Equipoise Consulting, Inc.

Energy Analysis

Project Management

Training

Final Report for

Local Energy Efficiency Program No. 1225-04
Energy Solutions' 2004/05
LightWash II Program

Prepared by:

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1 EXECUTIVE SUMMARY

The LightWash II Program offered rebates on the installation of energy and water efficient clothes washers in coin laundry stores (i.e., Laundromats), institutional common area laundry facilities, businesses with on-premise laundries, and multi family housing in collaboration with water utilities within the Pacific Gas and Electric (PG&E) service territory. LightWash II also offered rebates for high-efficiency water heaters installed in Laundromats, multifamily housing with common area laundry, hospitals and other institutions, hotels/motels and in other businesses with on premise laundry. In addition the LightWash II program offered turn key installation of energy efficient lighting in laundromats and businesses adjacent to participating laundromats. The lighting installations were incented up to a maximum cost effectiveness limit, which in some cases covered 100% of the project cost.

This evaluation focused primarily on data collection for two specific elements. The 2002-03 LightWash program evaluation had identified low retention rates for screw-in compact fluorescent lamps in laundromats, so this evaluation assessed that element to firm up the retention information. The second area focused on the most uncertain parameter in the Laundromat washer impact estimate, the number of turns per day for washing machines. In addition the evaluation was tasked with estimating energy and electric demand impacts based on findings from the two studies above, the database of installed units, and deemed per-unit impacts.

1.1 Findings – Screw in CFL Retention Assessment

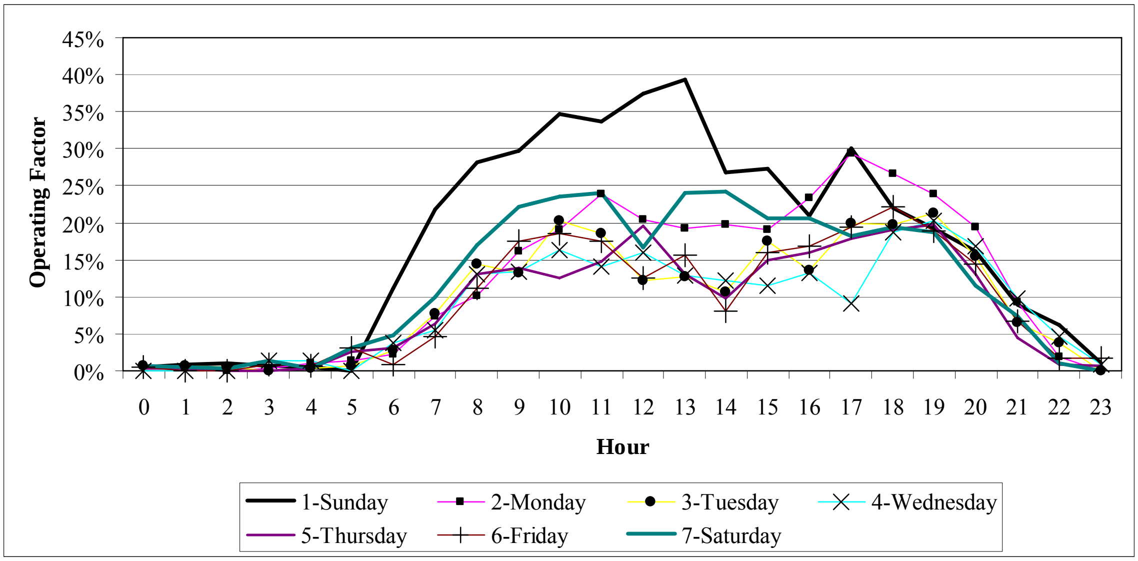
This evaluation found a retention rate of 88.7 percent for screw-in compact fluorescent lamps. Of the 186 bulbs expected, 168 were found to be in place and operating. This was greater than the 68 percent retention rate found in the PY2002/2003 evaluation. The reasons for the missing 21 bulbs were as follows:

1. Renovation of site (10 bulbs)
2. Reasons were unknown (6 bulbs)
3. Not installed (3 bulbs)
4. In place but burned out (2 bulbs)

1.2 Findings – Laundromat Washer Turns per Day Assessment

While a single machine averaged anywhere from 0.57 to 7.44 turns per day, the average turns per day across all machines was 2.97 ± 0.70 at the 90% confidence level. Using the analysis method outlined in Section 4.2, the hourly operating factor across all 77 metered machines is shown in Exhibit 1.1.

Exhibit 1.1
Hourly Operating Factor by Day of Week



1.3 Findings – Energy and Demand Impacts

On an ex ante basis, using deemed savings values, the program met it energy and demand goals. On an ex post basis, however, the LightWash program exceeded the net demand savings goals and provided less than the planned net energy goals, delivering the following results.

Exhibit 1.2
Net Annual Program Impacts

	kW	kWh	Therms
Total Program Net Impacts	314	1,790,719	240,943
Total Program Net Impact Goals	284	1,980,284	314,773
Program Net Realization Rate	111%	90%	77%

The demand impact is higher than expected because the actual measures installed had higher impacts than what had been forecasted to be installed. The electrical energy net value is lower than expected due to the decreased number of turns per day in laundromat clothes washers and the lower than expected hours of operation for laundromat lighting. The natural gas net energy value is lower than projected due to the lower turns per day value, which effected both the clothes washer and boiler measures.

1.4 Recommendations

The following program design recommendations evolved from the evaluation:

- The CFL persistence rate was higher in the PY2004/2005 evaluation than in the pervious program cycle. The reasons for why bulbs were not present were, for the most part, outside of the ability of the program to influence. It is recommended that a realization rate of at least 90 percent be used when calculating an ex ante impact value for CFLs during the program planning.

- PG&E[1] should immediately adjust the 2006-2008 program plans to account for the findings in laundromat washer turns per day.

The following evaluation recommendations are made for possible future efforts:

- Research is needed to determine if the expected number of times a machine is used per day within multi-family and institutional sites is similar to what has typically been expected or if there is a significant difference as was found for clothes washers at commercial laundromats.
- The use of the Watts Up? Pro meter has advantages due to it's ease of use and cost-effectiveness. The analytical challenges found by the evaluation team may be reduced some with the newer version of the meter that is now available with extensively greater memory capability.

[1] PG&E is currently offering a program similar to the LightWash program.

2 INTRODUCTION

2.1 Program Overview

The LightWash Programs were a collaboration with the California Urban Water Conservation Council (Council), 25 California water agencies and organizations concerned with water supply and conservation of natural resources in California--and numerous California water and wastewater agencies.

The Program operated in the service territories of the following participating water agencies:

Alameda County Water District

City of Antioch

California Water Service Co. (Salinas area)

California Water Service Co. (Stockton area)

Coastside County Water District

Contra Costa Water District

City of Cotati

City of Davis

Diablo Water District

East Bay Municipal Utility District

City of Hollister

City of Manteca

Marin Municipal Water District

City of Martinez

City of Menlo Park

City of Millbrae

North Marin Water District

City of Napa

City of Pittsburg

Redwood City

City of Rohnert Park

City of Sacramento

San Francisco PUC

City of San Juan Bautista

San Francisco Public Utilities Commission

Santa Clara Valley Water District

Santa Cruz Water Department

City of Santa Rosa

City of Sebastopol

Soquel Creek Water District

Sunnyslope County Water District

Valley of the Moon Water District

Water Resource Association of San Benito County

Through these partnerships, the LightWash II Program provided prescriptive rebates and targeted outreach and marketing to encourage the adoption of high efficiency clothes washer technology by laundromats, businesses, and institutional and multi-family common area laundry facilities. For laundromats, which are often “Very Small Nonresidential” hard-to-reach customers, the program also offered turnkey lighting retrofit services and water heater incentives.

At the heart of the LightWash program's success promoting efficient commercial clothes washers was Energy Solutions' initial collaboration in 2002 with the Council and the program's ongoing partnerships with 25 California water agencies. Through these partnerships, the LightWash program provided combined Public Goods Charge funded energy rebates with water rebates that were funded by participating water utilities in amounts determined by each water utility. The program also provided targeted outreach and marketing to encourage the adoption of high efficiency clothes washer technology by eligible customers in qualifying energy and water utility territories. In addition to incentive funding, many water agencies contributed to marketing efforts and education through their standard channels, including bill inserts, newsletters, etc. By consolidating resource-intensive activities, such as incentive processing and targeted outreach, the LightWash program attempted to remove substantial cost and staff resource barriers, thereby facilitating the active involvement of additional water agencies.

The LightWash program developed a qualifying product list based on the national Consortium for Energy Efficiency's (CEE) Commercial, Family-Sized Washer Initiative product list (www.cee1.org), which includes Water Factor (WF)[2] and Modified Energy Factor (MEF)[3] requirements. During its four years of operation, LightWash sometimes offered multiple energy rebate levels for a range of qualifying efficiency levels. Exhibit 2.1 lists the specifications and energy rebates for qualifying washers during the LightWash program. The water utility rebate component (not shown in Exhibit 2.1) varied from $50 to $350, and was provided in addition to the energy rebate shown.

Exhibit 2.1
LightWash Program Washer Specifications and Energy Rebates

Program/Year	LightWash Specifications	Modified Energy Factor (cubic feet/kWh)	Water Factor (gallons/cubic foot)	Rebate (not including water utility rebates)
LW I- 2002/03	All qualifying washers	≥ 1.26	≤ 9.5	$100-150 (depending on customer type)
LW I- Jan-Feb 2004	All qualifying washers	≥ 1.42	≤ 9.5	$150
LW II- Mar-Dec 2004	Washer Level 1	≥ 1.42	≤ 9.5	$50
LW II- Mar-Dec 2004	Washer Level 2	≥ 1.8	≤ 7.5	$150
LW II- Jan 2005-Mar 2006	Washer Level 2	≥ 1.8	≤ 7.5	$100

The lack of on-site staff puts laundromats into an especially-hard-to-reach category. Thus the program addressed this market segment more comprehensively, offering a turnkey

[2] The Water Factor is the standardized metric for water use, expressed as the number of gallons per cycle per cubic foot of tub capacity. The lower the water factor, the more efficient the washer.

[3] Modified Energy Factor (MEF) is the standardized metric for energy consumption of the average total laundry cycle (washing and drying). It is expressed as cubic feet of tub capacity divided by energy use (kWh) for the average total laundry cycle. The higher the number, the greater the efficiency.

lighting retrofit program. The lighting program was marketed by trade allies (who also did installations) and by Program staff through the local chapters of the Coin Laundry Association, trade show presentations, direct mail, and advertisements and articles placed in industry journals.

Experienced, small commercial lighting contractors conducted audits and provided retrofit design recommendations. The customer paid only a portion of the lighting retrofit with incentives paid to contractors covering the difference. The Program relied on a select group of experienced lighting contractors that had agreed to specified program protocols and fixed measure pricing. The lighting retrofit program removed the laundromat owner/manager from the difficulties associated with technical decisions, vendor screening, quality control, and other worries and time commitments. In addition to the laundromats, the program was allowed to offer the lighting retrofits to businesses in the same complex as the participating laundromat.

The program also offered post installation rebates for instantaneous water heaters installed by laundromat owners who purchased and installed these types of boilers with a thermal efficiency greater than or equal to 95 percent. To assist in identifying qualifying boilers, the program developed a qualified boiler list based on objective performance testing.

2.2 Background on this Evaluation

This evaluation builds upon the findings from the evaluation of the 2002-03 LightWash program. The earlier LightWash program identified two specific areas where further information would benefit future versions of the program. As a result, a research plan was developed and approved for LightWash II that was designed to gather additional data in these areas. The two areas were:

Screw-In CFL retention rates. The evaluation of the 2002-03 LightWash program identified unexpectedly low retention rates for screw in CFLs. While the sites acknowledged that the CFLs had been installed originally, there was no concerted effort by the evaluation team to determine why the bulbs were no longer present. Without additional information, the program does not know what the real savings from the measure is or whether program design changes are needed.

Number of turns per day in the commercial laundromat sector. The 2002-03 evaluation identified the washer turns per day as an area of significant uncertainty. Because primary data collection of turns per day is expensive, efforts during that evaluation concentrated on assessing program theory and program operation. Having assessed those issues within the last twelve months, the California Public Utilities Commission (CPUC), program staff, and evaluators concluded the best use of evaluation funds in 2004-05 would be to collect primary metered data on laundromat washer turns per day to create a higher level of certainty in the energy impact values. Again, because of the expense, the effort was limited to the commercial laundromat sector.

2.3 Evaluation Objectives

The objectives for this evaluation, as established in the evaluation research plan, were to:

- Independently assess the CFL installation/retention rates for the 2004-05 program. Unexpectedly low CFL retention rates were discovered during the 2002-03 evaluation. The current retention rates need to be assessed to explain the results and discover whether there are unexplained flaws in the program design.
- Develop primary metered data to document the number of turns per day in the commercial laundromat sector.
- Estimate the peak kW and annual kWh and Therm savings accrued by the program.

In addition to these requirements, the CPUC has stipulated eight overall objectives that must be addressed by the evaluation. The Administrative Law Judge (ALJ) stipulated items are summarized and discussed in Section 2.5 below.

2.4 The Approach Overview

The evaluation approach used to meet these objectives was generally compliant with the International Performance Monitoring and Verification Protocols (IPMVP) Option A and the appropriate portions of the CPUC Energy Efficiency Policy Manual[4].

The approach had two field data collection efforts, onsite field data collection for a census of lighting sites that had screw-in CFL measures installed, and logger metering of six washing machines at each of 13 laundromat sites (total sample of 77 machines). The washer sample was designed to achieve a precision of 90% plus or minus 10% on the number turns per day.

The program impact estimate approach stipulates the delta kWh, therm, and peak kW values for the lighting component and investigates one part of the change in energy use for the washing machines installed. The stipulated values used in the savings estimates have come from the data developed by the extensive evaluations conducted in the state of California over the past 10 years and from the California Energy Commission (CEC) databases. The types of lighting installed as part of the Program have been assessed in many studies, sectors, and utility service territories and the unit savings did not warrant further study here. The per unit per wash cycle savings due to the installation of energy efficient washing machines have been assessed and documented by the CEC and were stipulated for this study. This approach presents the best cost-benefit value for the evaluation of this program.

2.5 Stipulated Items

The ALJ issued a ruling on November 27, 2002 requiring all evaluations to address a set of eight overall objectives stated in the CPUC Energy Efficiency Policy Manual (EEPM)[5]. The eight objectives are listed below along with a description of how each

[4] California Public Utilities Commission, Energy Efficiency Policy Manual, Version 2, Prepared for the Energy Division, August 2003.

[5] California Public Utilities Commission. (2003) Version 2 *"Energy Efficiency Policy Manual."* Prepared by the Energy Division of the California Public Utilities Commission, August 2003.

objective would be addressed by the evaluation. The information was all presented in the Research Plan which was reviewed and approved by the CPUC.

