Application of San Diego Gas & Electric Company (U-902-M) for Approval of Electric and Natural Gas Energy Efficiency Programs and Budgets for Years 2009 through 2011

Application 08-07- 023

Exhibit No.: __________
Witness: Athena M. Besa

AMENDED

PREPARED DIRECT TESTIMONY

OF

SAN DIEGO GAS & ELECTRIC COMPANY

CHAPTER II

Appendix C: CFL Interactive Effects Report

Appendix D: IOU Joint Workpapers – Volume 1 of 2

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

MARCH 2, 2009

Appendix C

Appendix C

CFL Interactive Effects Report

Report for the CFL Energy Impact Study

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Background

In May 2008 the CPUC released an update of the Database for Energy Efficient Resources (DEER). A significant change was the inclusion of interactive effects associated with the replacement of incandescent light bulbs with compact fluorescent bulbs (CFL) in the residential sector. In this situation the reduced wattage of CFLs, relative to incandescent bulbs, generates less heat which, in turn, requires additional natural gas usage during the heating season. Thus, the interactive effect serves as an offset to the electricity savings associate with CFLs. The magnitude of the gas impact or interactive effect from CFLs created significant controversy. Many parties to the process, including San Diego Gas and Electric (SDG&E), believed that residential CFL interactive effects exist in theory but that the heat differential between the incandescent and compact fluorescent bulbs is not large enough to actually trip a home's thermostat and thereby increase heating requirements. To put the impact in perspective, the DEER estimates of annual interactive effects for single family homes in the SDG&E service area range from 0.44 therms for an 11 Watt CFL to 0.92 therms for a 23 Watt CFL.

In order to test the validity of the interactive effect, a data set that included the number of CFL bulbs installed and the installation date was required. In a perfect world, this data set would also include household income, square footage of living space, household size, and pre- and post-installation energy usage. The only program that had this comprehensive data set was the low-income energy efficiency program (LIEE). After review of the available data, it was determined that the LIEE data could be helpful in testing whether CFL interactive effects existed and were measurable.

Data Collection

In late November and early December 2008, SDG&E compiled a dataset for LIEE participants from 2006 and 2007 that included: quantity of energy efficiency measures installed; installation date; household income; household size; living area (square footage); air conditioner ownership (central, room and none); at least 12 months of pre-and post installation electric and natural gas usage; billing days; climate zone; and heating and cooling degree hours. The data included approximately 2,800 households that had *only* interior lighting installed. There were approximately 1,600 homes that had only 15 Watt and 23 Watt CFLs installed. Of this latter group 1,219 homes had only 15 Watt bulbs installed. It should be noted that very few customers had only 23 Watt Bulbs installed. After reviewing the installation rates, it was determined that the 15 Watt bulb only group was the best to analyze, because there are a significantly large number of customers that had only this measure installed.

Model Estimation

Using the data from above, a “fixed effects” regression model was run to estimate the electric savings associated with the 15 Watt CFLs. Our fixed effects model holds the variation within the home constant and allows for an innovative approach to household level weather adjustment. The dependent variable in the electric usage model was specified as kWh per day and isolates the marginal effects of adding the CFLs. The coefficient on CFLs was estimated to be -0.032, significant at the 5% level. This indicated that the savings for 15 Watt CFLs was 0.032 kWh per day or 11.7 kWh per year. This is consistent with the 11 kWh (90% Confidence Interval of 6 to 16 kWh) from the recent West Hill Energy and Computing, Inc. study (2007) of the 2005 LIEE Program. Once the electric savings were estimated, the gas impact was estimated.

The dependent variable in the model was specified as therms per day. Again, using the same basic model, holding all else constant, the coefficient for CFLs was estimated to be -0.002. This coefficient was not significant at any conventional level (i.e., t = 1.0). In order to determine whether or not other specifications would provide different results, models were estimated that included a variable that interacts CFLs with heating degree hours and a form that specifies CFLs on a per square foot basis. The model that had the most theoretical appeal included the number of CFLs per square foot and the number of CFLs per square foot multiplied by heating degree hours. The combined coefficients in this latter model were estimated to be 0.0009 or 0.14 therms per year, but were not statistically significant.

While the above results are very interesting, they beg the question of whether they apply to the general population that participates in utility sponsored CFL programs. To investigate this, the data were constrained to only include “high-use” customers that have average usage of 14.3 kWh per day or more to estimate the electric impact. This constraint results in a set of customers that have average consumption of 19.31 kWh per day or 587 kWh per month, consistent with SDG&E’s average usage. On the gas side, we used a separate constraint so that only customers that had an average gas usage of 0.68 therms per day were selected. This sample of customers has average gas usage of 1.06 therms per day or approximately 32 therms per month (387 therms per year), consistent with SDG&E’s average usage.

Following the same modeling approach used above for the full sample, the coefficient for CFLs in the electricity usage model was estimated to be -0.13, significant at the 5% level. This translates into savings for 15 Watt CFLs of 0.133 kWh per day or 48.5 kWh per year. This compares to 32.17 kWh from the DEER Update. On the gas side, the combined coefficients were estimated to be 0.0019 or 0.74 therms per year, but the coefficients were not statistically significant at any conventional level. It should be noted that, according to the model specification, as the square footage of living space increases the magnitude of the gas impact falls. For example, if a home were 1,725 square feet, consistent with the SDG&E average, the gas impact falls to 0.45 Therms per year. Again, this value is not significant at any level. The gas impact compares to 0.6 therms per year from the DEER Update.

Conclusions

The primary results of our research effort are twofold. First, there is strong statistical evidence that replacing incandescent lights with compact fluorescent lights in a residential setting generates significant electricity savings. The coefficient that relates the installation of CFLs to electricity usage is both negative and significantly different from zero at the five percent level. The magnitude of the effect (11.68 kWh/year) for the full sample of low-income households is consistent with a recent study authored by West Hill Energy and Computing, Inc., et al (2007). In addition, the magnitude of the effect (48.5 kWh/year) for our "high-use" sample, which is designed to be more closely representative of SDG&E service territory households is consistent with (although slightly greater than) estimated savings in the DEER documentation.

The second significant result is that there is no statistical evidence of any interactive effect of CFLs on the usage of natural gas. In the full sample of low-income households the estimated interactive effect is clearly indistinguishable from zero, both in the statistical sense and in the magnitude of the coefficient. In the "high-use" sample the estimated effect is also not significantly different from zero at any conventional significance level. In terms of the magnitude of the effect (ignoring statistical significance) the estimated coefficient converts to an interactive effect that ranges from 0.14 per year for the full sample to 0.74 therms per year for the "high-use" group. This effect diminishes with square footage of living area so that the range for an average sized home (approximately 1725 square feet) is 0.08 for the sample to 0.45 therms per year for the "high-use" group. The result that interactive effects of CFLs on natural gas usage are indistinguishable from zero holds regardless of the specific estimated model. That is, the results were invariant to various possible specifications of the relationship between CFLs and gas usage.

The primary policy implication of these results are that CFLs should be credited with the appropriate electricity savings while not being subjected to a penalty associated with interactive effects that are so variable across households as to be not statistically measurable.

The study results are subject to two caveats. First, the sample sizes are smaller than we would like to see. For example, the "high-use" sample of electricity usage is only 240 households. Second, this study considers only low-income households and they might not be representative of typical households in the SDG&E service territory that would participate in the energy efficiency programs. Therefore, it would be interesting to obtain a larger sample of low-income households (e.g., households from the Pacific Gas and Electric service territory) and/or a general sample of the overall population in order to replicate the results of this study.

1. Introduction

In the most recent Annual Energy Outlook (AEO 2008) from the Energy Information Administration annual electricity consumption for the U.S. is estimated at 3,717 billion kWh in 2008. Further, in the AEO reference case, which uses an annualized growth rate of 1.07%, this consumption is forecast to increase by 26 percent to 4,696 billion kWh by 2030. The residential sector represents the largest portion (37.7% or 1,403 billion kWh) of current and future electricity use[1]. Within the residential sector air conditioning (17%) is the largest individual use category with lighting a close second (15%)[2].

Energy efficiency, defined as physical, long-lasting changes to buildings and equipment that results in decreased energy use while maintaining a constant level of service, has been identified as an important resource for satisfying a significant portion of current and future energy demand. In addition, energy efficiency has significant spillover benefits related to global climate change and U.S. energy independence. Furthermore, energy efficiency is a growth industry. For example, the Environmental Protection Agency (EPA) reported that in 1999 alone Americans bought more than 100 million *Energy Star* products (see Banerjee and Solomon, 2003). Through 2006 *Energy Star* labeled products saved 4.8 EJ of primary energy and $47 billion dollars in energy bills, and avoided 82 Tg carbon equivalent (see Sanchez, et al., 2008). Going forward, energy efficiency is realistically expected to achieve savings of 236 billion kWh relative to the AEO 2008 reference case in 2030 (141 billion kWh in 2020). This value represents an approximate five percent reduction in projected consumption. Summer peak savings associated with energy efficiency are projected to be approximately seven percent in 2030 (see EPRI, 2009). The California Energy Commission (CEC) staff report estimates that achievable potential for energy efficiency is nine percent in California in 2016 (See CEC, 2007).

One of the core energy efficiency technologies is the use of compact fluorescent lights (CFLs) to replace incandescent bulbs, which are highly inefficient sources of light because about 90 percent of the energy used is lost as heat. The 2009 EPRI report suggests that lighting improvements, especially the use of CFLs represents a large savings opportunity in the residential sector, especially in the short run (i.e., next ten years). Awareness and usage of CFLs has increased dramatically over time as production costs have declined and availability has increased (the *Energy Star* website lists more than 100 manufacturers).

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[1] See EPRI (2009). The commercial sector comprises 36.3% (1,350 billion kWh) of current usage whereas the industrial sector makes up approximately 25.9% (964 billion kWh).
[2] Note that the Energy Information Administration's U.S. Household Electricity Report estimates that lighting is responsible for 8.8 percent of household electricity use (www.eia.doe.gov).

According to a recent market effects study (Cadmus Group, Inc., et al., 2009) consumer awareness of CFLs by California household has increased from 58% in 1998 to 96% in 2008. In addition, the percentage of California households purchasing at least one CFL within the previous 18 months has increased from 17% to 77% over the last decade. 79% of California households currently use at least one CFL inside or outside their home. Wall and Crosbie (2008) report that within their study group the mean number of bulbs/household was 21.7 and the mean percent of electricity consumption for lighting was 6.5 percent. They estimate that replacement of incandescent bulbs with CFLs would reduce the electricity consumption associated with lighting by 50.9 percent. They also suggest that savings could be much greater for the average household since their particular study group was unusually pro-environmental in their attitudes, lighting choices, and behavior (Wall and Crosbie, 2008).

However, there have been some concerns raised recently regarding the use of CFLs. In particular, the disposal of CFLs, given the mercury content in the bulbs has been raised as a potential problem. A second concern about CFLs was expressed in May 2008 when the California Public Utilities Commission (CPUC) released an update of the Database for Energy Efficient Resources (DEER). This document included "interactive effects" associated with the replacement of incandescent light bulbs with compact fluorescent bulbs (CFL) in the residential sector. In this situation the reduced wattage of CFLs, relative to incandescent bulbs, generates less heat which, in turn, requires additional natural gas usage during the heating season. Thus, the interactive effect serves as an offset to the electricity savings associate with CFLs. The magnitude of the effect is significant in energy terms according to the DEER revisions. That is, the DEER provides an estimate of annual interactive effects for single family homes that ranges from 0.44 therms for an 11 Watt CFL to 0.92 therms for a 23 Watt CFL. This is an important issue since an estimated 290 million CFLs were sold in the U.S. in 2007, with 55.6 million of those sold in California (see Cadmus Group, Inc., 2009).

The magnitude of the gas impact or interactive effect from CFLs has created significant controversy. On the one hand the existence of residential CFL interactive effects is consistent with theoretical models of energy use. On the other hand it is an empirical question as to whether the heat differential between the incandescent and compact fluorescent bulbs is large enough to actually trip a home's thermostat and thereby increase heating requirements. Ford (2008), using ASHRAE accepted principles has estimated that converting one incandescent bulb to a CFL (28 watt saving) will result in a heat loss of 36.1 BTU/hr[3]. This translates into 0.0036% of the heating capacity of a normal heating system (100,000 BTU/hr), which

[3] Note that the average person at rest emits a sensible heat gain of 245 BTU/hr per the 2005 ASHRAE Fundamentals (see Ford, 2008, page 30.4).

Ford suggests is insufficient to be sensed by the thermostat. Thus, ASHRAE recommends against the inclusion of internal heat gains, particularly from occupants and lighting, when sizing residential heating systems.

In this paper we take a different approach to investigating the efficacy of CFL interactive effects in residential situations. Specifically, we use billing analysis to test the validity of the interactive effect. Our analysis is based on a comprehensive data set that includes monthly household electricity and natural gas usage, the number of CFL bulbs installed, the installation date, and a set of household characteristics. Our results suggest that CFLs do indeed save electricity. However, we do not find any support for the hypothesis that CFLs cause increased usage of natural gas.

The paper is organized as follows. In the next section we describe our empirical approach. Data specifics and empirical results are presented in sections 3 and 4, respectively. Conclusions and policy implications are offered in the final section.

2. Empirical Specification

To examine the impact of replacing traditional incandescent bulbs with CFLs, we estimate the following model:

$$\begin{aligned} Usage_{it} &= \alpha_i + \beta_1 CFL_{it} + \beta_2 HDH_{it} + \beta_3 CDH_{it} + Year_t \gamma_1 + Month_t \gamma_2 \\ &\quad + (\alpha_i \cdot HDH_{it})\delta_1 + (\alpha_i \cdot CDH_{it})\delta_2 + \varepsilon_{it} \end{aligned}, \qquad (1)$$

where $Usage_{it}$ is either kilowatt hours per day or therms per day for household i in time period t, α_i is a vector of household fixed effects, CFL_{it} is the number of compact florescent light bulbs installed in household i in period t ($CFL_{it} = 0$ in pre-installation period), HDH_{it} is the number of heating degree hours, CDH_{it} is the number of cooling degree hours, $Year_t$ is a vector of year fixed effects, $Month_t$ is a vector of month fixed effects, $(\alpha_i \cdot HDH_{it})$ denotes the interaction of the number of heating degree hours for household i in period t with the household-specific fixed effects, $(\alpha_i \cdot CDH_{it})$ denotes the interaction of the number of cooling degree hours with the household-specific fixed effects, and ε_{it} is a random disturbance term.

Equation (1) is estimated separately for electricity consumption and gas consumption. The coefficient of primary interest is β_1. For the electricity usage model, β_1 should be negative since replacing traditional incandescent bulbs with CFLs should reduce electricity usage. In terms of interpretation, β_1 measures the average daily electricity savings associated with the installation of one additional CFL. For the gas usage model, if CFLs have an interactive affect on gas consumption due to their impact on ambient temperature, β_1 should be positive. Thus, in the gas model β_1 can be interpreted as the average daily increase in gas usage associated with the installation of one additional CFL.

Note that the inclusion of individual-specific fixed effects in equation (1) implies that we are only using within household variation in energy consumption to identify the model. Thus, any factor that influences energy consumption but does not vary over time (e.g. square feet of living space, number of occupants in household, etc) is captured by the individual fixed effects. Consequently, our model controls for any observable or unobservable factors that influence energy consumption but do not vary over time. In the literature on modeling residential energy consumption, this type of model is sometimes referred to as an Analysis of Covariance (ANACOVA) model. As noted by TecMarket Works, et al (2004), "controlling for fixed effects controls the amount of variance (noise) the model is faced with, since each customer has a different base load, a different response to weather, and a different pattern of consumption that changes over time" (TecMarket Works, et al ,2004, pp. 110). Furthermore, the inclusion of the interaction terms $(\alpha_i \cdot HDH_{it})$ and $(\alpha_i \cdot CDH_{it})$ adjusts for each household's weather sensitive energy usage (i.e. individual specific weather related energy consumption patterns). Thus, our empirical specification is similar to the PRISM models that are commonly used in the literature but allows for greater flexibility in modeling the impact of weather on individual energy usage patterns (TecMarket Works, et al, 2004).

Alternative Gas Consumption Models

While equation (1) provides a useful way of modeling electricity savings due to the installment of CFLs, it may be less useful for modeling the interactive effects that the installation of CFLs may have on gas consumption. Specifically, the interactive effect CFLs have on gas consumption arises due to the change in ambient air temperature associated with replacing a traditional incandescent bulb with compact fluorescents.[4] The change in ambient air temperature in turn, will depend on several factors such as the wattage of the traditional incandescent bulb that is being replaced, the flow or air through a home, and perhaps most importantly the volume (size) of the space within which the light bulbs are housed. To see

[4] Note that there is also a potential interactive effect for electricity. Specifically, replacing incandescent lights with CFLs may result is a lower cooling season temperature and hence a household may utilize its air conditioning system less often. The data set we have assembled for this study is not sufficiently comprehensive to estimate this effect.

this, note that if we consider a room that does not leak any heat, we can express the change in room temperature associated with using a traditional incandescent bulb of a given wattage as:

$$\Delta T = \frac{Watts \cdot t}{V \cdot d \cdot c}, \tag{2}$$

where ΔT denotes the change in temperature, $Watts$ is the wattage of a traditional incandescent bulb, t is time measured in seconds, V is the volume of the room measured in m^3 (meters cubed), d is the density of air measured in kg/m^3 (kilograms per meter cubed) and c is the specific heat capacity of air measured in $kJ/kg.^0C$ (kilojoules per kilograms degree Celsius). Thus, for any given values of d and c, the change in room temperature varies inversely with the size of the room --- the larger the room, the smaller the change in ambient air temperature. Consequently, the impact replacing traditional incandescent bulbs with CFLs has on ambient air temperature should be larger in smaller rooms and smaller in larger rooms. This suggests that the relationship between gas usage and the installation of CFL's is not linear as specified in equation (1). Rather, the impact CFLs have on gas usage depends critically on the *density* of CFLs, measured for example, as CFLs per square feet.

The discussion above suggests that an ideal way to measure the potential impact CFLs have on gas usage would be to construct some measure of the number of CFLs per volume (height x width x length) of heating area. Unfortunately, to our knowledge, no such data exists. However, we do have information on the square footage of homes, a variable that should be highly correlated with the volume of heating area. Thus, as an alterative to equation (1), we also estimate gas usage models of the following form:

$$\begin{aligned} Usage_{it} &= \alpha_i + \beta_1 (CFL_{it}/SQFT_i) + \beta_2 HDH_{it} + \beta_3 CDH_{it} + Year_t \gamma_1 + Month_t \gamma_2 \\ &\quad + (\alpha_i \cdot HDH_{it})\delta_1 + (\alpha_i \cdot CDH_{it})\delta_2 + \varepsilon_{it} \end{aligned}, \tag{3}$$

where $SQFT_i$ denotes the square footage of housing unit i. In equation (3), β_1 now measures the average effect of installing one additional CFL per square foot of living space. If interaction effects are present, β_1 should be positive. Furthermore, note that the marginal effect of installing one additional CFL has on gas usage can be expressed as:

$$\frac{\partial Usage}{\partial CFL} = \beta_1 \frac{1}{SQFT}, \tag{4}$$

which depends on the square footage of a home: the larger the home, the smaller the marginal effect of an additional CFL on gas usage.

Interactive Heating Degree Hour Models

In addition to the model given by equation (3) which uses CFLs per square feet as the key explanatory variable of interest, we also estimate several variants of equations (1) and (3) that allow the effect of CFLs to vary with the number of heating degree hours. Specifically, following ADM Associates, Inc. and TecMRKT Works, LLC (2002), we also estimate models of gas usage that take the following form:

$$\begin{aligned} Usage_{it} &= \alpha_i + \beta_1 CFL_{it} + \beta_2 HDH_{it} + \beta_3 CDH_{it} + \beta_4 (CFL_{it} \cdot HDH_{it}) \\ &+ Year_t \gamma_1 + Month_t \gamma_2 + (\alpha_i \cdot HDH_{it})\delta_1 + (\alpha_i \cdot CDH_{it})\delta_2 + \varepsilon_{it} \end{aligned} \tag{5}$$

$$\begin{aligned} Usage_{it} &= \alpha_i + \beta_1 \frac{CFL_{it}}{SQFT_i} + \beta_2 HDH_{it} + \beta_3 CDH_{it} + \beta_4 (\frac{CFL_{it}}{SQFT_i} \cdot HDH_{it}), \\ &+ Year_t \gamma_1 + Month_t \gamma_2 + (\alpha_i \cdot HDH_{it})\delta_1 + (\alpha_i \cdot CDH_{it})\delta_2 + \varepsilon_{it} \end{aligned} \tag{6}$$

where the term $(CFL_{it} \cdot HDH_{it})$ in equation (5) denotes the interaction of the number of CFLs with the number of heating degree hours and the term $\left(\frac{CFL_{it}}{SQFT_i} \cdot HDH_{ut}\right)$ in equation (6) is similarly defined. Note that in equations (5) and (6), the marginal effects of an additional CFL on gas consumption are respectively:

$$\frac{\partial Usage}{\partial CFL} = \beta_1 + \beta_4 HDH \tag{7}$$

$$\frac{\partial Usage}{\partial CFL} = (\beta_1 + \beta_4 \bullet HDH) \frac{1}{SQFT}, \tag{8}$$

both of which vary with the number of heating degree hours.

3. Data Collection

In late November and early December 2008, SDG&E compiled a dataset for LIEE participants from 2006 and 2007 that included: quantity of energy efficiency measures installed; installation date; household income; household size; living area (square footage); air conditioner ownership (central, room and none); at least 12 months of pre-and post installation electric and natural gas usage; billing days; climate zone; and heating and cooling degree hours. The data included approximately 2,800 households that had *only* interior lighting installed. There were approximately 1,600 homes that had only 15 Watt and 23 Watt CFLs installed. Of this latter group 1,219 homes had only 15 Watt bulbs installed. It should be noted that very few customers had only 23 Watt Bulbs installed. After reviewing the installation rates, it was determined that the 15 Watt bulb only group was the best to analyze, because there are a significantly large number of customers that had only this measure installed.

Weather data

Heating and cooling degree hours were developed by mapping individual weather station data to the three climate zones: maritime, coastal and transitional. Both the heating and cooling degree hours are based on a 65 degree set point assumption. Each participant's home was mapped to one of the three climate zones using a zip code reference table provided by SDG&E. As an alternative, we also tried mapping to the three climate zones using the California Energy Commission's climate zone to zip code list assuming that climate zone 7 was maritime, zone 10 was coastal and 14 was transitional. SDG&E's mapping was used in the regression results presented below.

