{i}}}$

n_{verified} = Number of verified measures in the sample.

The standard error, se_i, of the measure sample mean was calculated using **Equation 4, Equation 5** or both depending on the measure.[5]

Eq. 4 se_{i_p} = Standard Error of the Proportion $= \sqrt{\frac{\hat{p}_i(1-\hat{p}_i)}{n_i}}$

The standard error of mean savings was calculated using **Equation 5**.

Eq. 5 se_{i_s} = Standard Error of Mean Savings $= \sqrt{\frac{\sum_{j=1}^{n}(y_j - \bar{y})^2}{n(n-1)}}$

The measure error bound at the 90 percent confidence level was calculated using **Equation 6** combining the applicable standard errors from **Equations 4** and **5**.

Eq. 6 Measure Error Bound $= \hat{p}_i \bar{y}_i (1 \pm (t)\sqrt{se_{i_p}^2 + se_{i_s}^2})$

Where,

t = The value of the normal deviate corresponding to the desired confidence probability of 1.645 at the 90 percent confidence level per CADMAC Protocols.

Savings for all measures "m" in the program was calculated using **Equation 7**.

Eq. 7 $\hat{Y}$ = Program Savings $= \sum_{i=1}^{m}(N_{p_i} \times \hat{p}_i \bar{y}_i)$

Where,

N_{p_i} = Number of "i" measures in the entire program population.

The program error bound for all measures was calculated using **Equation 8**.

Eq. 8 Program Error Bound $= \sum_{i=1}^{m} N_{p_i} \left\{\hat{p}_i \bar{y}_i \left(1 \pm (t)\sqrt{se_{i_p}^2 + se_{i_s}^2}\right)\right\}$

Net savings were calculated as gross savings times the CPUC-accepted 0.96 net-to-gross ratio.

2.3.2 Sampling Plan

The sampling plan was used to verify measure installation as well as for estimating ex post energy savings. The statistical sample design involved selecting a random sample of customers from the program participant population. Samples were selected to obtain a reasonable level of precision and accuracy at the 90 percent confidence level per CPUC Energy Efficiency Policy

[5] The standard error for all measures was calculated based on the proportion of measures found properly installed from the on-site surveys. In addition, for measures where weighted average savings were for each climate zone were available, the standard error of the mean savings was also calculated. These two standard errors were then combined to characterize the statistical precision of the sample mean as an estimator of the population mean. The population total was estimated by multiplying both the sample mean and the corresponding combined error bound by the number of units in the population as per sampling procedures from *The California Evaluation Framework*, prepared for the CPUC and Project Advisory Committee, prepared by TecMarktWorks Framework Team, Chapter 13: Sampling, February 2004.

Manual (EEPM). The sample design was based on statistical survey sampling methods to select a sample of participants to meet the CADMAC Protocols.[6] Sampling methods were used to analyze the data and extrapolate mean savings estimates from the sample measurements to the population of all program participants and to evaluate the statistical precision of the results.[7]

The sample size necessary to obtain the desired 10 percent relative precision for program mean savings estimates was calculated using **Equation 9**.

Eq. 9 $$\text{Sample Size} = n_i = \frac{t^2 C_{vi}^2}{r^2}$$

Where,

n_i = Required sample size for measure "i",

t = The value of the normal deviate corresponding to the desired confidence probability of 1.645 at the 90 percent confidence level per CADMAC Protocols,

r = Desired relative precision, 10 percent per CADMAC Protocols,

C_{vi} = Coefficient of variation, $\frac{s_i}{\bar{y}_i}$, for measure "i."

For small populations, the sample size was corrected using the finite population correction (FPC) equation as follows.[8]

Eq. 10 $$\text{FPC Sample Size} = n_{FPCi} = \frac{n_i}{1+(n_i-1)/N}$$

Where,

n_{FPCi} = Sample size for measure "i" with finite population correction.

The preliminary and actual statistical sample sizes for the EM&V study are shown in **Table 2.7**.

Table 2.7 Statistical Sample Size for the EM&V Study

Measure Description	Ex Ante Units	Proposed Sample	Preliminary Cv	Ex Post Units	Actual Sample	Actual Cv	Relative Precision
Low Efficiency Boilers 82 to 84%	115	28	0.50	184	62	1.02	0.24
Med. Efficiency Boilers 85 to 92%	30	20	0.50	15	11	0.33	0.17
High Efficiency Boilers 93 to 97%	43	20	0.50	20	16	0.34	0.14
Total	188	68	n/a	219	71	n/a	n/a

[6] See Table 5c, Protocols for the General Approach to Load Impact Measurement, page 14, Evaluation design decisions related to sample design will be determined by the following protocols: if the number of program participants is greater than 200 for residential programs, a sample must be randomly drawn and be sufficiently large to achieve a minimum precision of plus/minus 10 percent at the 90 percent confidence level, based on total annual energy use. A minimum of 200 for residential programs must be included in the analysis dataset for each applicable end-use. *Protocols and Procedures for Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management Programs*, as adopted by the California Public Utilities Commission Decision 93-05-063, Revised March 1998.

[7] Cochran, William G. *Sampling Techniques*. New York: John Wiley & Sons, 1977, Kish, Leslie. *Survey Sampling*. New York: John Wiley & Sons, 1965. Thompson, Steven K. *Sampling*. New York: John Wiley & Sons, 1992.

[8] Ibid.

2.3.3 M&V Approach for Process Evaluation

The M&V approach for the process evaluation involved designing and implementing decision maker surveys to measure participant satisfaction, and to obtain suggestions to improve the program's services and procedures. Interview questions also assessed how the program influenced awareness of linkages between efficiency improvements and bill savings. A sample of 40 participants and 20 non-participants were asked process questions. The participant and non-participant surveys are provided in the **Appendices.** Surveys were randomly selected to include at least two surveys from the following building types: Laundromats, hotels, fabricators, small health care facilities, schools, and institutions. Participants were asked why and how they decided to participate in the program. Non-participants were asked why they chose not to participate. This was done to identify reasons why program marketing efforts were not successful with some customers as well as to identify additional hard-to-reach market barriers (i.e., incentives or other inducements to achieve greater participation). The process evaluation also assessed how many small commercial customers have installed efficient boilers under this program compared to the total number of small commercial customers in California. Analysis of process evaluation survey data included an ex post net-to-gross ratio and summary of what works, what doesn't work, and the level of need for the program.

2.4 Evaluation Approach

The evaluation approach includes:

- A list of questions answered by the study;
- A list of evaluation tasks undertaken by the study; and
- A description of how the study was used to meet all of the Commission objectives described in the CPUC EEPM (page 31).

2.4.1 List of Questions Answered by the Study

The following questions were answered by the study.

1. **Are measures being installed properly?**
   The study answered this question by performing verification inspections at a random sample of customer sites.

2. **Is the ex ante net-to-gross ratios appropriate and relevant to this program?**
   The ex ante 0.80 and 0.95 net-to-gross ratios (NTGR) were not correct. Instead the study uses a 0.96 NTGR since the Energx Program is similar to the Statewide Express Efficiency Program (for small and medium commercial customers). This is based on Table 4.2 Net-to-Gross Ratios, CPUC *Energy Efficiency Policy Manual*, 2003.

3. **Are the ex ante energy savings estimates per measure appropriate and relevant?**
   The study answered this question by performing field measurements at a random sample of sites. Ex post energy savings were evaluated using IPMVP Option A (i.e., partially measured retrofit isolation), and Option B (i.e., retrofit isolation). Field measurements of boiler combustion efficiency were made using a combustion efficiency analyzer and hours of operation were evaluated using billing data and motor loggers. The on-site data collection efforts analyzed baseline and measure assumptions by taking measurements and collecting data at customer sites. **Gross ex post savings** for each measure were calculated based on

information or measurements collected in the statistical random sample of on-site inspections and stipulated values.

4. **Are the total program savings estimates accurate?**
   The study answered this question by developing ex post energy savings for the program at the 90 percent confidence level as per CADMAC Protocols.

5. **Are customers satisfied with the program implementation and the measures that were offered and installed in the program?**
   The study answered this question by summarizing customer satisfaction questions from our telephone surveys.

6. **Are there some customers who choose not to participate in the program?**
   The study answered this question by conducting telephone interviews with non-participants. Surveys were randomly selected to include at least two surveys from the following building types: Laundromats, hotels, fabricators, small health care facilities, schools, and institutions. The following questions were included:
   1. What reasons are there for not participating and how might conditions be revised to motivate participation?
   2. Why have non-participants decided not to install more efficient boilers?
   3. What barriers tend to reduce or restrict participation?
   4. What percent of the small commercial market are affected by each of these barriers?
   5. How can marketing, design, implementation, delivery and follow-up efforts be changed to address these barriers?

7. **Is there a continuing need for the program?**
   The study met this objective by assessing customer demand and interest in the program. Process survey responses indicated significant demand for the program with 100 percent of participants saying all businesses would benefit from the program and 28 percent said they would like to see the program continue. Approximately 45 percent of non-participants would have participated if they knew the program provided rebates for new high efficiency boilers.