1. Measuring level of energy and peak demand savings achieved. – *This evaluation focused on collecting primary data for CFL installation/retention and laundromat washers turns per day. The evaluation used the updated estimates of CFL retention rates and washer turns per day for laundromats as part of an overall computation of estimated program savings. The remainder of the estimate used the program data from the tracking database on units installed and per-unit impacts and the realization rates for units installed from the prior evaluation. The exception to this rule was the washer realization rates. In the prior evaluation it was found that some realization rates for washers slightly exceeded 1.0 due to certain customer practices. For washers in this evaluation, since that field data was not reconfirmed, the realization rates were capped at 1.0.*
2. Measuring cost-effectiveness (except information-only) – *The evaluation computed ex post estimates of energy and demand savings. Energy Solutions will calculate cost effectiveness.*
3. Providing up-front market assessments and baseline analysis, especially for new programs. – *A market assessment and baseline analysis were not done as a part of this evaluation. The Statewide Residential Tracking study conducted by ITRON had assessed the market and baseline for the clothes washer measures addressed by this Program. The lighting baseline can be taken from the California Statewide Commercial Sector Energy Efficiency Potential Study.*
4. Providing ongoing feedback and corrective and constructive guidance regarding the implementation of programs. – *The main focus of this evaluation was on primary data collection for screw-in CFL retention and washer turns per day in laundromats. As those activities proceeded, if Equipoise became aware of program issues it informed the program staff. Otherwise, no concerted effort was made to provide feedback.*
5. Measuring indicators of the effectiveness of specific programs, including testing of the assumptions that underlie the program theory and approach. – *Equipoise developed and assessed program theory, identified indicators of effectiveness, and assessed baseline levels for program effectiveness indicators during the 2002-03 evaluation. That effort was only completed in July of 2004 and both the program and evaluation staff felt that issues of more import to the program were screw-in CFL retention rates and laundromat washer turns per day. Therefore, the decision was made to concentrate on collecting primary data in these areas. Since primary data collection (especially metering) is expensive, none of the evaluation budget had been allocated to reassessing program theory.*
6. Assessing the overall levels of performance and success of programs. *This evaluation reports estimates of energy and demand savings based on the primary data collection from the evaluation, recorded numbers of units installed from the program database, and where not covered by the primary data collection, unit savings and realization rates transferred from the 2002-03 evaluation.*
7. Informing decisions regarding compensation and final payments. – *Energy Solutions was required to report progress toward goals on a monthly basis. The evaluation did not attempt to augment or check these reports.*

8. Helping to assess whether there is a continuing need for the program. – *Equipoise used the information collected during the evaluation to draw conclusions about the probable ongoing need for the program.*

EM&V Components

Baseline Information

Baseline energy consumption for lighting is extremely well established in California evaluation literature and was not repeated here. The baseline energy consumption for washers is not well documented because of the cost of conducting the study. Such a study would require long term metering of a significant sample of non-energy efficient washers, which would be very expensive. For that very reason, such a study was not conducted in this evaluation.

Energy Efficiency Measure Information

This evaluation collected revised information on CFL retention and laundromat washer turns per day. The total number of fixtures installed through the lighting component and the total washers installed through the washer component are provided in this report.

Measurement and Verification Approach

This evaluation generally complies with IPMVP Option A to measure the peak demand and energy impact of the program for the washers in the laundromat sector. As detailed in Section 2, the approach supplemented the existing estimates of per unit savings via primary data collection on two areas of uncertainty, CFL retention rates and laundromat washer turns per day.

Evaluation Approach

The evaluation approach is covered in detail in Sections 3 and 4 of this report.

2.6 Report Contents

The remainder of this report is divided into the following sections

Section 3, Data Sources presents the sources for all data used in the evaluation, both existing and new data collection.

Section 4, Study Method provides the details of the methods used to fulfill the objectives and stipulated items presented in Sections 2.3 and 2.5 respectively.

Section 5, Results presents the results of the study objective-by-objective.

Section 6, Findings and Recommendations summarizes the key findings extracted from Section 5, and forms recommendations for improving future LightWash programs and evaluations of those programs.

Appendices:

A. References
B. Data Collection Instruments
C. Washer and CFL data collection memo
D. Laundromat Meter Data

3 DATA SOURCES

This section specifies the sources of data used to successfully complete this study.

3.1 Existing Data/Sources

The existing data sources available for this study include the LightWash II ex ante algorithms, program databases containing lists of participants in the LightWash II Program and installation information, manufacturers data, previous studies on washers, CEC database, and industry contacts that would be available from Energy Solutions' program design efforts.

As stated previously, the approach stipulates the pre-to-post installation change in kWh, therm, and peak kW usage for the lighting and does the same for the multi-family washing machines installed. The stipulated values used in the savings estimates for lighting came from the data developed by the extensive evaluations conducted in the state of California over the past 10 years. The washer values came from the CEC databases.

3.2 Primary Data Collection: Sampling and Data Gathering Approach

Both the planned and actual primary data collection is detailed in Exhibit 3.1 below.

Exhibit 3.1
Data Collection

Measure	Planned N	Sample Plan	Actual N	Actual Sample
CFL	45 Sites / 135 Lamps	2-stage sample	28 Sites/ 186 Lamps	Census
Laundromat Washers	12 Sites / 72 Washers	2-stage sample	13 sites/ 77 Washers	2-stage sample

CFLs

The evaluation of the 2002-03 LightWash program identified relatively low retention rates (66%) for screw-in compact fluorescent lamps (CFLs). This study reassessed this issue in more depth, attempting to collect data on the reasons for the missing lamps.

CFL Sample Design – The evaluation plan used a two-stage sample, with the intention of drawing a statistically representative sample of 45 sites where CFLs had been installed. At each of the selected sites, all CFLs would be physically inspected in order to estimate the proportion retained. It assumed an average of 3 CFLs per site, the total number of CFLs inspected resulting would have been 135. This sample would have achieved a level of precision greater than a 90 percent plus or minus 10 percent.

In actuality, screw-in compact fluorescent lamps were only installed at 32 sites, and the number installed per site was higher than anticipate. As a result, a census of all sites was performed, resulting in 28 sites inspected, covering 186 screw in compact fluorescent lamps.

CFL Data Collection – The CFL data collection was conducted on an unannounced basis. Since the CFLs were installed in commercial establishments, there was a high probability that the establishments would be open and lighting could be observed. The inspector simply identified him/herself, requested permission to inspect the lights, and conducted the inspection. All occupants were cooperative. The only sites that were difficult and required return visits were the unattended laundromats. On several occasions these required contacting the owner and arranging access.

Wherever lamps were missing, every effort was made to ascertain the reasons for the lamp removal and, where lamps have failed, to determine whether the site operator attempted to contact the program to obtain replacements. This information was to be used to develop recommendations on program design concerning installation of CFLs in various program applications.

Washers

In reviewing the energy and load estimates for the LightWash program during the 2002-03 program evaluation, the area of largest uncertainty in the impact calculations was the number of cycles per day (turns/day) that the typical machine performs. While this was considered important, it was determined at that time that the amount of effort required to assess that issue, along with the other core issues, was not within the budget.

This evaluation focused a considerable portion of the evaluation resources on collecting metered data on turns/day for the typical machine in the Laundromat application. Because this type of data collection is expensive, the evaluation needed to choose between laundromat and multi-family. Laundromats were chosen because of the high expected per day use of these machines and the high energy impact this may engender. This task had two challenges: (1) drawing a sample that allowed data collection of the typical machine, and (2) cost effectively collecting turns/day data.

Washer Sample Design – Because the number of clothes washers across all the laundromats was unknown[6], but the number of all participating laundromats was known, the two-stage cluster sample design was chosen. A two-stage cluster is obtained by first selecting a probability sample of clusters and then selecting a probability sample of elements from each sampled cluster (Scheaffer, Mendenhall & Lyman 1996). Each laundromat was considered to be a cluster and each washing machine was considered to be an element within each cluster.

The notation used for this discussion of the two-stage cluster design is presented below.

N=	the number of clusters in the population
n=	the number of clusters selected in a simple random sample

[6] As will be discussed later, the sample frame at each site consisted not only of the washer rebated, but of all washers at the site that were of the same load capacity of rebated washers. While the program data included the number of rebated washer, it did not contain a count of the number of other washers of the same size at each site that had not been replaced.

$M_i =$ the number of elements in cluster i

$m_i =$ the number of elements selected in a simple random sample from cluster i

$M = \sum_{i=1}^{N} M_i =$ the number of elements in the population

$\overline{M} = \frac{M}{N} =$ the average cluster size for the population

$y_{ij} =$ the j[th] observation of turns per day in the sample for the i[th] cluster

$\bar{y}_i = \frac{1}{m_i}\sum_{j=1}^{m_i} y_{ij} =$ the sample mean turns per day for the i[th] cluster

Using this sample design, the unbiased estimator of the population mean μ is:

$$\hat{\mu} = \left(\frac{N}{M}\right)\frac{\sum_{i=1}^{n} M_i \bar{y}_i}{n} = \frac{1}{\overline{M}}\frac{\sum_{i=1}^{n} M_i \bar{y}_i}{n} \qquad \text{(Equation 3.1)}$$

The estimated variance of $\hat{\mu}$ is:

$$\hat{V}(\hat{\mu}) = \left(\frac{N-n}{N}\right)\left(\frac{1}{n\overline{M}^2}\right)s_b^2 + \frac{1}{nN\overline{M}^2}\sum_{i=1}^{n} M_i^2\left(\frac{M_i - m_i}{M_i}\right)\left(\frac{s_i^2}{m_i}\right) \qquad \text{(Equation 3.2)}$$

where

$$s_b^2 = \frac{\sum_{i=1}^{n}(M_i\bar{y}_i - \overline{M}\hat{\mu})^2}{n-1}$$

and

$$s_i^2 = \frac{\sum_{j=1}^{m_i}(\bar{y}_{ij} - \bar{y}_i)^2}{m_i - 1} \qquad i = 1, 2, \ldots, n$$

As indicated above, the two-stage cluster sample was composed of (1) the laundromat sites selection, and (2) which washers at each site would be metered. The participant population from which to sample was derived from the LightWash II participants from January 1, 2004 through March 30, 2005 (the start of data collection). This population of

305 sites was first filtered based on the total number of washers at the site. Because the analysis was interested in laundromats, not multi-family sites, a filter was applied to all 305 sites to only keep those with greater than 20 machines (i.e., laundromats). The choice of 20 machines was based on filtering out the larger multi-family sites that had an average of 18.5 washers/site and conversations with the program staff. This filter reduced the potential metering population to 52 sites. Next these 52 sites were reviewed to determine if there were any non-laundromat or duplicate sites. Six sites were found to be duplicates and seven were assumed to be non-laundromat sites based on the site name (e.g., Park Apartments). Additional analysis of the remaining 39 sites caused two more sites to be removed from the potential metering sample because of the extraordinarily large number of washing machines at the site (76 and 100 machines), which we believed to be outliers and not representative of the general population[7]. The remaining metering sample of 37 sites was randomly ordered and recruited to participate in the metering effort, rigorously following the random order. Seventeen sites refused to allow metering at their site. Sites that agreed to allow metering were required to sign a release form authorizing installation of monitoring equipment.

At each site that agreed to participate, a systematic random sample of six machines was selected from all washers at the site that had a washer load capacity of less than 25 pounds. (This machine size matched the machine sizes being rebated by the LightWash program.) The approach of metering *all* 25 pound or smaller washers at each site, whether rebated through the LightWash program or not, was chosen to eliminate any bias that customers may have toward newer machines. Since the evaluation was trying to collect the number of turns per day for the typical machine, and was not trying to determine the kWh per load, the age of the washer was irrelevant to the effort. Once the six randomly chosen washing machines were identified, plug-in Watts Up? brand data loggers were installed between the outlet and the power cord behind each selected machine and left in place for approximately two weeks.[8] The loggers were installed on one set of randomly selected machines for the entire two weeks, thus requiring only two visits per site, one visit to install and initialize the loggers and one visit to remove the loggers and download the data. At some of the early sites, data was also downloaded after one week to assess the data and check data quality.

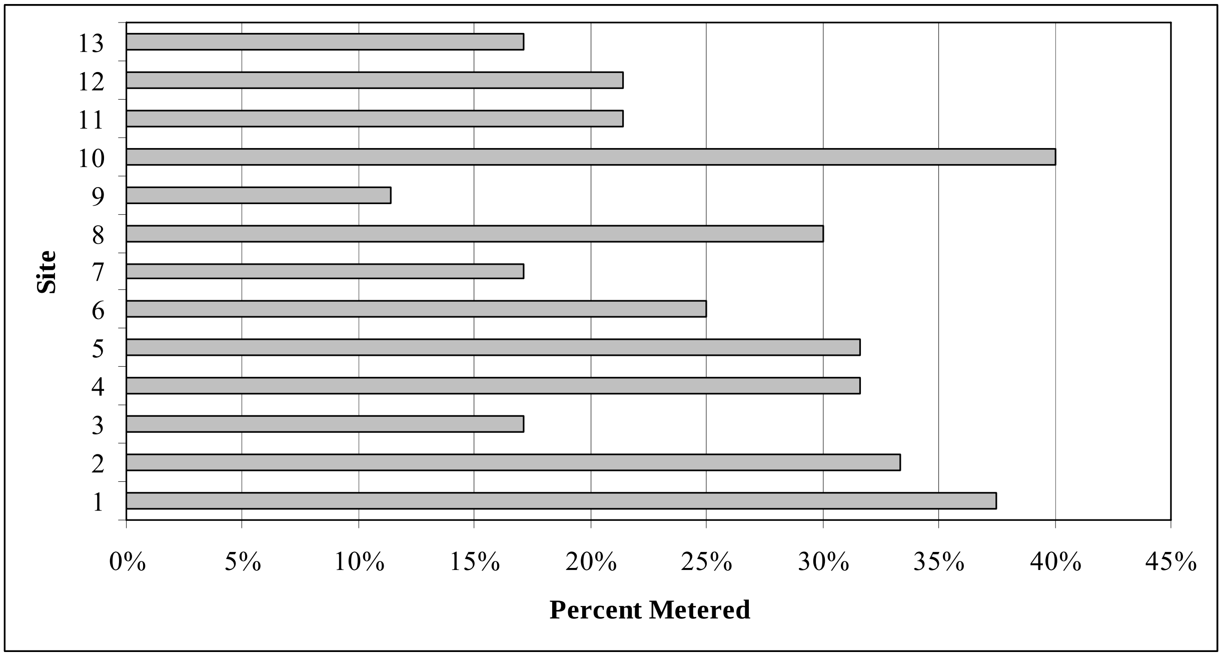
The research plan called for a total sample size of 72 individual machines. This sample size, assuming a coefficient of variation of 0.50, would have exceeded a 90 percent plus or minus 10 percent level of precision for turns per day from the average laundromat washer. One meter failure resulted in fewer machines being metered than planned, so a 13th site was recruited from the randomized list of sites. The six machines metered at the 13th site resulted in a total of 77 metered machines. Also, one meter was found unplugged at the site with the washer having a sign asking for service. While there was data in the meter, it only represented about five days worth of information. The 77 metered machines covered an average of 23 percent of the possible washers available for metering

[7] This number of washers per site was at least two standard deviations above the mean.

[8] Three sites were left in place for 16 days due to other commitments that precluded picking up the meters at 14 days.

at the 13 metered sites. (336 total machines possible for metering). Exhibit 3.2 shows the range in the percent of eligible machines metered across all metered sites.