4. Empirical Results

In the analysis that follows, we estimate equations (1), (3), (5) and (6) using a least squares dummy variable estimation procedure. This essentially involves creating an indicator variable for each household in the sample and then including the full set of indicator variables in the regression analysis. Note that because we also allow for individual responses to weather, our models also include the individual household indicator variables interacted with the number of heating degree hours and the number of cooling degree hours.

Electricity Usage Results

As indicated above our empirical analysis is limited to those LIEE customers that received only 15-Watt CFL installations. In Table 1 below we present the electricity usage variable definitions and summary statistics for two specific sample groups: (1) all low-income households (upper panel); and (2) low-income households that have average electricity consumption that equals or exceeds 14.3 kWh/day (lower panel). This latter group has average electricity consumption of approximately 19.3 kWh/day, which is consistent with overall average electricity usage in the San Diego Gas and Electric service territory (see McNulty, Murdoch, and Thayer, 2006). For each group, Column 1 contains electricity usage summary statistics for the entire time period of analysis. In Columns 2 and 3 we provide the same information for the pre-installation and post-installation periods, respectively. Note that household characteristics do not vary in the pre and post period.

As expected, low-income households in the full sample (upper panel) have smaller homes and incomes and use less electricity/day than representative San Diego households. On the other hand, family size exceeds the comparable value in San Diego (2.80 people/household in McNulty, Murdoch, and Thayer, 2006). The "high-use" sample was selected to more closely match the SDG&E service territory customer base. Therefore, the average electricity use is closely aligned with the surrounding population. However, home size, income, and household size are still quite different.[5]

In terms of the variable of interest, post-installation electricity usage/day declines from the pre-installation period, in spite of the increase in average heating degree hours. This trend is especially apparent for the "high-use" group, while the full sample shows no significant change.

[5] The following values were taken from the McNulty, Murdoch, and Thayer study: average daily electricity use = 19.3 kWh, average daily gas use = 1.07 therms, average home size = 1,725 square feet, average household size – 2.80 persons. In addition, since only low-income household qualify for the program being studied herein we know average income is below the comparable average service territory average.

Table 1
Summary Statistics for Full Sample and "High Use" Low-Income Households

All Low Income Households

	(1) Full Sample		(2) Pre-CFL Installation		(3) Post CFL Installation	
Variable	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Monthly Characteristics						
Usage (kwh per Day)	10.28	6.43	10.25	6.46	10.30	6.41
CFL's Installed (1=yes)	0.60	0.49	0.00	0.00	1.00	1.00
Heating Degree Hours (1,000's)	3.53	2.81	3.65	2.69	3.45	2.89
Cooling Degree Hours (1,000's)	2.46	2.20	2.22	2.19	2.61	2.19
2005	0.20	0.40	0.48	0.50	0.01	0.10
2006	0.26	0.44	0.35	0.48	0.21	0.41
2007	0.28	0.45	0.17	0.38	0.35	0.48
2008	0.26	0.44	0.00	0.00	0.44	0.50
Household Characteristics						
Number of CFL's	5.09	2.78	5.09	2.78	5.09	2.78
Square Footage of Home	896	306	896	306	896	306
Household Size	3.46	1.90	3.46	1.90	3.46	1.90
Single Family Home (1=yes)	0.48	0.50	0.48	0.50	0.48	0.50
Household Income	$22,844	$9,069	$22,844	$9,069	$22,844	$9,069

"High Use" Low Income Households

	(1) Full Sample		(2) Pre-CFL Installation		(3) Post CFL Installation	
Variable	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Monthly Characteristics						
Usage (kwh per Day)	19.24	7.20	19.67	7.33	18.97	7.10
CFL's Installed (1=yes)	0.61	0.49	0.00	0.00	1.00	1.00
Heating Degree Hours (1,000's)	3.65	2.88	3.80	2.76	3.55	2.95
Cooling Degree Hours (1,000's)	2.69	2.34	2.46	2.36	2.84	2.31
2005	0.19	0.39	0.48	0.50	0.01	0.09
2006	0.25	0.43	0.33	0.47	0.21	0.40
2007	0.28	0.45	0.19	0.39	0.34	0.47
2008	0.28	0.45	0.00	0.00	0.45	0.50
Household Characteristics						
Number of CFL's	5.28	2.83	5.28	2.83	5.28	2.83
Square Footage of Home	1095	408	1095	408	1095	408
Household Size	4.17	2.00	4.17	2.00	4.17	2.00
Single Family Home (1=yes)	0.62	0.49	0.62	0.49	0.62	0.49
Household Income	$25,995	$10,726	$25,995	$10,726	$25,995	$10,726

Results based on the estimation of equation (1) for electricity usage are presented in Table 2. In all regressions the dependent variable equals kWh per day. In the first column we present electricity usage estimates for the full sample of LIEE households that have had only 15-watt CFLs installed. In the second column we present electricity usage estimates for the "high-use" sample of LIEE households that have had only 15-watt CFLs installed. All models also include individual-specific heating degree hour slopes and individual-specific cooling degree hour slopes (see equation (1) above). For brevity the approximately 3,650 (full sample) or 720 ("high-use" sample) coefficients are not presented, but are available upon request. Clustered standard errors accounting for potential within-individual serial correlation of residuals are reported in parentheses below the estimated coefficient. No previous study in this area has accounted for this within-individual correlation and consequently has tended to overstate the significance of the estimates. The indicators *, **, and *** imply the variable is significant at the 10% level, 5% level, or 1% level, respectively.

There are several noteworthy results in Table 2. First, a high proportion of the variation in electricity usage is explained by the independent variables as the R-squared ranges from 0.72 ("high-use" sample) to 0.85 (full sample). Second, the monthly and yearly dummy variables, which are interpreted as variations from the relevant omitted category (2005 for year, January for month), perform as expected. Specifically, there is some evidence that electricity usage is increasing over time, especially for the full sample. In addition, the monthly effects suggest that, all else constant, electricity use/day in January is similar to the August – September period (July – September for "high-use" sample) whereas during all the other months, daily electricity usage is significantly below this level. Third, heating and cooling degree hours add very little explanatory power when the model includes individual-specific heating and cooling degree hour slopes. It should be noted that if the individual-specific heating and cooling degree hour slopes are omitted from the model then the heating and cooling degree hours variables are both positively related to daily electricity usage and are significant at one percent level.

The final important result pertains to our focus variable, the number of compact fluorescent (CFL) bulbs installed in the home. As is indicated in Table 2 the coefficient on number of CFLs is negatively related to daily electricity usage and is significant at the ten percent level in each of the estimated models.

The calculation of the impact of an additional CFL is straightforward. The coefficient multiplied by 365 yields the annual savings from an additional bulb. For the full sample of low-income households in Table 2, the savings value attributable to another CFL is approximately 11.7 kWh/year. This value is very close to those reported in a recent study by West Hill Energy and Computing, Inc., et al (2007).[6] These results

[6] In this study the estimated coefficient on CFLs produced annual savings of 11 kWh/year with a confidence interval of 6 – 16. The authors stated that the regression results were likely biased downward due to CFL attrition and purchase outside the program so they recommended the high end of the confidence interval (see West Hill Energy and Computing, Inc., et al., 2007)

can also be compared to our "high-use" sample in Table 2. The estimated coefficients on number of CFLs for this group suggest significantly larger savings than those for the full sample. That is, the savings attributable to another CFL for the "high-use" group are approximately 48.5 kWh/year.

Table 2
Estimated Model Results – Electricity Usage/Day

Specification:	Full Sample	High Use
Number of CFL's	-0.032*	-0.133**
	(0.020)	(0.056)
Heating Degree Hours (1,000's)	-0.199***	-0.092
	(0.032)	(0.095)
Cooling Degree Hours (1,000's)	-0.020	0.788***
	(0.033)	(0.077)
2006	-0.034	0.197
	(0.096)	(0.324)
2007	0.256**	0.520
	(0.130)	(0.431)
2008	0.441***	0.660
	(0.169)	(0.607)
February	-0.691***	-1.036***
	(0.060)	(0.201)
March	-1.195***	-1.925***
	(0.080)	(0.294)
April	-1.518***	-2.539***
	(0.105)	(0.393)
May	-1.381***	-2.293***
	(0.133)	(0.504)
June	-1.090***	-1.787***
	(0.164)	(0.607)
July	-0.663***	-0.567
	(0.186)	(0.682)
August	-0.163	0.619
	(0.200)	(0.718)
September	-0.177	0.249
	(0.193)	(0.680)
October	-0.841***	-1.444**
	(0.164)	(0.581)
November	-1.130***	-2.140***
	(0.137)	(0.481)
December	-0.625***	-1.031***
	(0.101)	(0.348)
Observations	37542	7310
Number of Households	1219	240
R-squared	0.85	0.72

Gas Usage Results

In Table 3 we present the summary statistics for both the full sample of LIEE customers (upper panel) and LIEE customers that are in the “high-use” group (lower panel). Each sample is restricted to customers that received installation of 15-watt CFLs only. “High-use” is defined as an average of 0.68 therms per day or more, which translates into an overall sample average of 1.06 therms/day. This latter value is consistent with the average natural gas use in the SDG&E service territory (see McNulty, Murdoch, and Thayer, 2006 - Home Energy Comparison Tool). As in Table 1, Column 1 contains gas usage summary statistics for the entire time period of analysis while Columns 2 and 3 provide the same information for the pre-installation and post-installation periods, respectively.

Note that the gas samples differ from the electricity samples for two reasons. First, for the full sample, there are fewer low-income gas customers then electricity customers. This point is especially apparent when one compares the upper panel of Table 1 to the upper panel of Table 3. Specifically, the full low-income sample for the gas usage model consists of 870 households, whereas the full low-income sample for the electricity usage model consists of 1,219 households. Second, the “high-use” gas group is larger (lower pane, Table 3) than the electricity “high-use” group (lower panel, Table 1). This occurs because the gas usage threshold is somewhat lower to qualify. Thus, our “high-use” gas group is about twice as large as the corresponding electricity group.

From the perspective of this study the most interesting result shown in Table 3 is that gas usage does not seem to be affected by the installation of CFLs as pre-installation and post-installation values are nearly identical for each sample. As with the electricity samples (Table 1), both the full sample of low-income households (upper panel) and the “high-use” sample have smaller homes and incomes but larger household size than representative San Diego households.

Table 3

Summary Statistics for Full Sample and "High Use" Low-Income Households

	All Low Income Households					
	(1)		(2)		(3)	
	Full Sample		Pre-CFL Installation		Post CFL Installation	
Variable	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Monthly Characteristics						
Usage (Therms per Day)	0.74	0.58	0.75	0.58	0.74	0.58
CFL's Installed (1=yes)	0.63	0.48	0.00	0.00	1.00	1.00
Heating Degree Hours (1,000's)	3.50	2.79	3.59	2.64	3.44	2.87
Cooling Degree Hours (1,000's)	2.38	2.14	2.08	2.08	2.55	2.15
2005	0.20	0.40	0.52	0.50	0.01	0.11
2006	0.26	0.44	0.33	0.47	0.22	0.42
2007	0.28	0.45	0.15	0.36	0.35	0.48
2008	0.26	0.44	0.00	0.00	0.41	0.49
Household Characteristics						
Number of CFL's	5.19	2.94	5.19	2.94	5.19	2.94
Square Footage of Home	931	318	931	318	931	318
Household Size	3.64	1.95	3.64	1.95	3.64	1.95
Single Family Home (1=yes)	0.63	0.48	0.63	0.48	0.63	0.48
Household Income	$23,226	$9,549	$23,226	$9,549	$23,226	$9,549

	"High Use" Low Income Households					
	(1)		(2)		(3)	
	Full Sample		Pre-CFL Installation		Post CFL Installation	
Variable	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Monthly Characteristics						
Usage (Therms per Day)	1.06	0.61	1.09	0.60	1.05	0.62
CFL's Installed (1=yes)	0.64	0.48	0.00	0.00	1.00	1.00
Heating Degree Hours (1,000's)	3.52	2.79	3.59	2.63	3.48	2.87
Cooling Degree Hours (1,000's)	2.41	2.15	2.12	2.09	2.57	2.16
2005	0.20	0.40	0.53	0.50	0.01	0.11
2006	0.26	0.44	0.33	0.47	0.23	0.42
2007	0.28	0.45	0.14	0.35	0.36	0.48
2008	0.26	0.44	0.00	0.00	0.41	0.49
Household Characteristics						
Number of CFL's	5.29	3.07	5.29	3.07	5.29	3.07
Square Footage of Home	1044	346	1044	346	1044	346
Household Size	4.18	2.05	4.18	2.05	4.18	2.05
Single Family Home (1=yes)	0.82	0.38	0.82	0.38	0.82	0.38
Household Income	$24,798	$10,742	$24,798	$10,742	$24,798	$10,742

Below we present the results of estimating equations (1), (3), (5), and (6). To simplify the summary of our findings, we first present the results for the full sample and later present the results for the "high-use" group. In all cases, customers were limited to LIEE participants that only had 15 Watt CFLs installed.

Full Sample Estimation

Table 4 presents four different model specifications for the full sample. In Specification 1 we present the baseline gas usage model estimation results (see equation (1) above). In Specifications 2, 3, and 4 we present the results from the estimation of equations (5), (3), and (6), respectively. In all Specifications the dependent variable is therms/day. All models include individual-specific heating degree hour slopes and individual-specific cooling degree hour slopes. These coefficients are not reported herein but are available upon request. Clustered standard errors are reported in parentheses below the estimated coefficient. The indicators *, **, and *** imply variable significance at the 10% level, 5% level, or 1% level, respectively.

The estimated models in Table 4 (full sample) show the following.

- A high proportion of the variation in electricity usage is explained by the independent variables as R-squared is constant at 0.86. The monthly and yearly dummy variables, which are interpreted as variations from the relevant omitted category (2005 for year, January for month), perform as expected. The annual trends indicate that gas consumption in 2006 – 2008 is significantly smaller than usage recorded in 2005 even though there has been no substantive change in heating degree hours. This may reflect a price effect. The months with relatively high gas usage are January and February. All other months have significantly smaller gas usage, relative to January/February. Minimum gas usage occurs in the September – November period.
- In spite of controlling for individual specific response to weather, the variable Heating Degree Hours is still a significant determinant of gas usage.
- The coefficient on Number of CFLs is not significantly different from zero at any commonly used significance level in any specification. In addition, the negative sign (Specifications 1 and 2) on the coefficient does not support the hypothesis of the presence of interactive effects.

Table 4

Estimated Model Results – Gas Usage/Day
Full Sample

	Full Sample			
Specification:	(1)	(2)	(3)	(4)
Number of CFL's	-0.002	-0.001		
	(0.002)	(0.002)		
CFL's X Heating Degree Hours		-0.00001		
		(0.0001)		
Number of CFL's per SQFT			0.347	1.023
			(1.598)	(1.628)
CFL's per SQFT X Heating Degree Hours				-0.195
				(0.281)
Heating Degree Hours (1,000's)	0.054***	0.055***	0.054***	0.055***
	(0.002)	(0.003)	(0.002)	(0.003)
Cooling Degree Hours (1,000's)	-0.031***	-0.031***	-0.031***	-0.031***
	(0.002)	(0.002)	(0.002)	(0.002)
2006	-0.031***	-0.031***	-0.036***	-0.037***
	(0.009)	(0.009)	(0.010)	(0.009)
2007	-0.018	-0.019	-0.026**	-0.027**
	(0.012)	(0.012)	(0.013)	(0.013)
2008	-0.015	-0.015	-0.026*	-0.026*
	(0.015)	(0.014)	(0.015)	(0.015)
February	0.006	0.006	0.006	0.006
	(0.008)	(0.008)	(0.008)	(0.008)
March	-0.043***	-0.043***	-0.044***	-0.043***
	(0.009)	(0.009)	(0.009)	(0.009)
April	-0.100***	-0.100***	-0.101***	-0.100***
	(0.011)	(0.011)	(0.011)	(0.011)
May	-0.091***	-0.090***	-0.092***	-0.091***
	(0.012)	(0.012)	(0.012)	(0.012)
June	-0.066***	-0.064***	-0.067***	-0.065***
	(0.015)	(0.015)	(0.015)	(0.015)
July	-0.084***	-0.082***	-0.085***	-0.083***
	(0.017)	(0.017)	(0.017)	(0.017)
August	-0.105***	-0.103***	-0.107***	-0.104***
	(0.018)	(0.018)	(0.018)	(0.018)
September	-0.131***	-0.129***	-0.133***	-0.130***
	(0.018)	(0.017)	(0.018)	(0.017)
October	-0.137***	-0.136***	-0.140***	-0.137***
	(0.016)	(0.016)	(0.016)	(0.016)
November	-0.117***	-0.116***	-0.120***	-0.118***
	(0.013)	(0.013)	(0.014)	(0.013)
December	-0.089***	-0.089***	-0.093***	-0.092***
	(0.010)	(0.010)	(0.010)	(0.010)
Observations	27484	27484	27484	27484
Number of Households	870	870	870	870
R-squared	0.86	0.86	0.86	0.86

The results presented in Table 4 specification 1 suggest that interactive effects for CFLs do not exist in residential settings. Since this result is counter to the DEER Team position we considered several other models of gas usage, presented in Specifications 2, 3, and 4 (see equations (5), (3), and (6), respectively) to determine whether or not this baseline result was robust.

CFLs per square feet of living area is the relevant independent variable in Specification 3, Table 4. As is indicated, the coefficient on the focus variable is not significantly different from zero at any conventional level. This result is fully consistent with those presented in Specification 1. If one ignores statistical significance (not recommended) and only considers the magnitude of the coefficient at the mean square footage in the sample the interactive effect (see equation (4)) would be 0.14 therms per year.[7] Further, the magnitude of this effect declines with square footage so that if a representative San Diego household (1,725) were used in the calculations the interactive effect fall to 0.07 therms per year.

In Specifications 2 and 4 we present the results in which the relevant independent variable is interacted with heating degree hours. The results are nearly identical with those reported in Specifications 1 and 3. Specifically, in Specification 2 the coefficient on the number of CFLs is not significant from zero and negatively related to gas usage per day whereas in Specification 4 the relevant coefficient is not significantly different from zero but positively related to gas usage per day. In this latter case the magnitude of the coefficient converts to an interactive effect equal to 0.14 per year.[8] In addition, the effect diminishes with square footage of living area so that the range for an average sized home (approximately 1725 square feet) is 0.08 therms per year.

High Use Sample Estimation

Table 5 presents four different models for the "high-use" group. Specification 1 is defined as the baseline gas usage model estimation results (see equation (1) above) for the "high-use" sample of LIEE households that have had only 15-watt CFLs installed. Specifications 2, 3 and 4 conform to the results from the estimation of equations (5), (3), and (6), respectively. In all specifications the dependent variable is therms/day. Clustered standard errors are reported in parentheses below the estimated coefficient. All models include individual-specific heating degree hour slopes and individual-specific cooling degree hour slopes. These coefficients are not reported herein but are available upon request. As

[7] 0.14 = (0.347 x 365 days) / 931 square feet average for the full sample.
[8] 0.14 = ((1.023 + (-0.195 x 3.44 thousands of HDH)) x 365 days) / 931 average square feet for the full sample.

in Table 4, the indicators *, **, and *** imply variable significance at the 10% level, 5% level, or 1% level, respectively.

The Results shown in Table 5 ("high-use" sample) are essentially identical to those presented in Table 4 for the full sample.[9]

- A high proportion of the variation in electricity usage is explained by the independent variables as R-squared is constant at 0.80. The monthly and yearly dummy variables, which are interpreted as variations from the relevant omitted category (2005 for year, January for month), perform as expected. The annual trends indicate that gas consumption in 2006 – 2008 is significantly smaller than usage recorded in 2005 even though there has been no substantive change in heating degree hours. The months with relatively high gas usage are January and February. All other months have significantly smaller gas usage, relative to January/February. Minimum gas usage occurs in the September – November period.
- In spite of controlling for individual specific response to weather, the variable Heating Degree Hours is still a significant determinant of gas usage.
- The coefficient on Number of CFLs is never significantly different from zero at any commonly used significance level. In addition, the negative sign on the coefficient in specifications 1 and 2 does not support the hypothesis of the presence of interactive effects.

The results presented in Table 5 suggest that interactive effects for CFLs do not exist in residential settings. This result, counter to the DEER Team position, is robust across the various gas usage models. For example, CFLs per square feet of living area is the relevant independent variable in Specification 3. As is indicated, the coefficient on the focus variable is not significantly different from zero at any conventional level. This result is fully consistent with those presented in Specification 1. If one ignores statistical significance and only considers the magnitude of the coefficient at the mean square footage in the sample the interactive effect (see equation (4)) would be 0.74 therms per year.[10] Further, the magnitude of this effect declines with square footage so that if a representative San Diego household (1,725) were used in the calculations the interactive effect would be 0.45 therms per year.

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[9] As a test of consistency we estimated the electricity savings associated with CFLs for this specific "high-use" gas group (n=435). Our results were consistent with the results presented in Table 2. As expected, the estimated coefficient (-.038) is negative and lies between the electricity results for the full electricity sample (n=1,219) and the "high-use" electricity sample (n=240).

[10] 0.74 = (2.11 x 365 days) / 1044 square feet average for the "high-use" group.

In Table 5, Specifications 2 and 4, we present the results in which the relevant independent variable is interacted with heating degree hours. The results are nearly identical with those reported in Specifications 1 and 3. Specifically, in Specification 2 the coefficient on the number of CFLs is not significant from zero and negatively related to gas usage per day whereas in Specification 4 the relevant coefficient is not significantly different from zero but positively related to gas usage per day. In this latter case the magnitude of the coefficient converts to interactive effect equal to 0.74 per year ,[11] which diminishes with square footage of living area (average sized home of approximately 1725 square feet has an estimated interactive effect of 0.45 therms per year).

Robustness of estimates

In order to test the stability of the results presented above for both the full sample and the "high-use" groups, we tested a variety of different assumptions. The following is a summary of the different assumptions that were tested in addition to the four different model specifications presented above.

- Installation date – In our preferred approach (presented in Tables 2, 4, and 5 above) we eliminate the installation month from our analysis. In this case the pre and post periods are exactly identified. However, we do lose a few observations. As an experiment we instead treated the install month as part of the pre-installation period which makes the first month after installation the beginning of the post-installation period. The results of this experiment were statistically identical to those presented above although the magnitude of the focus variable for both gas and electricity models was slightly smaller.
- Weather data mapping – In a perfect world a researcher would have site level weather data for each customer. The reality is that the best that can be done is to collect data at the weather station level and average the available data across weather stations within a climate zone. Mapping a customer to a weather zone creates a new challenge. In our preferred approach (presented in Tables 2, 4, and 5 above) we used a mapping system that SDG&E made available and that had been used in previous studies. As a test of robustness we utilized an assignment system that mapped household zip code locations to climate zones. In this case we used the California Energy Commission's (CEC) zip code to climate zone list. To do this we assumed that CEC climate zone 7 was the maritime zone, zone 10 was the coastal zone and zone 14 was the transitional zone. The estimation results corresponding to this approach were identical to those presented above.