8. **Are there measurable program multiplier effects?**
   Program multiplier effects questions were used to measure program participants sharing information learned from the program with non-participants, and if sharing of information is acted upon in a way that results in the installation of similar measures within a non-participant population. For example, the program provides rebates for early replacement and market transformation high efficiency boilers. Based on process survey responses, 40 percent of interviewed customers shared program information with 7.2 times as many peers (16 participants shared information with 115 businesses). Forty percent of these businesses (i.e., 46) decided to install similar measures or participate in the Energx program. The program helped expand impacts beyond the participant group to a larger group through direct installation of measures. The multiplier effect for the program is estimated at 42 percent.[9] Programs that link technologies with educational measures can have multiplier effects as

[9] Spillover of 97 percent is calculated based on 146 businesses adopting at least one spillover measure based on information shared by a group of 68 participants who adopted five measures (i.e., $146 \times (1 \div 5) \div 69 = 0.42$).

high as 25-30 percent including the sharing of program information to a population that is several times larger than the participant population. The following questions were considered.

1. Have you shared program information with any of your friends or peers about high efficiency boilers offered in the program?
2. With about how many people have you shared this information in the last 12 months?
3. Of these people, about how many have used this information to install any high efficiency boilers?

2.4.2 List of Tasks Undertaken by the Study

Seven tasks were undertaken by the study. The seven tasks are briefly summarized as follows.

Task 1. Prepare EM&V Plan

The EM&V Plan contained a detailed description of all activities required to complete the study.

Task 2. Tracking Database

The tracking database provided a listing of all jobs that are completed including on-site pre- and post measurements. Energx provided their tracking database and RMA reviewed the Energx database and made recommendations for improvements.

Task 3. Sample Design

A statistical sample design was used to select a sample of customers or projects from the local program participant populations. Samples were selected to obtain a reasonable level of precision and accuracy at the 90 percent level per CPUC Energy Efficiency Policy Manual (EEPM).

Task 4. Process Survey

Process surveys were used to evaluate what works, what doesn't work, and customer satisfaction. Process surveys also obtained suggestions for improvement in the program's services and procedures. Market research and saturation data was used to assess whether or not there is a continuing need for the program. The sample frame included 40 participants and 20 non-participants. Surveys were randomly selected to include at least two surveys from the following building types: Laundromats, restaurants, hotels, fabricators, fast food restaurants, small health care facilities, schools, and institutions.

Task 5. On-site EM&V Inspections

On-site EM&V inspections verified boiler make, model, proper installation/operation, rated/in-situ efficiency, and full load hours of operation. Ex post energy savings were determined using IPMVP Option A (i.e., partially measured retrofit isolation), and Option B (i.e., retrofit isolation). Field measurements of boiler thermal efficiencies were made using a combustion efficiency analyzer and hours of operation were evaluated using motor loggers. The study performed an analysis of the quantity and type of boilers that were installed by program participants by conducting 78 on-site inspections. In addition, combustion efficiency was measured on 71 new boilers at 31 participant sites (while conducting 40 participant surveys) to determine if the ex ante measure assumptions are appropriate and relevant.

Task 6. Statistical Analyses

Statistical analyses were used to extrapolate measurements of baseline and measure assumptions from the sample level to the program population. This task included an assessment of the relative precision of program-level energy savings.

Task 7. Progress, Draft, and Final Reports

Progress, draft, and final reports included a description of the study methodology and all deliverables as per the CPUC EEPM. The reports provided results of the impact evaluation including gross and net energy savings for each measure and the program as well as results.

2.4.3 How Study met CPUC EEPM Objectives

The study met the following CPUC objectives described in the CPUC EEPM (pg. 31).

- **Measure the level of energy savings achieved.**
  The study met this objective by performing on-site EM&V inspections of boilers for a statistically significant sample of participants. Field measurements of boiler efficiencies were made using a combustion efficiency analyzer and hours of operation were evaluated using motor loggers. On-site measurements were used to assess ex post therm savings. Statistical analyses were used to extrapolate therm savings at the sample level to the program level. This step included an assessment of the relative precision of program-level savings, mean savings estimates, standard deviations, and confidence intervals. This analysis included an assessment of all major assumptions used to calculate deemed savings.

- **Measure the cost-effectiveness.**
  The study met this objective by developing ex post energy savings and comparing these to ex-ante energy savings. Ex post measure savings and implementation costs were used to develop ex post Total Resource Cost (TRC) test values for the program using the CPUC cost effectiveness worksheets. The overall ex post TRC was 1.8 and this was 38 percent higher than the ex ante 1.3 TRC.

- **Provide up-front market assessments and baseline analysis.**
  The study met this objective by performing a simple market assessment and baseline analysis including an evaluation of the baseline unit energy consumption values. The telephone survey interviews included questions about market barriers to energy efficiency and the success of the program in meeting the needs of hard-to-reach customers.[10]

- **Provide ongoing feedback and corrective or constructive guidance regarding the implementation of programs.**
  The study met this objective by performing on-site inspections to verify that measures were installed properly. Results of on-site inspections were used to provide ongoing feedback and corrective or constructive guidance regarding implementation of the program. This included

[10] The CPUC definition of small commercial hard-to-reach customers are those who do not have easy access to program information or generally do not participate in energy efficiency programs due to language (i.e., primary language non-English), business size (less than ten employees); geographic (i.e., outside San Francisco Bay Area, Sacramento, Los Angeles Basin or San Diego), or lease (i.e., split incentives barrier).

any necessary improvements to the installation efforts or procedures. Inspections also documented that all activities were completed as per the contract requirements.

- **Measure indicators of the effectiveness of the programs, including testing of the assumptions that underlie the program theory and approach.**
  The study met this objective by performing a process evaluation of the program including telephone surveys of 40 participants and 20 non-participants.

- **Assess the overall levels of performance and success of the program.**
  The study provided ex post energy savings at the 90 percent confidence level. The study determined participant satisfaction and ways to improve the program. Some non-participating customers were interviewed to evaluate why they chose not to participate.

- **Help to assess whether there is a continuing need for the program.**
  The study met this objective by assessing customer demand and interest in the program. Process survey responses indicated significant demand for the program with 100 percent of participants saying all businesses would benefit from the program and 28 percent said they would like to see the program continue. Approximately 45 percent of non-participants would have participated if they knew the program provided rebates for new high efficiency boilers.

Section 3 provides a detailed description of each task to be undertaken during the course of the study. A timeline and deliverables for each task are also provided.

3. EM&V Findings

This section provides load impact results for the program and for each measure. This section also provides the process evaluation results based on participant and non-participant surveys and recommendations regarding what works, what doesn't work, and the continuing need of the program. Also provided are recommendations for each measure to increase savings, achieve greater persistence of savings, and improve customer satisfaction.

3.1 Load Impact Results

The ex ante program goals were to assist hard-to-reach small commercial building owners and businesses to meet the stricter emissions requirement of South Coast Air Quality Management District (SQAMD) Rule 1146 for boilers and water heaters by providing incentives for installation of 188 low, medium, and high efficiency natural gas boilers in the Southern California Gas Company (SCG) service area. The ex ante program goals, accomplishments, and cost effectiveness are shown in **Table 3.1**. The program exceeded its goals and provided incentives for 219 low, medium and high efficiency boilers at 136 hard-to-reach small commercial customer sites. The program ex ante cost effectiveness was 1.3 for the Total Resource Cost (TRC) test and 2.7 for the Participant test. The EM&V ex post cost effectiveness is 1.8 for the TRC and 3.7 for the participant test. These accomplishments were verified by randomly checking the tracking database with on-site measurements and inspections.

Table 3.1 Ex Ante Goals and Ex Post Accomplishments and Cost Effectiveness

Description	Ex Ante Goal	Ex Post Accomplishment
Low Efficiency Gas Boilers (82 to 84%)	115	184
Medium Efficiency Gas Boilers (85 to 92%)	30	15
High Efficiency Gas Boilers (93 to 97%)	43	20
Total Measures	188	219
Annual Energy Savings (therms/yr)	418,110	362,648
Lifecycle Energy Savings (therms)	5,547,000	7,252,954
Participant Test	2.7	3.7
Participant Test Benefits	$2,471,290	$2,818,132
Participant Test Costs	$908,100	$756,750
Participant Test Net Benefits	$1,563,190	$2,061,632
Total Resource Cost (TRC) Test	1.3	1.8
TRC Test Benefits	$1,632,020	$2,017,327
TRC Test Costs	$1,252,927	$1,152,347
TRC Test Net Benefits	$378,093	$864,980

Ex ante first year therm load impacts are summarized in **Table 3.2**. The first year gross ex ante load impacts for the program are 472,800 therms per year. The ex ante net-to-gross ratio (NTGR) was 0.80 for early replacement low efficiency boilers and 0.95 for medium and high efficiency boilers, and the net ex ante program savings are 418,110 therm per year.[11]

[11] NTGR represents the net program load impact divided by the gross program load impact. The ex ante NTGR was 0.80 for early replacement boilers and 0.95 for high efficiency boilers. The ex post NTGR is 0.96 based on Express Efficiency applicable to nonresidential rebate measures, see *Energy Efficiency Policy Manual*, Version 3, Chapter 4, Table 4.2, page 19, prepared by the California Public Utilities Commission, 2003.