Exhibit 3.2
Percent of Eligible Machines Metered at Each Site



All of the laundromats where metering occurred had machines that fell outside the metering criteria. Across the 13 metered sites, there were 131 machines with capacities over 25 pounds. Some sites had only 2 larger machines while others had 10 to 15 larger machines. One laundromat had 33 large machines. Therefore, the total of 467 total machines at these 13 sites had 131 machines excluded from metering. This left a total of 336 machines that were eligible for metering. However, the total number of eligible machines at all 37 sites was unknown since the only way to determine how many of the machines at the non-metered sites were actually eligible was to conduct on-site inspections, which was too expensive. Thus, the total, M (used in Equation 3.1), was calculated using the following formula:

$$Total\ Number\ of\ Eligible\ Machines = N * \frac{\sum_{i=1}^{n} m_i}{n} \qquad \text{(Equation 3.3)}$$

That is, the total number of sites, 37, is multiplied by the mean number of eligible machines at the 13 sites in the sample, 25.85. This yielded an estimated total of 956 eligible machines at the population of 37 laundromats for use in Equation 3.1.

Washer Data Collection – The Equipoise Team used the following approach to collect the data on turns/day for this evaluation:

- Selected sites were contacted by telephone in advance to obtain agreement to install monitoring equipment.

- Selected sites were required to sign a release form authorizing installation of monitoring equipment.
- The evaluation installed six plug-in Watts Up brand data loggers at each site and left them in place for approximately two weeks per site. The loggers were installed on one set of randomly selected machines for the entire two weeks, thus requiring only two visits per site, one visit to install and initialize the loggers and one visit to remove and download the data. At some of the early sites, data was also downloaded after one week to assess the data and check data quality.

3.2.1 Data Collection Instruments

The screw-in CFL data collection instrument attempted, where CFLs were missing or not found, to identify the reasons that they were not still in place. The washer program element instrument documented the washer location and model number, along with the meter installation date and initial load limit setting. The final data collection instruments for both evaluation segments are presented in Appendix B.

4 ANALYSIS METHODS

This section presents the specifics of the data analysis methods used in this project. The analyses were performed in three separate areas: (1) CFL retention percentages, (2) clothes washer average turns per day, and clothes washer average operating factor hourly profiles, and (3) program ex-post impacts.

4.1 Screw-In CFL Lamp Retention Percentage

The calculation of the retention percentage for the screw-in CFL lamps was very straight forward. The analysis was conducted on data from all sites where inspection allowed access to the installed lamps. The retention percentage is simply the number found still "in place and operable" divided by the total number of lamp installations expected – shown in Equation 4.1.

$$\text{Retention percent} = \frac{\text{number in place and operable}}{\text{number expected from program database}} \qquad \text{(Equation 4.1)}$$

Information is also supplied on the percentage of lamps missing or replaced by incandescent bulbs (i.e., not still in place) and on the percentage of lamps that are still in place but are burned out (i.e., in place but not operable). No spillover was included in the analysis. For example, if three bulbs were found where one was expected, only the one was accounted for in the analysis.

For program design purposes, the inspectors also attempted to collect information on the reasons that lamps had been removed, or if they were burned out, whether the operator had contacted the program to try to get them replaced. This information was analyzed qualitatively.

4.2 Washer Analysis

The metered washers provided data for two analyses: 1) average turns per day across all washers and 2) an hourly operating factor profile. These are presented next.

4.2.1 Turns per Day

The average turns per day (i.e., how many times the clothes washer was used per day) was calculated using the metered data from each individual washer. Although the chosen data logger was felt to be the most appropriate and cost effective for this effort, there were analytical challenges in using the output from the logger.

The Watts Up? Pro meters used in this evaluation recorded a series of watt-hour (Whr) values collected at uniform intervals. As the logger is left in place and the memory fills up, each collected "data point" represents longer intervals. For example, if the logger had been in place for one day, the data interval would have been two minutes long. The interval for each meter varied depending on the period of time between data downloads, with the interval becoming longer as the time between data downloads increased. Early in the metering effort, there were a few meters that were downloaded after one week (resulting in 17 minute data intervals) and a few after two weeks (with 34 minute data intervals) to ascertain if it was necessary to go onsite each week to collect data. When analyzed, there were no analytical gains from the one week download interval over the two week download interval, and the decision was made to leave the meters in place for two weeks without download to minimize data collection costs. In total, there were 59,628 intervals recorded across all 77 washers.

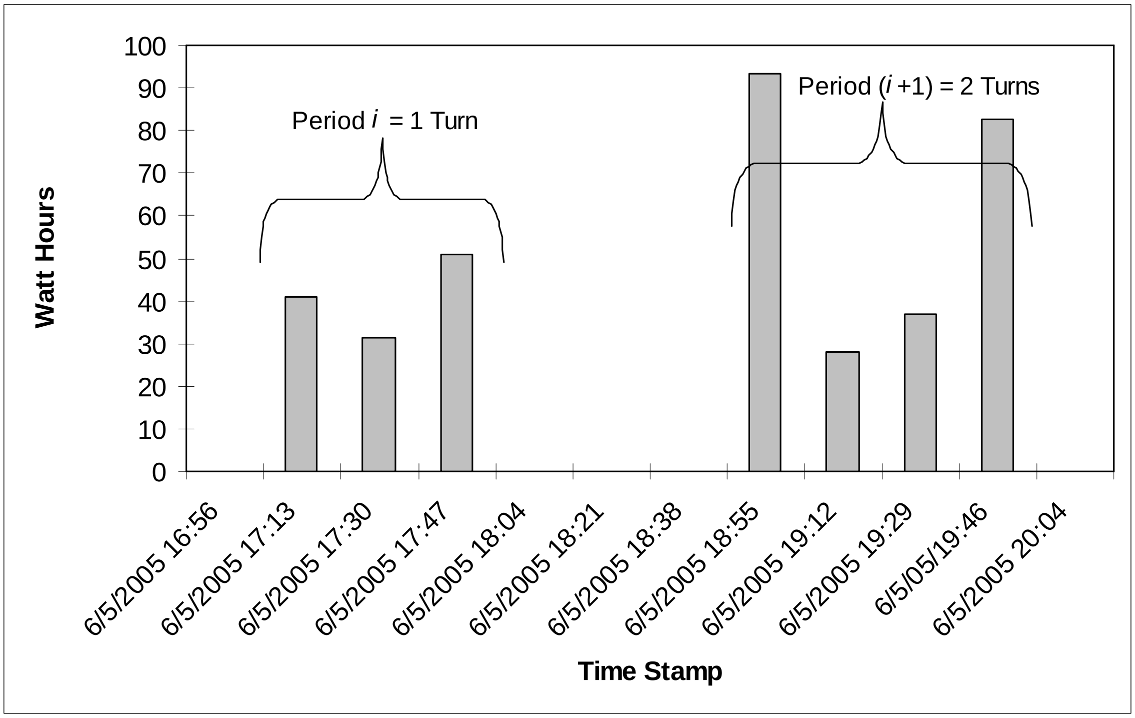
Because of the way the meters collected the data, a washer cycle could start in the middle of the metering interval, be on during the entire metering interval or stop sometime during the metering interval. Also, it was possible that a person could have completed one washer cycle and immediately begun another load of laundry in the middle of a metering interval. Analysis was required to determine how many washer cycles (turns) actually occurred during a metering interval.

To help explain this part of the analysis, Exhibit 4.1 shows an example of the raw data taken from one of the meters. The analysis set an "assigned period" (*i*) based on the watt-hour values. Because electronic controls have a constant base load, the watt hour value was given a zero value if the use during that interval was less than or equal to ten watts-hours[9] and the interval was re-labeled "Updated Watt Hours". The next period (*i*+1) was begun whenever a metering interval of zero updated watt-hours was followed by a metering interval greater than zero updated watt-hours. The energy for each period was summed. The summed values were then analyzed to determine how many turns occurred during that period.

The sum of updated watt-hour use for assigned periods *i* and *i*+1, shown in Exhibit 4.1, are 123.2 and 240.5, respectively. For this particular site, assigned period *i* was determined to be equal to one turn while assigned period *i*+1 was considered to be two turns.

[9] Ten watt hours was chosen based on the metered data. See section 4.2.2 for more detail about this value.

Exhibit 4.1
Example of Raw Metering Data and Periods



Thus, the raw data was a series of updated watt-hour usage values over varying time intervals, and the first task was determining how many turns had occurred during a single assigned period. The first attempt at setting the number of turns per assigned period tried to apply statistical analysis techniques to remove all human bias from the interpretation. Because of the variations in washer model numbers (recall that the sample included both new and existing machines) and the grouped format of the raw data, this method proved unsuccessful.

The approach used to analyze the data used two separate engineers to independently review the data from each meter at each site, and have each person decide the differentiation between the number of cycles represented in the data. In most cases, the differentiation was obvious, with gaps of 50 to 100 watt-hours between bunched data. Some cases required much closer scrutiny, sometimes involving plotting all machines of the same model from a given site to achieve clarity. Once both analysts had established break points, the two analysts reviewed any disputed values and agreed on the final break points. In no cases did the analysts disagree as to the final chosen value.

A factor confounding the analysis, was the sporadic appearance of watt-hour “blips” much smaller than the value expected for a single cycle. This was clarified by one laundromat operator, who said that they were most likely caused by owner/operators emptying machines that had not completed a cycle. Apparently operators have the ability to short-cycle the machine to empty it of water and reset it ready for use if it has not completed a wash cycle. The chosen turns per metering period break points for all 77 metered units are provided in Appendix F.

Once the break points were determined, each period for each machine was assigned a number of turns value based on the individual break points. The average turns per day for each metered washer was calculated as shown in Equation 4.2.

$$\text{Average Turns/Day} = \frac{\sum \text{turns in metering period}}{\text{metered days}} \qquad \text{(Equation 4.2)}$$

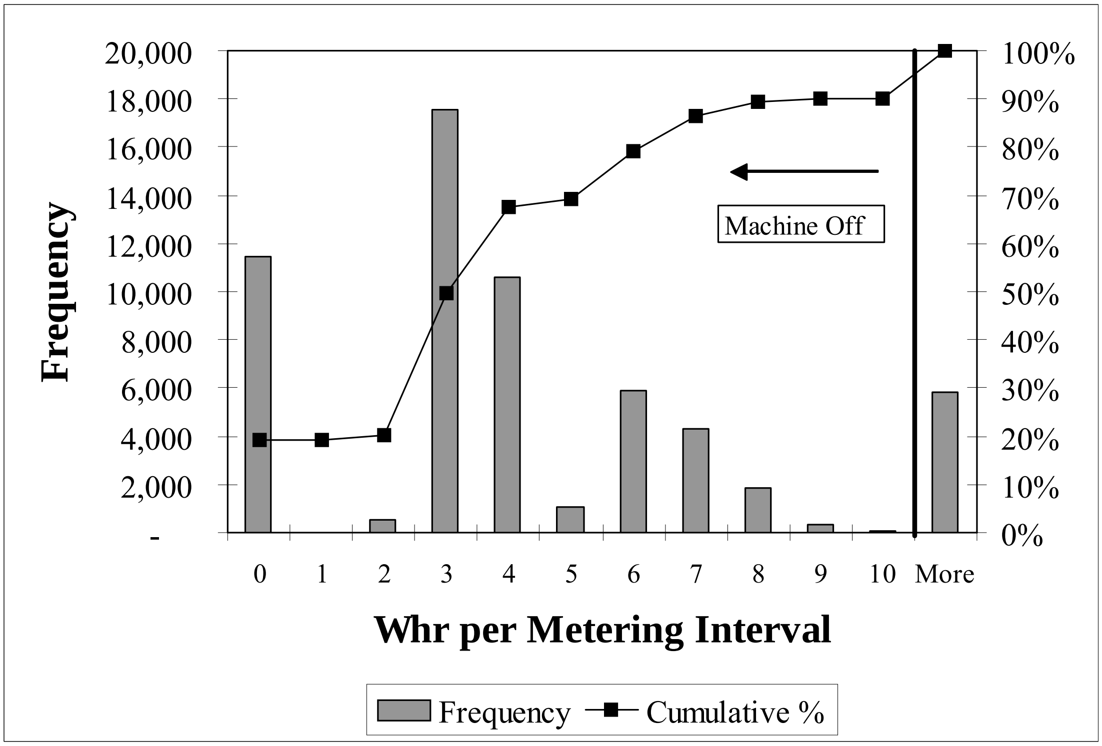
Once each washer had an average turns per day value, Equation 3.1 was used to calculate a population estimate of turns per day for commercial laundromats. Application of Equation 3.2 provided the estimated 90% upper and lower confidence intervals of the turns per day value.

4.2.2 Operating Factor

In addition to calculating the turns per day, the time-stamped metered data allowed a calculation of the operating factor across days and hours. The sites were metered sequentially, so an actual daily use metered across the same days could not be created (except for those 6 meters at the same site). However, the watt-hour use for a time stamp period was summed across each hour and the day of the week was based on the actual day metered.

A binary operating factor of one for "on" and zero for "off" was assigned to each metering interval based on the watt-hour usage. However, because electronic controls built into some washers use a small amount of energy all the time, a method was used to differentiate between actual machine use and control use (the stand-by loss when the machine is not in use). Also, if a machine were to have started moments before the time stamp, it may show only a few watt hours of use over the control usage. All 59,628 records of metered data were used to set the threshold value at which a machine was determined to be "off" (and hence the operating factor = 0). Ninety percent of the records were at or below ten watt-hours. This value was chosen as the threshold at or below which a washer was considered "off". Exhibit 4.2 plots the frequency with which metering interval energy use values corresponded to the watt-hour bins on the X axis of Exhibit 4.2.

Exhibit 4.2
Watt-hours per Metering Interval



While the analysis used the same determination of on/off for the operating factor as was used for summing the energy usage in the turns per day analysis (i.e., anything above ten watt-hours was included in each analysis), the time-stamp value was required for the operating factor analysis. Therefore, each of the 59,628 metering intervals had a binary on/off value applied and an hour and day of the week based on the time stamp value. For example, if the time stamp was 6/5/05 at 5:03 PM, the operating factor would be given a value for 5 PM on Sunday.

After setting the binary operating factor for the intervals, the operating factor for each site and meter by the day of the week and hour of the day was calculated by averaging the binary operating factors within that day of the week and hour. Therefore, there were 76 or 77 hourly operating factors[10] used for the next step in which the metered sample average operating factor was calculated using the algorithm shown in Equation 4.2. As indicated earlier, the hour and day of the week was set using the time stamp variable from the metered data.

$$\text{Average Hourly Operating Factor}_{i,d} = \frac{\sum \text{Operating Factor per hour}_{i,d}}{\text{N Hours with metered data}_{i,d}} \qquad \text{(Equation 4.3)}$$

[10] The fact that there were 76 values for some hours was due to the one meter that only had about 5 days of data as indicated in Section 3. There were 28 periods with 76 values and 140 periods with 77 values used in Equation 4.3.

Where: i = 0 to 23 (hour zero is from midnight to 1 AM)

d = day of the week

Although operating factors for all days are available, the operating factors for Saturday and Sunday, typically the busiest coin operated laundry days, were averaged to obtain a weekend profile while the rest of the days were averaged for a weekday profile in order to clearly see differences in use between weekends and weekdays.

4.3 Ex Post Computation of Savings

Once the analysis of the raw data was completed, these values were used within the ex post estimate of program impacts. One of the primary goals of the LightWash II evaluation was to develop ex post estimates of program impacts. To accomplish this goal Equipoise applied an evaluation method that was either compliant with the IPMVP Option A or indication is provided as to why the evaluation did not meet the IPMVP.