[11] 0.74 = ((1.948 + (.048 x 3.48 thousands of HDH)) x 365 days) / 1044 average square feet for the "high-use" group sample.

Table 5

Estimated Model Results – Gas Usage/Day
High Use Sample

	High Use			
Specification:	(1)	(2)	(3)	(4)
Number of CFL's	-0.001	-0.002		
	(0.003)	(0.003)		
CFL's X Heating Degree Hours		0.0001		
		(0.001)		
Number of CFL's per SQFT			2.110	1.948
			(2.756)	(2.751)
CFL's per SQFT X Heating Degree Hours				0.048
				(0.527)
Heating Degree Hours (1,000's)	0.047***	0.047***	0.047***	0.047***
	(0.004)	(0.004)	(0.004)	(0.004)
Cooling Degree Hours (1,000's)	-0.035***	-0.035***	-0.035***	-0.035***
	(0.003)	(0.003)	(0.003)	(0.003)
2006	-0.042***	-0.042***	-0.052***	-0.052***
	(0.016)	(0.016)	(0.016)	(0.016)
2007	-0.022	-0.021	-0.037*	-0.037*
	(0.021)	(0.021)	(0.022)	(0.022)
2008	-0.020	-0.020	-0.040*	-0.039*
	(0.024)	(0.024)	(0.024)	(0.024)
February	0.012	0.012	0.011	0.011
	(0.015)	(0.015)	(0.015)	(0.015)
March	-0.069***	-0.069***	-0.070***	-0.070***
	(0.015)	(0.014)	(0.015)	(0.015)
April	-0.155***	-0.155***	-0.157***	-0.157***
	(0.018)	(0.018)	(0.018)	(0.018)
May	-0.143***	-0.144***	-0.145***	-0.146***
	(0.021)	(0.021)	(0.021)	(0.021)
June	-0.100***	-0.101***	-0.103***	-0.103***
	(0.026)	(0.025)	(0.026)	(0.025)
July	-0.119***	-0.120***	-0.121***	-0.122***
	(0.029)	(0.029)	(0.029)	(0.028)
August	-0.147***	-0.148***	-0.149***	-0.150***
	(0.031)	(0.030)	(0.031)	(0.030)
September	-0.185***	-0.186***	-0.188***	-0.189***
	(0.030)	(0.029)	(0.030)	(0.029)
October	-0.202***	-0.203***	-0.206***	-0.206***
	(0.028)	(0.027)	(0.028)	(0.027)
November	-0.170***	-0.170***	-0.174***	-0.175***
	(0.023)	(0.023)	(0.024)	(0.023)
December	-0.124***	-0.124***	-0.130***	-0.130***
	(0.017)	(0.017)	(0.017)	(0.017)
Observations	14241	14241	14241	14241
Number of Households	435	435	435	435
R-squared	0.80	0.80	0.80	0.80

- Estimation of the electric savings from CFLs with different samples – In Table 2 we present an estimate of the electric savings from the 15 Watt CFLs for the "high-use" group. In Table 5 we provide estimates of the gas impact from the installation of CFLs for the "high-use" group. Given that our goal was to constrain the program participants to have a mean natural gas usage consistent with SDG&E's average usage, the group of customers was different for the two estimates. To test the validity of the CFL electric savings we re-estimated the savings using the same customers from Table 5. Our results were consistent with the results presented in Table 2. As expected, the estimated coefficient (-.038) was negative and lies between the electricity results for the full electricity sample (n=1,219) and the "high-use" electricity sample (n=240).

5. Concluding Remarks

The primary results of our research effort are twofold. First, there is strong statistical evidence that replacing incandescent lights with compact fluorescent lights in a residential setting generates significant electricity savings. The coefficient that relates the installation of CFLs to electricity usage is both negative and significantly different from zero at the five percent level. The magnitude of the effect (11.68 kWh/year) for the full sample of low-income households is consistent with a recent study authored by West Hill Energy and Computing, Inc., et al (2007). In addition, the magnitude of the effect (48.5 kWh/year) for our "high use" sample, which is designed to be more closely representative of SDG&E service territory households is consistent with (although slightly greater than) estimated savings in the DEER documentation.

The second significant result is that there is no statistical evidence of any interactive effect of CFLs on the usage of natural gas. In the full sample of low-income households the estimated interactive effect is clearly indistinguishable from zero, both in the statistical sense and in the magnitude of the coefficient. In the "high-use" sample the estimated effect is also not significantly different from zero at any conventional significance level. In terms of the magnitude of the effect (ignoring statistical significance) the estimated coefficient converts to an interactive effect that ranges from 0.14 per year for the full sample to 0.74 therms per year for the "high-use" group. This effect diminishes with square footage of living area so that the range for an average sized home (approximately 1725 square feet) is 0.08 for the sample to 0.45 therms per year for the "high-use" group. The result that interactive effects of CFLs on natural gas usage are indistinguishable from zero holds regardless of the specific estimated model. That is, the results were invariant to various possible specifications of the relationship between CFLs and gas usage.

The primary policy implication of these results are that CFLs should be credited with the appropriate electricity savings while not being subjected to a penalty associated with interactive effects that are so variable across households as to be not statistically measurable.

The study results are subject to two caveats. First, the sample sizes are smaller than we would like to see. For example, the "high-use" sample of electricity usage is only 240 households. Second, this study considers only low-income households and they might not be representative of typical households in the SDG&E service territory that would participate in the energy efficiency programs. Therefore, it would be interesting to obtain a larger sample of low-income households (e.g., households from the Pacific Gas and Electric service territory) and/or a general sample of the overall population in order to replicate the results of this study.

6. References

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Appendix D Part 1

Appendix D:

IOU Joint Workpapers

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Appliance Recycling

Appliance Recycling

Appliance Recycling

Introduction

This section summarizes the issues encountered in DEER 2008 for the following areas in the Appliance Recycling program savings assumptions:

- Refrigerator Recycling Gross Savings
- Freezer Recycling Gross Savings
- Freezer Recycling NTFR
- Refrigerator, Freezer and Room Air Conditioning Recycling EUL

Summary Issues

- **Refrigerator Recycling Gross Savings**
  The DEER 2008 Update deviated significantly from an established and accepted EM&V methodology for estimating gross savings for this appliance measure. The refrigerator usage data used from a 1991 study[1] is small sample based, unrepresentative of the program units and unsupportable for the intended purpose and use in the DEER. Additionally, the DEER update considers all of the refrigerators in this measure category as being "Second" refrigerators which is contrary to the intent of the program and available program data.
- **Freezer Recycling Gross Savings**
  The DEER 2008 Update deviated significantly from an established and accepted EM&V methodology for estimating gross savings for this measure. There is no freezer data akin to the data used from the 1991 study. The DEER 2008 Update appears to have used the same performance curve for both refrigerators and freezers.
- **Freezer Recycling NTFR**
  The DEER 2008 update incorrectly lists a NTFR value of 0.702 from the 2004-05 EM&V study for the Appliance Recycling Program.[2] The correct NTFR value from this Study for freezer recycling is 0.706. See the referenced workpaper in the supporting documentation for Appliance Recycling.
- **Refrigerator and Freezer Recycling EUL**
  The DEER 2008 Update uses a default Remaining Useful Life (RUL) value, based on one third of the corresponding new appliance EUL, of 5 years for refrigerators, 4 years for freezers, and 3 years for room air conditioners. Using a default assumption for RUL is inappropriate when a persistence study is available for these measures. See the referenced workpaper in the supporting documentation for Appliance Recycling.

Recommendations

- Continue claiming only the direct effects from these measures and not the interactive effects as indicated in DEER 2008.

- Start reporting accomplishment and claiming savings for refrigerators and freezers based upon actual unit sizes of recycled (average values indicated below) units collected by the program tracking data. The savings estimates address the recycled units prevented from of further consumption in either the pick up dwelling or in a "would be transfer" dwelling. Currently, the DEER 2008 estimates and methodology used do not allow for the estimates to vary by unit characteristics, which the past EM&V studies have demonstrated to affect the unit energy consumption estimates of these appliances. The average values based on unit size characteristics picked up by the program are:
  - Refrigerator Recycling Gross Savings 1461 kWh per recycled refrigerator
  - Freezer Recycling Gross Savings 1,348 kWh per recycled freezer
    Freezer Recycling NTFR = 0.706
- Refrigerator and Freezer Recycling EUL = 10 years. Room A/C EUL=7.3 years.

The workpapers referenced below are from the 2006-2008 Appliance Recycling Program, and are available at http://eega2006.cpuc.ca.gov. Note that they will be updated as needed for the latest assumptions indicated above and for code and EM&V study updates.

- WPSCREAP0004- Refrigerator Recycling
- WPSCREAP0005- Freezer Recycling
- WPSCREHC0002- Residential Room Air Conditioner Replacement and Recycling

1 DEER 2008 documentation cites a link for this study at www.homenergy.org weblink. However, none of the studies really relate directly to what is being claimed.

2 Evaluation Study of the 2004-05 Statewide Residential Appliance Recycling Program Final Report April 2008 ADM Associates www.calmac.org

Appliance Recycling Supporting Documentation

I. Introduction

Southern California Edison conducted a review of the DEER 2008 Update data and documentation for the refrigerator and freezer recycling measures. While the DEER 2008 Update provides eight measures under the refrigerator and freezer recycling category, there are only four DEER 2008 measures that could be relevant to the statewide Appliance Recycling Program (ARP). The available DEER 2008 technical documentation is very limited for the four relevant DEER 2008 measures:

- Refrigerator recycling – conditioned space,
- Refrigerator recycling - unconditioned space,
- Freezer recycling – conditioned space, and
- Freezer recycling - unconditioned space.

The set of DEER-defined measures exclude recycled appliances that are not secondary units for the program participants. In addition, there is a significant deviation from the CPUC accepted statistical-based methodology used for the ARP measures as adopted in past EM&V studies, including recent 2004-05 EM&V study and the DEER 2004-2005 Update. The following section presents and discusses the problems with the DEER 2008 Update approach, and the basis for the recommended estimates for the Appliance Recycling measures.

II. Issues in 2008 DEER ARP measures

There are many significant issues with the DEER 2008 technical team's interpretation of existing M&E studies and their data, and their use and implementation within the simulation models. In this summary discussion we divide these issues into three parts:

II.1 Gross Savings Impact

a) Measure description - DEER 2008 measures do not connect very well with the program theory. Hence, only four measures out of the eight measures under this category in DEER 2008 could be relevant for the ARP, although still very questionable in terms of applicability to the participating households, in general.
b) The building simulation approach to energy savings for the appliance recycling programs makes too many simplistic assumptions compared to the statistical-based analysis approach. The simulation software suffers from the same in-situ condition data, such as door openings and ambient temperature data that the DOE-lab data is allegedly weak on. However, the powerful statistical analysis of the DOE-lab data is able to produce, as done in the EM&V studies, results that are reliable with identified standard errors that are expected to be much smaller than the DEER 2008 adopted building simulation-based methodology for this program. In addition, the statistically-based data approach with a large and sufficiently varied set of data points is capable of producing savings estimates by appliance types and climate zones.

c) The base case for the building simulation based DEER 2008 approach has a questionable basis. The DEER 2008 attempts to use a temperature performance curve for refrigerators. On page 10 of DEER documentation[1], the temperature performance curve in Figure 5 seems to borrow from a 1991 study on the relationship between rated energy use and actual use of refrigerators. The limited documentation on how this relationship was arrived at makes the reliance of the DEER 2008 data on this simplistic relationship highly questionable:
   1. Why is the line so straight? It is very unlikely that the actual normalization ratio is linearly related to temperature in this way.
   2. What other variables are in the model?
   3. Are the points empirical or predicted assuming a linear relationship?
   4. What attempts were made to consider nonlinearities in the relationship?
   5. How was this constructed? Is it an aggregate relationship that is being imputed to individual appliances without respecting the variance in te relationship?
   6. What is the standard error or root mean square error for each level?
   7. How can one justify that at temperature of 90 degrees the adjustment ratio is 1.15 when the rated usage estimate is based upon a laboratory test at 90 degrees?
   8. The assumption is that this relationship applies to old appliances too. This contradicts common sense, as well as some empirical evidence of interactions between appliance age and the rated usage-in situ relationship.
   9. How is the relationship relevant for freezers?

This is an extraordinarily indirect way of adjusting when empirical data is available in a recent 2004-05 EM&V study (albeit the 2004-05 ADM study authors opine that working with the small 200 sample for such an adjustment to DOE-estimated usage is not warranted). It is important to note that the DEER 2008 Update draws (somehow) from a study that uses the same data set that was later (e.g. Goett[2]) used to establish that there is no significant rated usage/in-situ difference from 1.0.

II.1 a. Recommended Gross Savings Approach

Given that recent evidence is available from the 2004-05 EM&V study that provides modeled results on energy savings for the ARP measures, IOUs choose to use the 2004-05 EM&V results as provided on page 2-9 Table 2-6[3]. Energy savings for refrigerator and freezer recycling measures are estimated to be equal to full annual energy consumption for recycled refrigerators and freezers adjusted for "partial use" among refrigerators and freezers that are recycled. The full-year energy consumption estimate for refrigerators is 1,775 kWh/year and 1,406 kWh/year for freezers based on Table 2-5 on page 2-8 in the ADM Study[4]. Estimation of annual energy consumption for refrigerators and freezers was based on metered data conducted using DOE protocol laboratory at BR labs in Huntington Beach, CA that is used in a regression model to

[1] Summary of 2008 DEER Measure Energy Analysis Revisions, May 2008
[2] Analysis of SCE and PG&E Refrigerator Load Data Final Report April 5, 1995 AAG & Associates, Inc.
[3] Evaluation Study of the 2004-05 Statewide Residential Appliance Recycling Program Final Report April 2008 ADM Associates www.calmac.org.
[4] ibid.

predict full year UEC for all population units. This full-year energy consumption is then adjusted for partial use by using an average part use factors in Table 2-6 page 2-9 of the ADM study. Table 2-6 provides the partial use-adjusted energy savings of 1,655kWh per recycled refrigerator and 1,265 kWh per recycled freezer. The unit savings is the prevented continued usage of inefficient refrigerators and freezers. This approach properly decouples the problem of estimating savings associated with appliances that have an estimable probability of being various places on the grid absent the program from the unnecessary complications of forcing the appliance into a whole-dwelling simulation model, with all the unnecessary error that clearly entails.

II.2 Effective Useful Life (EUL)

The approach to refrigerator and freezer recycling EUL estimation requires special retention analysis methods, because the program measure is the removal, rather than the installation, replacement, or improvement of energy-using equipment. A retention study conducted by KEMA estimated the EUL for the 2002 Appliance Recycling Program from the survival curve that combines the survival curve for savings from removing appliances from participating premises that otherwise would have kept the appliance, and the survival curve for savings resulting from avoiding the transfer of a used unit to another household. In general, when such a EUL/RUL study is available, it cannot be ignored and should be built upon given the dearth of new retention studies. See attached copy of the KEMA EUL analysis for the Appliance Recycling Program.

II.3 Error in Freezer Recycling DEER NTG value

The DEER 2008 Update erred in citing the NTG value for freezers from the 2004-05 EM&V ADM study[5] at 0.702. The 2004-05 EM&V study reports on page 3-14, Table 3-11, a NTG value of 70.6%. Also see Table 1, page 6, in the attached Joint Utilities Refrigerator and Freezer Recycling NTG supporting document.

Extended EUL
Analysis for RARP.do

Joint Utility DEER
Comments - NTG Wor

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[5] ibid.

HVAC Measures

HVAC Measures

Introduction

This section discusses changes made to the following HVAC Measures:

- Residential Room Air Conditioners Incremental Measure Costs.

Summary Issues

- **Energy Star Qualified Residential Room Air Conditioners**
  The DEER 2008 measure equipment cost update lists a price of $537.39 for Energy Star qualified room air conditioners. This measure equipment cost is significantly higher than the utilities market experience and anticipated retail pricing for the 2009-2011 program time period. The DEER 2008 May 30th update[1] lists only the measure's equipment material cost, provides no incremental measure cost, does not indicate the size of the unit priced, and does not indicate what normalizing units apply to the cited costs.

Recommendations

- **Energy Star Qualified Residential Room Air Conditioners**
  The installation and incremental measure costs for Energy Star qualified room air conditioners were obtained from SCE's work paper for Energy Star qualified room air conditioners (WPSCREHC0001.1 – Energy Star Room Air Conditioners.doc, Section 4, page 25):

  Installation Cost = $376.00 per Room AC
  Incremental Measure Cost = $81.00 per Room AC

[1] Cost Case ID "RAC-RoomAC-ES," Excel Workbook "Revised DEER Measure Cost Summary (05_30_2008).xls," spreadsheet tab "Res-HVAC," Row 45.

Work Paper WPSCREHC0001
Revision 1

Southern California Edison Company
Design & Engineering Services

Energy Star Room Air Conditioners

At a Glance Summary

Measure Name:	**Energy Star Room Air Conditioners**
Savings Impacts Common Units:	**12,906 Btu Weighted Mean Room Air Conditioner Unit**
Customer Base Case Description:	**9.4 Weighted Mean EER (Current Code basis)**
Code Base Case Description:	**Same as Customer Base Case**
Costs Common Units:	**Same as Savings Impacts.**
Measure Equipment Cost ($/unit):	**$376.00 per room air conditioner**
Measure Incremental Cost ($/unit):	**$81.00 per room air conditioner**
Measure Installed Cost ($/unit):	**$0.00**
Measure Load Shape:	**AC_Cooling-RC**
Effective Useful Life (years):	**15 years**
Program Type:	**Replace On Burnout (ROB) and New**
TOU AC Adjustment:	**100%**
Net-to-Gross Ratios:	**For Residential Contractor Program: 0.89** **For all other residential programs: 0.80**
Building Type:	**All Residential**
Building Vintage:	**All**
Important Comments:	**This work paper presumes the customer is either replacing a failed room air conditioner (RAC) or purchasing a RAC to be installed where there was no prior RAC.** **(This work paper also includes calculations and results for the Residential RAC Recycling to delineate efficiencies for the Residential RAC Recycling work paper and this work paper.)**

Work Paper RunID WPSCREHC0001.1-	Climate Zone	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)
001	6	197.7	0.132	197.7	0.132
002	8	247.0	0.132	247.0	0.132
003	9	232.3	0.132	232.3	0.132
004	10	219.8	0.132	219.8	0.132
005	13	217.9	0.132	217.9	0.132
006	14	201.3	0.132	201.3	0.132
007	15	293.5	0.132	293.5	0.132
008	16	158.2	0.132	158.2	0.132

Document Revision History

Revision 0	February 22, 2007	Original short form work paper.
Revision 1	**October 16, 2007**	**Revision 0 (Rev 0) of this work paper was based on SCE engineering estimates of energy savings and demand reduction using Database for Energy Efficiency Resources (DEER) Annual Energy Consumption (kWh) per Multi-Family Apartment (RASS Weight Averaged) for a 14,000 Btu room air conditioner (RAC).**

Revision 1 (Rev 1) replaces the Rev 0 energy savings methodology with DEER database measure for Packaged Terminal Air Conditioners (PTAC) units for motel rooms as a basis. The PTAC measure is the only DEER measure using Energy Efficiency Ratios (EER) to measure performance for cooling of any kind: all other measures use the significantly different Seasonal EER. PTAC units are nearly identical to RACs in cooling performance but also provide heat. Establishing an equation for energy savings performance for PTAC EERs, Rev 1 uses a 12,906 Btu RAC and previous & current code and Energy Star room air conditioner EERs to establish energy savings.

For demand reduction, Rev 1 retains the Rev 0 methodology. The DEER motel room PTAC measure's 24 hour profile for power demand varies significantly from residential room air conditioner power demand profile.

The table below lists values for Rev 0, Rev 1 and the change between the revisions.

E3 Input	Rev 0	Rev 1	Change
Measure Cost	$106.00 per RAC	$81.00 per RAC	-$25.00 per RAC
Effective Useful Life	15	15	Unchanged

The table below lists the energy savings and demand reductions for Rev 0, Rev 1 and the change between the revisions. Rev 0 14,000 Btu RAC numbers were modified to 12,906 Btu RAC to match the RAC size of Rev 1.

Energy Star RAC Summary: Rev 0 to Rev 1 Comparison							
For One 12,906 Btu Room Air Conditioner							
Climate Zone	Rev 0	Rev 1	Change	Climate Zone	Rev 0	Rev 1	Change
Energy Savings (kWh/square foot)				**Demand Reduction (kW/square foot)**			
6	52	198	146	6	0.258	0.132	-0.126
8	101	247	146	8	0.258	0.132	-0.126
9	148	232	84	9	0.258	0.132	-0.126
10	182	220	38	10	0.258	0.132	-0.126
13	361	218	-143	13	0.258	0.132	-0.126
14	220	201	-19	14	0.258	0.132	-0.126
15	594	293	-301	15	0.258	0.132	-0.126
16	56	158	102	16	0.258	0.132	-0.126

Note: The information provided in this Work Paper was developed using the best available technical resources at the time this document was prepared.

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Section 1. General Measure & Baseline Data

1.1 Measure Description & Background

This work paper details the E3 Calculator inputs for purchase of residential room air conditioners (RAC) that meet Energy Star requirements or Energy Star RACs (ES-RAC) instead of minimum efficiency Code RACs (C-RAC). Thus, purchase of a C-RAC is the base case for this work paper and purchase of an ES-RAC is the measure case. Installation costs are presumed to be identical.

In 1992 the U.S. Environmental Protection Agency (EPA) introduced Energy Star as a voluntary labeling program designed to identify and promote energy-efficient products to reduce greenhouse gas emissions. Through 1995, EPA expanded the label to additional office equipment products and residential heating and cooling equipment. In 1996, EPA partnered with the U.S. Department of Energy (DoE) for particular product categories[1]. Energy Star announced labels for RACs in October 1996[2]. Energy Star RACs (ES-RAC) are defined as having a minimum of 10% energy efficiency improvement over minimum DoE requirements[3].

1.2 DEER Differences Analysis

This paper covers residential RAC applications. However, there are no residential RAC application calculations available in the Database for Energy Efficiency Resources (DEER). Residential DEER applications evaluate more efficient split systems and central air conditioning systems with higher Seasonal EER (SEER) requirements.

To determine energy savings, this work paper uses DEER Measure D03-099 which provides an analysis of Packaged Terminal Air Conditioners (PTAC or Packaged Terminal Heat Pumps (PTHP) (collectively: PT units) installed in Motel Lodging Guest Rooms. PT units use similar equipment to RACs for cooling, but also feature heating functions RACs do not have. PT unit EERs are similar to RAC EER requirements. This work paper uses PT unit vintage, code and 20% above code EERs and their related energy savings as points for Least Square Linear Regression (LSLR) Method) to establish a function to calculate equivalent RAC energy savings figures.