Table 3.2 Ex Ante First Year Therm Load Impacts for the Energx Program

Description	Ex Ante Qty.	Ex Ante Efficiency	Ex Ante Full Load Hours (hrs)	Gross Ex Ante Unit Savings (therm/yr)	Gross Ex Ante Program Savings (therms/yr)	Ex Ante Net-to-Gross Ratio	Ex Ante Net Program Savings (therm/yr)
Low Eff. Boilers (82 to 84%)	115	84.5%	2,000	1,800	207,000	0.8	165,600
Medium Eff. Boilers (85 to 92%)	30	91.4%	2,000	3,270	98,100	0.95	93,195
High Eff. Boilers (93 to 97%)	43	96.0%	2,000	3,900	167,700	0.95	159,315
Total	188			2,515	472,800	0.88	418,110

Ex post first year therm load impacts are summarized in **Table 3.3**. The ex post first year gross therm load impacts are 377,758 ± 43,023 therms per year at the 90 percent confidence level. The ex post NTGR is 0.96, and the first-year ex post net program savings are 362,648 ± 41,302 therm per year at the 90 percent confidence level. The first year ex post net realization rate for therm savings is 0.87 ± 0.10. The first year net realization rate is less than one due to ex post full load operating hours and ex post measured efficiencies being less than ex ante values. Ex post field measured efficiencies are lower than rated efficiencies due to markedly different inlet and outlet temperature conditions compared to the ANSI Z21.13-2000 test conditions under which boilers are rated. Another reason for the reduced efficiency might be due to the performance of randomly selected boilers in the field compared to manufacturer test results which are done for a selected sample of manufactured boilers. Field measured efficiencies might also be lower due to piping insulation, buried versus unburied piping and weather conditions that affect annual operating efficiency, and fuel consumption of the boilers. In-situ field measurements of old boilers were performed and the pre-retrofit combustion efficiency values were in the 75% range and generally consistent with the ex ante pre-retrofit efficiency values.

Table 3.3 Ex Post First Year Therm Load Impacts for the Energx Program

Description	Ex Post Qty.	Ex Post Efficiency	Ex Post Full Load Hours (hrs)	Gross Ex Post Ante Unit Savings (therm/yr)	Gross Ex Post Program Savings (therms/yr)	Ex Post Net-to-Gross Ratio	Ex Post Net Program Savings (therm/yr)	Ex Post Net Realization Rate
Low Eff. Boilers (82 to 84%)	184	81.2%	1,869	1,512	278,208	0.96	267,080	1.61
Med. Eff. Boilers (85 to 92%)	15	80.9%	1,971	1,858	27,870	0.96	26,755	0.29
High Eff. Boilers (93 to 97%)	20	87.3%	1,850	3,584	71,680	0.96	68,813	0.43
Total	219			1,725	377,758	0.96	362,648	0.87

Lifecycle therm savings are summarized in **Table 3.4**. The ex-ante net lifecycle savings are 5,547,000 therms. The EM&V study ex-post net lifecycle savings are 7,252,954 ± 328,611 therms. The ex-post net lifecycle therm realization rate is 1.31 ± 0.06. The lifecycle net realization rate is greater than one due to the ex post NTGR and effective useful life (EUL) being greater than ex ante values.[12]

[12] Ex post 0.96 NTGR and 20 year EUL are based on Express Efficiency applicable to nonresidential rebate measures, see *Energy Efficiency Policy Manual*, Version 3, Chapter 4, Tables 4.1 and 4.2, prepared by the California Public Utilities Commission, 2003.

Table 3.4 Lifecycle Therm Load Impacts for the Energx Program

Measure	Net Ex Ante Program Savings (therm/yr)	Ex Ante Effective Useful Life (EUL)	Net Ex Ante Lifecycle Program Savings (therm)	Net Ex Post Program Savings (therm/yr)	Ex Post Effective Useful Life (EUL)	Ex Post Net Lifecycle Program Savings (therm)	Ex Post Net Realization Rate
Low Eff. Boilers (82 to 84%)	165,600	3	496,800	267,080	20	5,341,594	10.75
Med. Eff. Boilers (85 to 92%)	93,195	20	1,863,900	26,755	20	535,104	0.29
High Eff. Boilers (93 to 97%)	159,315	20	3,186,300	68,813	20	1,376,256	0.43
Total	418,110		5,547,000	362,648		7,252,954	1.31

The verification inspection findings and detailed load impact results for low, medium, and high efficiency gas boilers are provided in the following sections.

3.1.1 Measurement and Verification Findings

Measurement and verification inspections were conducted for the study in October and November 2003 and May 2004. All measures were verified as properly installed consistent with the Energx database. Results of the on-site verification inspections were used in the impact evaluation to estimate the overall energy savings. Combustion efficiency was measured on 71 new gas boilers at different sites as shown in **Figures 3.1** and **3.2** and **Table 3.4**.[13] Field measurements of combustion efficiency were matched to all boilers in the population. Boilers manufactured by Laars and Raypack generally had measured efficiencies closer to the rated efficiency compared to other manufacturers. Measured efficiency for Laars boilers was 0.5% less than rated efficiency and measured efficiency for Raypak boilers was 3.6% less than the rated efficiency. Boilers manufactured by Fulton, Lochinvar, and Ajax had the greatest difference between measured and rated efficiency. Measured efficiency for Fulton boilers was 6.7% less than rated efficiency, measured efficiency for Ajax boilers was 7.3% less than rated efficiency, and measured efficiency for Lochinvar boilers was 8.5% less than rated efficiency.

[13] Combustion efficiency measurements were made in a manner consistent with the American National Standards Institute (ANSI) procedures except for the inlet and outlet temperatures where in-situ values were used for the application. See ANSI Z21.13-2000, Gas-Fired Low Pressure Steam and Hot Water Boilers.