The approach for the 2004-05 evaluation used the updated information from the CFL and washer turns per day data collection, in conjunction with data for other measures transferred from the 2002-03 evaluation (i.e., the found ratio for T8 lighting and values for clothes washer impacts by location), and information from the program database. The ex post computation of savings approach is detailed first for lighting and then for washers.

4.3.1 Lighting Impacts

There were three groups of lighting measures installed through the program – T8 fluorescent fixtures, CFLs, and Light Emitting Diode (LED) exit signs. These measures were verified in the 2002-2003 evaluation resulting in the ratio of expected to found fixtures shown in Exhibit 4.3. As shown, the T8 and LED measure groups were found to be "in place and operable" virtually 100% of the time. The found-to-expected ratio established during the PY2002-2003 evaluation was used for the PY2004-2005 impact evaluation for these two measures.

The low found-to-expected ratio for the CFL measure was explored during this evaluation effort and the found-to-expected ratio was updated for the CFLs installed by the PY2004-2005 program using the analysis indicated in Section 4.1.

Exhibit 4.3
PY2002-2003 Evaluation Ratio of Expected-to-Found Fixtures

Measure	Expected	Found	Difference	Ratio
T8	1135	1130	-5	99.6%
CFL*	103	70	-33	68.0%
LED	13	13	0	100.0%

*updated in this evaluation effort

The algorithm that was used to determine the gross energy impact for the lighting components is shown in Equation 4.3.

$$\text{kW Impact} = \sum_{i=1}^{n} \left(\Delta U_i \ * \text{lamps}_i \ * N_i * RR_t * CDF_m * IE_m \right) \qquad \text{(Equation 4.4)}$$

Where:

ΔU	=	Stipulated per lamp impact from program database or from DEER
Lamps	=	number of lamps for that fixture from program database
N	=	Number of fixtures installed per program database
RR	=	Realization rate from onsite audits for CFLs or from 2002-03 evaluation for T8 and LED measures
CDF	=	Coincident Diversity Factor for that market segment from the program database
IE	=	Interactive effects with the HVAC for that market segment from the program database

AND

$$\text{kWh Impact} = \sum_{i=1}^{n} \left(kW_i * \frac{\text{Hours of Operation}_m}{CDF_m} \right)$$

Where:

kW = Demand impact from earlier algorithm

Hours of Operation = Operating hours for that market segment from the program database

CDF = Coincident Diversity Factor for that market segment from the program database (variable taken out of the kW value through this algorithm as it is not part of the kWh impact)

The evaluation team had reviewed the program database assumptions for the per-lamp impacts, CDF, IE values, and hours of operation thoroughly in the previous evaluation and found no problems. This review was not performed again during this evaluation.

For the laundromat market segment, the program collected hours of operation during program implementation (called the "found" lighting hours). As planned, these values were used to calculate the site by site savings for the laundromat segment, resulting in the overall kWh impact estimates. If the program database had a zero for the found lighting hours, the laundromat average found lighting hours by measure type (i.e., T8, CFL, etc) was used for the fixture.

The lighting hours of operation in the laundry sector were handled differently depending on whether the measure was a T8 or CFL because these measures were found in distinctly different locations during the onsite audits. Thus, the data were analyzed using the hours of operation for T8's, delamping, and CFL's. (The LED measure was not in the Laundromat sector.) There were a few items of which to be aware with this approach:

1) The delamping measure only had 7 records with "found" values while the T8 measure had 172 records. Since delamping occurs only in T8 fixtures, the 7 delamping records were included with the T8 values to obtain an average hours of operation for both T8 and delamping measures. This average value was 4,911 hours.

2) Of the 172 T8 measures with a "found" value in Laundromats, 80 of them were the deemed value of 5840. These deemed values were used to calculate the average since there was no valid reason to drop them from the average.

3) There were 2 instances in which the average was applied to T8 measures and 87 records to which the average was applied to delamping measures.

4) There are no CFL measures to which the average value of 2,639 hours was required (i.e., all CFL measures had a "found" value). This was felt to further reinforce the decision to use the averages for T8 and delamping only since these were the only measures to which the average was applied.

The other hours of operation by market sector used in the analysis are shown in Exhibit 4.4.

Exhibit 4.4
Lighting Hours of Operation and Coincident Diversity Factor by Market Sector

Market Sector	Deemed Operating Hours	Coincident Diversity Factor	Demand IE	Energy IE
Laundromat	NA*	0.88	1.16	1.11
Office	4,000	0.81	1.25	1.17
Restaurant	4,600	0.68	1.26	1.15
Retail	4,450	0.88	1.16	1.11

*Analysis used the operating hours by fixture as found at the site and input in the program database. If this value was zero, the average value of 4,911 was used for that measure.

A change from the research plan occurred in an effort to use the latest per-unit impact values. Equipoise reviewed the Database for Energy Efficient Resources (DEER)[11] for the measures installed under the program. The T8 values in the DEER were not specific enough compared to the values in the program database and the delamping values in the DEER were for a fixture, not a lamp. The program database handled delamping at the lamp level and was felt to be the most appropriate value to use, as were the specific T8 values. However, the DEER had similar measures for the CFL measures in most cases.

[11] DEER Version 2.01 dated October 26, 2005.

The program database per unit impact values were used for 2X13 CFL flood fixtures and 9 watt screw-in CFLs since DEER had nothing close to these measures. Also, the DEER values for a 40 watt screw-in CFL were used for the 42 watt CFLs installed through the program and the DEER values for a 26 watt CFL were used for the 27 watt CFLs installed through the program. The exact values used in analysis are shown below in Exhibit 4.5.

Exhibit 4.5
CFL Impacts in Analysis

Deemed Name	Measure Description	Ex Ante Watts Impact/ bulb	Ex Post Watts Impact /bulb	Ex Ante kWh Impact/ bulb	Ex Post kWh Impact /bulb
Standard CFL: 14-26 watts / incandescent base case	15 watt Screw-in CFL	50.2	43.4	293.3	171.1
Standard CFL: 14-26 watts / incandescent base case	18 watt Screw-in CFL	44.5	47.7	297.5	188.2
Standard CFL: 14-26 watts / incandescent base case	20 watt Screw-in CFL	46.4	53.0	282.9	209.2
Standard CFL: 14-26 watts / incandescent base case	23 watt Screw-in CFL	38.8	74.2	589.9	292.8
Standard CFL: > 26 watts / incandescent base case	27 watt Screw-in CFL	60.7	47.2	307.1	186.3
Standard CFL: > 26 watts / incandescent base case	42W CFL Flood	60.7	106.0	403.0	418.3
Standard CFL: 5-13 watts / incandescent base case	9 watt Screw-in CFL	35.1	35.1	203.6	203.6
Standard CFL: 14-26 watts / incandescent base case	LWI 15 watt Screw-in CFL	46.4	43.4	282.9	171.1
Standard CFL: 14-26 watts / incandescent base case	LWI 18 watt Screw-in CFL	48.9	47.7	316.2	188.2
Standard CFL: 14-26 watts / incandescent base case	LWI 23 watt Screw-in CFL	48.7	74.2	294.3	292.8
Standard CFL: 5-13 watts / incandescent base case	New 2X13 CFL Flood Fixture (silver or black)	45.0	45.0	262.8	262.8

For completeness it should be noted that most of the program per unit savings values used in the 2004-05 savings estimates came from data developed by the extensive evaluations conducted in the state of California over the past 10 years and from the California Energy Commission (CEC) databases. The types of lighting installed as part of the Program have been assessed in many studies, sectors, and utility service territories and do not warrant further study here.

The IPMVP Option A in the revised March 2002 edition of the protocol states:

> "Savings are determined by partial field measurement of the energy use of the system(s) to which an ECM was applied, separate from the energy use of the rest of the facility. Measurements may be either short-term or continuous" (p. 22)

As the research plan indicated, there was no field measurement of the energy use of the lighting systems. Two reasons were supplied to justify this in the final Research Plan approved by the CPUC:

1) as indicated above, there has been extensive prior work in the lighting field indicating that the stipulated variables result in savings estimates of similar certainty to first hand data collection, and
2) the budget for the evaluation did not allow for the statistically valid measurement of the lighting retrofits across the program.

While following the IPMVP protocols is desirable in some cases, the evaluation team believes that strict adherence to the application of the M&V within the IPMVP is not always cost effective or viable when considering programs that install energy savings measures across a wide geographical area and with many owners. The basis of the IPMVP savings is a base year energy data from a comprehensive audit. In the case of California programs that provide rebates, there is no ability to obtain base year energy data through any method other than billing data. Not only is the billing data difficult to obtain for the periods needed (particularly with third party programs), regression analysis also has a high degree of uncertainty unless enough parameters can be gathered to account for the multitude of possible changes seen within the billing data across all the sites. In addition, the measure impact must be a significant proportion of the total billed energy in order not to be drowned out by noise in the data. Nested sample designs have been used in the past that allow the use of onsite audits data to correct telephone survey responses and then the survey responses can be applied to the population. However, this type of research is expensive and could not be performed given the evaluation budget. Additionally, there are competing requirements of the evaluation outside of M&V.

Therefore, while the evaluation team acknowledges that there has not been strict adherence to IPMVP Option A for the lighting component, the approach was the most viable for this situation.

In addition to the first year impacts, the effective useful life (EUL) of each measure had to be taken into account for the final lifecycle savings from the program to complete a table required by the CPUC. (This table is provided in Appendix G.) The EULs used to calculate lifecycle savings are from Table 4.1 of the Energy Efficiency Policy Manual V2 (August 2003). The ex ante values were identical to what was used in this analysis with the exception of the CFL measure. (Exhibit 4.6)

Exhibit 4.6
Lighting Effective Useful Life Values Used in Analysis

Measure	Ex ante EUL	Ex Post EUL
CFL	16	8
Delamping	16	16
LED	16	16
T8	16	16

Exhibit 4.7 provides a summary of the updates made during the lighting analysis.

Exhibit 4.7
Summary Table of Lighting Parameters

Parameter	Was value updated over program value?	Which value was updated?	Updated Source
ΔU	Yes	CFL kW and kWh values	DEER for small retail stores
Lamps	No	NA	
N	No	NA	
RR	Yes	CFL RR	Evaluation findings
CDF	No	NA	
IE	No	NA	
Hours of Operation	Yes	Laundromat hours	Program data collection
EUL	Yes	CFL	Policy Manual V2

4.3.2 Washer Impacts

Because of the standards change at the end of 2004, the washer impacts varied based on the year in which the washer was installed. For this evaluation, all washers (except laundromat washers) installed in PY2004 used the same impact values as the previous evaluation. For PY2005, the ex ante analysis only calculated a single value, regardless of location. The planned approach was to apply impacts in a way similar to the PY2004 washers. Therefore, the inputs to the PY2005 ex ante calculation were used to vary the ex post impacts by location for PY2005 by simply applying a ratio of the ex post turns per day value to the ex ante turns per day value. If the ex post turns per day value was lower than the ex ante value, the impacts were similarly reduced.

The washers are installed in multi-family and institutional properties with common area laundry rooms and in commercial laundromats. In the multi-family setting, the estimated number of times the average washer was used per day varies based on the number of residential units per site. As indicated earlier, the current evaluation metered washers to obtain improved estimates of the turns per day in the coin operated laundromat sector. The updated turns per day value from the metered data was used for the Laundromat segment only. The impact values are shown in Exhibit 4.8.

Exhibit 4.8
Ex Post and Ex Ante Impact Values used in Washer Analysis

PY	Location	RR	Turns per Day	Annual kWh Impact	Annual Therm Impact	Average Peak kW Impact
2004	Washers in multi-unit facilities with 9 or less units per site (stipulated)	0.99	3	233	45.6	0.058
	Washers in multi-unit facilities with 10 or greater units per site (stipulated)	0.99	4	311	60.8	0.058
	Laundromat Sites (metered data)	1.00	2.97	231	45.2	0.022
	Institutional Sites (stipulated)	1.00	6	505	98.8	0.058
	Ex Ante Values	*NA*	*4.5*	*411*	*70*	*0.058*
2005	Washers in multi-unit facilities with 9 or less units per site (stipulated)	0.99	3	120	15.9	0.017
	Washers in multi-unit facilities with 10 or greater units per site (stipulated)	0.99	4	160	21.2	0.017
	Laundromat Sites (metered data)	1.00	2.97	119	15.7	0.014
	Institutional Sites (stipulated)	1.00	6	240	31.8	0.017
	Ex Ante Values	*NA*	*4.5*	*178*	*23.6*	*0.017*

The impacts for all washers used the algorithm in Equation 4.4.

$$\text{Energy Impact} = \sum_{i=1}^{4} \left(N_i * RR_i * \text{Energy Impact}_i \right) \qquad \text{(Equation 4.5)}$$

$$\text{Demand Impact} = \sum_{i=1}^{4} \left(N_i * RR_i * \text{Demand Impact}_i \right) \qquad \text{(Equation 4.6)}$$

Where:

N = Number installed per program database for sector *i*

RR = Installed realization rate from 2002-03 evaluation for sector *i*., capped at 1.0

Energy Impact = Calculated using stipulated turns per day for multi-unit and institutional washers and data from onsite metering for laundromats.

Demand Impact = Average Peak Demand impact for sector "i"

Equipoise used the operating hour data to estimate an operating factor for commercial washing machines in Laundromat applications (the plan stated that this would be attempted). The operating factors for Monday through Friday, noon to 7 PM were averaged to calculate a peak period operating factor. This estimate was used in the evaluation estimate of ex post washer demand impact. However, with the exception of the laundry sector, the peak demand impact value was not varied by market sector in the impact analysis as there was no information to reasonably adjust the run time during peak periods for each market sector.

The per unit savings due to the installation of energy efficient washing machines have been assessed and documented by the CEC. (The evaluators wish to be clear that these were not empirically found per unit savings estimates, they were engineering estimates.) Reassessment of the turns per day for institutional and multi-family applications will need to wait for future evaluation. This approach presented the best cost-benefit value for this program.

This evaluation only developed gross impact estimates. Assessment of net-to-gross ratios or net impacts was not requested as part of the request for proposal that led to this evaluation. The program stipulated net-to-gross ratio of 0.96 was used to calculate net impacts for the clothes washer and lighting retrofits while a net-to-gross ratio of 1.0 was applied to the boiler measure.

5 RESULTS

This results section is organized according to the three primary evaluation objectives stated in Section 2.3, Evaluation Objectives. Explanations of how the CPUC Stipulated Items are addressed or not addressed by the evaluation effort are covered in Section 2.3, and will not be repeated here.

5.1 Screw-In Compact Fluorescent Lamp Retention Results

At lighting sites, the inspections consisted of comparing the number of CFLs expected, based on the LightWash database, to what was found at the site. In order to be included as 'found' in Exhibit 5.1, the fixture must have been both in place and operating[12]. As indicated earlier, the expected-to-found ratio for T8s and LED exit signs were transferred forward form the 2002-03 LightWash evaluation, on the basis that the 2004-2005 program is very similar and these values represent the best estimate of expected-to-found for these measures. The ratio used by measure type are shown in Exhibit 5.1.

Exhibit 5.1
Expected and Found Fixture and Lamp Data

Measure	Expected	Found	Difference	Ratio	Ratio Source
T8 Fixture	1,135	1,130	-5	99.6%	2002/2003 Evaluation
LED Fixture	13	13	0	100%	2002/2003 Evaluation
CFL	186	165	-21	88.7%	2004/2005 Evaluation

The evaluation paid close attention to the reasons provided for why the CFLs were missing. There were two CFLs (one in each of two sites) that were in place, but not operating. They had burned out by the time of the onsite audit and had not been replaced by the owner. At one of these sites, the building was unoccupied. At the other site, there were four bulbs expected, three were found and one of those three was burned out. The owner did not know where the missing bulb was initially located, but thought it might have been in the bathroom.