This work paper does not use DEER to determine demand reduction. The twenty four hour Time-Of-Use (TOU) profile for DEER measure D03-099 is significantly different from residential RAC TOU. Also, as the PT units include provisions for heating and RACs do not, this paper does not use the DEER cost data that would include capital costs for the PT unit heating elements.

In DEER Section 6 for Motel Lodging Guest Rooms Table 1 and
Table 2 list the following information:

Table 1: DEER Table 6-1 (Partial): Nonresidential Space Characteristics[4]

Activity Area Type	Occupant Density (ft^2/person)	Sensible Occupant Load (Btuh/person)	Latent Occupant Load (Btuh/person)	Ventilation Rate (cfm/person)
Motel Guest Room	**300.0**	**245**	**155**	**30.00**

Table 2: DEER Table 6-2 (Partial): Nonresidential Prototype Descriptions[5]

Prototype	Source	Activity Area Type	Area	% Area	Simulation Model Notes
10. Lodging - Motel	**DEER**	**Corridor**	**3,333**	**11.1**	**Thermal Zoning: One zone per activity area.**
		Motel Guest Room (incl. toilets)	**25,587**	**85.3**	**Model Configuration: Matches 1994 DEER configuration. Guestrooms are divided among: 12 hour occupied (12,794 ft^2/ 42.6%), 24-hour occupied (6,397 ft^2/ 21.3%) and unoccupied rooms (6,397 ft^2/ 21.3%).**
		Laundry	**480**	**1.6**	
		Office (General)	**600**	**2.0**	
		Total	**30,000**		**HVAC Systems: The oldest vintage uses PTAC systems with electric resistance heating. All other vintages use PTHP systems.**

Table 1 lists DEER loads and ventilation rates for Motel Lodging Guest Rooms. The Lodging – Motel section from DEER Table 6-2 identifies PTAC and PTHP (

Table 2 above) as being used in the simulation of Motel Lodging Guest Rooms. The Motel Lodging Guest Room applications appear to be best available DEER simulation for residential RAC applications which are most likely to be for cooling one room with some interior and some exterior walls and ceilings. DEER Measure D03-099 Run IDs differ from the

Table **2** description stating all vintages in the Measure use PTACs.

Motels on average are cooled at 1 ton of cooling (12,000 Btu) per 300 square feet (ft^2)[6]. Based on the DEER occupant density of 300 ft^2 this paper sets PT units at 12,000 Btu cooling 300 ft^2. The DEER Lodging – Motel total floor area is 30,000 ft^2 so dividing total floor area by 300 ft^2 results in 100 total PT units installed in the DEER Lodging – Motel.

DEER uses the PTAC EER values listed in Table 3 below:

Table 3: DEER PTAC EER Values for Lodging - Motel[7]

DEER: PTAC
(7-15 kBtu/unit or 0.583 to 1.25 cooling tons/unit)

Buildings Vintages	**Measure Case Description (EER)**	**Base Case Description (EER)**	**Code Base Description (T24 minimum EER)**
Built before 1978	**10.27**	**6.80**	**8.56**
Built between 1978 and 1992	**10.27**	**7.80**	**8.56**
Built between 1993 and 2001	**10.27**	**8.50**	**8.56**
Built between 2002 and 2005	**10.27**	**8.50**	**8.56**

Built 2006 and later (measures as retrofit for	**12.19**	**10.16**	**10.16**

1.3 Codes & Standards Requirements Analysis

U.S. DoE Office of Energy Efficiency and Renewable Energy Energy's "Conservation Program for Consumer Products: Final Rule Regarding Energy Conservation Standards for Room Air Conditioners: 10 CFR Part 430" is summarized in the State of California Code Of Regulations, Title 20: Division 2, Chapter 4, Article 4, Appliance Efficiency Regulations (Title 20).

Definitions

Title 20 establishes the following selected definitions in Section 1602(c) Air Conditioners[8]:

> "Air conditioner" means an appliance that supplies cooled air to a space for the purpose of cooling objects within the space.
> "Air-source heat pump" means an appliance that consists of one or more factory-made assemblies, that includes an indoor conditioning coil, a compressor, and a refrigerant-to-air heat exchanger, and that provides heating and cooling functions.
> "Btu" means British thermal unit. .
> "Casement-only room air conditioner" means a room air conditioner with an encased assembly designed for mounting in a casement window with a width of 14.8 inches or less and a height of 11.2 inches or less.
> "Casement-slider room air conditioner" means a room air conditioner with an encased assembly designed for mounting in a sliding or casement window with a width of 15.5 inches or less.
> "Casement window" means a window that opens on hinges at the side.
> "Coefficient of Performance (COP)" of a heat pump means the ratio of the rate of useful heat output delivered by the complete heat pump unit (exclusive of supplementary heating) to the corresponding rate of energy input, in consistent units and as determined using the applicable test method in Section 1604(b) or 1604(c).
> "Cooling capacity" means a measure of the ability of an air conditioner to remove heat from an enclosed space, as determined using the applicable test method in Section 1604(b) or 1604(c).
> "Energy efficiency ratio (EER)" means the cooling capacity of an air conditioner in Btu per hour divided by the total electrical input in watts, as determined using the applicable test method in Section 1604(b) or 1604(c).
> "Heat pump" means an appliance, other than a packaged terminal heat pump, that consists of one or more assemblies; that uses an indoor conditioning coil, a compressor, and a refrigerant-to-outdoor air heat exchanger to provide air heating; and that may also provide air cooling, dehumidifying, humidifying, circulating, or air cleaning.
> "Packaged Terminal Air Conditioner" (PTAC) means a wall sleeve and a separate un-encased combination of heating and cooling assemblies that:
> (1) is intended for mounting through the wall and
> (2) includes a prime source of refrigeration, separable outdoor louvers, forced ventilation, and heating availability by hot water, steam, or electric resistance heat.

"Packaged Terminal Heat Pump" (PTHP) means a packaged terminal air conditioner that uses reverse cycle refrigeration as its prime heat source and that has a supplementary heat source of hot water, steam, or electric resistance heat.
"Room Air Conditioner" (RAC) means a factory-encased air conditioner that is designed:
(1) as a unit for mounting in a window, through a wall, or as a console, and
(2) for delivery without ducts of conditioned air to an enclosed space.
"Room air-conditioning heat pump" means a room air conditioner that is capable of heating by refrigeration.
"Seasonal energy efficiency ratio (SEER)" means the total cooling output of an air-cooled central air conditioner during its normal annual usage period for cooling, divided by the total electrical energy input in watt-hours during the same period, as determined using the applicable test method in Section 1604(c).

While PTAC units can also provide heat thru either in-unit or externally supplied sources, this paper does not evaluate efficiency of PTAC heating.

RAC Requirements

As stated in Section 1605.1 (b), code took effect as of Jan 1, 1990, several years before the advent of Energy Star. Code was revised as of Oct 2000 to the higher current standard. This enactment date was after the calendar year 2000 air conditioning season so energy savings and demand reduction due to this code change would not take effect until calendar year 2001[9].

Section 1605.1 (b) **Room Air Conditioners, Room Air-Conditioning Heat Pumps, Packaged Terminal Air Conditioners, and Packaged Terminal Heat Pumps.**
(1) **Room Air Conditioners and Room Air-Conditioning Heat Pumps.** The EER of room air conditioners and room air-conditioning heat pumps that are manufactured on or after the effective dates shown shall be not less than the applicable values shown in Table B-2. The EER of room air conditioners and room air-conditioning heat pumps that are labeled for use at more than one voltage shall be not less than the applicable values shown in Table B-2 at each of the labeled voltages.

Table 4: 1605.1 (b) Table B-2 Standards for Room Air Conditioners and Room Air-Conditioning Heat Pumps

Appliance	Louvered Sides	Cooling Capacity (Btu/hr)	Minimum EER or COP Effective January 1, 1990	Minimum EER or COP Effective October 1, 2000
Room Air Conditioner	**Yes**	**< 6,000**	**8.0**	**9.7**
Room Air Conditioner	**Yes**	**≥ 6,000 - 7,999**	**8.5**	**9.7**
Room Air Conditioner	**Yes**	**≥ 8,000 - 13,999**	**9.0**	**9.8**
Room Air Conditioner	**Yes**	**≥ 14,000 - 19,999**	**8.8**	**9.7**
Room Air Conditioner	**Yes**	**≥ 20,000**	**8.2**	**8.5**
Room Air Conditioner	**No**	**< 6,000**	**8.0**	**9.0**
Room Air Conditioner	**No**	**≥ 6,000 - 7,999**	**8.5**	**9.0**
Room Air Conditioner	**No**	**≥ 8,000 - 19,999**	**8.5**	**8.5**
Room Air Conditioner	**No**	**≥ 20,000**	**8.2**	**8.5**

Appliance	Louvered Sides	Cooling Capacity (Btu/hr)	Minimum EER or COP Effective January 1, 1990	Minimum EER or COP Effective October 1, 2000
Room Air Conditioning Heat Pump	**Yes**	**< 20,000**	**8.5**	**9.0**
Room Air Conditioning Heat Pump	**Yes**	**≥ 20,000**	**8.5**	**8.5**
Room Air Conditioning Heat Pump	**No**	**< 14,000**	**8.0**	**8.5**
Room Air Conditioning Heat Pump	**No**	**≥ 14,000**	**8.0**	**8.0**
Casement-Only Room Air Conditioner	**Either**	**Any**	*****	**8.7**
Casement-Slider Room Air Conditioner	**Either**	**Any**	*****	**9.5**

***Casement-only room air conditioners and casement-slider room air conditioners are not separate product classes under standards effective January 1, 1990. Such appliances, if manufactured before October 1, 2000, are subject to the applicable standards in Table B-2 for the other room air conditioners and room air-conditioning heat pumps based on capacity and the presence or absence of louvered sides.**

The Minimum EER or COP Effective October 1, 2000 column lists the current code requirements for C-RAC units. In Section 2.1, this work paper combines these various design and capacity EERs into a weighted mean EER for energy savings evaluation.

PTAC Requirements

Section 1605.1.2 defines Code requirements for the PT Units. For this work paper, these figures are only applicable to the determination of the LSLR Method for EER to Energy Savings Equations used to then determine energy savings for RACs[10] in Section 2.1.

> **Section 1605.1** (2) **Packaged Terminal Air Conditioners and Packaged Terminal Heat Pumps.** The EER and COP, as applicable, of packaged terminal air conditioners and packaged terminal heat pumps shall be not less than the applicable values shown in Table B-3.

Table 5: 1605.1 (2) Table B-3 (Partial) Standards for Packaged Terminal Air Conditioners and Packaged Terminal Heat Pumps

Appliance	Mode	Cooling Capacity (Btu/hr)	Minimum EER or COP
Packaged terminal air conditioners and packaged terminal heat pumps	**Cooling**	**=< 7,000**	**8.88 EER**
		> 7,000 and < 15,000	**10.0 - (0.00016 x Cap.) EER**
		>=15,000	**7.6 EER**

1.4 EM&V, Market Potential, and Other Studies

The Residential Appliance Saturation Survey (RASS) 2003 indicates an annual Unit Energy Consumption (UEC) of 240 kWh for RACs in the Southern California Edison (SCE) service area[11] and statewide:

"Room air conditioning has a UEC of 214 kWh and evaporative systems 684 kWh. These values are somewhat lower than previous studies and forecasting values used at the Energy Commission. One possible reason for the lower than average use is attributed to the Statewide 20/20 Program. Billing data for the Conditional Demand Analysis is from the second half of 2001, all of 2002, as well as 2003 and 2004 to include years when the 20/20 program was not available. UEC results have all been annualized and calibrated to 2002 service territory total usage. It is likely that the UECs reflect the 20/20 program impact and thus these air conditioning values should be considered conservative estimates."[12]

The RASS states:

"A similar (to central air conditioning) albeit more parsimonious specification will be used for room air conditioning (RACUSEht), except that a term will be used to reflect the number of room air conditioning units (RACCNTh). This stems from the assumption that total usage depends on the number of room air conditioners."[13]

The RASS states RAC:

"Unit Energy Consumptions are also fairly low relative to prior estimates, varying from 105 kWh for multi-family units in buildings with 5+ units to 227 kWh for single family homes and mobile homes."[14]

The RASS does not state:

1) Size, design or capacity of RACs analyzed,
2) EERs of RACs or
3) Square footage cooled.

Without this information it is difficult to compare the RASS information to other sources in this work paper. There appears to be some questioning even in the RASS verbiage as to the accuracy of the UEC RAC figures.

The RASS estimates about 20 percent of SCE homes have room air conditioners. The SCE Residential Room Air-Conditioner Recycling Scoping Study (Scoping Study)[15] estimates 50% of those homes have units ten years old or more, similar to the RASS estimate of 47% of homes that have units more than nine years old. The average age of room air conditioners in RASS data is calculated to be 7.71 years.

For a Weighted Mean RAC (WM-RAC) that provides 12,906 Btu of cooling and averaging estimated energy savings for all climate zones, replacing a Jan 1990 code RAC with an Energy Star RAC produces a total annual 397.7 kWh/WM-RAC unit savings (From Table 17). This number compares with the 372.2 kWh/ room air conditioner unit annual savings reported for multifamily housing in the Low-Income Energy Efficiency (LIEE) program[16].

1.5 Base Cases for Savings Estimates: Existing & Above Code

The base case is a C-RAC that meets the Federal Standard EER requirements. For this work paper, Customer Savings and Above Code Savings estimates are the same and are based on the Energy Star EERs as defined in **Table 6**: Energy Star Qualified RAC Eligibility. Customer Savings from early retirement of existing RAC (vintage code to current code) are only counted in the separate Room Air Conditioner Recycling Work Paper.

Federal Standard and Energy Star Energy Efficiency Ratio (EER) requirements are detailed in **Table 6**.[17] As Title 20 has adopted these Federal Standard EERs, this paper refers to the Federal Standards as Title 20 code.

Table 6: ENERGY STAR Qualified Room Air Conditioner (RAC) Eligibility

Capacity (Btu/Hr)	Federal Standard EER, with louvered sides	ENERGY STAR EER, with louvered sides	Federal Standard EER, without louvered sides	ENERGY STAR EER, without louvered sides
< 6,000 **6,000 to 7,999**	**≥ 9.7**	**≥ 10.7**	**≥ 9.0**	**≥ 9.9**
8,000 to 13,999	**≥ 9.8**	**≥ 10.8**		
14,000 to 19,999	**≥ 9.7**	**≥ 10.7**	**≥ 8.5**	**≥ 9.4**
≥ 20,000	**≥ 8.5**	**≥ 9.4**		
Casement	Federal Standard EER		ENERGY STAR EER	
Casement-only	**≥ 8.7**		**≥ 9.6**	
Casement-slider	**≥ 9.5**		**≥ 10.5**	
		REVERSE CYCLE		
Capacity (Btu/Hr)	Federal Standard EER, with louvered sides	ENERGY STAR EER, with louvered sides	Federal Standard EER, without louvered sides	ENERGY STAR EER, without louvered sides
< 14,000	**n/a**	**n/a**	**≥ 8.5**	**≥ 9.4**
≥ 14,000			**≥ 8.0**	**≥ 8.8**
< 20,000	**≥ 9.0**	**≥ 9.9**	**n/a**	**n/a**
≥ 20,000	**≥ 8.5**	**≥ 9.4**	**n/a**	**n/a**

1.6 Base Case & Measure Effective Useful Lives

A table in the ASHRAE HVAC Equipment Handbook indicates the Effective Useful Life (EUL) for window unit RACs is ten years and fifteen years for all other air conditioning units and heat pumps. However, a footnote to that same table also indicates this data from Akalin (1978) "may be outdated and not statistically relevant. Use this data with caution until enough updated data are accumulated in Abramson et. al."[18].

The Association of Home Appliance Manufacturers (AHAM) web site includes a 1996 survey by National Family Opinion, Inc. (NFO) stating the EUL for RACs is 12 years. The NFO's basis for EUL is: "age of an appliance when it is replaced because it cannot be repaired or costs too much to repair. (This does not infer the appliance will be without repair during its lifetime.)"[19].

The Table of Discarded Window/Wall (RAC) AGE (DWWAGE) by Window/Wall (RAC) ADDed (WWADD)[20] from the RASS 2003 data of homes that replaced their old wall/window RAC with a new unit, 20.59% of replaced units were up to ten years old, 38.71% were 11 to 20 years old and the remaining 40.70% units were more than 20 years old. Based on the RASS 2003 study, this paper uses a new RAC EUL for the SCE region of the half life of these units: 15 years.

1.7 Net-to-Gross Ratios for Different Program Strategies

This work paper covers customer driven appliance Replace on Burnout (ROB) and New Construction of RACs in residential installation. Per the CPUC Energy Efficiency Policy Manual and on the DEER web site the Net-to-Gross (NTG) ratio is 0.80 for all programs except the Residential Contractor program. For Residential Contractor replaced units, the NTG ratio is 0.89.[21]

Table 7: Net-to-Gross Ratios

Residential Construction	Program Approach	NTG
Multifamily unit	**Residential Contractor Program**	**0.89**
All unit	**All other residential programs**	**0.80**

Section 2. Calculation Methods

No study was available to quantify either where in what type of residence one or more RACs may be located or how many people may be in what size of how much conditioned space.

DEER Measure ID D03-099 Run IDs (DEER Calcs)[22] is the only DEER measure evaluating similar equipment cooling performance in EER. This measure evaluates PT units installed in the DEER two story building model Lodging-Motel. The construction elements used in the Lodging-Motel model are similar to residential construction elements. The measure also randomly loads PTAC units with mixed interior and exterior floors, walls and ceilings and mixes operating hours between none, 12 hour and 24 hour operation.

The randomness of PTAC unit installation and operation provides something of a reasonable basis for estimating RAC energy savings. However, the DEER PTAC 24-hour usage distribution (percentage of the motel that is actively being cooled: Figure 1) does not match a typical residential air conditioning end use profile. Therefore, RAC power demand was estimated at full power demand during a three day heat wave in the SCE service area.

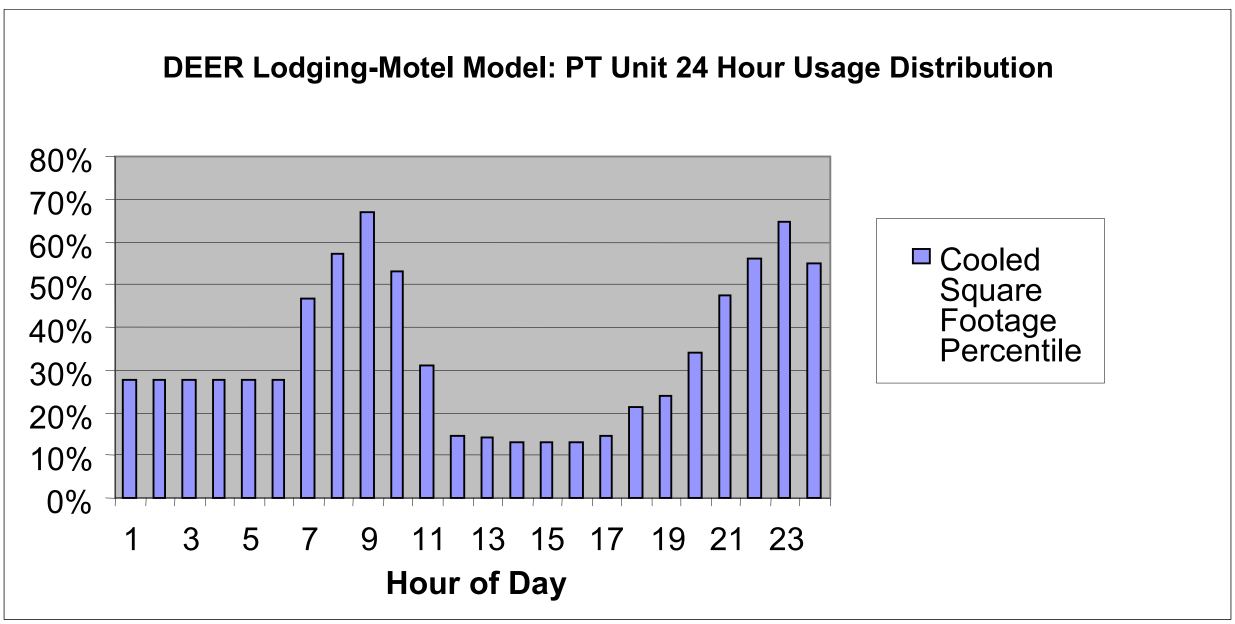


Figure 1 Hotel Room PTAC Usage[23]

2.1 Energy Savings Estimation Methodologies

This work paper takes DEER data for PT units and uses the LSLR Method to establish an EER to energy savings equation for each motel building vintage in each SCE climate zone. By weighing the equation slope and Y intercept by motel building population data for each vintage in a climate zone a vintage weighted mean EER to energy savings equation is established for each climate zone.

To determine a single RAC cooling capacity with C-RAC and ES RAC EERs, this work paper establishes the following. For each cooling capacity range in British thermal units (Btu) all unique RAC units listed in the Energy Star web site are counted for each design type with that number divided by the total RACs of the same capacity. Using the percentage of units SCE rebated (SCE Rebate Scale) for each Btu range and translating the SCE ranges to match the Title 20 code Btu ranges, this work paper establishes an cooling capacity weighted mean RAC for evaluation in each climate zone. Using the same SCE Rebate Scale this paper further weights the design weighted mean EERs to establish EERs for the WM-RAC. Using the energy savings equation, this paper estimates energy savings for both codes and Energy Star RAC in each climate zone.

LSLR Method for Equations

The DEER Calcs provide estimated energy savings for replacing vintage PT units with PT units that meet T24 minimum EER code requirements and 20% higher efficiency EER PT units.

The first point is set at the X-axis intercept (no energy savings) DEER base case EER found in the DEER Calcs: Base Case Description. This point represents the existing PT units in each DEER model which meet each building vintage's Nonresidential Compliance Manual For California's 2005 Energy Efficiency Standards (Title 24)[24] code requirements, if any.

1) DEER building vintage Title 24 construction code EER: X_1;
   YE_1 - energy savings equal zero (X_i – X-axis Intercept),

The second point represents the fact the Title 24 code requires the building vintage PT units be upgraded on replacement to at least the current Title 20 EER figure. This upgrade produces the code energy savings (ECImpact).

2) DEER Basis 2000 Title 20 code EER: X_2; YE_2 - ECImpact

The third point is the DEER measure energy savings (EImpact).