Figure 3.1 Measuring Boiler Efficiency

Figure 3.2 Combustion Efficiency Analyzer

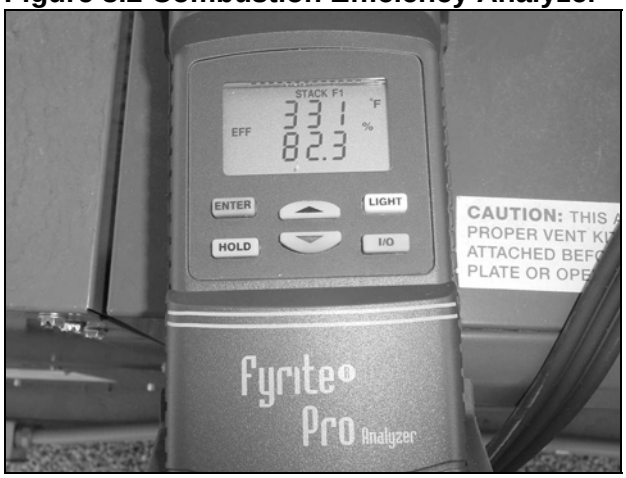


Table 3.4 Field Measurements of Gas Boiler Combustion Efficiency

Site #	Efficiency Class	Make	Model	MBtuh (in/out)	Rated Efficiency	EM&V Efficiency	Efficiency Ratio	Average Eff. Ratio
164	Low	Laars	PW0400	399/320	80.0%	77.3%	0.97	
165	Low	Laars	PW0400	399/320	80.0%	81.3%	1.02	
102	Low	Laars	PW0400	399/	81.0%	80.6%	1.00	
102	Low	Laars	PW0400	399/	81.0%	81.2%	1.00	1.00
124	Low	Raypak	CR405AL	399/	84.0%	80.7%	0.96	
125	Low	Raypak	CR405AL	399/	84.0%	81.2%	0.97	
129	Low	Raypak	CR405AL	399/	84.0%	81.7%	0.97	
130	Low	Raypak	CR405AL	399/	84.0%	81.9%	0.98	
3	Low	Raypak	WH3-0402	399/	85.0%	85.1%	1.00	
4	Low	Raypak	WH3-0402	399/	85.0%	84.9%	1.00	
20	Low	Raypak	WH3-0402	399/	85.0%	79.1%	0.93	
21	Low	Raypak	WH3-0402	399/	85.0%	81.3%	0.96	0.97
157	Low	Raypak	WH3-0652	650/	85.0%	82.1%	0.97	
158	Low	Raypak	WH3-0652	650/	85.0%	82.2%	0.97	
159	Low	Raypak	WH3-0652	650/	85.0%	82.3%	0.97	
51	Low	Raypak	WH3-652	650/	85.0%	82.2%	0.97	0.97
10	Low	Raypak	WH3-0752	750/	85.0%	82.7%	0.97	
11	Low	Raypak	WH3-0752	750/	85.0%	82.6%	0.97	
139	Low	Raypak	WH3-0752	750/	85.0%	81.7%	0.96	
138	Low	Raypak	H3-0752	750/630	84.0%	81.7%	0.97	0.97
92	Low	Raypak	WH8-0992	990/	85.0%	82.7%	0.97	
97	Low	Raypak	WH8-0992	990/	85.0%	81.0%	0.95	
105	Low	Raypak	WH8-0992	990/	85.0%	80.2%	0.94	
106	Low	Raypak	WH8-0992	990/	85.0%	82.1%	0.97	
135	Low	Raypak	WH8-0992	990/	85.0%	80.1%	0.94	
5	Low	Raypak	H8-0992	990/832	84.0%	81.4%	0.97	
39	Low	Raypak	H8-0992	990/832	84.0%	81.9%	0.98	
95	Low	Raypak	H8-0992	990/832	84.0%	81.4%	0.97	0.96
107	Low	Raypak	WH9-1262	1260/	85.0%	78.9%	0.93	
108	Low	Raypak	WH9-1262	1260/	85.0%	79.3%	0.93	
132	Low	Raypak	WH9-1262	1260/	85.0%	81.5%	0.96	
6	Low	Raypak	H9-1262	1260/1058	84.0%	81.1%	0.97	
7	Low	Raypak	H9-1262	1260/1058	84.0%	80.7%	0.96	
60	Low	Raypak	H9-1262	1260/1058	84.0%	82.7%	0.98	
89	Low	Raypak	H9-1262	1260/1058	84.0%	78.5%	0.93	
94	Low	Raypak	H9-1262	1260/1058	84.0%	77.0%	0.92	0.95

Table 3.4 Field Measurements of Gas Boiler Combustion Efficiency

Site #	Efficiency Class	Make	Model	MBtuh (in/out)	Rated Efficiency	EM&V Efficiency	Efficiency Ratio	Average Eff. Ratio
8	Low	Raypak	WH9-1532	1530/	85.0%	80.8%	0.95	
128	Low	Raypak	WH9-1532	1530/	85.0%	80.9%	0.95	0.95
42	Low	Raypak	WH9-1802	1800/	85.0%	80.6%	0.95	
93	Low	Raypak	WH9-1802	1800/	85.0%	80.6%	0.95	
98	Low	Raypak	WH9-1802	1800/	85.0%	81.9%	0.96	
80	Low	Raypak	H9-1802	1800/1512	84.0%	81.4%	0.97	0.96
40	Low	Raypak	WH9-2002	1999/	85.0%	77.0%	0.91	
96	Low	Raypak	WH9-2002	1999/	85.0%	80.6%	0.95	
101	Low	Raypak	WH9-2002	1999/	85.0%	78.3%	0.92	
91	Low	Raypak	H9-2002	1999/1679	84.0%	79.6%	0.95	0.93
131	Medium	Lochinvar	ERN401	400/	88.0%	83.0%	0.94	
153	Medium	Lochinvar	ERN401	400/	88.0%	83.0%	0.94	0.94
142	Medium	Lochinvar	CFN751PM	750/	89.0%	84.0%	0.94	
133	Medium	Lochinvar	CPN0991	990/	89.0%	80.2%	0.90	0.92
171	Medium	Lochinvar	CPN1260	1260/1058	89.0%	79.5%	0.89	
172	Medium	Lochinvar	CPN1260	1260/1058	89.0%	79.6%	0.89	
173	Medium	Lochinvar	CPN1260	1260/1058	89.0%	81.9%	0.92	0.90
117	Medium	Lochinvar	CPN1440	1440/1210	89.0%	80.0%	0.90	
118	Medium	Lochinvar	CPN1440	1440/1210	89.0%	80.5%	0.90	
119	Medium	Lochinvar	CPN1440	1440/1210	89.0%	79.5%	0.89	0.90
185	High	Fulton Pulse	PHW-1400	1400/1260	95.0%	88.5%	0.93	
219	High	Fulton Pulse	PHW-1400	1400/1260	95.0%	88.7%	0.93	
220	High	Fulton Pulse	PHW-1400	1400/1260	95.0%	88.0%	0.93	
221	High	Fulton Pulse	PHW-1400	1400/1260	95.0%	88.4%	0.93	0.93
74	High	Lochinvar	1WN2000	2000/	98.0%	87.2%	0.89	
75	High	Lochinvar	1WN2000	2000/	98.0%	88.0%	0.90	
76	High	Lochinvar	1WN2000	2000/	98.0%	87.9%	0.90	
77	High	Lochinvar	1WN2000	2000/	98.0%	86.4%	0.88	0.89
215	High	Ajax	GS1.0	1000/800	93.0%	87.0%	0.94	
216	High	Ajax	GS1.0	1000/800	93.0%	85.0%	0.91	
217	High	Ajax	GS1.0	1000/800	93.0%	84.9%	0.91	
218	High	Ajax	GS1.0	1000/800	93.0%	86.5%	0.93	
219	High	Ajax	GS1.0	1000/800	93.0%	85.0%	0.91	0.92
44	High	Raypak	ADB-500	500/	93.0%	88.3%	0.95	0.95
115	High	Raypak	CHX-15000	1499/1260	93.0%	88.8%	0.95	
116	High	Raypak	CHX-15000	1499/1260	93.0%	88.8%	0.95	0.95

Average rated and measured efficiencies by classification are shown in **Table 3.5**. Measured efficiencies were generally closer to rated efficiencies for lower efficiency boilers with a 3.3% difference between rated and measured efficiency. The difference was 7.7% for medium efficiency, and 7.5% for high efficiency boilers. Based on field measurements, the average medium efficiency boiler was 0.1% more efficient than low efficiency, and high efficiency was 6.2% more efficient than medium efficiency. In-situ field measurements of combustion efficiency are more indicative of actual field efficiencies. In-situ field measurements of old boilers were performed and the pre-retrofit combustion efficiency values were in the 75% range and generally consistent with the ex ante pre-retrofit efficiency values.

Table 3.5 Average Rated and Measured Boiler Combustion Efficiency

Efficiency	Qty.	Rated Efficiency	Measured Efficiency	Difference	Incremental Difference
Low Efficiency Gas Boilers (82 to 84%)	184	84.3%	81.0%	3.3%	
Medium Efficiency Gas Boilers (85 to 92%)	15	88.8%	81.1%	7.7%	0.1%
High Efficiency Gas Boilers (93 to 97%)	20	94.8%	87.3%	7.5%	6.2%

Manufacturers' ratings are generally 3 to 11 percent greater than field measured efficiency due to lower inlet and outlet temperature conditions depending on the application.[14] Manufacturer ratings are based on ANSI Z21.13-2000 which uses an 80 ± 5°F inlet temperature and 180 ± 2°F outlet temperature. The ANSI Z21.13-2000 inlet and outlet temperatures are not typical of normal operation where average return temperatures are in the 115 ± 11°F range and outlet temperatures are 146 ± 11°F.

Field measured efficiencies are generally lower than rated efficiencies due to markedly different inlet and outlet temperature conditions compared to the ANSI Z21.13-2000 test conditions under which boilers are rated. Another reason for the reduced efficiency could be due to the performance of randomly selected boilers in the field compared to manufacturer test results which are done for a selected sample of manufactured boilers. Field measured efficiencies might also be lower due to piping insulation, buried versus unburied piping and weather conditions that affect annual operating efficiency, and fuel consumption of the boilers.

Motor logger measurements and billing data were used to estimate Full Load Hours (FLH). Motor loggers were installed on the blower fan since this turns on every time the boiler fires and the logger captures hours of operation as shown in **Figures 3.3** and **3.4**.