For the remaining 19 bulbs that were not found, half (10) were lost during a remodel of a restaurant. This site had originally had 35 CFLs installed, but had recently undergone a renovation in which the ambiance of the eating area was changed. They had installed an amber type of incandescent lighting. While the owners were not certain about the exact

[12] "In place and operating" is the criteria used for retention studies carried out under the pre 1998 Protocols.

number of CFLs that had been in the eating area, 25 bulbs were found in other areas of the restaurant.

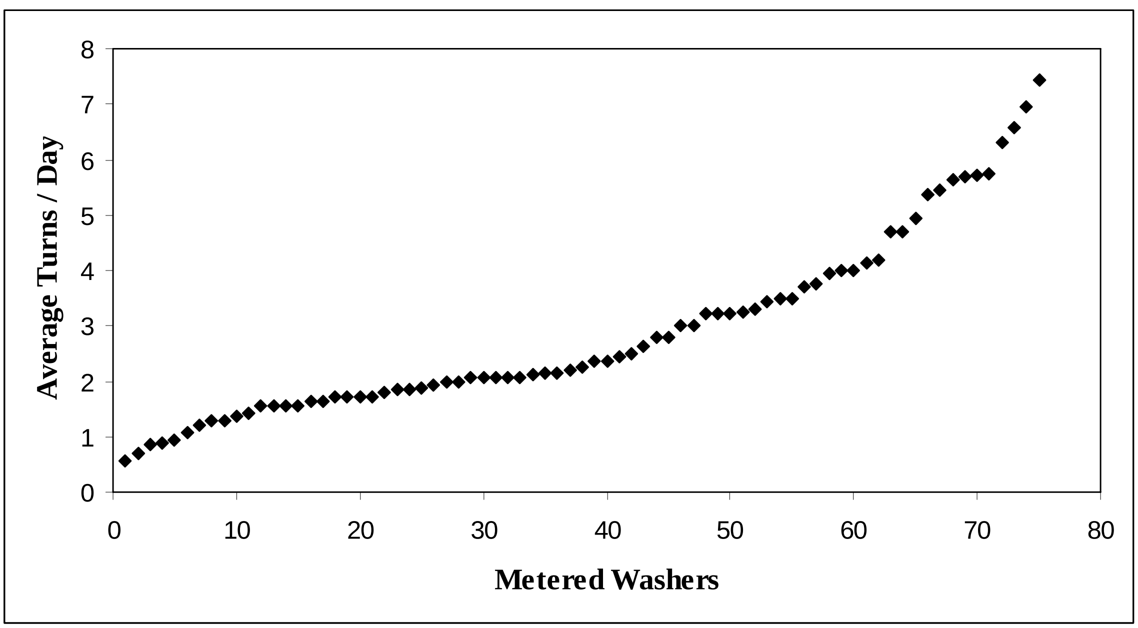
For the last nine bulbs not found, six bulbs (across four sites) were missing for reasons unknown. The owner or person at the site could not ascertain why the expected bulbs could not be found. For two bulbs, the owner could not remember ever having CFLs installed and none could be found inside or outside the store. The owner's daughter provided interpretation at this site. The odd part about this site was that the store next door had three CFLs installed in the eaves in front of the store, where one was expected. However, the owner here stated that he had purchased and installed the other two bulbs, plus these bulbs were of a different manufacture than the other one. While there is the possibility that this store owner 'borrowed' the two bulbs from the other store, it was not counted as such since the expectation would have been for similar bulbs. For the last bulb, it was found to be in a bucket at the site. It had simply not been installed, but was waiting for burn out of an incandescent.

5.2 Laundromat Turns per Day Assessment Results

One washer had an estimated thirteen loads of laundry done in a row. However, 83 percent of the time, the washer was used only a single time. Twelve percent of the time, two loads of laundry were done with one immediately following the other.

The number of turns per day were calculated (using the algorithm in Equation 4.1) for each machine, as shown in Exhibit 5.2

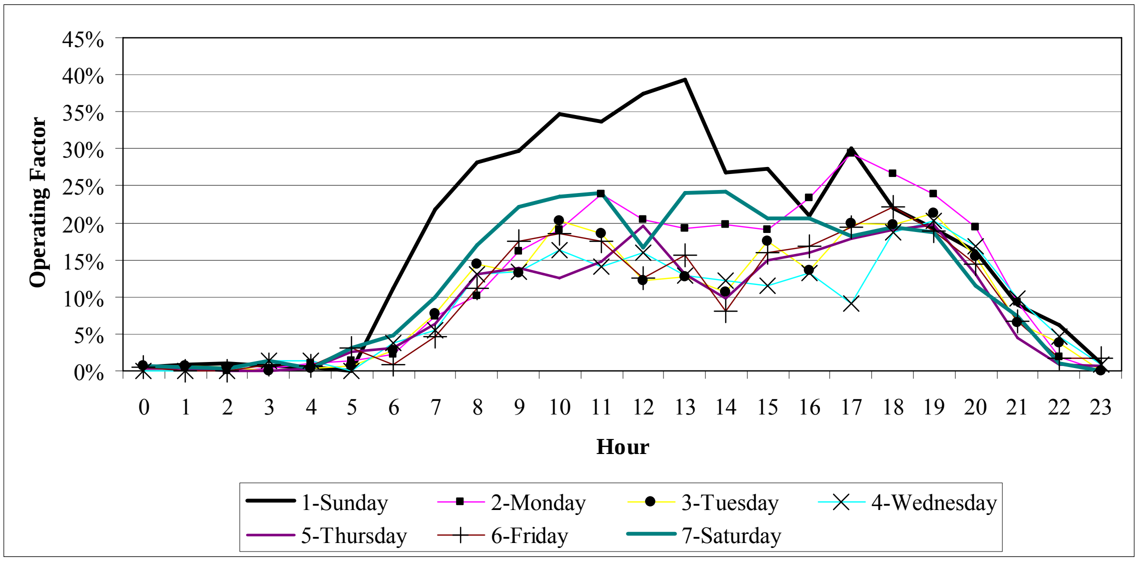
Exhibit 5.2
Average turns per day for each metered machine



The average turns per day across all machines was 2.97 ± 0.70 (at the 90% confidence level).

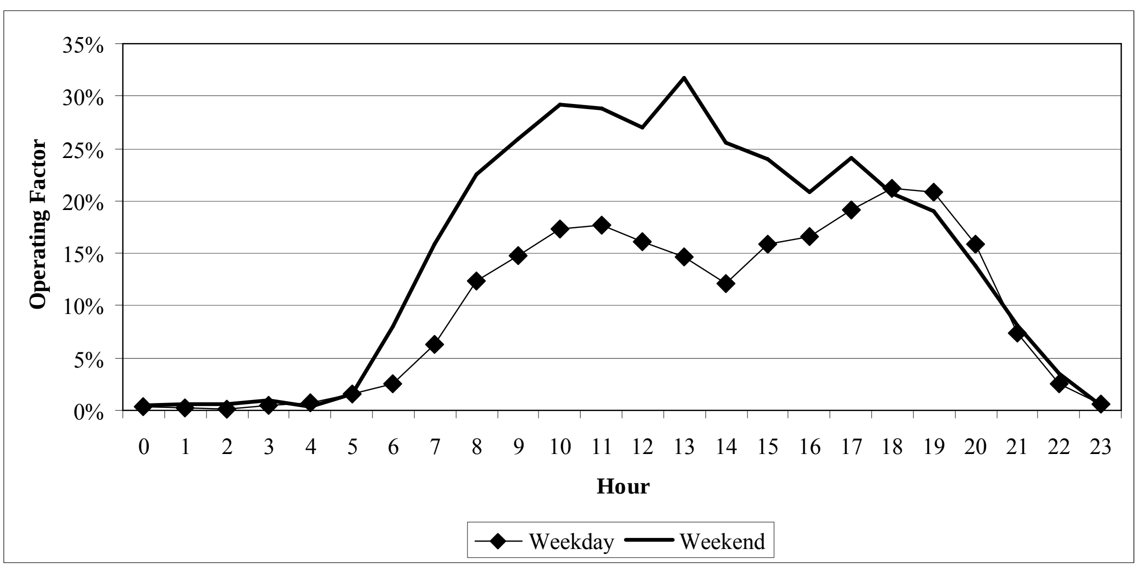
Using the analysis method outlined in Section 4.2, the hourly operating factor across all metered machines is shown by day of the week in Exhibit 5.3.

Exhibit 5.3
Hourly Operating Factor by Day of Week



As shown here, the machines are used most often on Saturday and Sunday, although Monday also has a relatively high usage, especially in the evening hours. The average weekend/weekday profiles are shown in Exhibit 5.4.

Exhibit 5.4
Hourly Operating Factor by Daytype



As indicated earlier, the operating factors for Monday through Friday, noon to 7 PM were averaged to calculate a peak period operating factor. This value was 17.1 percent.

There was a mixture of machines with and without electronic control found during the field work. The addition of an electronic control appears to add at least a 3 watt standby load. Annually, this can add 26 kWh per machine. While this is not a large value, it could represent 10 to 20 percent of the current expected impact if the new machine had electronic control while the previous unit did not.

5.3 Energy and Demand Impacts

This section presents the program estimated energy and demand impacts from the installation of energy efficient lighting at coin operated laundromats and adjacent sites, high efficiency water heaters in laundromats or other laundry facilities, and high efficiency commercial clothes washers, throughout the PG&E service territory. The methods used to calculate the impacts are as indicated in Section 4.

5.3.1 Review of Deemed Savings Estimates

The 2002-2003 evaluation had reviewed the deemed savings estimates for lighting and washers. With the exceptions noted in Section 4, this was not re-visited in this evaluation. However, the hot water boilers were a new measure this year and an assessment of the ex ante estimates occurred. Equipoise found the calculations to be acceptable and accurate with one small issue (the algorithm for the surface area of the hot water tank needed to be revised). The program implementer was apprised of this assessment via email on 3/22/05.

5.3.2 Program Energy and Demand Impacts

Using the methods described in Section 4, the gross impacts of the program are shown in Exhibit 5.5.

Exhibit 5.5
First Year Gross Program Impacts

	Measure	N	kW	kWh	Therm
Ex Ante	Washer	2,300	96	735,596	119,222
	Lighting	200	200	1,327,200	-
	Boilers	32,000	-	-	208,667
	Total	-	***296***	***2,062,796***	***327,889***
Ex Post	Washer	2,283	89	612,338	113,131
	Lighting	239	239	1,252,995	-
	Boilers	30,600	-	-	137,852
	Total	-	***328***	***1,865,332***	***250,983***
Realization Rate	Washer	99%	92%	83%	95%
	Lighting	119%	119%	94%	-
	Boilers	96%	-	-	66%
	Total	-	***111%***	***90%***	***77%***

The deemed net-to-gross ratio (NTGR) of 0.96 (based on the rebate-type program NTGR from the Efficiency Policy Manual) was applied to the gross impacts for the clothes washer and lighting measures and a NTGR of 1.0 (as per the PIP) was applied to the boiler measures to provide the net program impacts shown in Exhibit 5.6.

Exhibit 5.6
First Year Net Program Impacts

	Measure	N	kW	kWh	Therm
Ex Ante	Washer	2,300	92	706,172	114,453
	Lighting	200	192	1,274,112	-
	Boilers	32,000	-	-	200,320
	Total	-	***284***	***1,980,284***	***314,773***
Ex Post	Washer	2,283	85	587,844	108,606
	Lighting	239	229	1,202,875	-
	Boilers	30,600	-	-	132,338
	Total	-	***314***	***1,790,719***	***240,943***
Realization Rate	Washer	99%	92%	83%	95%
	Lighting	119%	119%	94%	-
	Boilers	96%	-	-	66%
	Total	-	***111%***	***90%***	***77%***

Washer Realization Rate Reconciliation: While the program installed 99 percent of the expected number of washers, the energy realization rates were below that value due to the reduced number of turns per day in the laundromat sites. The discrepancy between the washer realization rate for kWh and therms is explained by comparing the number washers installed and per-unit impacts for each type of energy for 2004 and 2005. As shown in Exhibit 5.7, the per unit impact realization rates were different for kWh and therms in 2004, leading to a 2004-05 program wide realization rate that is lower for kWh than therms. The fact that roughly twice as many washers were installed in 2004 than in 2005 compounds this effect. (Note: Because the increased installations in 2004 effected the savings more than the 2005, the 2004 realization rates appear to be the same in Exhibit 5.5 as Exhibit 5.7. However, this is only at the integer level – they are not the exact numbers, but do round to the same integer value.)

Exhibit 5.7
Washer Realization Rate Reconciliation

Realization Rate*			
PY	N Installed	kWh per-unit impacts	Therm per-unit impacts
2004	110%	83%	95%
2005	83%	80%	80%

*Realization rate is ex post over ex ante. Ex post per-unit impacts are weighted by the number installed in specific locations.

Lighting Realization Rate Reconciliation: The demand impact was shown to be higher than the ex ante value mainly because each site had a higher demand impact than expected. The ex ante value assumed 182 sites with a 1.1 peak kW impact per site for a value of 200 kW. While there were fewer sites with lighting installed (143), each had a higher impact (1.67 kW/site). Included within the per-site increase was the different kW values used for the CFL measure. However this made a minimal difference in the overall lighting kW impact (the DEER kW values added 0.4 kW impact overall). The interactive effects of the HVAC added 12.1 kW to the overall impact of the program.

On the energy side, the decreased operating hours of the laundromats caused the lighting realization rate to drop from 103 percent to 95 percent. The decreased kWh impact for the CFL's caused the realization rate to drop another 1 percent to 94 percent.

Boiler Realization Rate Reconciliation: There were two reasons for the 66 percent realization rate for laundromat boilers. The program did not install all the boilers that it had expected to install, which accounts for a small portion of the decrease. The main reason for the realization rate is the drop in laundromat average turns per day. With 75 percent of the boilers installed in laundromats (the remaining were installed at sites that performed large scale laundry activities), the decrease in clothes washer use meant that there was less water required for heating, less use of the boilers, and subsequently a smaller impact. If the original number of turns per day for laundromats were substituted into the energy impact equation, the program would have seen a realization rate of 91 percent for this measure.

6 FINDINGS AND RECOMMENDATIONS

6.1 Findings

6.1.1 Screw-In CFL Retention Assessment Findings

The found retention rate was 88.7 percent. Of the 186 bulbs expected, 168 were found to be in place and operating. This was greater than the 68 percent retention rate found in the PY2002/2003 evaluation. The reasons for the missing 21 bulbs were as follows:

- Renovation of site (10 bulbs)
- Reasons were unknown (6 bulbs)
- Not installed (3 bulbs)
- In place but burned out (2 bulbs)

6.1.2 Laundromat Turns per Day Assessment Findings

The metered analysis performed in this evaluation shows that for coin-operated laundromats in the PG&E service territory, the following conclusions can be made:

- The average turns per day across all machines was 2.97 ± 0.70 at the 90% confidence level.
- The peak operating factor for typical weekday operation is 21% and occurs at approximately 6 to 7 PM.
- The peak operating factor for typical weekend operation is 32% and occurs at approximately 1 PM.
- The peak operating factor for weekdays from noon to 7 PM is 17%

The data show (Exhibit 5.2) that while there are machines that do have high use, for a commercial laundromat, the average use is approximately three turns per day. If these findings are representative of both California and the nation, generally, they have significant implications for commercial clothes washer program planners and policy makers with respect to cost-effectiveness and resource savings assumptions as it is generally assumed that typical laundromat washer use rates are considerably higher.