3) DEER measure EER: X_3; YE_3 - EImpact

Using these figures for each vintage and climate zone and LSLR Method, an equation expressing energy savings for various EERs is established. The following variables are used in the LSLR Method:

X_a is any EER value,
YE_a is the corresponding energy efficiency savings to the X_a figure,
n is the total number of data points (n = 3 for these calculations), and

Σ is the Greek Letter sigma that stands for summation. Equation (1) is an example:

$$\Sigma(X_a) = X_1 + X_2 + X_3 \quad (1)$$

Equation (2) is used to determine a linear slope (SE):

$$SE = (n*\Sigma(X_a*YE_a) - \Sigma(X_a)*\Sigma(YE_a))/(n* \Sigma(X_a^2)- (\Sigma X_a)^2 \quad (2)$$

Once SE is determined, the Y intercept (YE_i) where EER equals zero can be determined by Equation (3):

$$YE_i = (\Sigma(YE_a) - S * \Sigma(X_a))/n \quad (3)$$

By determining SE and YE_i, this paper establishes an EER to energy savings equation for each building vintage within a climate zone (Equation (4)):

$$YE_a = YE_i + SE * X_a \quad (4)$$

Data and calculations for all forty of the SE and YE_i values are detailed in DEER Measure D03-099 Lodging-Motels.xls: Sheet: LSLR Method & Vintage Weighing[25].

Example 1 - LSLR Method for Equations

Determine the Slope (SE) and Y intercept (YE_i) for the EER to energy savings equation for a 12,000 Btu PTAC unit installed in a motel built before 1978 in the City of Long Beach.

DEER Measure ID D03-099 Run ID CMtl0675PTAC2 provides estimated energy savings for replacing a vintage PT unit with a PT unit that meets T24 current minimum EER code requirements and 20% higher efficiency EER PT unit installed in a motel built before 1978 in the City of Long Beach. The DEER common units are Cooling Tons (CTon) or 12,000 Btu. DEER energy savings are in kilowatt-hour (kWh) per CTon.

The first point is set at the X-axis intercept (no energy savings) DEER base case EER found in the DEER Calcs: Base Case Description. This point represents the existing PT units in each DEER model which meet each building vintage's Title 24 code requirements, if any.

1) DEER building vintage Title 24 construction code EER: $X_1 = 6.80$;
   YE_1 is where energy savings equal zero: (X_i – X-axis Intercept): $YE_1 = 0$ kWh/CTon,

The second point represents the fact the Title 24 code requires the building vintage PT units be upgraded on replacement to at least the current Title 20 EER figure. This upgrade produces the code energy savings ECImpact.

2) DEER Basis 2000 Title 20 code EER: X_2; = 8.56; ECImpact $YE_2 = 277.691$ kWh/CTon

The third point is the DEER measure energy savings (EImpact).

3) DEER measure EER: X_3; = 10.27; EImpact $YE_3 = 709.349$ kWh/CTon

Using these figures and LSLR Method, an equation expressing energy savings for various EERs is established. The following variables are used in the LSLR Method:

X_a is any EER value,

Y_a is the corresponding energy efficiency savings to the X_a figure,
n is the total number of data points (n = 3 for these calculations), and
Σ is the Greek Letter sigma that stands for summation.

Variables for Equation (2) are:

$\Sigma(X_a)$ = $X_1 + X_2 + X_3$ = 6.80 + 8.56 +10.27 = **25.63**

$\Sigma(X_a^2)$ = $(X_1 * X_1) + (X_2 * X_2) + (X_3 * X_3)$
= (6.80 * 6.80) + (8.56 * 8.56) + (10.27 * 10.27) = **224.987**

$\Sigma(YE_a)$ = $YE_1 + YE_2 + YE_3$ = 0 + 277.691 + 709.349 = **987.040**

$\Sigma(X_a*YE_a)$ = $X_1 * YE_1 + X_2 * YE_2 + X_3 * YE_3$
= 6.8 * 0 + 8.56 * 277.691 + 10.27 * 709.349 = **9,662.049**

Equation (2) is used to determine the linear slope (SE):

SE = $(n*\Sigma(X_a*Y_a) - \Sigma(X_a)*\Sigma(Y_a))/(n* \Sigma(X_a^2)- (\Sigma X_a)^2$
= (3 * 9,662.049 - 25.63 * 987.040) / (3 * 224.987 – (25.63 * 25.63)
= 204.196

Once S is determined, the Y intercept (YE_i) where EER equals zero can be determined by Equation (3):

YE_i = $(\Sigma(YE_a) - SE * \Sigma(X_a))/n$ = (987.040 - 204.196 * 25.63) / 3
= -1415.502

By determining SE and YE_i, the EER to energy savings equation (Equation (4)) is:

$YE_a = YE_i + SE * X_a$ = **-1415.502 + 204.196** * X_a

Data and calculations for the SE and YE_i values and a graph of the resulting equation are detailed in DEER Measure D03-099 Lodging-Motels.xls: Sheet: LSLR Method Example+Graph[26].

Vintage Weighted Mean Equations

Using the YE_{ia} for each building vintage (YE_{i1} thru YE_{i5}) allows the vintage weighted mean (YE_{vwm}) for all vintages in a climate zone to be determined. The Commercial End Use Saturation[27] surveys (CEUS) provides a basis for a total number of buildings (NLOCS) per each building vintage within the same climate zone. This work paper uses DEERCD building type MTL (Motel) and establishes a variable $NLOCS_a$ which is the NLOCS value for a particular vintage within the same climate zone. Thus, $NLOCS_1$ thru $NLOCS_5$ ^{are} the total number of buildings for each building vintage oldest to newest. Equation (5) calculates the weighted mean YE_i (YE_{vwm}) for all vintages of the building per climate zone:

$$YE_{vwm} = (\Sigma(NLOCS_{a*}\ YE_{ia})) / \Sigma(NLOCS_a) \qquad (5)$$

In a similar way, using the slope SE_a for each building vintage of a climate zone (SE_1 thru SE_5) the vintage weighted mean slope (SE_{vwm}) can be determined (in equation (5): YE becomes SE).

By determining YE_{vwm} and SE_{vwm}, this paper establishes an equation of EER to energy savings for each climate zone (Equation (6)):

$$YE_a = YE_{vwm} + SE_{vwm} * X_a \qquad (6)$$

Data and calculations for all YE_{vwm} and SE_{vwm} values are detailed in DEER Measure D03-099 Lodging-Motels.xls: Sheet: LSLR Method & Vintage Weighing[28]. The resulting values are listed in Table 8.

Table 8: Vintage Weighted Mean Slopes & Y Intercepts

Vintage Weighted Mean Slopes & Y Intercepts

DEER Values		Energy Savings:	
Climate Zone City	**CA T24 CZ:**	**Weighted Slope** SE_a	**Weighted Y Intercept** YE_{ia}
Long Beach	**6**	**183.835**	**-1,297.400**
El Toro	**8**	**229.651**	**-1,624.025**
Burbank	**9**	**216.026**	**-1,537.142**
Riverside	**10**	**204.380**	**-1,458.538**
Fresno	**13**	**202.615**	**-1,423.334**
China Lake	**14**	**187.204**	**-1,323.838**
El Centro	**15**	**272.872**	**-1,912.036**
Mt. Shasta	**16**	**147.093**	**-1,033.533**

Example 2 - Vintage Weighted Mean Equation

Given the slopes (SE_a) and Y intercepts (YE_{ia}) for each DEER vintage of motel built in Long Beach, find the vintage weighted mean linear slope, Y intercept and the EER to energy savings equation on a cooling ton basis.

For the slope calculation, the required data from the "LSLR Method & Vintage Weighing" sheet of "DEER Measure D03-099 Lodging-Motels.xls"[29] are the CEUS Weight Factors $NLOCS_a$ and the LSLR Method Slopes SE_a for each building vintage. Multiplying the SE_a by the respective $NLOCS_a$ produces the Vintage Weighting Factor (SE_a * $NLOCS_a$) for each vintage. Values for these variables are shown in Table 9.

Table 9: Example 2 - Climate Zone 6 Vintage Weighted Mean Linear Slope Calculations

For Motels in Long Beach Climate Zone 6:

Buildings Vintages	Vintage Order	CEUS Weight Factors $NLOCS_a$	LSLR Method Slopes SE_a	Vintage Weighting Factors (SE_a *$NLOCS_a$)
Built before 1978	**1**	**254**	**204.196**	**51,866**
Built between 1978 and 1992	**2**	**107**	**164.463**	**17,598**
Built between 1993 and 2001	**3**	**14**	**77.640**	**1,087**
Built between 2002 and 2005	**4**	**10**	**76.968**	**770**

Built 2006 and later (measures as retrofit for nonresidential)	**5**	**4**	**47.907**	**192**
Totals (Σ):		**389**		**71,512**

Equation (5) modified to calculate the weighted mean SE (SE_{vwm}) for all vintages of the building type per climate zone is:

$SE_{vwm} = (\Sigma(NLOCS_a * SE_a)) / \Sigma(NLOCS_a) = 71{,}512 / 389 =$ **183.835**

For the Y intercept calculation, the required data from the "LSLR Method & Vintage Weighing" sheet of "DEER Measure D03-099 Lodging-Motels.xls"[30] are the CEUS Weight Factors $NLOCS_a$ and the LSLR Method Y intercepts YE_{ia} for each building vintage. Multiplying the YE_{ia} by the respective $NLOCS_a$ produces the Vintage Weighting Factor ($YE_{ia} * NLOCS_a$) for each vintage. Values for these variables are shown in Table 10.

Table 10: Example 2 - Climate Zone 6 Vintage Weighted Mean Y Intercept Calculations

For Motels in Long Beach Climate Zone 6:

Buildings Vintages	Vintage Order	CEUS Weight Factors $NLOCS_a$	LSLR Method Y intercepts YE_{ia}	Vintage Weighting Factors (YE_{ia} * $NLOCS_a$)
Built before 1978	**1**	**254**	**-1,415.502**	**-359,537**
Built between 1978 and 1992	**2**	**107**	**-1,220.122**	**-130,553**
Built between 1993 and 2001	**3**	**14**	**-545.310**	**-7,634**
Built between 2002 and 2005	**4**	**10**	**-540.586**	**-5,406**
Built 2006 and later (measures as retrofit for nonresidential)	**5**	**4**	**-389.487**	**-1,558**
Totals (Σ):		**389**		**-504,689**

Equation (5) calculates the weighted mean YE_i (YE_{vwm}) for all vintages of the building type per climate zone:

$YE_{vwm} = (\Sigma(NLOCS_a * YE_{ia})) / \Sigma(NLOCS_a) = -504{,}689 / 389 =$ **-1,297.400**

For Motels in Long Beach Climate Zone 6, the EER to energy savings Equation (5) is:

$YE_a = YE_{vwm} + SE_{vwm} * X_a =$ **-1,297.400** + **183.835** * X_a

MS Excel versions of Table 9 and Table 10 are shown in the "Vintage Weighted Mean Example" sheet of "DEER Measure D03-099 Lodging-Motels.xls"[31].

RAC EER Design Variance Weighted Mean Values

The Energy Star Web site[32] provides a list of available Energy Star RACs from 5,000 to 28,000 Btu/hr cooling capacity. This list includes various design details like which RACs have reverse cycles (Heat Pumps), side louvers and or casement-only or slider style units. Title 20 Table B-2 lists code EERs based on those design details for various cooling capacity ranges. Counting the available unique units with each of these design characteristics and cooling capacities provides a design weighing factor to determine a design weighted mean RAC EER for the Title 20 Table B-

2 cooling capacity ranges. This work paper adds together the counts of unique units with similar RAC EER & cooling capacities and then finds a design variance weighted mean EER for each Title 20 Table B-2 cooling capacity range. The resulting EERs are shown in **Table 11**.

Table 11: EER Weighted Mean by Unit Design for Cooling Capacity

EER Weighted Mean by Unit Design for Cooling Capacity		
Cooling Capacity (Btu/hr)	Effective January 1, 1990	Effective October 1, 2000
< 6,000	**8.00**	**9.69**
≥ 6,000 - 7,999	**8.50**	**9.64**
≥ 8,000 - 13,999	**8.77**	**9.27**
≥ 14,000 - 19,999	**8.78**	**9.65**
≥ 20,000	**8.22**	**8.50**

Complete tables of Energy Star Product Listings and calculations for Unique Unit Design Weighted Mean EERs are listed in Appendix A: RAC EER Design Variance Weighted Mean and in the "EER Weighting by Unique Units" sheet of MS Excel Workbook "Energy Star RACs-20070802.xls"[33].

Example 3 - RAC EER Design Variance Weighted Mean Values

Count the RACs with capacities equal to or greater than 8,000 and less than 13,999 Btu by unique design features listed in the Energy Star web site to determine the number of Unique Unit (UUs) RACs. Find the EER Weighted Mean Factor for each type of these UU designs and the weighted mean EER for all of these UU RAC units.

Example 3 column & row references can be found in Table 12 below. The Energy Star web site lists four unique designs for RACs with capacities equal to or greater than 8,000 and less than 13,999 Btu: standard RACs with & without louvered sides and heat pumps with & without louvered sides (columns (A) & (B) in T-X). Also listed are the Jan 1990 and Oct 2000 minimum EERs for each of these designs (columns (C) & (D)).

Counting the number of unique RACs listed in the Energy Star Product Listing[34] results in the numbers in column (E). Column (F) shows the addition of ten 8,000 Btu casement units from Row 27 to Row 11 which have identical EERs with the results of the addition in column (G) and subtotal of all the 8,000 and less than 13,999 Btu manufacturer RACs.

For Row 11: (G) = (E) + (F) = 310 + 10 = **320**

Column (H) is the column (G) number divided by the column (G) subtotal resulting in the percentile of each unique design relative to the total number of unique designs:

Row 15 Column (G) Subtotal: Σ(G) = 320 + 193 + 20 + 19 = **552**

For Row 11: (H) = (G) / Σ(G) = 320 / 552 = **0.58 or 58.0%**

Columns (I) & (J) are the Minimum EERs (columns (C) & (D)) multiplied by the percentile.

For Row 11: (I) = (C) * (H) = 9.0 * 0.58 = **5.22**
(J) = (D) * (H) = 9.8 * 0.58 = **5.68**

Summing column (I) results in the design weighted EER of 8.77 for the Jan 1990 Code.

Row 15 Column (I) Subtotal: Σ(I) = 5.22 + 2.97 + 0.31 + 0.28 = **8.77**

Summing column (J) results in the design weighted EER of 9.27 for the Oct 2000 Code.

Row 15 Column (J) Subtotal: Σ(J) = 5.68 + 2.97 + 0.33 + 0.29 = **9.27**

Table 12: Example 3 - RAC Design Weighted Mean Values

Row:	Appliance	Louvered Sides	Minimum EER Effective Jan 1990	Minimum EER Effective Oct 2000	No. of UUs	Adjust-ments to equiv. EERs	Adjust-ed No. of UUs	% of UUs per Cap	EER Weighted Mean Factors by Unit Design for Capacity Effective Jan 1990	EER Weighted Mean Factors by Unit Design for Capacity Effective Oct 2000
	Cells in Blue Arial font are from Title 20 Table B-2				Energy Star Product Search Unique Units (UU)					
	Column (A)	(B)	(C)	(D)	(E)	(F)	(G) = (E)+(F)	(H) = (G) / Subtotal	(I) = (C)*(H)	(J) = (D)*(H)
				For Capacities ≥ 8,000 - 13,999 Btu/hr						
11	**RAC**	**Yes**	**9.0**	**9.8**	**310**	**10 from Row 27**	**320**	**58.0%**	**5.22**	**5.68**
12	**RAC**	**No**	**8.5**	**8.5**	**193**	**None**	**193**	**35.0%**	**2.97**	**2.97**
13	**RAC Heat Pump**	**Yes**	**8.5**	**9.0**	**20**	**None**	**20**	**3.6%**	**0.31**	**0.33**
14	**RAC Heat Pump**	**No**	**8.0**	**8.5**	**19**	**None**	**19**	**3.4%**	**0.28**	**0.29**
15						Subtotal:	552	Weighted EERs:	8.77	9.27
	For Casement RACs the only available capacity is 8,000 Btu/hr									
26	**Casement-Only RAC**	**Either**	**(1)**	**8.7**	**0**	**None**	**0**			
27	**Casement-Slider RAC**	**Either**	**(1)**	**9.5**	**10**	**Add 10 to Row 11**	**0**			
				Totals:	**1032**		**1032**			

Notes:

(1) **Not a separate class until Oct 2000.**

RAC Population Weighted Mean Values

An SCE study[35] establishes a distribution of RAC unit cooling capacity for the SCE service area as listed in **Table 13**.

Table 13: SCE Service Area: RAC Cooling Capacity Distribution

Cooling Tons	BTU/hr	Percentage of Total RAC Units in SCE Service Area
0.5 to < 1.0	6,000 to <12,000	47%
1.0 to < 1.5	12,000 to <18,000	41%
1.5 to < 2.0	18,000 to 24,000	6%
> 2.0	> 24,000	6%

These unit cooling capacity ranges do not match Title 20 Table B-2 (

Table 4 in this work paper under: 1.3 Codes & Standards Requirements Analysis) so this work paper weighted the SCE area RAC distribution evenly over the Title 20 Table B-2 requirements as follows to establish a population Weighted Mean RAC (WM-RAC)[36].

Table 14: Basis for determining the Population Weight Mean RAC for SCE Service Area

<table>
<tr><th colspan="3">Population Weighted Mean RAC Capacity</th><th colspan="5">Title 20</th><th rowspan="2">Weighted Mean Factor BTU/hr</th></tr>
<tr><th>BTU/hr</th><th>SCE Cooling Capacity Range BTU/ hr</th><th>% of Total RAC Units in SCE Service Area</th><th>Title 20 Cooling Capacity Range BTU/ hr</th><th>Title 20 Average Cooling Capacity BTU/ hr</th><th>Title 20: % of SCE Dist</th><th>SCE Count/ 100 RAC Units</th><th>Title 20 % Dist</th></tr>
<tr><th></th><th>Column (A): From Table 13</th><th>(B): From Table 13</th><th>(C): From Table 4</th><th>(D): Average of (C)</th><th>(E) = % of (B)</th><th>(F) = (B) * (E) *100</th><th>(G) = (F) / 100</th><th>(H) = (D) * (G)</th></tr>
<tr><td>5000</td><td rowspan="7">6,000 to <12,000</td><td rowspan="7">47%</td><td>> 6,000</td><td>5000</td><td>14.3%</td><td>7</td><td>6.7%</td><td>336</td></tr>
<tr><td>6000</td><td rowspan="2">≥ 6,000 - 7,999</td><td rowspan="2">6500</td><td rowspan="2">28.6%</td><td rowspan="2">13</td><td rowspan="2">13.4%</td><td rowspan="2">873</td></tr>
<tr><td>7000</td></tr>
<tr><td>8000</td><td rowspan="6">= 8,000 - 13,999</td><td rowspan="6">11000</td><td rowspan="4">57.1%</td><td rowspan="4">27</td><td rowspan="6">40.5%</td><td rowspan="6">4458</td></tr>
<tr><td>9000</td></tr>
<tr><td>10000</td></tr>
<tr><td>11000</td></tr>
<tr><td>12000</td><td rowspan="6">12,000 to <18,000</td><td rowspan="6">41%</td><td rowspan="2">33.3%</td><td rowspan="2">14</td></tr>
<tr><td>13000</td></tr>
<tr><td>14000</td><td rowspan="6">≥ 14,000 - 19,999</td><td rowspan="6">16500</td><td rowspan="4">66.7%</td><td rowspan="4">27</td><td rowspan="6">29.3%</td><td rowspan="6">4840</td></tr>
<tr><td>15000</td></tr>
<tr><td>16000</td></tr>
<tr><td>17000</td></tr>
<tr><td>18000</td><td rowspan="6">18,000 to 24,000</td><td rowspan="6">6%</td><td rowspan="2">33.3%</td><td rowspan="2">2</td></tr>
<tr><td>19000</td></tr>
<tr><td>20000</td><td rowspan="9">≥ 20,000</td><td rowspan="9">24000</td><td rowspan="4">66.7%</td><td rowspan="4">4</td><td rowspan="9">10.0%</td><td rowspan="9">2400</td></tr>
<tr><td>21000</td></tr>
<tr><td>22000</td></tr>
<tr><td>23000</td></tr>
<tr><td>24000</td><td rowspan="5">> 24,000</td><td rowspan="5">6%</td><td rowspan="5">100.0%</td><td rowspan="5">6</td></tr>
<tr><td>25000</td></tr>
<tr><td>26000</td></tr>
<tr><td>27000</td></tr>
<tr><td>28000</td></tr>
<tr><td colspan="8">Weighted Mean RAC BTU/hr:</td><td>12,906</td></tr>
</table>

For the SCE service area, the WM-RAC BTU/hr is 12,906. The following **Table 15** takes the EER Weighted Mean by Unit Design for Cooling Capacities figures from **Table 11** and further weights the EERs by the Title 20 % distribution from

Table 14[37].

Table 15: Basis for determining the Weight Mean RAC EERs for SCE Service Area

EER Weighted Mean by Unit Design for Cooling Capacity (from Table 11)			Energy Star EER	Title 20 % Dist (from Table 14)	Weighted Mean EER Factors		
Cooling Capacity (Btu/hr)	Effective 1-Jan-90 Column (A)	Effective 1-Oct-00 (B)	(C) = (B) * 1.1	(D) = Table 14: Col (G)	Jan-90 (E) = (A) * (D)	Oct-00 (F) = (B) * (D)	Energy Star (G) = (C) * (D)
< 6,000	**8.0**	**9.7**	**10.7**	**6.7%**	**0.537**	**0.651**	**0.718**
≥ 6,000 - 7,999	**8.5**	**9.6**	**10.6**	**13.4%**	**1.141**	**1.289**	**1.423**
≥ 8,000 - 13,999	**8.8**	**9.3**	**10.2**	**40.5%**	**3.566**	**3.769**	**4.133**
≥ 14,000 - 19,999	**8.8**	**9.7**	**10.7**	**29.3%**	**2.581**	**2.845**	**3.139**
≥ 20,000	**8.2**	**8.5**	**9.4**	**10.0%**	**0.820**	**0.850**	**0.940**
			Weighted Mean EERs:		8.6	9.4	10.4

For the SCE service area, WM-RACs are 12,906 BTU/hr units that would meet EERs of 8.6 after Jan 1990, 9.4 as of Oct 2000 or an Energy Star rating of at least 10.4.

Energy Savings for WM-RAC

Table 16 below lists the SCE climate zones and repeats the SE_{vwm} Weighted Slope and YE_{vwm} Weighted Y Intercept from Table 8. Using Equation (6), Columns (C), (D) and (E) show the resulting energy savings calculations for WM-RACs for Jan 1990 code, Oct 2000 code and Energy Star (10% above Oct 2000 code) for the SCE climate zones. Column (F) numbers are the total energy savings of upgrading from a Jan 1990 Code to Energy Star WM-RAC. Column (G) numbers are the energy savings for buying an Energy Star WM-RAC instead of a current (Oct 2000) C-RAC: the energy savings for this work paper. Column (H) is the energy savings for replacing an existing Jan 1990 code RAC with a C-RAC: the energy savings for the RAC Recycling work paper[38].