Figure 3.3 Installing Motor Logger

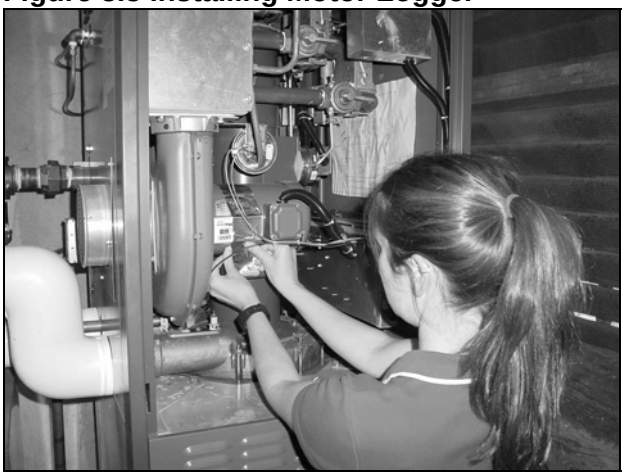
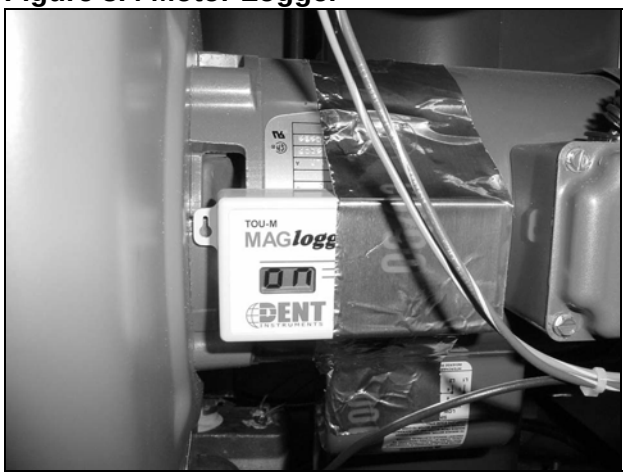


Figure 3.4 Motor Logger



The ex post average FLH is 1,873 hours per year based on motor logger measurements and billing data from 37 sites as shown in **Table 3.6**. The ex ante average FLH was 2,000 from the program implementation plan. Survey responses were used to evaluate ex ante assumptions and

[14] Combustion efficiency measurement procedures are discussed in 10 CFR Part 431, Docket No. EE-RM/TP-99-470, Federal Register, Vol. 65, No. 154, Wednesday, August 9, 2000, Proposed Rules. See http://www.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/boilers_nopr_080900.pdf.

determine an appropriate ex post savings estimate. On-site measurement and verification along with engineering analysis and existing studies were used to determine appropriate ex post savings estimates.

Table 3.6 Field Measurements of Boiler Full Load Hours (FLH)

Site #	Efficiency Class	Business	Make	Model	Rated Efficiency	EM&V Meas. Eff.	MBtuh in/out	Percent On	FLH
117	Medium	College	Lochinvar	CPN1440	89.00%	80.00%	1440/1210	4.40%	385
118	Medium	College	Lochinvar	CPN1440	89.00%	80.50%	1440/1210	5.00%	438
119	Medium	College	Lochinvar	CPN1440	89.00%	79.50%	1440/1210	60.90%	5,333
131	Low	Health Club	Lochinvar	CRN401	84.00%	83.00%	400/	18.60%	3,748
124	Medium	Health Club	Raypak	CR405AL	84.00%	80.70%	399/	47.50%	4,161
125	Medium	Health Club	Raypak	CR405AL	84.00%	81.20%	399/	47.70%	4,179
126	Medium	Health Club	Raypak	CR405AL	84.00%	81.20%	399/	47.70%	4,179
129	Medium	Health Club	Raypak	CR405AL	84.00%	81.70%	399/	53.80%	4,715
128	Low	Health Club	Raypak	WH9-1532	85.00%	80.90%	1530/	38.50%	3,373
171	Medium	High School	Lochinvar	CPN1260	89.00%	79.50%	1260/1058	41.30%	3,618
172	Medium	High School	Lochinvar	CPN1260	89.00%	79.60%	1260/1058	23.90%	2,094
173	Medium	High School	Lochinvar	CPN1260	89.00%	81.90%	1260/1058	44.30%	3,879
89	Low	High School	Raypak	H9-1262	84.00%	78.50%	1260/1058	4.70%	412
93	Low	High School	Raypak	WH9-1802	85.00%	80.60%	1800/	0.00%	0
153	Low	Hotel	Lochinvar	ERN401	88.00%	83.00%	400/	42.89%	3,748
74	High	Hotel	Lochinvar	1WN2000	98.00%	87.20%	2000/	0.00%	0
75	High	Hotel	Lochinvar	1WN2000	98.00%	88.00%	2000/	5.20%	456
77	High	Hotel	Lochinvar	1WN2000	98.00%	86.40%	2000/	0.00%	0
106	Low	Hotel	Raypak	WH8-0992	85.00%	82.10%	990/	7.50%	657
107	Low	Hotel	Raypak	WH9-1262	85.00%	78.90%	1260/	4.20%	368
108	Low	Hotel	Raypak	WH9-1262	85.00%	79.30%	1260/	0.00%	0
135	Low	Hotel	Raypak	WH8-0992	85.00%	80.10%	990/	25.90%	2,269
157	Low	Hotel	Raypak	WH3-0652	85.00%	82.10%	650/	15.30%	1,340
158	Low	Hotel	Raypak	WH3-0652	85.00%	82.20%	650/	26.10%	2,286
159	Low	Hotel	Raypak	WH3-0652	85.00%	82.30%	650/	40.60%	3,557
132	Low	Kitchen	Raypak	WH9-1262	85.00%	81.50%	1260/	18.60%	1,629
164	Low	Laundry	Laars	PW0400	80.00%	77.30%	399/320	13.40%	1,174
165	Low	Laundry	Laars	PW0400	80.00%	81.30%	399/320	25.10%	2,199
102	Low	Laundry	Laars	PW0400	81.00%	81.20%	399/	19.90%	1,743
103	Low	Laundry	Laars	PW0400	81.00%	80.60%	399/	14.40%	1,261
5	Low	Laundry	Raypak	H8-0992	84.00%	81.40%	990/832	5.30%	464
60	Low	Laundry	Raypak	H9-1262	84.00%	82.70%		0.00%	651
3	Low	Lodge	Raypak	WH3-0402	85.00%	85.10%	399/	13.00%	1,139
4	Low	Lodge	Raypak	WH3-0402	85.00%	84.90%	399/	4.00%	350
115	High	Office	Raypak	CHX15000	97.00%	88.80%	1499/1260	28.50%	1,248
116	High	Office	Raypak	CHX15000	97.00%	88.80%	1499/1260	25.00%	1,095
142	Low	School	Lochinvar	CPN750	89.00%	84.00%	750/	13.40%	1,170
Average								21.4%	1,873

3.1.2 Load Impacts for Low Efficiency Boilers

Load impacts for early replacement low efficiency boilers are based on field measurements of thermal efficiency at 45 participant sites and motor logger measurements consistent with IPMVP Option B (see **Figures 3.5** and **3.6**). Energx assumed ex ante savings are 1,800 therms per year. The gross ex post savings per measure are 1,512 ± 166 therms per year at the 90 percent confidence level. The difference between ex ante and ex post savings for boilers is primarily due to EM&V findings of lower combustion efficiency. The Energx database reported installing 184

low efficiency boilers, and the total net ex post savings are 267,080 ± 29,261 therms per year at the 90 percent confidence level. The inspections verified proper installation at 100 percent of sites. The effective useful lifetime (EUL) for this study is assumed to be 20 years. The 20 year EUL is based from Table 4.1, page 18, of the CPUC Energy Efficiency Policy Manual, 2003.

Figure 3.5 Site #157 Low Efficiency Boiler

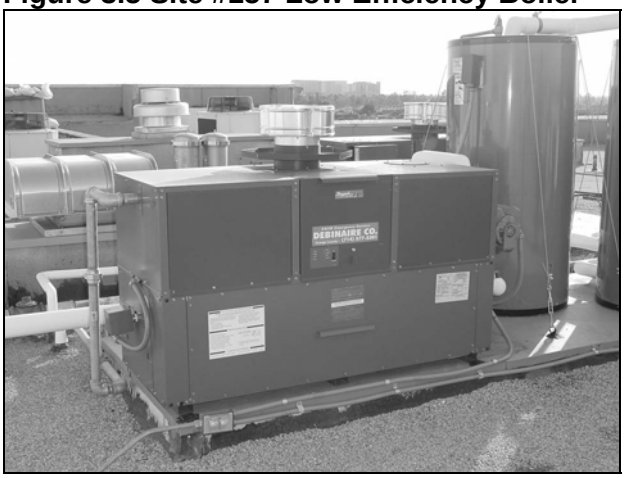
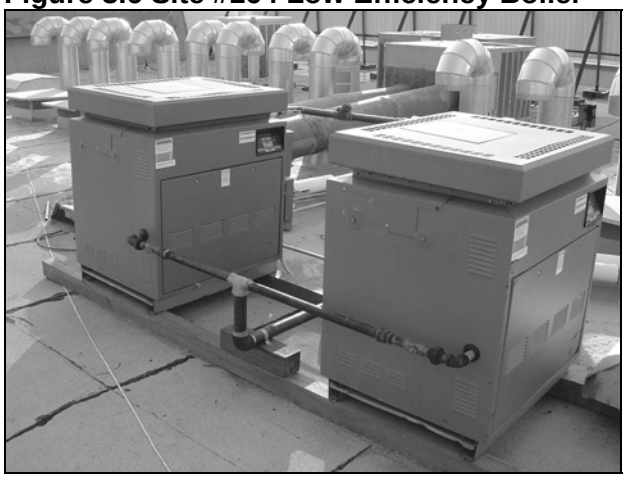


Figure 3.6 Site #164 Low Efficiency Boiler



3.1.3 Load Impacts for Medium Efficiency Boilers

Load impacts for market transformation medium efficiency boilers are based on field measurements of thermal efficiency at 10 participant sites and motor logger measurements consistent with IPMVP Option B (see **Figures 3.7** and **3.8**).[15] Energx assumed ex ante savings are 3,270 therms per year. The gross ex post savings per measure are 1,858 ± 217 therms per year at the 90 percent confidence level. The difference between ex ante and ex post savings for boilers is primarily due to EM&V findings of lower combustion efficiency. The Energx database reported installing 15 medium efficiency boilers, and the total net ex post savings are 26,755 ± 3,130 therms per year at the 90 percent confidence level. The inspections verified proper installation at 100 percent of sites. The effective useful lifetime (EUL) for this study is assumed to be 20 years.