6.1.3 Energy Impact Assessment Findings

On an ex ante basis, the program exceeded its goals. On an ex post basis, the LightWash program exceeded the net demand savings goals and provided less than the planned net energy goals, delivering the following annual results:

	kW	kWh	Therms
Total Program Net Impacts	314	1,790,719	240,943
Total Program Net Impact Goals	284	1,980,284	314,773
Program Net Realization Rate	111%	90%	77%

6.1.4 Overall Findings

The program net energy realization rates are lower than expected based on changes made in accepted industry values and findings from the metered data. If the changes had not been made in the laundromat hours, the program level kWh realization rate would have been 96 percent.

6.2 Recommendations

Given the evaluations finding presented above, the evaluation team has the following recommendations:

6.2.1 Program Recommendations

The following program design recommendations evolved from the evaluation:

- While the CFL persistence rate was higher in the PY2002/2003 evaluation, the reasons for why bulbs were not present were, for the most part, outside of the ability of the program to influence. It is recommended that a realization rate of at least 90 percent be used when calculating an ex ante impact value for CFLs during the program planning. For example, if the program expects to install 100 bulbs, within the ex ante impact, only claim savings for 90 bulbs.
- PG&E should immediately adjust the 2006-2008 program plans to account for the findings in laundromat washer turns per day.

6.2.2 Evaluation Recommendations

Based on what was found in the field, the following recommendations are made for possible future evaluation efforts:

- Research is needed to determine if the expected number of times a machine is used per day within multi-family and institutional sites is similar to what has typically been expected or if there is a significant difference as was found for clothes washers at commercial laundromats.
- The use of the Watts Up? Pro meter has advantages due to it's ease of use and cost-effectiveness. The analytical challenges found by the evaluation team may be reduced some with the newer version of the meter that is now available with extensively greater memory capability.

This completes the evaluation report of the PY2004/2005 LightWash program. Appendices follow.

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B. DATA COLLECTION INSTRUMENTS

C. WASHER AND CFL DATA COLLECTION MEMO

November 29, 2005

To: Erika Walther, Energy Solutions

From: Tim Caulfield, Equipoise Consulting Incorporated

cc: Peter Lai, CPUC Energy Division

Nick Hall, MECT

Re: LightWash II, CPUC Program No. 1225-04
Data Collection Memorandum, CFL Retention and Laundromat Washer Turn/day Measurement.

In accordance with the final research plan for Energy Solution's LightWash II 2004-05 program (LightWash II) (CPUC Program No. 1225-04), Equipoise Consulting Inc. (Equipoise) was required to deliver memoranda summarizing the final statistics on the data collection for the CFL retention (11/30/05) and Laundromat washer turn/day measurement (11/23/05). This memorandum combines those two deliverables into one, covering both subjects.

CFL Retention Data Collection.

The research plan called for collection of screw-in CFL retention data from 45 sites, and assumed an average of three CFLs per site, resulting in a retention assessment on a total of 135 screw in lamps. As it turned out, only 32 sites had CFLs installed in during the 2004-05 LightWash II program, so the evaluation team conducted a census of these 32 sites. The following summarizes the attrition that occurred:

- Inspections identified that at two of the sites, the CFLs installed were actually hard wired CFLs, so these two sites were dropped from the sample.
- At one site no CFLs were visible, when contacted the owner claimed that no CFLs had been installed, and refused to meet the inspector at the site and open closed areas. This site was considered a refusal.
- At one site, in a remote area, the single CFL lamp was not visible. The economics of traveling back out to this site did not justify the single point. The site was dropped form the sample.

This left a population of 28 sites and 186 CFLs. Data collection has been completed on all but one site. This site requires a meeting with the owner at the site, which has been difficult to arrange, but Equipoise anticipates completing this site in early December 2005.

Laundromat Washer Turn/day Data Collection.

The research plan called for a two stage sample, installing meters on a systematic random sample of 6 washing machines at 12 Laundromats randomly select from the early participants in LightWash II program (January 1, 2004 through March 30, 2005), yielding a total sample size of 72 individual machines.

In the end, 13 sites were actually recruited to compensate for meter failure.

There were 305 sites in the early participant population. The following is the data attrition from that population:

- 250 were dropped because they had fewer than 15 machines at the site.
- 2 were dropped because they had greater than 75 machines at the site.
- 6 records were duplicates.
- 10 were multifamily sites, not Laundromats.

This left 37 appropriate sites in the population. This sample of the population was randomized and sites were recruited in strict compliance with the random order. Thirty-four of the 37 sites were solicited in order to get agreement from 13 sites. Of the 34 sites solicited the following summarizes the attrition:

- 17 refused.
- 3 sites agreed but were physically not amenable to be metering once we were onsite.
- 1 site supplied their own metered data on the 8 machines that would have been in the sample. All other machines at that site were too large to be in the sample.
- 3 sites remained unsolicited.

Once a site agreed to allow metering, they were sent a disclaimer and agreement form to sign. Signed forms were obtained for all metered sites. No incidents were reported as associated with metering.

Only machines less than 25 pound load size were metered (i.e., those with 110V plugs). All machines at the site, not just the new ones, were included when randomly selecting the machines for metering. At each site, the washing machines were numbered from left to right as one entered a doorway. The 'Random' function in Excel was used to assign a random number to each of the washing machines and the top 6 numbers were chosen to be metered. Meters collected data for 2 weeks at a site.

As mentioned earlier, one meter failed so an additional site was recruited and a total of 77 washers were metered.

The first set of meters was installed on 4/4/05 and the final set of meters was pulled out of the last site on 10/6/05.

D. LAUNDROMAT METER DATA

Site	Meter #	Make	Model	Cylinder Volume (cubic feet)	Age	Elec. Control	kWh / Day	Turns / Day
Site 1	1	Speed Queen	SWTT21	2.69	New	Yes	0.596	1.86
Site 1	2	Speed Queen	SWTT21	2.69	New	Yes	0.589	2.00
Site 1	3	Speed Queen	SWTT21	2.69	New	Yes	0.394	0.71
Site 1	4	Speed Queen	SWTT21	2.69	New	Yes	0.694	2.64
Site 1	5	Speed Queen	SWTT21	2.69	New	Yes	0.557	1.71
Site 1	6	Speed Queen	SWTT21	2.69	New	Yes	0.536	1.71
Site 2	1	Maytag	MAH21PDDW	2.86	New	Yes	0.225	0.86
Site 2	2	Maytag	MAH21PDDW	2.86	New	Yes	0.288	1.57
Site 2	3	Maytag	MAH21PDDW	2.86	New	Yes	0.320	2.21
Site 2	4	Speed Queen	Unknown	Unknown	Old	No	0.066	0.57
Site 2	5	Speed Queen	Unknown	Unknown	Old	No	0.127	1.07
Site 2	6	Speed Queen	Unknown	Unknown	Old	No	0.246	1.93
Site 3	1	Speed Queen	SWTT21	2.69	New	Yes	0.529	2.07
Site 3	2	Speed Queen	SWTT21	2.69	New	Yes	0.460	1.43
Site 3	3	Speed Queen	SWTT21	2.69	New	Yes	0.442	1.36
Site 3	4	Speed Queen	SWTT21	2.69	New	Yes	0.641	2.36
Site 3	5	Speed Queen	SWTT21	2.69	New	Yes	0.417	0.93
Site 3	6	Speed Queen	SWTT21	2.69	New	Yes	0.493	1.57
Site 4	1	Maytag	MAH21PD	2.86	New	Yes	0.293	2.07
Site 4	2	Maytag	MAH21PD	2.86	New	Yes	0.321	2.07
Site 4	3	Maytag	MAH21PD	2.86	New	Yes	0.295	2.00
Site 4	4	Maytag	MAH21PD	2.86	New	Yes	0.259	1.86
Site 4	5	Maytag	GA230S	Unknown	Old	No	0.210	1.71
Site 4	6	Kenmore	110.21072	Unknown	Old	No	0.185	1.21
Site 5	1	Speed Queen	SWFB61	2.84	New	Yes	0.440	1.29
Site 5	2	Speed Queen	EA1121	Unknown	Old	No	0.246	2.14
Site 5	3	Speed Queen	SWFB61	2.84	New	Yes	0.592	3.00
Site 5	4	Speed Queen	EA1121	Unknown	Old	No	0.209	1.71
Site 5	5	Speed Queen	EA1121	Unknown	Old	No	0.329	2.79
Site 5	6	Speed Queen	SWFB61	2.84	New	Yes	0.567	2.43
Site 6	1	Speed Queen	SWTT21	2.69	New	Yes	1.151	5.44
Site 6	2	Speed Queen	SWTT21	2.69	New	Yes	1.226	6.31
Site 6	3	Speed Queen	SWTT21	2.69	New	Yes	0.925	4.19
Site 6	4	Speed Queen	SWTT21	2.69	New	Yes	1.048	4.94
Site 6	5	Dexter	WCN18	2.7	Old	Yes	0.795	3.75

Site	Meter #	Make	Model	Cylinder Volume (cubic feet)	Age	Elec. Control	kWh / Day	Turns / Day
Site 6	6	Dexter	WCN18	2.7	Old	Yes	0.709	3.25
Site 7	1	Speed Queen	SWT521LM	2.69	Old	Yes	1.111	6.57
Site 7	2	Speed Queen	SWT521LM	2.69	Old	Yes	0.782	5.71
Site 7	3	Speed Queen	SWT521LM	2.69	Old	Yes	0.813	5.36
Site 7	4	Speed Queen	SWT521LM	2.69	Old	Yes	0.748	4.71
Site 7	5	Speed Queen	SWT521LM	2.69	Old	Yes	1.162	7.93
Site 7	6	Speed Queen	SWTB21QN	2.69	Old	Yes	1.217	4.93
Site 8	1	Speed Queen	SWTT21	2.69	New	Yes	0.866	3.50
Site 8	2	Speed Queen	SWTT21	2.69	New	Yes	0.634	2.36
Site 8	3	Speed Queen	SWTT21	2.69	New	Yes	0.685	2.50
Site 8	4	Speed Queen	SWTT21	2.69	New	Yes	0.551	1.79
Site 8	5	Speed Queen	SWTT21	2.69	New	Yes	0.533	1.57
Site 8	6	Speed Queen	SWTT21	2.69	New	Yes	0.581	2.14
Site 9	1	Speed Queen	SWTT21	2.69	New	Yes	0.432	0.88
Site 9	2	Speed Queen	EA2121	Unknown	Old	No	0.222	1.63
Site 9	3	Speed Queen	EA2121	Unknown	Old	No	0.338	2.25
Site 9	4	Speed Queen	EA2121	Unknown	Old	No	0.234	1.88
Site 9	5	Speed Queen	EA2121	Unknown	Old	No	0.313	2.06
Site 10	1	Speed Queen	SWFB61	2.84	New	Yes	0.794	3.94
Site 10	2	Speed Queen	SWFB61	2.84	New	Yes	0.916	5.69
Site 10	3	Speed Queen	SWT521	2.69	New - not ES	Yes	1.276	6.94
Site 10	4	Speed Queen	SWT521	2.69	New - not ES	Yes	1.314	7.44
Site 10	5	Speed Queen	SWT221	2.69	New - not ES	No	0.214	2.13
Site 10	6	Speed Queen	SWTT21	2.69	New	Yes	1.236	5.75
Site 11	1	Speed Queen	SWTT21	2.69	New	Yes	0.640	2.07
Site 11	2	Speed Queen	SWTT21	2.69	New	Yes	0.841	3.21
Site 11	3	Speed Queen	SWTT21	2.69	New	Yes	0.859	3.43
Site 11	4	Speed Queen	SWTT21	2.69	New	Yes	0.810	3.00
Site 11	5	Speed Queen	SWTT21	2.69	New	Yes	0.904	3.71
Site 11	6	Speed Queen	SWTT21	2.69	New	Yes	0.898	4.14
Site 12	1	Speed Queen	EX218	Unknown	Old	Yes	1.345	5.64
Site 12	2	Speed Queen	SWTT21	2.69	New	Yes	0.941	4.71
Site 12	3	Speed Queen	SWTT21	2.69	New	Yes	0.747	3.29
Site 12	4	Speed Queen	SWTT21	2.69	New	Yes	0.726	3.21
Site 12	5	Speed Queen	EX218	Unknown	Old	Yes	0.856	3.21
Site 12	6	Dexter	WCH18	2.7	Old	Yes	0.781	2.79
Site 13	1	Maytag	MAH21PD	2.86	New	Yes	0.450	4.00
Site 13	2	Maytag	MAT12PD	2.5	New	Yes	0.434	4.00
Site 13	3	Maytag	MAT10PD	2.5	Old	Yes	0.331	1.29
Site 13	4	Maytag	MAT10PD	2.5	Old	Yes	0.361	1.64
Site 13	5	Maytag	MAT10PD	2.5	Old	Yes	0.601	3.50

Site	Meter #	Make	Model	Cylinder Volume (cubic feet)	Age	Elec. Control	kWh / Day	Turns / Day
Site 13	6	Maytag	MAT10PD	2.5	Old	Yes	0.374	1.57

E. WATER HEATER ALGORITHM REVIEW MEMO

This memo was written by the program and reviewed by the evaluation team.

LightWash Water Heater Deemed Savings Calculation

Confirmation and Documentation of Preliminary Calculations

February 10, 2005

Revised: 3/4/05

Overview

Purpose

The LightWash program team elected to confirm and more completely document the savings calculations (deemed savings) in our original proposal to ensure accurate and realistic estimates for the difference between efficiency of standard versus high efficiency water heaters. This was appropriate because the original calculations were based largely on information supplied by water heater manufacturers and were provided without significant third party documentation.

Findings

The results of this investigation generally confirm the deemed savings offered in our proposal, but incorporate a model of real-world water heater operation. The original deemed savings calculations were based on an operating efficiency (not thermal efficiency) of 67% for baseline units and 95% for high efficiency units expected to be rebated in the program. After thorough literature search and analysis, we have determined that a more representative efficiency spread for water heaters in the LightWash program is 65.5% to 91.2%.

Explanation of Methods

Looking for an Operational Efficiency Rating

The LightWash program has a clear efficiency standard for determining the eligibility of high-efficiency water heaters, but this efficiency level does not describe actual operating performance. LightWash uses thermal efficiency ratings (or the equivalent Recovery Efficiency ratings) to determine product eligibility because thermal efficiency is the only widely used efficiency metric for this product class, which includes water heaters and boilers. Thermal efficiencies for this product class, measured in independent testing, are published by the Gas Appliance Manufacturers Association (GAMA), and are also listed with the California Energy

Commission's (CEC) Appliance Certification Program. LightWash rebates products with 95% or higher thermal efficiency. Natural gas savings for rebated products are therefore determined relative to the 80% thermal efficiency of a standard water heater, as required by California Title 20 Standards. The availability of thermal efficiency ratings makes them ideal for product comparisons and in fact is the basis of comparison in the DEER database. However, thermal efficiency is measured at steady-state conditions, which means it is not an ideal predictor of *in situ* efficiency performance. For a more accurate calculation of natural gas consumption, our aim was to use "operational efficiency", an efficiency that takes into account not just steady-state performance, but also losses due to burner cycling.