Table 16: WM-RAC Annual Energy Savings (AES)

For Weighted Means RAC:		BTU/ hr:	12,906	Weighted Means EERs					
				8.6	9.4	10.4			
DEER Values		Annual Energy Savings (AES): (From Table X)		WM-RAC Total AES: (kWh/WM RAC)			WM-RAC Energy Star AES less: (kWh/Unit)		Code Differential AES: Oct 2000 less Jan 1990 (kWh/Unit) (Note 2)
Climate Zone City	CA T24 CZ:	SE_{vwm} Weighted Slope	YE_{vwm} Weighted Y Intercept	Code: Jan 1990	Code: Oct 2000	Energy Star	Code: Jan 1990	Code: Oct 2000 (Note 1)	
		Column (A)	(B)	(C) (Note 3)	(D) (Note 4)	(E) (Note 5)	(F) = (E) - (C)	(G) = (E) - (D)	(H) = (F) - (G)
Long Beach	6	183.835	-1,297.400	305.0	463.2	660.9	355.9	197.7	158.2
El Toro	8	229.651	-1,624.025	377.5	575.1	822.1	444.6	247.0	197.6
Burbank	9	216.026	-1,537.142	344.9	530.8	763.1	418.2	232.3	185.9
Riverside	10	204.380	-1,458.538	321.7	497.6	717.4	395.7	219.8	175.8
Fresno	13	202.615	-1,423.334	343.3	517.6	735.5	392.2	217.9	174.3
China Lake	14	187.204	-1,323.838	307.7	468.8	670.1	362.4	201.3	161.1
El Centro	15	272.872	-1,912.036	467.5	702.3	995.7	528.3	293.5	234.8
Mt. Shasta	16	147.093	-1,033.533	248.9	375.5	533.7	284.8	158.2	126.6
Notes:	(1)	Energy Star RAC energy savings: Purchase an Energy Star Unit instead of an Oct 2000 Code Unit.							
	(2)	Residential RAC Recycling energy savings: Recycle a Jan 1990 Code Unit and replace with an Oct 2000 Code Unit.							
	(3)	(C) = ((B) + (A) * 8.6) / (12,000 / 12,906)							
	(4)	(D) = ((B) + (A) * 9.4) / (12,000 / 12,906)							
	(5)	(E) = ((B) + (A) * 10.4) / (12,000 / 12,906)							

Example 4 - Table 14 Calculations

As an example, the equation to determine the total annual energy savings for an RAC with a BTU/hr capacity of 12,906 and EER of 8.6 in the Long Beach climate zone is:

YE_a = (YE_{vwm} + SE_{vwm} * X_a) * (WM-RAC Capacity (BTU/hr) / 12,000 ((BTU/hr)/Cooling Ton)

YE_a = (-1,297.400 (kWh / Cooling Ton year)
+183.835((year-kWh/Cooling Ton year) / (BTU/W))*8.6(BTU/W))
* 12906(BTU/hr)/(WM-RAC Unit)) / (12000((BTU/hr)/(Cooling Ton))

YE_a = 305.0 kWh / year WM-RAC Unit

Averaging the last three columns of **Table 16** produces average annual energy savings for the Residential RAC Recycling and Energy Star RAC work papers and a combined total savings as shown in Table 17[39]. The total savings is comparable to the RAC energy savings from the LIEE program of PY 2001[40].

Table 17: Average Annual Energy Savings for a WM-RAC

For a WM-RAC rated at 12,906 Btu:	Average Annual Energy Savings (kWh/WM-RAC):
Residential RAC Recycling: Replace a Jan 1990 Code Unit with an Oct 2000 Code Unit	**176.8**
Energy Star RAC: Purchase an Energy Star Unit instead of an Oct 2000 Code Unit	**221.0**
Total Savings: Replace a Jan 1990 Code Unit with an Energy Star Unit	**397.7**

2.2. Demand Reduction Estimation Methodologies

To derive the demand reduction, this work paper uses the Weighted Mean RAC of 12,906 Btu. The equation for EER is:

EER = Cooling Capacity (Btu/hr) / Power(Watts)

To determine Power in kW:

Power (kW) = [Cooling Capacity (Btu/hr) / EER] * [1 (kW) / 1000 (Watts)]

Power and Demand Reduction for the Weighted Mean EERs are shown in the following table:

Table 18: Weighted Mean RAC Demand Reduction

For Weighted Mean RAC 12,906 Btu / hr			
	Code: Jan 1990	Code: Oct 2000	Energy Star
EER	**8.6**	**9.4**	**10.4**
Power (kW)	**1.501**	**1.373**	**1.241**
Demand Reduction (kW)			
		Energy Star - Code: Oct 2000 (1):	**0.132**
		Code: Oct 2000 - Code: Jan 1990 (2):	**0.128**

Notes: **(1) Energy Star RAC Demand Reduction: Purchase an Energy Star Unit instead of an Oct 2000 Code Unit.**
(2) Residential RAC Recycling Demand Reduction: Recycle a Jan 1990 Code Unit and replace with an Oct 2000 Code Unit.

The Energy Star demand reduction is 0.132 kW for all climate zones in SCE's service area. This is based on the assumption that for a typical summer three day heat wave peak demand period RACs will operate at or above the 10 CFR Section 430.23(f) (2005) test condition of 95°F. As a result, the peak demand would be close to the same value for all units across different climate zones. This assumption simplifies the demand estimation process and also reduces any discrepancies due to under estimation of the potential demand reduction.

Section 3. Load Shapes

Load Shapes are an important part of the life-cycle cost analysis of any energy efficiency program portfolio. The net benefits associated with a measure are based on the amount of energy saved and the avoided cost per unit of energy saved. For electricity, the avoided cost varies hourly over an entire year. Thus, the net benefits calculation for a measure requires both the total annual energy savings (kWh) of the measure and the distribution of that savings over the year. The distribution of savings over the year is represented by the measure's load shape.

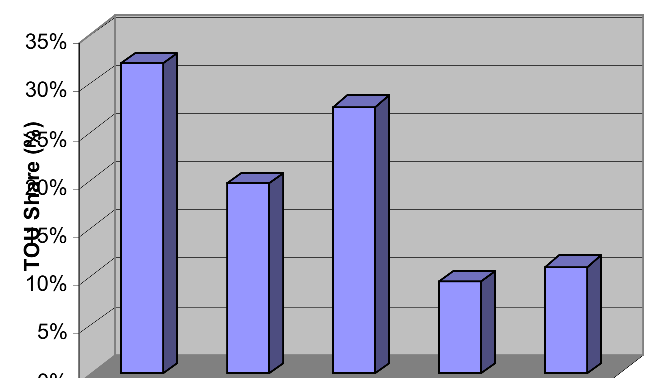
The measure's load shape indicates what fraction of annual energy savings occurs in each time period of the year. An hourly load shape indicates what fraction of annual savings occurs for each hour of the year. A TOU load shape indicates what fraction occurs within five or six broad time-of-use periods, typically defined by a specific utility rate tariff. Formally, a load shape is a set of fractions summing to unity, one fraction for each hour or for each TOU period. Multiplying the measure load shape with the hourly avoided cost stream determines the average avoided cost per kWh for use in the life cycle cost analysis that determines a measure's Total Resource Cost (TRC) benefit[41].

3.1 Base Case Load Shapes

The existing base case RAC energy use and peak demand load shapes would follow typical air conditioner hourly demand profile. Seasonal variations should follow the typical seasonal outdoor dry-bulb temperature variation for each climatic zone over a course of a year. The Load Shapes for this work paper are AC_Cooling-RC which is inclusive of both building type and climate zone.

3.2 Measure Load Shapes

The RAC measure would move the typical RAC hourly demand profile lower in all times except when load is zero when compared to the base system. Figure 2 and Figure 3 represent the TOU End Use Energy and Peak Demand factors for air conditioning: cooling RC measures that are embedded within the SCE E3 Calculator[42].



	Smr On	Smr Ptl	Smr Off	Wtr Ptl	Wtr Off
TOU %	32%	20%	28%	10%	11%

Figure 2: TOU AC Cooling-RC Energy Share

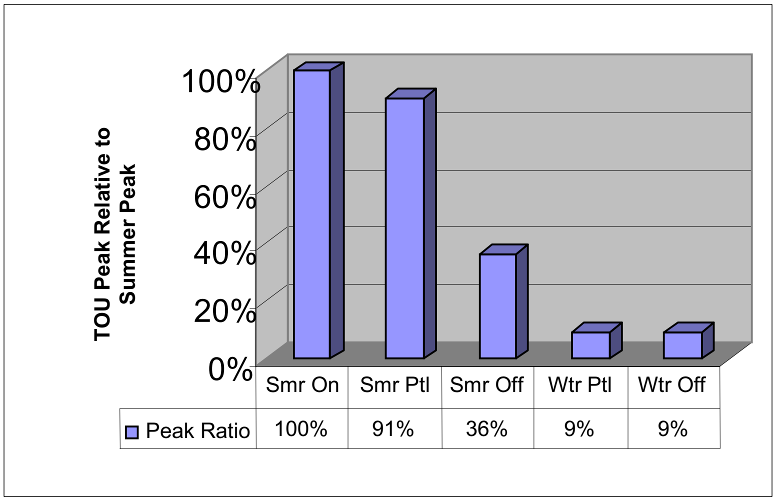


Figure 3: TOU Peak kW Factors

Section 4. Base Case & Measure Costs

The only difference in costs between the base case and measure costs would be for the greater cost of ES-RAC units over C-RAC units that simply meet Federal and State appliance standards. Other costs such as installation labor and materials are assumed to be identical. This work paper uses WM-RAC of 12,906 BTU/hr and provides average costs sourced from Consumer Reports Magazine for 9,800 to 12,500 BTU/hr units which may under price an actual WM-RAC unit.[43]

4.1 Base Case Costs

The base case costs are the purchase prices of C-RAC units that meet minimum Federal and State of California appliance standards. Base costs are estimated at $295.00[44].

4.2 Measure Costs

The measure costs are the greater cost of ES-RAC units that exceed the Federal EER appliance standards by at least 10%. Measure costs are estimated at $376.00[45].

4.3 Incremental & Full Measure Costs

The only cost differences are the extra capital costs of purchasing an Energy Star unit over a non-energy star unit. Thus the incremental cost is estimated at $81.00. Installation costs are presumed to be identical. To determine the full measure costs, this work paper presumes customers will self install RAC units and therefore the Full Measure cost is estimated at $376.00.

Appendices

Appendix A: RAC EER Design Variance Weighted Mean

RAC Design Variance EER Merge										
Row:	Cells in Blue Arial font are from Title 20 Table B-2				Energy Star Product Search Unique Units (UU)				EER Weighted Mean Factors by Unit Design for Capacity	
	Appliance	Louvered Sides	Minimum EER: Effective Jan 1990	Minimum EER: Effective Oct 2000	No. of UUs	Adjust-ments to equiv. EERs	Adjust-ed No. of UUs	% of UUs per Cap	Effective Jan 1990	Effective Oct 2000
	Column (A)	(B)	(C)	(D)	(E)	(F)	(G) = (E)+(F)	(H) = (G)/ Subtotal	(I) = (C)*(H)	(J) = (D)*(H)
	For Capacities < 6,000 Btu/hr									
1	RAC	Yes	8.0	9.7	123	None	123	99.2%	7.9	9.6
2	RAC	No	8.0	9.0	1	None	1	0.8%	0.1	0.1
3	RAC Heat Pump	Yes	8.5	9.0	0	None	0	0.0%	0.0	0.0
4	RAC Heat Pump	No	8.0	8.5	0	None	0	0.0%	0.0	0.0
5						**Subtotal:**	**124**	**Weighted EERs:**	**8.0**	**9.7**
	For Capacities ≥ 6,000 - 7,999 Btu/hr									
6	RAC	Yes	8.5	9.7	98	None	98	90.7%	7.7	8.8
7	RAC	No	8.5	9.0	8	2 from Row 10	10	9.3%	0.8	0.8
8	RAC Heat Pump	Yes	8.5	9.0	2	Add 2 to Row 9	0	0.0%	0.0	0.0
9	RAC Heat Pump	No	8.0	8.5	0	None	0	0.0%	0.0	0.0
10						**Subtotal:**	**108**	**Weighted EERs:**	**8.5**	**9.6**
	For Capacities ≥ 8,000 - 13,999 Btu/hr									
11	RAC	Yes	9.0	9.8	310	10 from Row 27	320	58.0%	5.2	5.7
12	RAC	No	8.5	8.5	193	None	193	35.0%	3.0	3.0
13	RAC Heat Pump	Yes	8.5	9.0	20	None	20	3.6%	0.3	0.3
14	RAC Heat Pump	No	8.0	8.5	19	None	19	3.4%	0.3	0.3
15						**Subtotal:**	**552**	**Weighted EERs:**	**8.8**	**9.3**
	For Capacities ≥ 14,000 - 19,999 Btu/hr									
16	RAC	Yes	8.8	9.7	143	None	143	94.7%	8.3	9.2
17	RAC	No	8.5	8.5	3	None	3	2.0%	0.2	0.2
18	RAC Heat Pump	Yes	8.5	9.0	5	None	5	3.3%	0.3	0.3
19	RAC Heat Pump	No	8.0	8.0	0	None	0	0.0%	0.0	0.0
20						**Subtotal:**	**151**	**Weighted EERs:**	**8.8**	**9.7**

RAC Design Variance EER Merge

Row:	Cells in Blue Arial font are from Title 20 Table B-2				Energy Star Product Search Unique Units (UU)				EER Weighted Mean Factors by Unit Design for Capacity	
	Appliance	Louvered Sides	Minimum EER Effective Jan 1990	Minimum EER Effective Oct 2000	No. of UUs	Adjust-ments to equiv. EERs	Adjust-ed No. of UUs	% of UUs per Cap	Effective Jan 1990	Effective Oct 2000
	Column (A)	(B)	(C)	(D)	(E)	(F)	(G) = (E)+(F)	(H) = (G)/ Subtotal	(I) = (C)*(H)	(J) = (D)*(H)
	For Capacities ≥ 20,000 Btu/hr									
21	RAC	Yes	8.2	8.5	92	None	92	94.8%	7.8	8.1
22	RAC	No	8.2	8.5	0	None	0	0.0%	0.0	0.0
23	RAC Heat Pump	Yes	8.5	8.5	5	None	5	5.2%	0.4	0.4
24	RAC Heat Pump	No	8.0	8.0	0	None	0	0.0%	0.0	0.0
25						**Subtotal:**	**97**	**Weighted EERs:**	**8.2**	**8.5**
	For Casement RACs the only available capacity is 8,000 Btu/hr									
26	Casement-Only RAC	Either	(1)	8.7	0	None	0			
27	Casement-Slider RAC	Either	(1)	9.5	10	Add 10 to Row 11	0			
	Total for all Capacities:				**1032**		**1032**			
Notes:										
(1)	Not a separate class until Oct 2000.									

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25. Ibid: Note 22, Sheet "LSLR Method & Vintage Weighing"

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28. Ibid: Note 22, Sheet "LSLR Method & Vintage Weighing"

29. Ibid: Note 22, Sheet "DEER Measure D03-099 Lodging-Motels.xls".

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CFL Lighting

Cover Page for CFLs

Introduction

The following Supporting Documentation summarizes the issues encountered with the following CFL savings parameters:

- EUL
- NTG
- Base Wattage
- IMC
- Gross Savings
- Hours of Operation

Summary Issues

- EUL: DEER uses inappropriate methods to arrive at a proxy estimate, when actual EUL estimates are available.
- NTG: DEER uses a conjectured value that does not agree with various ex-post evaluations.
- Base Wattage: DEER uses an invalid comparison to arrive at a proxy estimate, disregards lumen equivalencies. Better comparisons that agree with ex-post evaluation exist.
- IMC: DEER uses participant cost in place of incremental measure cost.
- Gross Savings: DEER does not utilize load profiles from ex-post evaluation.
- Hours of Operation: DEER uses results based on subsets of data to make statistically insignificant changes.

Supporting Documentation for CFLs

1. DEER Difference Analysis

EUL

DEER 2008 recommends an effective useful life (EUL) estimate that is based on a non-compliant methodology not conforming to standards on approach and precision level as established for EUL studies in the CPUC Protocols. SCE does not recommend the use of this estimate. Instead, SCE recommends the adoption of results from the CPUC-approved retention studies that were designed to achieve CPUC-required precision levels. The DEER 2008 value is of indeterminate (and unknowable) but extremely large standard error and is based on laboratory testing of a small number of bulbs, using only a subset of the bulbs. That is, it is a highly uncertain estimate of one of the factors that affects the effective useful life of CFLs, not the EUL itself. The retention studies, on the other hand, have known and modestly sized standard errors and are designed to estimate the EUL itself in accordance with CPUC Protocols.

NTG

DEER 2008 recommends a net-to-gross ratio that tries to forecast the future freeridership in upstream lighting programs based on unproven assumptions about program and market characteristics. SCE does not recommend the use of this estimate. Instead, SCE recommends the adoption of results from CPUC-approved impact evaluations. The CPUC has defined Net-to-Gross Ratio (NTG) as “A factor representing net program load impacts divided by gross program load impacts that is applied to gross program load impacts to convert them into net program load impacts.” That is, it is the portion of program activity that is due to the program, rather than due to other factors; it is not an arbitrary factor in a savings calculation meant to achieve certain policy objectives. Therefore, SCE uses a net-to-gross ratio based on CPUC-approved impact evaluations, rather than conjectures about the effects of market and program factors that do not have ex-post data to support them.

The Draft DEER recommends a value of .60 for the net-of-free-ridership (NOFR) of residential CFLs distributed through upstream programs. SCE believes that the Draft DEER NOFR values for CFLs lack a substantive basis and are overly conservative. We recommend a market channel weighted value at this time of 0.74 for 2009-11, with individual NOFR numbers to assist in the development of portfolios that maximize cost-effective energy savings for California. The current recommended NOFR estimate of 0.74 is net of any free-ridership, ignoring any spillover effects, and hence already making the final savings estimates conservative for the 2009-11 program cycle.

Base Wattage

The 2008 DEER Update Measure Revisions for Residential Interior Lighting uses RLW's 2005 CLASS[1] study results for the average wattage of existing screw-in incandescent bulbs and average wattage of existing CFLs to calculate a ratio of the average wattages and a wattage reduction factor (the ratio minus one). The DEER approach calculates the base case screw-in incandescent wattage by multiplying the CFL wattage by the ratio between the average wattages and the change in wattage by multiplying the CFL wattage by the wattage reduction factor. That is, DEER 2008 recommends a change in wattage based on the ratio between all existing installed CFL wattages and all existing incandescent wattages. Because the SCE programs have the effect of replacing incremental incandescents with new CFLs, rather than changing all incandescents with existing CFLs, SCE recommends instead methodology that is in agreement with results of the CPUC-approved impact evaluation's assessment of the change in wattage as the incremental incandescent is replaced with a new CFL.

The problem with the DEER methodology is that, first, it does not measure what it is supposed to measure, that is, the expected baseline for CFL, and second, it does not make a valid comparison in its use of the CLASS data. By including all non-CFL wattages in the baseline the approach ignores consumer behavior as regards the probability of installing a CFL in any given socket. Fundamentally, the issue is that this approach implicitly assumes a uniform probability distribution of CFL installation across all remaining incandescents, and assumes an equivalent wattage distribution between previous and future CFLs and base cases. With regard to replacement probability distribution, the RLW study showed conclusively that certain room types and fixture types are more likely than others to contain CFLs.[2] With regard to past versus future bulbs, it is entirely possible that many higher-wattage incandescents have already been replaced with CFLs, depressing the average incandescent wattage and inflating the average CFL wattage. In addition, the approach does not factor in lumen equivalency, which adds to the significant weakness in the DEER 2008 approach for wattage assumptions.

IMC

DEER 2008 recommends using participant costs as the incremental measure costs. SCE instead recommends using incremental measure costs as the incremental measure costs.

Gross Savings

While DEER 2008 does not include an explicit load factor, the data do reflect an implicit one. This implicit load factor is significantly higher than the value found in the CFL Metering Study, a CPUC-approved study.[3] This large disagreement with empirical

[1] RLW Analytics. *2005 California Statewide Residential Lighting and Appliance Efficiency Saturation Study*. August 2005.
[2] RLW Analytics. *2005 California Statewide Residential Lighting and Appliance Efficiency Saturation Study*. August 2005.
[3] KEMA Inc. *CFL Metering Study*. February 2005.

results leads SCE to be suspicious of the Gross Savings values found in DEER. Additionally, SCE does not consider HVAC interactive effects when calculating the demand and energy savings of CFLs installed in residential applications because of lack of ex-post evidence.

Hours of Operation

DEER 2008 recommends a value for the daily hours of operation that is a recalculation of data from the CFL Metering Study,[4] a CPUC-approved study. The difference is not statistically significant. SCE recommends using the value found in the study, rather than other values that are not statistically different and make selective use of the data. DEER 2008 does not estimate hours of operation for the portion of the bulbs that are purchased for non-residential use.

EM&V and Other Studies

EUL

The effective useful life of a measure is the estimated duration at which exactly 50% of measures of the same cohort will remain installed and functional. That is, it is affected by the durability of the measure itself, where applicable, as well as the behavior of the end user. This is exactly what is measured by a retention study. Therefore, SCE proposes to use retention study results for the EUL of CFLs. This is in accordance with CPUC Protocols. SCE recommends the use of 6.25 years for residential CFLs,[5] and 2.8 years for non-residential CFLs.[6]

NTG

Recent studies from other states corroborate the higher NTG estimates. A Connecticut study found a NTG of 1.09, with .06 free ridership and .15 spillover; that is, a NOFR of .94.[7] NMR mentioned that sales in Massachusetts "more than tripled" during program promotion, i.e. net of free-riders of at least 2/3.[8] In New Hampshire, NMR finds a NTG of .847 with .191 free-ridership; that is, .801 NOFR and .046 spillover.[9] Focus on Energy found NTGs in Wisconsin by retail channel, including .98 for hardware .61 for home improvement and 1.18 for grocery and other. The program-wide value is .81

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[4] KEMA Inc. *CFL Metering Study*. February 2005.
[5] Athens Research. *Southern California Edison 1994 Residential CFB Manufacturers' Incentive Program: 2004 Retention Study*. July 2004.
[6]DSRA. *1994 Commercial CFL Manufacturers' Rebate Ninth Year Retention Study*.
[7] United Illuminating. *UI and CL&P Program Savings Documentation for 2006 Program Year*. 2005.
[8] NMR. *Market Progress and Evaluation Report (MPER)For the 2005 Massachusetts ENERGY STAR® Lighting Program. 2003.*
[9] NMR. *Process and Impact Evaluation of the New Hampshire Residential Lighting Program. 2003.*

with the NOFR indeterminate from the chosen methodology.[10] The SFEER residential customer survey documents multiple barriers to customers' purchase of additional CFLs, suggesting that a continuing program is needed to reduce these obstacles.[11]

The Utility estimate of 0.74 is based upon the latest information with regard to free-ridership for these measures. The SFEER study found distinct free-ridership rates for different retail channels, and then calculated a weighted average of these based on rebated sales volume.[12] This is still a conservative estimate when consumer price is taken into consideration. We recommend DEER provide NOFR values for the market delivery channels for the Upstream Lighting Program. As noted above, the documentation supporting the Draft DEER value for 2009-11 indicates that the recommended NOFR values are by target market, delivery method and measure. Such values should be utilized to provide data that can assist the IOUs in portfolio planning.