[15] The Fulton Pulse model PW-1400 boiler (shown in Figure 3.8) is rated at 90 to 97 percent depending on the inlet water temperature and modulating control. At low temperature inlet conditions of 80°F and modulating control, the manufacturer's efficiency rating is 97%. However, four boilers measured in the study had an average in-situ efficiency of 88.4 percent under typical operating conditions.

Figure 3.7 Site #117 Medium Efficiency

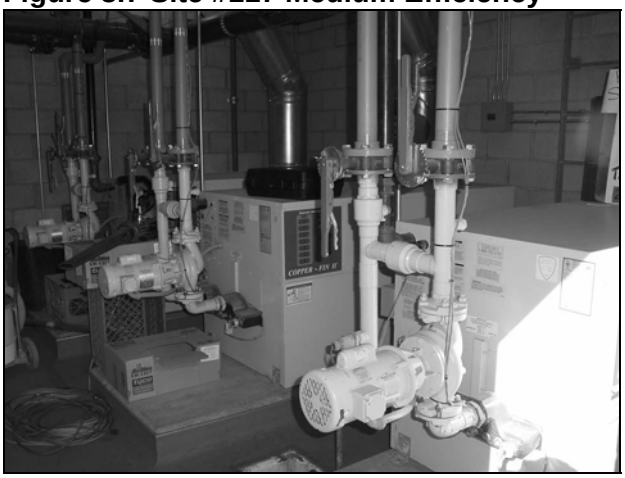


Figure 3.8 Site #219 Medium/High Efficiency

3.1.4 Load Impacts for High Efficiency Boilers

Load impacts for market transformation high efficiency boilers are based on field measurements of thermal efficiency at 16 participant sites and motor logger measurements consistent with IPMVP Option B (see **Figures 3.9** and **3.10**). Energx assumed ex ante savings are 3,900 therms per year. The gross ex post savings per measure are 3,584 ± 464 therms per year at the 90 percent confidence level. The difference between ex ante and ex post savings for boilers is primarily due to EM&V findings of lower combustion efficiency. The Energx database reported installing 20 high efficiency boilers, and the total gross ex post savings are 68,813 ± 8,911 therms per year at the 90 percent confidence level. The inspections verified proper installation at 100 percent of sites. The effective useful lifetime (EUL) for this study is assumed to be 20 years.

Figure 3.9 Site #115 High Efficiency Boiler

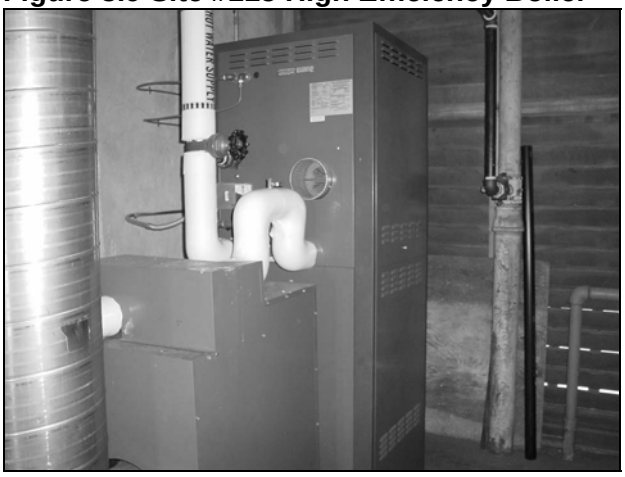
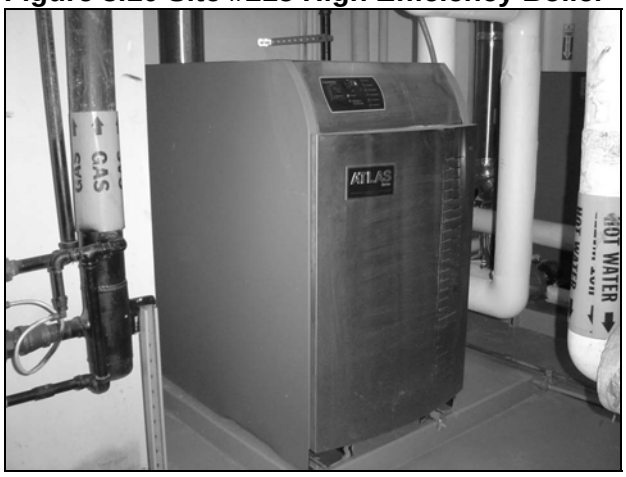


Figure 3.10 Site #215 High Efficiency Boiler



3.2 Process Evaluation Results

Process evaluation recommendations are based on process surveys conducted in-person and over the telephone with 40 participants and 20 non-participants. Surveys were randomly selected to include at least two surveys from the following building types: Laundromats, hotels, fabricators,

small health care facilities, schools, and institutions. Interviews assessed how the program influenced awareness of linkages between efficiency improvements and bill savings. The process surveys were used to evaluate participant satisfaction and obtain suggestions to improve the program's services and procedures. Interview questions assessed how the program influenced awareness of linkages between efficiency improvements and bill savings. Participants were asked why and how they decided to participate in the program. Non-participants were asked why they chose not to participate. The surveys identified reasons why program marketing efforts were not successful with non-participants as well as to identify additional hard-to-reach market barriers. The process survey instruments are provided in Appendix A.

3.2.1 Participant Survey Results

Participant process survey results are summarized to answer the following questions from the CPUC-approved EM&V plan.

1. **Are participants satisfied with services or information provided by the program?**
   Participant satisfaction is very high as indicated by the following survey responses.
   - Overall Satisfaction with Program – 92 percent satisfaction rating (i.e., average score of 9.2 out of 10 points).
   - Courteous and Professional Crew – 91 percent satisfaction rating (i.e., 9.1 out of 10 points).
   - Timeliness (i.e., customer felt that rebate was paid within a reasonable timeframe) – 100 percent satisfaction rating. Average reported number of weeks between submitting application and receiving rebate was 6.3 weeks.
   - Increased Understanding of Link between Energy Efficiency and Savings – 74 percent indicating Energx energy education efforts could be improved.

2. **Are customers satisfied with rebated high efficiency boilers?**
   Customers were very satisfied with measures as indicated by the following ratings.
   - 100 percent of customers indicated high satisfaction with rebated high efficiency boilers.

3. **Are customers satisfied with services or information provided by the program?**
   Customer satisfaction with the services or information provided by the program is indicated by the following customer ratings.
   - 94.0 percent usefulness rating for the Energx Boiler Incentive Program.
   - 90.8 percent presentation rating for the Energx Boiler Incentive Program.
   - 91.8 percent overall service rating for the Energx Boiler Incentive Program.
   - 70 percent rating of program increasing understanding of the linkage between energy efficiency and bill savings.
   - 100 percent of participants indicated that all or any businesses would benefit from the program.

4. **What are the participant hard-to-reach demographics?**
   Participant demographics have been verified as "hard-to-reach" as indicated by the following results.[16]
   - Average conditioned floor area is 116,326 ft^2.
   - 40 percent leased the building.
   - Average number of employees is 134.9.
   - 80 percent spoke English as their primary language.
   - 7.5 percent spoke Spanish as their primary language.
   - 5 percent spoke Hindi as their primary language.
   - 5 percent spoke Chinese as their primary language.
   - 2.5 percent spoke Vietnamese as their primary language.
   - The participating businesses included the following categories: Laundromat 22.5%; School 20%; Motel 17.5%; Health Care 10%; Office 7.5%; Health Club 7.5%; Church 5%; Theater 2.5%; City Pool 2.5%; Farm 2.5%; and Food Service 2.5%.

5. **Do participants have any suggestions to improve the program?**
   32.5 percent of participants provided comments or suggestions to improve the program.
   - 27.5 percent said "great program, liked the rebate" and would like to see the program continue.
   - 5 percent expressed Energx employee appreciation.

6. **Did participants share information with business associates about the benefits of measures offered by the program (i.e., multiplier effects)?**
   Based on process survey responses, 40 percent of interviewed customers shared program information with 7.2 times as many peers (16 participants shared information with 115 businesses). Approximately 40 percent of these businesses (i.e., 46) decided to install similar measures or participate in the Energy program. The program helped expand impacts beyond the participant group to a larger group through direct installation of measures. The multiplier effect for the program is estimated at 42 percent.[17]

3.2.2 Non-Participant Survey Results

Non-participant process survey results are summarized to in order to answer the following questions from the CPUC-approved EM&V plan.