We began our search for information on operational efficiency by reviewing other published product ratings. In addition to thermal efficiency, there are three other measurements of water heater efficiency specified in appliance energy regulations: Annual Fuel Utilization Efficiency (AFUE), combustion efficiency, and Energy Factor. Neither AFUE nor combustion efficiency is a better measure than thermal efficiency for estimating the energy needed to supply hot water. AFUE is a rating for residential space-heating boilers that incorporates assumptions of seasonal temperature variation. Combustion efficiency is a steady-state measurement less comprehensive than thermal efficiency, as it does not include jacket radiation losses.

Energy Factor measures efficiency over a full day of operation with six scheduled draws of hot water and standby time between. It is designed as a test for residential-sized water heaters, but it is used to rate small commercial equipment as well, including water heaters that we expect to rebate under LightWash. As the only government-regulated testing method that includes full cycle operation, Energy Factor ratings were useful in guiding our savings calculations, and we discuss them further later in this explanation. Beyond Energy Factor, other product ratings were not useful in quantifying operational water heater efficiency.

Next, we looked for studies examining water heater efficiency. We hoped to find a large study that included field measurements of operational efficiency. We contacted numerous experts in the water heater and boiler field at Brookhaven, Pacific Northwest, and Berkeley National Laboratories, at independent testing labs, at the California Energy Commission, and in the energy-efficiency community. No one was able to recommend a comprehensive study of operational efficiency pertaining to the commercial, hot water-supply segment. Many expressed surprise at what they felt was a lack of research and literature in this area.

A Starting Point

One larger study that did address the savings potential of high-efficiency water heaters was the Southern California Gas Company's Conservation Potential Study from 1992. This report determined that high-efficiency water heaters could save 37.0% over a standard water heater, with the technical savings potential for 11,459 therms of natural gas. This figure was significantly larger than the savings in our original LightWash Proposal, 29.5%. While this figure provided a useful start to our investigation, the technical appendices of this report that were available left us wanting more documentation for a savings estimate.

Water heater experts offered opinions on real-world operational efficiencies for standard and high-efficiency units. The combination of their estimates and our original savings calculation, showing a 29.5% savings, induced us to conduct further research on the thought that this 37% estimate might be too high.

A Closer Look at Energy Factor

We decided to take a closer look at the test method and product ratings for the Energy Factor measurement in order to better understand the difference between steady-state (reflected in thermal efficiency ratings) and operational (reflected in Energy Factor) efficiencies. This understanding later allowed us to adjust published thermal efficiency ratings to more accurately reflect real-world operational efficiencies.

Gas-fired water heating equipment is divided by California Title 20 appliance code into five categories: Small Boilers, Large Boilers, Large Water Heaters, Small Instantaneous Water Heaters, and Small Storage Water Heaters. Each category has its own testing methods and measurements. For most of these categories, the only published ratings of efficiency are measured at steady-state conditions. Of all water heating equipment, only the two categories of small water heaters have a rating that takes into consideration use over a full burner cycle: the Energy Factor measurement. These are mostly residential categories, and many of the products in these categories would not be applicable for commercial use in coin laundry stores because they incorporate residential-size storage tanks. However, the field is not strictly divided between residential and commercial products, but instead by size, and products for each market end up on both lists. Many of the products we will be rebating are classified as Small Instantaneous Gas Water Heaters by the CEC, including the Hamilton Evo99 series, for which our market research indicates we will be receiving the most applications. Besides the Evo99 series, other high-efficiency products appear on the CEC Small Instantaneous Water Heater list, including the HTP Voyager and Natco water heaters, both of which use the same burner as the Evo99 series, and all of which are manufactured by Heat Transfer Products.

For a water heater in this category, the Title 20 Standard minimum Energy Factor is set at (62 - 0.19 x V) %, where V is the tank volume in gallons. Since LightWash is rebating products based on the burner efficiency alone, we can consider the tank volume to be zero, and the minimum standard to be 62%. Thus, a water heater with 200,000 Btu/hr input and no built-in tank, similar to the smaller sizes among LightWash's eligible units, would have to meet the 62% Energy Factor standard. We can consider these Energy Factor listings to be indicative of operational performance because this water heater class includes many products eligible for the LightWash rebate. However, it is not determinative of minimum standard operational performance, as this rating is not designed for commercial standards use.

Comparing Operational and Steady-State Efficiency Ratings:

Standard Water Heaters

An exhaustive literature search has convinced us that the CEC's Energy Factor listings are the most thoroughly published measurements in the industry that include full operational efficiency. To compare tankless water heater efficiencies measured by both Energy Factor and Thermal/Recovery Efficiency, we looked at the CEC Appliance listings for Water Heaters in the

Small Instantaneous and Large categories. We hoped to see the published Energy Factor ratings for relevant small products and compare them to recovery efficiency ratings to get an idea of the difference between full-cycle and steady-state efficiencies. Again, because we are interested in the operational efficiencies of the burner, we considered truly tankless units (i.e., tank-type units that qualify as instantaneous due to relatively small tank-to-input ratios) and ignored listings for units with volumes greater than 15 gallons. Most manufacturers from the Small Instantaneous Water Heater list do not appear on the list for larger sizes, and vice versa. However, there are some larger products appropriate for commercial use that have been rated with Energy Factor, even though Energy Factor is more commonly used for units appropriate for residential applications. One manufacturer, Lochnivar, had seven products from their RWN series spanning the Large and Small lists. These products range in size from 90,000 to 360,000 Btu/hr. This product line shows identical values for recovery efficiency in the Small units and thermal efficiency in the large units, which indicates that these two ratings are comparable to each other even though they are governed by different test procedures for different size categories. Between the RWN180 and RWN0225 there is no difference in technology discernible from the manufacturer's product specifications (S:/-/LochinvarSpecs.pdf), or from the full CEC listings: The tables do not list Energy Factors for units with larger Btu/hr input ratings merely because they fall into the large category. The Lochinvar RWN published listing is shown in Table 1 below (The full CEC listings are available on the Energy Solutions company shared drive at S:/ES Programs/LightWash –II/Water Heater Element/CEC-InstantWH_Comparison.xls.):

Table 1: CEC Listings for Lochinvar RWN-Series

Brand Name	Model Number	Volume G	Input BTU/Hr	Recov Effy %	Therm Effy %	EF
LOCHINVAR WATER HEATER	RWN090	0.8	90,000	82.0		0.62
LOCHINVAR WATER HEATER	RWN135	0.9	135,000	82.0		0.62
LOCHINVAR WATER HEATER	RWN180	1.0	180,000	82.0		0.62
LOCHINVAR WATER HEATER	RWN0225	1.0	225,000		82.0	
LOCHINVAR WATER HEATER	RWN0270	1.0	270,000		82.0	
LOCHINVAR WATER HEATER	RWN0315	1.1	315,000		82.0	
LOCHINVAR WATER HEATER	RWN0360	1.1	360,000		82.0	

(From SoCalGas version of CEC tables, available at www.socalgas.com/business/cash_for_you/er_cec_files.shtml)

The most important piece of information here is the magnitude of the difference between the energy factor and the recovery efficiency. This gives us a point of comparison between steady-state efficiency and full-cycle efficiency. Given the absence of listed full-cycle efficiencies for

90% of products in our market, we consider this a benchmark for the difference between steady-state efficiency and full-cycle efficiency in standard commercial water heaters. This series of water heaters is marketed for commercial use, and is listed as well as advertised as having uniform 82% thermal efficiency. 82% thermal efficiency is close to the minimum of 80% for Title 20 compliance, so this product line is also useful as an indicator of baseline efficiency in our comparison. It is additionally helpful in providing a measure of confidence that thermal efficiency and recovery efficiency are comparable. This product series spans a range of sizes applicable to the LightWash target customer, and we can be fairly confident that it performs at a steady-state thermal efficiency of 82% and an overall cyclical efficiency of 62% for the residential-testing cycle.

Comparing Operational and Steady-State Efficiency Ratings:

High-Efficiency Water Heaters

In evaluating high-efficiency products, we note that the CEC listings do not include any tankless water heater with at least 95% Thermal/Recovery Efficiency that also has a listed Energy Factor. However, there are LightWash-qualifying products that were tested with tanks and achieved 95.4% recovery efficiency and 0.90/90% Energy Factor. These units are manufactured by Heat Transfer Products, and incorporate a burner identical to the qualifying product for which we expect to receive the majority of LightWash applications. Testing this burner with a tank would result in a lower measured Energy Factor than testing the same burner without a tank, because the unit must burn additional gas to maintain the tank water at supply temperature. So we would estimate an overall cyclical efficiency higher than the 90% Energy Factor rating.

Adjusting Published Ratings to Reflect Commercial Use

Published ratings tell us that relevant commercial water heaters perform at operating efficiencies of 62% for standard units and at least 90% for high-efficiency units as determined by the residential Energy Factor test method. These numbers provide a framework for our calculations of gas consumption and deemed savings. But these numbers need to be adapted for use in our commercial gas use calculation, because they imply a draw schedule for hot water designed to simulate residential usage.

In a commercial laundry, there is likely to be more consistent hot water demand than in a residential setting. The amount of time on standby in a 24-hour period should be less in a laundry than that assumed in the Energy Factor test because there will be greater hot water demand over more hours each day. Thus, in a commercial laundry setting, the water heaters will be expected to perform higher than their rated Energy Factor, and somewhat closer to their thermal efficiency. However, there is still a significant amount of standby time in coin laundries: Engineers who specify and service high-efficiency equipment tell us that laundry owners do leave their water heaters on standby all night. Consequently, our model of water heater use does include time in standby mode, rather than constant use at steady-state efficiency.

The next step was to identify and then quantify as best as possible the factors in new, properly working units that degrade thermal efficiency (to operating efficiency) under representative operating conditions over time in commercial applications. The difference between the two efficiency metrics is commonly described as "cycling losses." We ignore losses specifically associated with aging equipment, such as scaling of the heat exchangers.

Understanding Mechanisms of Cycling Loss

Water heater design engineers and national laboratory scientists suggested splitting the losses that arise with cyclical performance into two numbers: Standby losses, incurred when the burner is off; and short cycling losses, incurred when the burner is on, but is not yet operating at steady-state efficiency. These losses are incorporated in separate columns on our Operating Efficiency Calculation worksheet. Ultimately, our operating efficiency assumptions aim to account for the difference between Energy Factor and recovery efficiency ratings through an understanding of the mechanisms of loss due to cycling. This understanding allows us to adjust the widely published steady-state thermal efficiency ratings for products we expect to rebate, so that they more accurately reflect operational efficiencies we expect to see in real-world applications.

After an extensive literature review, we found there has been no large study into the size of these losses for the equipment and application in which we are interested. The figures on our Operating Efficiency Calculation worksheet reflect the input we have received from many sources in the water heater efficiency and engineering communities (Ackerly, 2005; Parker, 2005).

That the sizes of standby and short-cycling losses are different between high-efficiency units and standard units is clear from the Energy Factor values already shown, but the reasons for the difference may not be obvious.

Standby Losses

According to Wylie (2004), standby losses can come from three sources:

- Standing pilot lights-- Pilot lights are present in some standard Title20-compliant water heaters, but not a large portion; our research has not turned up any LightWash-eligible water heaters with continuous pilot lights.
- Exterior burner surfaces-- The exterior surfaces of baseline units are made of sheet metal that heats up during operation; however, market-leading high-efficiency products are encased in non-conductive plastic cabinets, which is possible because the combustion chambers have been sealed to reduce radiative losses.
- Interior burner surfaces-- Interior surfaces are the largest source of heat loss in natural draft gas burners. Natural draft burners in the off-cycle are constantly pulling cool air across the heat exchanger and up the stack, though this can be reduced with a stack damper. Most baseline water heaters are natural draft-fired. Forced-draft burners, on the other hand, are included on most of the units we expect to rebate under LightWash. In this type, the flow of air over the burner is controlled by a fan, and therefore is limited during the burner off-cycle.

Representing the sum of these standby loss factors, our calculations assume standby losses (when the burner is off) at 2% for high-efficiency units and 8% for baseline units, as shown in column G of the Operating Efficiency Calc worksheet. These numbers came from our conversations with water heater experts, and align with the efficiencies indicated by published ratings. Studies available on standby loss focused on water heating equipment in multi-family apartments. They suggested that standby losses could account for as much as 13% of the total energy used (Perlman and Milligan, 1988). Design of high-efficiency units eliminates or significantly reduces the mechanisms of standby loss. Note that on-cycle flue losses, a source of considerable difference between condensing high-efficiency and baseline units, are included in thermal efficiency measurements and not in these standby loss figures.

Short-cycling Losses

Short-cycling losses are transient declines in efficiency occurring at the start of each burner cycle. When the burner kicks on, the combustion chamber and heat exchanger surfaces are cool and heat up until normal steady-state conditions are established. During this part of each cycle, the water heater achieves lower combustion efficiency than normal. The magnitude of this difference depends on how large the effect is on instantaneous combustion efficiency, and on the cycling frequency:

- The size of the combustion efficiency decrease depends on how internal temperatures affect airflow through the burner. In natural draft-fired water heaters, the draft from the stack and burner is responsible for pulling the correct amount of air into the burner, thus providing the correct air-fuel mixture for complete combustion. Cooler temperatures will have a greater effect on natural draft systems than forced draft systems, where airflow depends more on the fan. As stated above, natural draft systems are much more common in standard water heaters than in high-efficiency water heaters.

- Cycling frequency is the other factor in short cycling losses. Studies have shown that cycling frequency is inversely related to efficiency (Biederman and Katrakis, 1986). Providing for modulation in gas input levels cuts cycling losses by allowing the unit to remain on more consistently. Operating full-time at 50% input will produce less cycling loss (and also less standby loss) than operating half-time at 100% input, because there are fewer instances of cool interior start-up temperatures. (As a secondary effect, reducing input provides an additional efficiency advantage because when input Btu/hr is reduced, the heat exchanger becomes relatively oversized; thus, units tested at reduced input are commonly seen to achieve higher thermal efficiency than when tested at full input. Baseline units more often have fixed gas input rates than high-efficiency units, according to CEC listings. Not all CEC product categories list whether systems have modulating input levels. But where this information is given, in products rated as boilers, 56% of baseline units have modulating gas input rates, whereas 100% of examined LightWash-eligible products have modulating gas input rates.

In consideration of these differences between standard and high-efficiency water heaters, our calculations assume short cycling losses (transient losses when the burner is on) at 2% for high-efficiency units and 10% for baseline units, as shown in column E of the Operating Efficiency

Calc worksheet. These models came from suggestions by water heater experts, and are consistent with the performance of water heaters in published ratings.

Early Retirement of Water Heaters

Discussion with industry representatives made us certain that LightWash rebates will have a significant effect on the early retirement of older, inefficient water heaters. Water heater salesmen say that just 10% or less of new high-efficiency water heaters are sold upon failure of the unit being replaced. One estimate was as low as 4%. This figure is specific to sales of high-efficiency water heaters. We expect the purchasers of this high-end equipment to be a self-selecting group, with greater awareness of the profitability impacts of energy-efficient equipment and rebates.