Regarding Multifamily CFLs, the NTG should be maintained at the value of .78 determined by the MFEER study.[13]

Base Wattage

SFEER looked at the wattage of CFLs and the base they replaced. [14] The study found that incandescent bulbs averaging 64.9 W (800-1099 lumens) were replaced by CFLs with an average wattage of 13.6 W. This is compared to the 64.14 W incandescent replaced by 18.15 W CFL assumed by the DEER team, which is a 33.5% difference, well outside the confidence interval for a "90/10" estimate. That is, the DEER value, which uses a proxy to measure their desired parameter, disagrees with the ex-post evidence of the exact parameter DEER is trying to estimate. The SFEER number is based on making comparisons about actual bulbs that were exchanged. There is some question about the methodology used for the SFEER number regarding bulbs for which the owner did not remember the base wattage, but is surely better than a blind comparison between all incandescents and all CFLs.

Currently, California's Title 20 Appliance Efficiency Regulation uses a lumen equivalency mapping approach. Table K3 of the Title 20 report exhibits the standards for state regulated general service incandescent lamps. Effective January 1st, 2008, the maximum power draw for clear, frost, and soft white incandescent bulbs must comply with Title 20's lumen equivalency requirements as shown in Figure 1 and Figure 2. SCE recommends the adoption of these standards as the base incandescent case. This mapping agrees well with the SFEER results: a 950 lumen CFL (at the midpoint between 800 and 1099) would be projected to replace a 66 W incandescent, a 1.7% difference, well within the confidence interval. Furthermore, it is mandated by the State Regulated Code and is thus a legally recognized equivalence.

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[10] Focus on Energy. *Comprehensive CFL Market Effects Study— Final Report.* 2007.
[11] Itron, Inc. *2004/2005 Statewide Residential Retrofit Single Family Energy Efficiency Rebate Evaluation*. June 29, 2007.
[12] Itron, Inc. *2004/2005 Statewide Residential Retrofit Single Family Energy Efficiency Rebate Evaluation*. June 29, 2007.
[13] KEMA, Inc. *Evaluation of the 2004-2005 Statewide Multifamily Rebate Program*. 2007.
[14] Itron, Inc. *2004/2005 Statewide Residential Retrofit Single Family Energy Efficiency Rebate Evaluation*. June 29, 2007.

Figure 1

Table K-3
Standards for State-Regulated General Service Incandescent Lamps

Frost or Clear		
	Maximum Power Use (watts)	
Lumens (L)	**January 1, 2006**	**January 1, 2008**
L < 340	(0.0500 * Lumens) + 21	(0.0500 * Lumens) + 21
340 ≤ L < 562	(0.0500 * Lumens) + 21	38
562 ≤ L < 610	(0.0500 * Lumens) + 21	(0.2400 * Lumens) – 97
610 ≤ L < 760	(0.0500 * Lumens) + 21	(0.0500 * Lumens) + 19
760 ≤ L < 950	(0.0500 * Lumens) + 21	57
950 ≤ L < 1013	(0.0500 * Lumens) + 21	(0.2000 * Lumens) – 133
1013 ≤ L < 1040	(0.0500 * Lumens) + 21	(0.0500 * Lumens) + 19
1040 ≤ L < 1300	(0.0500 * Lumens) + 21	71
1300 ≤ L < 1359	(0.0500 * Lumens) + 21	(0.2700 * Lumens) – 280
1359 ≤ L < 1520	(0.0500 * Lumens) + 21	(0.0500 * Lumens) + 19
1520 ≤ L < 1850	(0.0500 * Lumens) + 21	95
1850 ≤ L < 1900	(0.0500 * Lumens) + 21	(0.4200 * Lumens) - 682
L ≥ 1900	(0.0500 * Lumens) + 21	(0.0500 * Lumens) + 21

Figure 2

Table K-3 (Continued)
Standards for State-Regulated General Service Incandescent Lamps

Soft White		
	Maximum Power Use (watts)	
Lumens (L)	**January 1, 2006**	**January 1, 2008**
L < 310	(0.0500 * Lumens) + 22.5	(0.0500 * Lumens) + 22.5
310 ≤ L < 514	(0.0500 * Lumens) + 22.5	38
514 ≤ L < 562	(0.0500 * Lumens) + 22.5	(0.2200 * Lumens) – 75
562 ≤ L < 730	(0.0500 * Lumens) + 22.5	(0.0500 * Lumens) + 20.5
730 ≤ L < 909	(0.0500 * Lumens) + 22.5	57
909 ≤ L < 963	(0.0500 * Lumens) + 22.5	(0.2200 * Lumens) – 143
963 ≤ L < 1010	(0.0500 * Lumens) + 22.5	(0.0500 * Lumens) + 20.5
1010 ≤ L < 1250	(0.0500 * Lumens) + 22.5	71
1250 ≤ L < 1310	(0.0500 * Lumens) + 22.5	(0.2500 * Lumens) – 241.5
1310 ≤ L < 1490	(0.0500 * Lumens) + 22.5	(0.0500 * Lumens) + 20.5
1490 ≤ L < 1800	(0.0500 * Lumens) + 22.5	95
1800 ≤ L < 1850	(0.0500 * Lumens) + 22.5	(0.4000 * Lumens) – 625
L ≥ 1850	(0.0500 * Lumens) + 22.5	(0.0500 * Lumens) + 22.5

IMC

The DEER 2008 measure costs update has deviated from past Measure Cost Update studies and used CFL "shelf" pricing to establish measure equipment and incremental measure costs for the upstream program approach; that is, it has supplied a list of upstream participant costs. This approach to measure costs requires that any upstream incentive already reflected in the shelf price be removed to properly reflect the actual measure equipment and incremental measure costs that are used as inputs to the cost-effectiveness analysis in the E3 Calculators. Hence, the utilities have added the specific, upstream measure incentives to the upstream DEER 2008 CFL incremental measure costs to create the proper inputs for the E3 Calculators. The resulting participant costs in the E3 calculators thus match the DEER 2008 Update values for upstream CFLs for the cases that match the utilities programs.

Hours of Operation

The *CFL Metering Study* used light loggers to monitor CFL use in the homes of 375 people in the territories of the California IOUs for six months to one year.[15] The study found an average of 2.34 hours of use for CFLs (Section 4). The study found different hours of use for different rooms. The SFEER study used the results of the study and the specific mix of room locations found in the on-site inspections and determined an average of 2.6 hours of operation per day[16]. DEER 2008 used some of the data from the CFL Metering Study to recalculate the value. The result was not statistically different from the value in the original report. That is, the exercise was not statistically valid and will not be used by SCE. We recommend retaining the 2.34 hours found in the Metering Study. SCE also recommends retaining the hours of operation for non-residential bulbs purchased through the Upstream Lighting Program at 8.8 hours, an average value based on the types of buildings where these bulbs tend to be installed.

In-Service Rate

Based on the telephone survey, the SFEER study estimates a 76% in-service rate for CFLs purchased during 2004-2005.[17] Adopting this estimate is not recommended. This estimate also does not reflect the necessary time dependency of the in-service rate, but rather assumes that 24% of bulbs do not yield any savings at all. Currently, there are no ex-post studies that provide an accurate estimate (or appropriate proxy estimate) of the in-service rate. Thus, we recommend retaining the default 90% in-service rate found in

[15] KEMA Inc. *CFL Metering Study*. February 2005.

[16] Itron, Inc. *2004/2005 Statewide Residential Retrofit Single Family Energy Efficiency Rebate Evaluation*. June 29, 2007.

[17] Itron, Inc. *2004/2005 Statewide Residential Retrofit Single Family Energy Efficiency Rebate Evaluation*. June 29, 2007.

DEER 2005 in order to account for any bulbs that might be broken or otherwise not yield savings.

Work Paper WPSCRELG0017
Revision 1

Southern California Edison Company
Design & Engineering Services

Integral (Screw-in) Compact Fluorescent Lamp (CFL) - Residenital

At a Glance Summary

Measure Description	Screw-in Compact Fluorescent Lamps 5 Watts 55 to Watts Residential Upstream
Savings Impacts Common Units	Lamp
Customer Base Case Description	Incandescent Lamp
Code Base Case Description	Screw-in Compact Fluorescent Lamp
Costs Common Units	Lamp
Measure Equipment Cost ($/unit)	Various – See table below
Measure Incremental Cost ($/unit)	Various – See table below
Measure Installed Cost ($/unit)	Various – Same as Equipment Cost
Measure Load Shape	CFL-RC
Effective Useful Life (years)	9.4 years
Program Type	Replace on Burnout (ROB)
TOU AC Adjustment	0%
Net-to-Gross Ratio	75% (Subject to completion of the study referenced in this work paper and in accordance with any direction provided by the Commission in the final decision on energy efficiency incentives)
Building Type	Residential
Building Vintage	All
Climate Zone	All
Important Comments	Values in the “At a Glance Summary” section below are rounded representations of full decimal values. The full values will be used when calculating program results for reporting purposes.

Work Paper RunID: WPSCRELG0017.1-	Measure Name	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)	Measure Equipment Cost ($/unit)	Measure Incremental Cost ($/unit)
001	Screw-in CFL 5 Watt <450 Lumens	15.4	0.001	15.4	0.001	$4.98	$4.40
002	Screw-in CFL 7 Watt 450 to 799 Lumens	25.4	0.002	25.4	0.002	$4.98	$4.40
003	Screw-in CFL 9 Watt 450 to 799 Lumens	23.8	0.002	23.8	0.002	$4.98	$4.40
004	Screw-in CFL 10 Watt <450 Lumens	11.5	0.001	11.5	0.001	$4.98	$4.40
005	Screw-in CFL 10 Watt 450 to 799 Lumens	23.1	0.002	23.1	0.002	$4.98	$4.40
006	Screw-in CFL 10 Watt 800 to 1,099 Lumens	38.4	0.003	38.4	0.003	$4.98	$4.40
007	Screw-in CFL 11 Watt <450 Lumens	10.8	0.001	10.8	0.001	$4.98	$4.40
008	Screw-in CFL 11 Watt 450 to 799 Lumens	22.3	0.002	22.3	0.002	$4.98	$4.40
009	Screw-in CFL 11 Watt 800 to 1,099 Lumens	37.7	0.003	37.7	0.003	$4.98	$4.40
010	Screw-in CFL 12 Watt <450 Lumens	10.0	0.001	10.0	0.001	$4.98	$4.40
011	Screw-in CFL 12 Watt 450 to 799 Lumens	21.5	0.002	21.5	0.002	$4.98	$4.40
012	Screw-in CFL 12 Watt 800 to 1,099 Lumens	36.9	0.003	36.9	0.003	$4.98	$4.40
013	Screw-in CFL 13 Watt <450 Lumens	9.2	0.001	9.2	0.001	$4.98	$4.40
014	Screw-in CFL 13 Watt 450 to 799 Lumens	20.8	0.002	20.8	0.002	$4.98	$4.40
015	Screw-in CFL 13 Watt 800 to 1,099 Lumens	36.1	0.003	36.1	0.003	$4.81	$4.26

Work Paper RunID: WPSCRELG0017.1-	Measure Name	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)	Measure Equipment Cost ($/unit)	Measure Incremental Cost ($/unit)
016	Screw-in CFL 14 Watt 450 to 799 Lumens	20.0	0.002	20.0	0.002	$5.25	$4.64
017	Screw-in CFL 14 Watt 800 to 1,099 Lumens	35.4	0.003	35.4	0.003	$5.25	$4.64
018	Screw-in CFL 15 Watt 450 to 799 Lumens	19.2	0.002	19.2	0.002	$5.62	$5.01
019	Screw-in CFL 15 Watt 800 to 1,099 Lumens	34.6	0.003	34.6	0.003	$5.62	$5.01
020	Screw-in CFL 15 Watt 1,100 to 1,399 Lumens	46.1	0.004	46.1	0.004	$5.62	$5.01
021	Screw-in CFL 16 Watt 800 to 1,099 Lumens	33.8	0.003	33.8	0.003	$6.00	$5.39
022	Screw-in CFL 16 Watt 1,100 to 1,399 Lumens	45.4	0.004	45.4	0.004	$6.00	$5.39
023	Screw-in CFL 17 Watt 450 to 799 Lumens	17.7	0.002	17.7	0.002	$6.74	$6.14
024	Screw-in CFL 17 Watt 800 to 1,099 Lumens	33.1	0.003	33.1	0.003	$6.74	$6.14
025	Screw-in CFL 17 Watt 1,100 to 1,399 Lumens	44.6	0.004	44.6	0.004	$6.74	$6.14
026	Screw-in CFL 18 Watt 450 to 799 Lumens	16.9	0.001	16.9	0.001	$6.74	$6.14
027	Screw-in CFL 18 Watt 800 to 1,099 Lumens	32.3	0.003	32.3	0.003	$6.74	$6.14
028	Screw-in CFL 18 Watt 1,100 to 1,399 Lumens	43.8	0.004	43.8	0.004	$6.37	$5.77
029	Screw-in CFL 19 Watt 450 to 799 Lumens	16.1	0.001	16.1	0.001	$6.73	$6.12
030	Screw-in CFL 19 Watt 800 to 1,099 Lumens	31.5	0.003	31.5	0.003	$6.73	$6.12

Work Paper RunID: WPSCRELG0017.1-	Measure Name	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)	Measure Equipment Cost ($/unit)	Measure Incremental Cost ($/unit)
031	Screw-in CFL 19 Watt 1,100 to 1,399 Lumens	43.0	0.004	43.0	0.004	$6.73	$6.12
032	Screw-in CFL 20 Watt 800 to 1,099 Lumens	30.7	0.003	30.7	0.003	$7.08	$6.47
033	Screw-in CFL 20 Watt 1,100 to 1,399 Lumens	42.3	0.004	42.3	0.004	$7.08	$6.47
034	Screw-in CFL 21 Watt 800 to 1,099 Lumens	30.0	0.003	30.0	0.003	$6.66	$6.05
035	Screw-in CFL 21 Watt 1,100 to 1,399 Lumens	41.5	0.004	41.5	0.004	$6.66	$6.05
036	Screw-in CFL 22 Watt 800 to 1,099 Lumens	29.2	0.003	29.2	0.003	$6.66	$6.05
037	Screw-in CFL 22 Watt 1,100 to 1,399 Lumens	40.7	0.004	40.7	0.004	$6.66	$6.05
038	Screw-in CFL 23 Watt 800 to 1,099 Lumens	28.4	0.002	28.4	0.002	$6.66	$6.05
039	Screw-in CFL 23 Watt 1,100 to 1,399 Lumens	40.0	0.004	40.0	0.004	$6.66	$6.05
040	Screw-in CFL 23 Watt 1,400 to 1,599 Lumens	51.5	0.005	51.5	0.005	$6.66	$6.05
041	Screw-in CFL 23 Watt 1,600 to 1,999 Lumens	59.2	0.005	59.2	0.005	$6.66	$6.05
042	Screw-in CFL 24 Watt 800 to 1,099 Lumens	27.7	0.002	27.7	0.002	$8.85	$8.24
043	Screw-in CFL 24 Watt 1,100 to 1,399 Lumens	39.2	0.003	39.2	0.003	$8.85	$8.24
044	Screw-in CFL 24 Watt 1,400 to 1,599 Lumens	50.7	0.004	50.7	0.004	$8.85	$8.24

Work Paper RunID: WPSCRELG0017.1-	Measure Name	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)	Measure Equipment Cost ($/unit)	Measure Incremental Cost ($/unit)
045	Screw-in CFL 24 Watt 1,600 to 1,999 Lumens	58.4	0.005	58.4	0.005	$7.24	$6.63
046	Screw-in CFL 25 Watt 800 to 1,099 Lumens	26.9	0.002	26.9	0.002	$8.85	$8.24
047	Screw-in CFL 25 Watt 1,100 to 1,399 Lumens	38.4	0.003	38.4	0.003	$8.85	$8.24
048	Screw-in CFL 25 Watt 1,400 to 1,599 Lumens	50.0	0.004	50.0	0.004	$8.85	$8.24
049	Screw-in CFL 25 Watt 1,600 to 1,999 Lumens	57.7	0.005	57.7	0.005	$7.24	$6.63
050	Screw-in CFL 26 Watt 800 to 1,099 Lumens	26.1	0.002	26.1	0.002	$7.52	$6.92
051	Screw-in CFL 26 Watt 1,100 to 1,399 Lumens	37.7	0.003	37.7	0.003	$7.52	$6.92
052	Screw-in CFL 26 Watt 1,400 to 1,599 Lumens	49.2	0.004	49.2	0.004	$7.52	$6.92
053	Screw-in CFL 26 Watt 1,600 to 1,999 Lumens	56.9	0.005	56.9	0.005	$7.52	$6.92
054	Screw-in CFL 27 Watt 800 to 1,099 Lumens	25.4	0.002	25.4	0.002	$8.10	$7.50
055	Screw-in CFL 27 Watt 1,100 to 1,399 Lumens	36.9	0.003	36.9	0.003	$8.10	$7.50
056	Screw-in CFL 27 Watt 1,400 to 1,599 Lumens	48.4	0.004	48.4	0.004	$8.10	$7.50
057	Screw-in CFL 27 Watt 1,600 to 1,999 Lumens	56.1	0.005	56.1	0.005	$8.10	$7.50
058	Screw-in CFL 28 Watt 1,100 to 1,399 Lumens	36.1	0.003	36.1	0.003	$8.10	$7.50
059	Screw-in CFL 28 Watt 1,400 to 1,599 Lumens	47.7	0.004	47.7	0.004	$8.10	$7.50

Work Paper RunID: WPSCRELG0017.1-	Measure Name	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)	Measure Equipment Cost ($/unit)	Measure Incremental Cost ($/unit)
060	Screw-in CFL 28 Watt 1,600 to 1,999 Lumens	55.3	0.005	55.3	0.005	$8.10	$7.50
061	Screw-in CFL 29 Watt 1,100 to 1,399 Lumens	35.4	0.003	35.4	0.003	$9.26	$8.65
062	Screw-in CFL 29 Watt 1,400 to 1,599 Lumens	46.9	0.004	46.9	0.004	$9.26	$8.65
063	Screw-in CFL 29 Watt 1,600 to 1,999 Lumens	54.6	0.005	54.6	0.005	$9.26	$8.65
064	Screw-in CFL 30 Watt 1,100 to 1,399 Lumens	34.6	0.003	34.6	0.003	$9.26	$8.65
065	Screw-in CFL 30 Watt 1,400 to 1,599 Lumens	46.1	0.004	46.1	0.004	$9.26	$8.65
066	Screw-in CFL 30 Watt 1,600 to 1,999 Lumens	53.8	0.005	53.8	0.005	$9.26	$8.65
067	Screw-in CFL 30 Watt 2,000 to 2,599 Lumens	69.2	0.006	69.2	0.006	$9.26	$8.65
068	Screw-in CFL 31 Watt 1,100 to 1,399 Lumens	33.8	0.003	33.8	0.003	$9.19	$6.97
069	Screw-in CFL 31 Watt 1,400 to 1,599 Lumens	45.4	0.004	45.4	0.004	$9.19	$6.97
070	Screw-in CFL 31 Watt 1,600 to 1,999 Lumens	53.0	0.005	53.0	0.005	$9.19	$6.97
071	Screw-in CFL 32 Watt 1,100 to 1,399 Lumens	33.1	0.003	33.1	0.003	$9.19	$6.97
072	Screw-in CFL 32 Watt 1,400 to 1,599 Lumens	44.6	0.004	44.6	0.004	$9.19	$6.97
073	Screw-in CFL 32 Watt 1,600 to 1,999 Lumens	52.3	0.005	52.3	0.005	$9.19	$6.97
074	Screw-in CFL 33 Watt 1,100 to 1,399 Lumens	32.3	0.003	32.3	0.003	$9.19	$6.97

Work Paper RunID: WPSCRELG0017.1-	Measure Name	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)	Measure Equipment Cost ($/unit)	Measure Incremental Cost ($/unit)
075	Screw-in CFL 33 Watt 1,400 to 1,599 Lumens	43.8	0.004	43.8	0.004	$9.19	$6.97
076	Screw-in CFL 33 Watt 1,600 to 1,999 Lumens	51.5	0.005	51.5	0.005	$9.19	$6.97
077	Screw-in CFL 34 Watt 1,100 to 1,399 Lumens	31.5	0.003	31.5	0.003	$9.19	$6.97
078	Screw-in CFL 34 Watt 1,400 to 1,599 Lumens	43.0	0.004	43.0	0.004	$9.19	$6.97
079	Screw-in CFL 34 Watt 1,600 to 1,999 Lumens	50.7	0.004	50.7	0.004	$9.19	$6.97
080	Screw-in CFL 35 Watt 1,400 to 1,599 Lumens	42.3	0.004	42.3	0.004	$9.19	$6.97
081	Screw-in CFL 35 Watt 1,600 to 1,999 Lumens	50.0	0.004	50.0	0.004	$9.19	$6.97
082	Screw-in CFL 35 Watt 2,000 to 2,599 Lumens	65.3	0.006	65.3	0.006	$9.19	$6.97
083	Screw-in CFL 36 Watt 1,400 to 1,599 Lumens	41.5	0.004	41.5	0.004	$9.19	$6.97
084	Screw-in CFL 36 Watt 1,600 to 1,999 Lumens	49.2	0.004	49.2	0.004	$9.19	$6.97
085	Screw-in CFL 36 Watt 2,000 to 2,599 Lumens	64.6	0.006	64.6	0.006	$9.19	$6.97
086	Screw-in CFL 37 Watt 1,400 to 1,599 Lumens	40.7	0.004	40.7	0.004	$12.77	$10.55
087	Screw-in CFL 37 Watt 1,600 to 1,999 Lumens	48.4	0.004	48.4	0.004	$12.77	$10.55
088	Screw-in CFL 37 Watt 2,000 to 2,599 Lumens	63.8	0.006	63.8	0.006	$12.77	$10.55
089	Screw-in CFL 38 Watt 1,400 to 1,599 Lumens	40.0	0.004	40.0	0.004	$12.77	$10.55