1. **Is there a continuing need for the program?**
   The following responses indicate a continuing need for the program.
   - Process survey responses indicated significant demand for the program with 100 percent of participants indicating that they think all businesses would benefit from the program.
   - 45 percent of non-participants would have participated if they knew the Energx program gave rebates for new high efficiency boilers.

[16] The CPUC definition of small commercial hard-to-reach customers are those who do not have easy access to program information or generally do not participate in energy efficiency programs due to language (i.e., primary language non-English), business size (less than ten employees); geographic (i.e., outside San Francisco Bay Area, Sacramento, Los Angeles Basin or San Diego), or lease (i.e., split incentives barrier). Energx further defines hard-to-reach as less than 50kW and 5,000 ft^2.

[17] Spillover of 97 percent is calculated based on 146 businesses adopting at least one spillover measure based on information shared by a group of 68 participants who adopted five measures (i.e., $146 \times (1 \div 5) \div 69 = 0.42$).

2. **Why have customers chosen not to participate (i.e., market barriers)?**
   - 45 percent didn't know about the Energx program (i.e., information cost barrier).
   - 35 percent said that they are waiting for the SCAQMD deadline of January 1, 2006 to replace their boilers.
   - 20 percent said that they didn't have the money to replace their boilers.
   - 20 percent indicated that their existing boilers didn't need replacing.
   - 7.5 percent gave additional reasons for not participating. The top reasons include:
     - Already received a boiler rebate in 2003.
     - Bought or installed the new boiler themselves.

3. **Do non-participants have any suggestions to improve participation?**
   - 45 percent of non-participants suggested better advertising through boiler dealers, boiler installers, utility bill inserts, or mail. This is consistent with 45 percent who indicated they would have participated if they knew about the program.

4. **What are the non-participant hard-to-reach demographics?**
   Non-participants had the following hard-to-reach demographics.
   - 55 percent of non-participants leased their building.
   - 95 percent spoke English as their primary language.
   - 5 percent spoke Chinese as their primary language.
   - Non-participants had an average of 57.3 employees.
   - The non-participating businesses included the following categories: Motel 30%; Laundromat 25%; Health Care 25%; Retail 10%; Office 5%; and Food Production 5%.

The following section provides process evaluation recommendations to improve the program.

3.2.3 Process Evaluation Recommendations

The following process evaluation recommendations are provided as per the CPUC-approved EM&V plan regarding what works, what doesn't work, and suggestions to improve the program's services and procedures.

3.2.3.1 General Program Recommendations

This program was exceptionally well managed and implemented. The following general program recommendations are provided to improve the program's services, procedures, and cost effectiveness.

1. The program implementer designed the program based on manufacturer reported performance data and product literature. Future programs might be based on verified boiler efficiency ratings by measuring combustion efficiency in the field with accurate and calibrated combustion efficiency analyzers according to manufacturers' specifications. Measured efficiencies were generally closer to rated efficiencies for lower efficiency boilers with a 3.3% difference between rated and measured efficiency for low efficiency. The difference was 7.7% for medium efficiency, and 7.5% for high efficiency boilers. Based on field measurements, the average medium efficiency boiler was 0.1% more efficient than low efficiency, and high efficiency was 6.2% more efficient than medium efficiency.

2. The program incentive levels were based on feedback from contractors and manufacturers and the program implementation plan (PIP) was revised with increased incentive levels to induce participation. Revised PIP was approved by CPUC Staff. Future programs might consider incentives based on verified efficiencies rather than rated efficiencies (which were found to be overstated especially for high efficiency boilers examined in this study).
3. The program tracking database should capture and track rated efficiencies from manufacturers and operational hours based on customer information. Capturing this information in the Energx program tracking database will help make measure savings more accurate.
4. Participants provided the following suggestions to improve the program.
   - Great program, liked the rebate, and please continue the program.
   - Appreciated knowledgeable Energx employees.
5. Consider obtaining customer billing data release forms for a sample of sites for quality control checking of measures to ensure the program is delivering savings. This will facilitate better EM&V analysis of program savings.

3.2.3.2 Recommendations for Database

Energx had an excellent program tracking database. The EM&V study evaluated the database and found areas where it might be improved. Most important is capturing rated efficiencies of participating boilers from manufacturers. It might also help to obtain operational hours based on customer information (i.e., hours boiler is on rather than hours business is open). Operational hours based on interviews with participants were compared to motor logger data and findings indicated most customers had an accurate understanding of their operational hours. Capturing this information in the Energx program tracking database will help make measure savings more accurate.

3.2.3.3 Other Cost Effective Measures to Consider

Energx might want to consider other cost effective measures for the future as follows.

1. Consider including boiler controls such as the Energx water heater controller for water heating applications. This measure is highly cost effective and could be coupled with the boiler rebate program to achieve greater savings.
2. Consider Energy Star programmable thermostats for space heating applications since this is a cost effective measure to reduce heating energy use at night or during unoccupied periods.
3. Consider insulating hot water supply and cold water return on water heaters since this is a low-cost measure with significant savings opportunities. If implemented this measure should include installation of 1” thick insulation (minimum) on the first 5 feet of the hot pipe coming out of the storage tank and the first 5 feet going into the storage tank or the first major bend as per CEC Standards. For exterior applications, consider using insulation with UV protection and a guaranteed 11-year life for exterior applications to protect insulation from solar radiation, reduce heat loss, and improve persistence and savings.
4. Consider lowering hot water temperatures since this is a low-cost measure with significant savings opportunities. If implemented make sure to capture pre/post hot water temperature readings in the Energx database for verification.

Appendix A: Process Survey Instrument
Energx #208 Local Small Comm. EE & MT Program

Interview Instructions for Process Survey

1. Purpose

The purpose of the Process Survey is to evaluate what works, what doesn't work, customer satisfaction, and suggestions for improvement in the program's services and procedures. Complete 40 participant and 40 non-participant surveys.

2. Selection of Respondent

Surveys will be randomly selected to include at least two surveys from the following building types: Laundromats, restaurants, hotels, fabricators, fast food restaurants, small health care facilities, schools, and institutions.

1. **Participants** must be the person responsible for allowing program measures to be installed at the site. If this person is unavailable locate someone who is at least familiar with how that decision was made. Participant question #13 is used to verify whether or not participant is a small-business with one or more of the following CPUC EEPM attributes: 1) Primary language non-English; 2) <10 employees; 3) Located outside the Los Angeles Basin; 4) Lease; or 4) Use <20 kW or <10,000 therm/yr.
2. **Non-participants** must be a small-business in the local utility service area who was unaware of the program or decided not to allow program measures to be installed at their facility (see non-participant survey at end). Non--participant question #3 is used to verify whether or not participant is a small-business with one or more of the following CPUC EEPM attributes: 1) Primary language non-English; 2) <10 employees; 3) Located outside the Los Angeles Basin; 4) Lease; or 4) Use <20 kW or <10,000 therm/yr.

3. Two Types of Sites

This survey will be used for two types of sites:

1. **On-Site EM&V Only**. Sites that receive an EM&V on-site inspection or process survey.
2. **Telephone Only**. Sites that only receive a telephone survey (participants or non-participants).

4. How to Start a Survey

Complete the following steps to start one of these surveys:

1. Review Energx customer file information (for participants).
2. Make sure you understand what Energx installed prior to initiating the visit or call.
3. Participant Survey Introduction.
   Say: "Hello! My name is [_____], and I am conducting a survey regarding the Energx, Inc. Local Small Commercial Energy Efficiency & Market Transformation Program. The program provided incentives for high efficiency boilers for your business. Funding for the program came from the California Public Utilities Commission. Would you mind spending 10 minutes to answer a few questions to help us evaluate and improve the program?
4. Non-participant Survey Introduction.
   Say: "Hello! My name is [_____], and I am conducting a survey regarding the Energx, Inc. Local Small Commercial Energy Efficiency & Market Transformation Program that was funded by the California Public Utilities Commission in 2002 and 2003. You didn't participate in the program, but your feedback will help us evaluate and improve the program. The program provided incentives for three types of high efficiency gas boilers in the 400 to 2,000 MBTUH input range: 1) Early replacement 82 to 84% thermal efficiency boilers to meet the new SCAQMD Rule 1146 (incentives up to $2.50/ MBTUH input); 2) Market transformation 85 to 92% thermal efficiency boilers in the condensing operating range but lower cost than full condensing boilers to exceed the SCAQMD Rule 1146 (incentives of $4/MBTUH input); 3) Market transformation 93 to 97% thermal efficiency full condensing boilers to exceed the SCAQMD Rule 1146 (incentives of $7/ MBTUH input). Would you mind spending 5 minutes to answer a few questions?