In the 90% of high-efficiency sales where the unit being replaced has not failed, we expect that many purchasers has decided to purchase a new water heater, and then has made a decision to purchase a high-efficiency unit because of energy savings and rebates (and thus no credit for early replacement should be received by LightWash). But some of the sales will have been influenced by the availability of the LightWash rebate, with gas prices up and a rebate of more than $1000 available for a limited time, laundry owners will decide to replace their existing units with LightWash-qualified high efficiency models years before failure or replacement.

The availability of LightWash rebates, therefore, will accelerate a portion of the 90% non-failure replacements. Our conservative estimate is that 20% of high-efficiency water heater sales rebated will have been influenced in this manner. Water heater experts indicate that old, poorly functioning water heaters often can continue to operate for years despite poor performance. Cases of 30 and even 50 year-old boilers and water heaters have been documented. We estimate that the average early retirement installation in our program will on average avert 5 years continued inefficient operation.

Existing water heaters will have additional factors affecting their operating efficiency. Scaling—mineral buildup in the water side of the heat exchanger tubes—is a small but important source of loss. Our sources suggested a 2% loss for this factor (Ackerly, 2005). Water heater experts also suggested we account for the decrease in combustion efficiency as a burner naturally deviates over years from perfectly-tuned operation. Experts and salesmen indicated that re-tuning the combustion is rarely done in laundries. A factor of 10% accounts for this imperfect combustion. The assumed thermal efficiency for existing units is also lower than for new standard units; we assumed 75%, current thermal efficiency on existing units to account for degraded performance in these older models as well as lower initial thermal efficiency (industry standards have risen over time).

The water heater early retirement factor slightly increases the deemed gas savings claim. The gas consumption that our rebate program claims to avoid is a weighted average of the consumption of a standard new water heater and that of an existing water heater. The average is strongly weighted towards the new unit consumption because we claim only 20% of rebates and a fraction of the total product lifetime. Between the 66.2% operating efficiency for new standard water heaters and the 54.8% for existing units, the weighted average that we use to represent avoided operating efficiency is 65.5%.

Summary of Findings

Based on insight from water heater experts and following on published efficiency ratings, we assumed the following losses for each type of water heater:

- Standby losses of 8% for standard units and 2% for high-efficiency units.
- Short-cycling losses of 10% for standard units and 2% for high-efficiency units.
- We used these assumptions to determine operating efficiencies. The resultant efficiencies for new equipment are 66.2% and 91.2%.
- We expect that the LightWash rebate program will lead to early retirement of less efficient equipment. The weighted average operating efficiency when accounting for early retirements (54.8% operating efficiency) is calculated to be 65.5% operating efficiency.

The 65.5% standard and 91.2% high-efficiency performances are then used to calculate deemed savings. The results are very similar to those used in our proposal, but incorporate a much better understanding of real-world water heater operation. Detailed calculations of these operating efficiencies and the implications for therm savings are contained in the attached spreadsheets. An explanation for each of the spreadsheets is included in the appendix below.

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Appendix: Explanation of Calculation Methodologies in the Water Heater Gas Savings Calculation Workbook

Operating Efficiency Calculation spreadsheet

The Operating Efficiency Calc spreadsheet provides the operating efficiencies used to determine gas consumption.

- The calculation starts with the thermal efficiency ratings: 95% for high-efficiency and 80% for standard, code-compliant units.[13]
- Short Cycling and Standby losses are shown in separate columns. Rather than subtracting the amount of loss, the effects of each are included by multiplication, the product of which is the operating efficiency.
- For the existing units, other loss factors are included. Scaling and reduced combustion efficiency further reduce operating efficiency.
- The result for the LightWash-eligible units is 91.2% operating efficiency.
- The 65.5% operating efficiency is a weighted average of the two numbers above it. The existing 54.8% performance is counted only for 20% of units and only for 5 years of the 15 year measure life.

Tank Loss Calculation spreadsheet

The Tank Loss Calc spreadsheet calculates the energy needed to replace heat lost from the walls of the storage tank. Laundries require storage tanks because hot water demand can fluctuate greatly. While we include losses from the tank, we have not claimed losses from the hot water pipes that carry hot water from the water heater to the tank and back, the losses from which are much more variable. These losses will depend on the distance between tank and heater, which can vary greatly. Pipe insulation will also affect pipe losses, though our experience indicates that pipes are rarely insulated.

- We assumed a 250 gallon tank, in accordance with the tank size recommended for our modeled 36-washer laundry by sizing software used to specify water heating systems.
- We took tank dimensional measurements from Hamilton.

[13] The Hamilton Evo99 200 (Munchkin 199) water heater was tested by a third-party testing lab with a 20 degree F differential between inlet and outlet temperature and was found to have a thermal efficiency of 95.3%. This temperature differential is conservative for our purposes, but it confirms that, for a product encompassing the majority of our expected rebates, steady-state performance at expected installation conditions meets our standard of 95% thermal efficiency. Other testing procedures involve different assumptions about inlet and outlet temperatures, but because the Evo99 200 results occurred under a conservative temperature differential, we consider this reasonable evidence that actual on-site performance would result in similar, if not better, thermal efficiency results.

- We assumed a heat loss meeting the Energy Policy Conservation Act standard of 6.5 Btu per hour per square foot, roughly equivalent to R-12.5 insulation.

- In actuality, insulation may be significantly less. Our informal survey of laundry boiler rooms indicate this standard is as often not met.

Therm Savings Calculation spreadsheet

The Therm Savings Calc spreadsheet calculates gas consumption given the operating efficiencies already calculated.

- The gallons of hot water needed per day are calculated from assumptions of the size and usage of an average laundry. We model a 36 washer facility with a 400,000 Btu/hr input water heater. This size relationship has been confirmed with software used commercial to size water heaters for laundries.

- The daily gallons of hot water needed are shown in cells E5 and F5, according to a distribution of wash cycles suggested by industry sources: 50% warm, 30% cold, 20% hot.

- The energy demands of heating this water are summed in column H. The energy demands of replacing tank losses are added for the sum in column J. The total is divided by the operating efficiency to give daily energy input.

- The Annual Therms saved per MBtu/hr is determined by dividing the difference in annual gas consumption between the baseline and high-efficiency units by the input size of the water.

- The Annual Therms saved per MBtu/hr is 6.17, slightly less than our original proposal assumption of 6.26.

- Our field work in laundries indicates that hot water pipes are un-insulated in the majority of cases, and that storage tanks are insulated with makeshift material as often as with proper factory-installed material.

Water Usage Data spreadsheet

The Water Usage Data spreadsheet shows actual billing data from a laundry in Redwood City. This data was never requested, but provided to us by someone who thought we could help him pick a water heater. We include it to show corroboration of our estimates of total water usage.

- Water use at this laundry slightly exceeds our estimate of 180 gallons per day per washer. His water usage was found to be 189.6 gallon per washer per day.
- Other uses of water at this site are insignificant relative to the washers.

F. CLOTHES WASHER TURNS PER DAY BREAK POINTS

The following data were applied to each period by specific washer to determine the turns within the metered period. Not all washers had up to eight turns per period. As such, the break points were set only up to the maximum Whr per period.

ID	Site	Meter	Elec. Control	Age	Whr 1 turn	Whr 2 turns	Whr 3 turns	Whr 4 turns	Whr 5 turns	Whr 6 turns	Whr 7 turns	Whr 8 turns
1	Site 1	1	Yes	New	230	400	575	750	900	1100	1400	1700
2	Site 1	2	Yes	New	230	400	575	750	900	1100	1400	1700
3	Site 1	3	Yes	New	230	400	575	750	900	1100	1400	1700
4	Site 1	4	Yes	New	230	400	575	750	900	1100	1400	1700
5	Site 1	5	Yes	New	230	400	575	750	900	1100	1400	1700
6	Site 1	6	Yes	New	230	400	575	750	900	1100	1400	1700
7	Site 2	1	Yes	New	102	200	300	0	0	0	0	0
8	Site 2	2	Yes	New	102	200	300	0	0	0	0	0
9	Site 2	3	Yes	New	102	200	300	0	0	0	0	0
10	Site 2	4	No	Old	150	300	0	0	0	0	0	0
11	Site 2	5	No	Old	150	300	0	0	0	0	0	0
12	Site 2	6	No	Old	150	300	0	0	0	0	0	0
13	Site 3	1	Yes	New	250	400	0	0	0	0	0	0
14	Site 3	2	Yes	New	250	400	0	0	0	0	0	0
15	Site 3	3	Yes	New	250	400	0	0	0	0	0	0
16	Site 3	4	Yes	New	250	400	0	0	0	0	0	0
17	Site 3	5	Yes	New	250	400	0	0	0	0	0	0
18	Site 3	6	Yes	New	250	400	0	0	0	0	0	0
19	Site 4	1	Yes	New	114	150	200	0	0	0	0	0
20	Site 4	2	Yes	New	114	150	200	0	0	0	0	0
21	Site 4	3	Yes	New	114	150	200	0	0	0	0	0
22	Site 4	4	Yes	New	113	150	200	0	0	0	0	0
23	Site 4	5	No	Old	150	300	0	0	0	0	0	0
24	Site 4	6	No	Old	175	300	0	0	0	0	0	0
25	Site 5	1	No	Old	150	260	400	550	700	850	1000	1150
26	Site 5	2	No	Old	150	260	400	550	700	850	1000	1150
27	Site 5	3	Yes	New	150	260	400	550	530	600	730	800
28	Site 5	4	Yes	New	150	260	400	550	530	600	730	800
29	Site 5	5	Yes	New	150	260	400	550	530	600	730	800
30	Site 5	6	No	Old	150	260	400	550	700	850	1000	1150
31	Site 6	1	Yes	New	230	400	550	700	950	1200	0	0
32	Site 6	2	Yes	New	230	400	550	700	950	1200	0	0
33	Site 6	3	Yes	New	230	400	550	700	950	1200	0	0
34	Site 6	4	Yes	New	230	400	550	700	950	1200	0	0
35	Site 6	5	Yes	Old	230	400	550	750	950	1200	0	0
36	Site 6	6	Yes	Old	230	400	550	750	950	1200	0	0
37	Site 7	1	Yes	Old	215	430	600	0	0	0	0	0
38	Site 7	2	Yes	Old	160	320	480	640	750	900	0	0
39	Site 7	3	Yes	Old	160	320	480	640	750	900	0	0
40	Site 7	4	Yes	Old	160	320	470	640	750	900	0	0
41	Site 7	5	Yes	Old	160	320	480	640	750	900	0	0
42	Site 7	6	Yes	Old	160	320	480	640	750	900	0	0
43	Site 8	1	Yes	New	250	400	550	0	0	0	0	0
44	Site 8	2	Yes	New	250	400	550	0	0	0	0	0

ID	Site	Meter	Elec. Control	Age	Whr 1 turn	Whr 2 turns	Whr 3 turns	Whr 4 turns	Whr 5 turns	Whr 6 turns	Whr 7 turns	Whr 8 turns
45	Site 8	3	Yes	New	250	400	550	0	0	0	0	0
46	Site 8	4	Yes	New	250	400	550	0	0	0	0	0
47	Site 8	5	Yes	New	250	400	550	0	0	0	0	0
48	Site 8	6	Yes	New	250	400	550	0	0	0	0	0
49	Site 9	1	Yes	New	245	400	0	0	0	0	0	0
50	Site 9	2	No	Old	240	400	0	0	0	0	0	0
51	Site 9	3	No	Old	240	400	0	0	0	0	0	0
52	Site 9	4	No	Old	240	400	0	0	0	0	0	0
53	Site 9	5	No	Old	240	400	0	0	0	0	0	0
54	Site 10	1	Yes	New	160	300	420	540	660	780	900	1020
55	Site 10	2	Yes	New	160	300	420	540	660	780	900	1020
56	Site 10	3	Yes	New - not ES	230	400	600	800	1000	1200	1400	1600
57	Site 10	4	Yes	New - not ES	200	400	600	750	900	1200	1400	1600
58	Site 10	5	No	New - not ES	200	400	600	800	1000	1200	1400	1600
59	Site 10	6	Yes	New	210	400	600	800	950	1200	1400	1600
60	Site 11	1	Yes	New	230	400	575	750	900	1100	1400	1700
61	Site 11	2	Yes	New	230	400	575	750	900	1100	1400	1700
62	Site 11	3	Yes	New	250	400	575	750	900	1100	1400	1700
63	Site 11	4	Yes	New	230	400	575	750	900	1100	1400	1700
64	Site 11	5	Yes	New	230	400	575	750	900	1100	1400	1700
65	Site 11	6	Yes	New	230	400	575	750	900	1100	1400	1700
66	Site 12	1	Yes	Old	250	500	750	950	1100	1350	0	0
67	Site 12	2	Yes	New	217	400	600	800	1000	1200	0	0
68	Site 12	3	Yes	New	217	400	600	800	1000	1200	0	0
69	Site 12	4	Yes	New	217	400	600	0	0	0	0	0
70	Site 12	5	Yes	Old	250	500	750	950	1100	1350	0	0
71	Site 12	6	Yes	Old	250	500	750	950	1100	1350	0	0
72	Site 13	1	Yes	New	100	200	300	400	500	0	0	0
73	Site 13	2	Yes	New	110	200	304	0	0	0	0	0
74	Site 13	3	Yes	Old	150	300	450	0	0	0	0	0
75	Site 13	4	Yes	Old	150	300	450	0	0	0	0	0
76	Site 13	5	Yes	Old	155	300	450	0	0	0	0	0
77	Site 13	6	Yes	Old	150	300	450	0	0	0	0	0

G. PROGRAM LIFECYCLE SAVINGS TABLE

Program ID: 1225-04

Program Name: Energy Solution's PY2004-2005 LightWash II Program

Year	Calendar Year	Gross Program-Projected MWh Savings	Net Evaluation Confirmed Program MWh Savings	Gross Program-Projected Peak MW Savings	Evaluation Projected Peak MW Savings**	Gross Program-Projected Therm Savings	Net Evaluation Confirmed Program Therm Savings
1	2004	2,061	1,770	0.296	0.314	319,740	245,599
2	2005	2,061	1,770	0.296	0.314	319,740	245,599
3	2006	2,061	1,722	0.296	0.314	319,740	245,599
4	2007	2,061	1,714	0.296	0.300	319,740	245,599
5	2008	2,061	1,714	0.296	0.300	319,740	245,599
6	2009	2,061	1,714	0.296	0.300	319,740	245,599
7	2010	2,061	1,714	0.296	0.300	319,740	245,599
8	2011	2,061	1,714	0.296	0.300	319,740	245,599
9	2012	2,061	1,714	0.296	0.300	319,740	245,599
10	2013	2,061	1,714	0.296	0.300	319,740	245,599
11	2014	1,327	1,714	0.200	0.300	319,740	245,599
12	2015	1,327	593	0.200	0.086	319,740	245,599
13	2016	1,327	593	0.200	0.086	319,740	245,599
14	2017	1,327	593	0.200	0.086	319,740	245,599
15	2018	1,327	5	0.200	0.001	200,320	132,338
16	2019	1,327	5	0.200	0.001		-
17	2020	-	-	-	-		-
18	2021	-	-	-	-		-
19	2022	-	0	-	-		-
20	2023	-	0	-	-		-
TOTAL	**2004-2023**	28,577	20,762	0.296	0.314	4,676,680	3,570,724

**Definition of Peak MW as used in this evaluation: Noon to 7 PM, Monday through Friday for laundromat lighting. Unable to determine for other measures from the stipulated values