ENERGX PARTICIPANT SURVEY #_____

Business_____ Name _____ Title _____

Address _____ City _____ ZIP _____

Phone Number_____ Survey Date _____Surveyor Initials _____

Participant Survey

1. Do you remember receiving an incentive from Energx for high efficiency gas boilers at your facility?
   ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer
2. What type of business or facility is this?
   __ **1** (Retail) __ **2** (Landromat) __ **3** (Restaurant) __ **4** (Health Care) __ **5** (Schools) __ **6** (Office) __ **7** (Other) **99** Refused
3. How did you learn about the Energx Boiler Incentive Program?
   __ **1** (word of mouth) __ **2** (Energx) __ **3** (Contractor) __ **4** (Distributor) __ **5** (Manufacturer) **98** DK **99** Refused
4. How would you rate the Energx staff in terms of being courteous and professional on a scale from 1 to 10?
   ___ Response (**1 is low and 10 is high**) **98** Don't Know **99** Refused to Answer
5. Was the incentive processed and paid within a reasonable timeframe?
   ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer
6. How long did it take to get your incentive after you submitted your application?
   ___ 1 wk ___2 wks ___3 wks ___4 wks ___>4 wks **98** Don't Know **99** Refused to Answer
7. How would you rate the Energx Boiler Incentive Program in terms of usefulness on a scale from 1 to 10?
   ___ Response (**1 is low and 10 is high**) **98** Don't Know **99** Refused to Answer
8. How would you rate the Energx Boiler Incentive Program in terms of presentation on a scale from 1 to 10?
   ___ Response (**1 is low and 10 is high**) **98** Don't Know **99** Refused to Answer
9. How would you rate the Energx Boiler Incentive Program overall service on a scale from 1 to 10?
   ___ Response (**1 is low and 10 is high**) **98** Don't Know **99** Refused to Answer
10. How would you rate the program in terms of increasing your understanding of the linkage between energy efficiency and bill savings?
    ___ Response (**1 is low and 10 is high**) **98** Don't Know **99** Refused to Answer
11. To the best of your knowledge was your boiler installed correctly?
    ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer
12. Are you still using the boiler that was installed?
    ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

    Please list measures not used? _____

13. Have you shared information with any of your business associates about the benefits of high efficiency boilers?
    ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

    With how many other businesses have you shared this information in the last 12 months? _____

    About how many of these people have installed any of these measures? _____
14. Do you know any other businesses that would benefit from this program (name/address)? _____

    _____

ENERGX PARTICIPANT SURVEY (cont'd) #_____

15. Please provide the following demographic information (*obtain utility bill data from Energx, if possible*)?
_____Language ____# Employees Own Lease _____ Floor Area _____therm/yr **98** DK **99** Refused

16. Do you have any suggestions to improve the program?
___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

If so, please provide the suggestion(s). _____
_____

17. Please provide boiler make, model, s/n, efficiency, input/output, (i.e., kBtuh), setting, and floor area served?

Old Boiler

Measure	Manufacturer	Model	Serial	Rated Eff.	EM&V Eff.	MBtuh (in/out)	Setting °F	EM&V °F	Area	Mtr Log
Boiler #1						/				
Boiler #2						/				
Boiler #3						/				
Boiler #4						/				
Boiler #5						/				
Boiler #6						/				
Boiler #7						/				
Boiler #8						/				
Boiler #9						/				
Boiler #10						/				

New Boiler

Measure	Manufacturer	Model	Serial	Rated Eff.	EM&V Eff.	MBtuh (in/out)	Setting °F	EM&V °F	Area	Mtr Log
Boiler #1						/				
Boiler #2						/				
Boiler #3						/				
Boiler #4						/				
Boiler #5						/				
Boiler #6						/				
Boiler #7						/				
Boiler #8						/				
Boiler #9						/				
Boiler #10						/				

18. How much hot water do you think you use per day? (Example: Hotels: 40 gal/day-room x Occupancy; Laundromats: [6.4 gal/load vertical or 2 gal/load horizontal] x [# Loads/day]; Restaurant: 1 gal/meal; Health Club: 10 gal/person-day; Schools: 6 gal/person-day, etc.)
_____ **1** (Gal/day) ___ **2** (No) **98** Don't Know **99** Refused to Answer

19. Would you mind providing your gas billing information so we can estimate your savings?
___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

Month	**Gas (therms)**	**Notes**
Jan		
Feb		
Mar		
Apr		
May		
Jun		
Jul		
Aug		
Sep		
Oct		
Nov		
Dec		

ENERGX NON-PARTICIPANT SURVEY #_____

Business _____ Name _____ Title _____

Address _____ City _____ ZIP _____

Phone Number _____ Survey Date _____ Surveyor Initials _____

Non-Participant Survey

Surveys will be randomly selected to include at least two surveys from the following building types: Laundromats, restaurants, hotels, fabricators, fast food restaurants, small health care facilities, schools, and institutions. I am conducting a survey regarding Energx, Inc. *Local Small Commercial Energy Efficiency & Market Transformation Program* that was funded by the California Public Utilities Commission in 2002 and 2003. You didn't participate in the program, but your feedback will help us evaluate and improve the program. The program provided incentives for three types of high efficiency gas boilers in the 400 to 2,000 MBTUH input range: 1) Early replacement 82-84% thermal efficiency boilers to meet the new SCAQMD Rule 1146 (incentives up to $2.50/MBTUH input); 2) Market transformation 85-92% thermal efficiency boilers in the condensing range to exceed SCAQMD Rule 1146 (incentives of $4/MBTUH input); 3) Market transformation 93-97% thermal efficiency full condensing boilers to exceed SCAQMD Rule 1146 (incentives of $7/MBTUH input). Would you mind spending 5 minutes to answer a few questions?

1. Does your business have a boiler that is greater than 400MBTUH or less than 2MBTUH input?

   ___ **1** (Yes) ___ **2** (No**–STOP–**Thank you and Goodbye) **98** Don't Know **99** Refused

2. What type of business or facility is this?

   __ **1** (Retail) __ **2** (Landromat) __ **3** (Restaurant) __ **4** (Health Care) __ **5** (Schools) __ **6** (Office) __ **7** (Other) **99** Refused

3. Please tell me why you choose not to participant in the program? (Read list – Multiple answers are okay.)

   1 Didn't know about the program (i.e., information cost).
   2 Didn't understand energy savings benefits of the program (i.e., performance uncertainty).
   3 Don't own the building (i.e., renter–misplaced or split incentive).
   4 Didn't have time to consider the program or understand high efficiency boilers (i.e., hassle cost).

   Would you have participated if someone else you know (i.e., an employee) had taken time to help you participate (i.e., apply for an incentive)?

   ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

   5 Would you have participated if the program had better marketing, design, implementation, delivery and follow-up efforts?

   ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

   6 Are you planning to wait until the SCAQMD Deadline of January 1, 2006 to replace your boiler?

   ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

   7 Did you not have enough money to replace the boiler with incentives from the program?

   ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

   8 Other _____

   98 Don't Know **99** Refused to Answer

3. Please provide the following demographic information?

   _____Language ____# Employees Own Lease _____ Floor Area _____therm/yr **98** DK **99** Refused

4. Do you have any suggestions that might have helped you participate in the program?

   ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

   If so, please provide the suggestion(s). _____

   _____

Energx Local Small Commercial EE and MT Program Audit Form

Business Name_____ **#**_____ **Contact** _____ **Suite#** _____

Address _____ **City** _____ **ZIP** _____

Phone_____ **Vintage** _____ **Windows Face:** N NE E SE S SW W NW N

Floor Area_____ **Window Area** _____ **Window Type:** Single Double Low-e Metal Wood Vinyl **Shading:** Interior Exterior **Window Film:** Y N

Ceiling: Concrete Wood **Walls:** Concrete Wood **Floor:** Concrete Wood

Ceiling R-Value: Adiabatic R0 R11 R19 R30 R38 **Adiabatic Walls:**___ **Wall R-Value:** R0 R11 R19 **Floor R-Value:** Adiabatic R0 R11 R19

WATER HEATER

Fuel Type: Gas Electric **Vol. (gal.):** 30 40 50 **Energy Factor:**____ **Blanket?** Y N **Pipe Insul?** Inlet – Y N Outlet – Y N

Manufacturer:_____ **Model:**_____ **FTC Annual Use:** _____ **Condition:** Pass Fail **Age:** _____

HEATING (circle all that apply)

Fuel: Gas Electric **System:** Boiler Furnace HP **Make:**_____ **Model:**_____ **kBtuh:**____ **Efficiency:**_____ **Age:**_____

COOLING (circle all that apply)

System: Split-System HP Swamp **Make:**_____ **Model:**_____ **Tons:**____ **Condition:** Pass Fail **Age:**_____

THERMOSTAT SETTINGS Tstat Reading: EM&V Check:

	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11
Old Cool																								
New Cool																								
Old Heat																								
New Heat																								

DUCT SYSTEM & INFILTRATION (circle all that apply)

Distribution: Floor Supply Ceiling Supply Floor Return Ceiling Return Wall Return Single-Return Closet Return

Pre/Post Duct Leakage (cfm) @ 25Pa:_____ **Pre/Post Ring:**_____ **Pre/Post CFM50:**_____ **Pre/Post EOA:**_____

FLOOR PLAN DRAWING:

EM&V Technician (Print Name)_____ **EM&V Technician (Sign)**_____**Date**_____