Work Paper RunID: WPSCRELG0017.1-	Measure Name	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)	Measure Equipment Cost ($/unit)	Measure Incremental Cost ($/unit)
090	Screw-in CFL 38 Watt 1,600 to 1,999 Lumens	47.7	0.004	47.7	0.004	$12.77	$10.55
091	Screw-in CFL 38 Watt 2,000 to 2,599 Lumens	63.0	0.006	63.0	0.006	$12.77	$10.55
092	Screw-in CFL 38 Watt 2,600 to 3,599 Lumens	86.1	0.008	86.1	0.008	$12.77	$10.55
093	Screw-in CFL 39 Watt 1,400 to 1,599 Lumens	39.2	0.003	39.2	0.003	$12.77	$10.55
094	Screw-in CFL 39 Watt 1,600 to 1,999 Lumens	46.9	0.004	46.9	0.004	$12.77	$10.55
095	Screw-in CFL 39 Watt 2,000 to 2,599 Lumens	62.3	0.005	62.3	0.005	$12.77	$10.55
096	Screw-in CFL 39 Watt 2,600 to 3,599 Lumens	85.3	0.007	85.3	0.007	$12.77	$10.55
097	Screw-in CFL 40 Watt 1,600 to 1,999 Lumens	46.1	0.004	46.1	0.004	$12.77	$10.55
098	Screw-in CFL 40 Watt 2,000 to 2,599 Lumens	61.5	0.005	61.5	0.005	$12.77	$10.55
099	Screw-in CFL 40 Watt 2,600 to 3,599 Lumens	84.6	0.007	84.6	0.007	$12.77	$10.55
100	Screw-in CFL 41 Watt 1,600 to 1,999 Lumens	45.4	0.004	45.4	0.004	$12.77	$10.55
101	Screw-in CFL 41 Watt 2,000 to 2,599 Lumens	60.7	0.005	60.7	0.005	$12.77	$10.55
102	Screw-in CFL 41 Watt 2,600 to 3,599 Lumens	83.8	0.007	83.8	0.007	$12.77	$10.55
103	Screw-in CFL 42 Watt 1,600 to 1,999 Lumens	44.6	0.004	44.6	0.004	$12.77	$10.55
104	Screw-in CFL 42 Watt 2,000 to 2,599 Lumens	60.0	0.005	60.0	0.005	$12.77	$10.55

Work Paper RunID: WPSCRELG0017.1-	Measure Name	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)	Measure Equipment Cost ($/unit)	Measure Incremental Cost ($/unit)
105	Screw-in CFL 42 Watt 2,600 to 3,599 Lumens	83.0	0.007	83.0	0.007	$12.77	$10.55
106	Screw-in CFL 43 Watt 1,600 to 1,999 Lumens	43.8	0.004	43.8	0.004	$12.77	$10.55
107	Screw-in CFL 43 Watt 2,000 to 2,599 Lumens	59.2	0.005	59.2	0.005	$12.77	$10.55
108	Screw-in CFL 43 Watt 2,600 to 3,599 Lumens	82.2	0.007	82.2	0.007	$12.77	$10.55
109	Screw-in CFL 44 Watt 1,600 to 1,999 Lumens	43.0	0.004	43.0	0.004	$12.77	$10.55
110	Screw-in CFL 44 Watt 2,000 to 2,599 Lumens	58.4	0.005	58.4	0.005	$12.77	$10.55
111	Screw-in CFL 44 Watt 2,600 to 3,599 Lumens	81.5	0.007	81.5	0.007	$12.77	$10.55
112	Screw-in CFL 45 Watt 1,600 to 1,999 Lumens	42.3	0.004	42.3	0.004	$12.77	$10.55
113	Screw-in CFL 45 Watt 2,000 to 2,599 Lumens	57.7	0.005	57.7	0.005	$12.77	$10.55
114	Screw-in CFL 45 Watt 2,600 to 3,599 Lumens	80.7	0.007	80.7	0.007	$12.77	$10.55
115	Screw-in CFL 46 Watt 1,600 to 1,999 Lumens	41.5	0.004	41.5	0.004	$12.77	$10.55
116	Screw-in CFL 46 Watt 2,000 to 2,599 Lumens	56.9	0.005	56.9	0.005	$12.77	$10.55
117	Screw-in CFL 46 Watt 2,600 to 3,599 Lumens	79.9	0.007	79.9	0.007	$12.77	$10.55
118	Screw-in CFL 47 Watt 1,600 to 1,999 Lumens	40.7	0.004	40.7	0.004	$12.77	$10.55
119	Screw-in CFL 47 Watt 2,000 to 2,599 Lumens	56.1	0.005	56.1	0.005	$12.77	$10.55

Work Paper RunID: WPSCRELG0017.1-	Measure Name	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)	Measure Equipment Cost ($/unit)	Measure Incremental Cost ($/unit)
120	Screw-in CFL 47 Watt 2,600 to 3,599 Lumens	79.2	0.007	79.2	0.007	$12.77	$10.55
121	Screw-in CFL 48 Watt 1,600 to 1,999 Lumens	40.0	0.004	40.0	0.004	$12.77	$10.55
122	Screw-in CFL 48 Watt 2,000 to 2,599 Lumens	55.3	0.005	55.3	0.005	$12.77	$10.55
123	Screw-in CFL 48 Watt 2,600 to 3,599 Lumens	78.4	0.007	78.4	0.007	$12.77	$10.55
124	Screw-in CFL 49 Watt 1,600 to 1,999 Lumens	39.2	0.003	39.2	0.003	$12.77	$10.55
125	Screw-in CFL 49 Watt 2,000 to 2,599 Lumens	54.6	0.005	54.6	0.005	$12.77	$10.55
126	Screw-in CFL 49 Watt 2,600 to 3,599 Lumens	77.6	0.007	77.6	0.007	$12.77	$10.55
127	Screw-in CFL 50 Watt 2,000 to 2,599 Lumens	53.8	0.005	53.8	0.005	$12.77	$10.55
128	Screw-in CFL 50 Watt 2,600 to 3,599 Lumens	76.9	0.007	76.9	0.007	$12.77	$10.55
129	Screw-in CFL 50 Watt 3,600 to 4,599 Lumens	115.3	0.010	115.3	0.010	$12.77	$10.55
130	Screw-in CFL 51 Watt 2,000 to 2,599 Lumens	53.0	0.005	53.0	0.005	$12.77	$10.55
131	Screw-in CFL 51 Watt 2,600 to 3,599 Lumens	76.1	0.007	76.1	0.007	$12.77	$10.55
132	Screw-in CFL 51 Watt 3,600 to 4,599 Lumens	114.5	0.010	114.5	0.010	$12.77	$10.55
133	Screw-in CFL 52 Watt 2,000 to 2,599 Lumens	52.3	0.005	52.3	0.005	$12.77	$10.55
134	Screw-in CFL 52 Watt 2,600 to 3,599 Lumens	75.3	0.007	75.3	0.007	$12.77	$10.55

Work Paper RunID: WPSCRELG0017.1-	Measure Name	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)	Measure Equipment Cost ($/unit)	Measure Incremental Cost ($/unit)
135	Screw-in CFL 52 Watt 3,600 to 4,599 Lumens	113.8	0.010	113.8	0.010	$12.77	$10.55
136	Screw-in CFL 53 Watt 2,000 to 2,599 Lumens	51.5	0.005	51.5	0.005	$12.77	$10.55
137	Screw-in CFL 53 Watt 2,600 to 3,599 Lumens	74.6	0.007	74.6	0.007	$12.77	$10.55
138	Screw-in CFL 53 Watt 3,600 to 4,599 Lumens	113.0	0.010	113.0	0.010	$12.77	$10.55
139	Screw-in CFL 54 Watt 2,000 to 2,599 Lumens	50.7	0.004	50.7	0.004	$12.77	$10.55
140	Screw-in CFL 54 Watt 2,600 to 3,599 Lumens	73.8	0.006	73.8	0.006	$12.77	$10.55
141	Screw-in CFL 54 Watt 3,600 to 4,599 Lumens	112.2	0.010	112.2	0.010	$12.77	$10.55
142	Screw-in CFL 55 Watt 2,000 to 2,599 Lumens	50.0	0.004	50.0	0.004	$12.77	$10.55
143	Screw-in CFL 55 Watt 2,600 to 3,599 Lumens	73.0	0.006	73.0	0.006	$12.77	$10.55
144	Screw-in CFL 55 Watt 3,600 to 4,599 Lumens	111.5	0.010	111.5	0.010	$12.77	$10.55

Document Revision History

Revision 0	March 2007	Original work paper short form WPSCRELG0017.0.
Revision 1	September 2007	• Split original work paper into compact fluorescent lamps (CFL) groups • Expanded to final work paper template format • Measure equipment costs added • Net-to-gross ratio (NGR) reduced from 80% to 75% (Subject to completion of the study referenced in this work paper and in accordance with any direction provided by the Commission in the final decision on energy efficiency incentives)

Note: The information provided in this work paper was developed using the best available technical resources at the time this document was prepared.

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Section 1. General Measure and Baseline Data

1.1 Measure Description and Background

Screw-in compact fluorescent lamps (CFL) consist of two main parts: A gas-filled tube and an electronic ballast. Electric current flows from the ballast through the gas, causing it to emit ultraviolet light. The ultraviolet light then excites a white phosphor coating on the inside of the tube, making it emit visible light. This measure replaces incandescent lamps. An incandescent lamp is also a source of artificial light that works through a different process known as incandescence. In the incandescent process, an electrical current passes through a thin filament heating it and causing it to become excited and release photons. Incandescent lamps are less efficient than CFLs because incandescent lamps convert approximately 90% of the energy they consume into heat compared to approximately 30% for a CFL. Modern CFLs typically have a life span of between 6,000 and 15,000 hours. CFL wattages covered by this work paper range in values from 5 watts through 55 watts with lumen rages from under 450 lumens through 4,599 lumens replacing incandescent lamps with wattages that range from under 24 watts through 500 watts with matching lumen ranges. The measures discussed in this work paper are integral (screw in) compact fluorescent lamps.

1.2 DEER Differences Analysis

The 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report (Itron 2005)[1], December 2005 contains energy savings for screw-in compact fluorescent lamps (CFL) measures that range from 13 watts through 40 watts identified as measures D03-801 through D03-837. These measures are contained in Table 2-1: 20004-05 DEER Residential CFL Lamp Measures and Table 2-2: 2004-05 DEER Residential CFL Measure IDs and Savings Estimates on pages 2-4 and 2-5. As explained on page 2-2 of the DEER report*,* the measure savings in these tables are based on several factors that include the calculation of demand savings based on a matching of base technologies with CFL measures, calculating the delta watts, and then multiplying the result by an In-Service Rate and Peak Hour Load Share. The calculation of energy savings is accomplished in a similar manner, calculating the delta watts and multiplying the results by an In Service Rate and hours of daily use or annual operating hours, however a Peak Hour Load Share is not applied to the energy savings calculation.

As explained in Section 3 on Load Shapes, SCE has determined that the Peak Demand Saving used in calculating demand savings in the current version of DEER are no longer appropriate. Due to this change and the fact that the wattages and lumen ranges of many of the measures in the upstream program are not contained in the DEER tables a simplified mapping system was developed patterned after the DEER methodology and a mapping system developed by Energy Star® which is explained further in Section 1.5.

SCE then recalculated each of the measure energy impacts with a Peak Hour Load Share of 7.5% [0.075]

DEER measure costs were used whenever possible. As explained further below in Section 4, there are several measures covered by this work paper that could not be matched to measures in DEER. In those instances, the closest available costs were used.

1.3 Codes and Standards Requirements Analysis

There are currently no known codes or standards applicable to this measure.

1.4 EM&V, Market Potential, and Other Studies

The most directly applicable study for residential upstream lighting is the *2004/2005 Statewide Residential Retrofit Single-Family Energy Efficiency Rebate Evaluation* (Itron 2007)[2]. Sections 5 and 6 of this study provide an updated analysis of the upstream CFL program covered by this work paper. Itron gathered general energy efficiency data from a telephone survey (n=4,718), with a portion being asked in-depth questions about residential lighting (n=1000), an on-site inspection (n=100) and surveys of manufacturers and retailers.

Delta Wattage Assumption (ΔW): The Itron 2007 study developed ΔkW assumptions based on lumens using data from the on-site inspections[3]. Rather than determining a base wattage from which to calculate the ΔkW for each bulb, they calculated an average ΔkW for various lumen ranges. That is, a 13W and a 14W CFL of the same luminosity would be assumed to have the same average ΔkW. Unfortunately, lamps with output of 1,100 to 2,599 lumens were considered as one category, even though that range includes the lumen output of 75W, 100W, and 150W incandescent bulbs replacements. The study results were used, together with the number of non specialty CFLs from each lumen category sold under the 2006 SCE Residential Upstream Lighting Program, to determine a base-wattage assumption. The ΔW assumptions were drawn from the study. Using program data, the wattages of all the bulbs in each lumen category were summed to find the average wattage of CFLs in that category. The average wattage was added to the ΔW to find a base wattage for each lumen category as shown in [Equation 1:

[Equation 1]
$$\overline{\Delta W} = \frac{\Sigma(W_{base} - W_{new})}{n} \rightarrow \overline{W_{base}} = \frac{\Sigma W_{new}}{n} + \overline{\Delta W} = \overline{W_{new}} + \overline{\Delta W}$$

In addition, the same calculations were done for all of the bulbs in the 1100-2599 lumen range, using weighted averages based on the number of bulbs that were sold under the 2006 program in each category. The results are contained in Table 1.

Table 1. Base Wattage Assumptions

Lumen Range	SCE Base Wattage (Energy Star)	Average CFL Wattage (SCE 2006 Program)	SCE Average Delta W	SFEER Delta W	Inferred Base Wattage
0-799	40	9.0	31.0	46.8	55.8
800-1099	60	13.8	46.2	51.3	65.1
1100-1599	75	19.2	55.8	68.5	87.7
1600-2000	100	23.9	76.1	68.5	92.4
2000-2599	150	30.0	120.0	68.5	98.5
1100-2599	96.6	23.2	73.4	68.5	91.7

*This category is based on weighted averages for the three smaller categories

In each case the ENERGY STAR® wattage equivalence used in the DEER report and the program assumptions is more conservative, except for the 1600-1999 and 2000-2599 lumen range. This is most likely due to the fact that such a large lumen range was used. For the grouped 1100-2599 lumen category, the difference between the effective SCE base wattage and the inferred base wattage based on SFEER is 5.3%, well within an expected 10% error bound on the SFEER estimate. This exercise was only meant to demonstrate that the program assumptions, based on ENERGY STAR®, are reasonable and somewhat conservative. The survey relied on self-reported data about what light bulb had preceded an existing light bulb, which may not be highly reliable data. This exercise is not meant to support an increase in the base wattage assumption. We recommend maintaining the DEER equivalence over the Itron finding because it is more conservative and more specific to the lumen range of a bulb.

Net-to-Gross Assumption: To determine the net-to-gross ratio (NTG) the study relied on surveys of retailers and manufacturers. This was due to the fact that in the telephone survey only 24% of respondents who had purchased CFLs during the program were aware they had received a discount, and so direct self-reporting data were scarce. This is characteristic of upstream programs where it is difficult to adopt standard end-use-based survey methodologies for determining a net-to-gross ratio. Hence, in the surveys of retailers and manufacturers, the study asked respondents to estimate free ridership based on their sales data for various retail channels. Although the number of respondents was very small in many cases, we accept this because the respondents represented a large portion of the sales volume in that retail channel. The study found distinct free-ridership rates for different retail channels, and then calculated a weighted average of these based on rebated sales volume during 2004-05. The overall free-ridership for Southern California Edison (SCE) was calculated to be 33%, yielding a 0.67 NTG for 2004-05. Of the 24% of those surveyed who remembered receiving a discount, 63% were somewhat likely, not very likely, or very unlikely to purchase a CFL in the absence of the discount, and thus demonstrated some influence by the program[4]. The 0.67 NTG value is close to the value determined by the retailer and manufacturer survey data so the two different methodologies corroborate one another.

Because the study NTG results are retail channel specific and the Upstream Lighting program retail channel distribution of CFLs has shifted, the NTG was calculated using weights developed from 2006 program data. Weights were calculated using proportions of sales volume, dollar amount paid by the utility and energy savings for the utility. The results are contained in Table 2.

Table 2. Net-to-Gross Values by Distribution Channel

Channel	Units	Dollars	kWh	SFEER 04/05	Channel Free-ridership
Big Box	8.5%	6.6%	6.2%	18.0%	75%
Discount	19.2%	20.2%	20.4%	12.0%	3%
Drug	5.5%	5.6%	5.4%	4.0%	41%
Grocery	56.4%	57.4%	57.6%	51.0%	16%
Home Improvement	8.1%	7.8%	8.1%	12.0%	66%
Small Hardware	1.4%	1.3%	1.3%	2.0%	52%
Other	0.9%	0.9%	1.0%	1.0%	38%
Total	100.0%	100.0%	100.0%	100.0%	
Parameter Free-ridership	24.8%	23.4%	23.2%	33.4%	
NTG	0.75	0.77	0.77	0.67	

Weighting by dollars or energy saved yields a slightly higher NTG, but the figures are quite similar and SCE recommends using the 0.75 NTG determined using the methodology used in the study.

In-service factor/first year installation rate: Based on the telephone survey, the Itron 2007 study estimates a 76% in-service rate for CFLs purchased during 2004-2005[5]. Adopting this estimate is not recommended. The estimate was based on 100 on-site inspections of the homes of telephone survey respondents who volunteered to partake in the on-site portion. This was not a representative sample (on-site participants on average had 63% more CFLs installed per home than phone survey participants). Additionally, the estimate disregards burned out CFLs, which should be included in the in-service rate as it is assumed they have been accounted for in the shortened EUL estimate. Although the phone survey estimated a small number of bulbs had burned out, this assertion was based on inference as no question directly asked all respondents about burn-outs. This estimate also does not reflect the necessary time dependency of the in-service rate. Thus, we recommend retaining the default 90% in-service rate found in DEER.

Hours of Operation: The *CFL Metering Study* (KEMA 2005). Light loggers monitored CFL use in the homes of 375 people in the territories of the California IOUs for six months to one year. The study found an average of 2.34 hours of use for CFLs (Section 4). The study found different hours of use for different rooms. The Itron 2007 study used the results of the study and the specific mix of room locations found in the on-site inspections and determined an average of 2.6 hours of operation per day[6]. We recommend retaining the 2.34 hours found in the Metering Study due to unknown location mix of the installed bulbs in the 2006 program.

Effective Useful Life: The program assumes DEER effective useful life (EUL) for screw-in CFLs that is 9.4 years and is based on 8,000 hours of manufactured rated bulb life given the average 2.34 hours of operation. In order to determine the average EUL for bulbs we used 2006 program data on manufacturer- rated bulb-life hours. The rated life was summed for the different bulb types used, weighting by the sales volume of the bulb type. In 2006, 0.50% of bulbs were rated for 5,000 hours, 3.5% for 6,000 hours, 19% for 8,000 hours and 77% for 10,000 hours. This yielded an average rated life of 9,530 hours. Using the operating hours assumption described above, this yields an EUL of 11.4 years. Southern California Edison recommends retaining the DEER assumption of 9.4 years due to decreased life caused by on-off stress, heat and other CFL savings retention issues that remain to be explored in a future study.

Residential/Non-Residential Split: Currently there are no studies available that directly measure the proportion of upstream rebated lighting products purchased for commercial use. This work paper assumes 10% of the measure purchased are for commercial applications. To validate this assumption, we used data gathered in a previous manufacture buy-down program. The 1994 Compact Fluorescent Lamp Manufacturers' Rebate Program provided financial incentives directly to CFL manufacturers to sell compact fluorescent equipment in Southern California Edison territory at discounted prices. As part of the program, consumer bounce–back cards collected basic information for the CFL product usage. The bounce back card included a question on use of the purchased product for business or home use. The responses to this question are provided in Table3 as both unweighted and weighted proportions, where the weights are based on the number of CFLs purchased. Two questions were used to calculate the weighted proportions: weighted proportions based on responses to either question on "number of CFL bulbs purchased" (Q7) or "number of CFLs by location used(Q5 a-g)"; and weighted proportions based on "number of bulbs purchased (Q7) where information on location was unknown. Thus column X in Table 3 is based on an amalgam of weight proportions sensitive to location and records that could only be weighted with respect to bulb count.

Table 3. 1994 CFL Manufacturers Bounce Back Card Survey

1994 CFL Manufacturer's Bounce Back Card Survey						
Is this Compact Fluorescent Bulb for your Home or Business?						
Source Question *	Column X: No. of bulbs and bulbs with location		Column Y: No. of bulbs		Column Z: No. of Cards	
	CFL(c)	Wtd.Percent	CFL(b)	Wtd.Percent	CFL(a)	Percent
Business	5,860	16%	122	11%	1,931	10%
Household	30,567	81%	934	86%	16,424	88%
Household/Business	1,350	4%	33	3%	272	1%
TOTAL	37,777		1,089		18,627	
Percent Business		19%		14%		12%

*Column X: Q7- How Many CFLs Purchased or Q5A-Q5G - No. of CFLs in a different location
Column Y: Q7- How Many CFLs Purchased
CFL(c) and CFL(b) are weighted counts by number of CFLs purchased. CFL(a) is unweighted count of cards.

As shown in Table 3 at least 12% or as high as 19% bulbs purchased through the Manufacturers' Rebate program were for commercial use, hence supporting the conservative program planning estimate of 10%. Future EM&V study needs to update this proportion for the Upstream lighting program measures assumed to be used in commercial application as well.

Incandescent Equivalency: The CFL to incandescent equivalency assumptions made in this work paper can be validated by creating a metric using available data from field observations. This metric is the CFL–to-incandescent ratio, which tells us the observed relationship between the wattages of CFLs and wattages of incandescent lamps they replaced. The equivalence need not be based on wattage alone but rather can be based on lumen output as is assumed in this work paper. SCE compared the CFL to incandescent ratio implied by the ENERGY STAR® Light Output Equivalency Table (Section 1.5 below) to the ratio calculated using the results of the KEMA CFL Metering Study (Table 4). For the ENERGY STAR® equivalence, the categories are based on lumen levels; for the CFL Metering Study they are based on incandescent base wattage. In each case, a range of CFL wattages fall into each category, and so minimum and maximum value were calculated for each category and the mean was chosen. The weighted average was then calculated based on 2006 program volume for the ENERGY STAR® equivalence and from KEMA's reported relative frequency. The aggregated CFL to incandescent ratio from the ENERGY STAR® chart is 0.267 and that for the CFL Metering Study was 0.254. This is a difference of 5%. This suggests that the lumen mapping method recommended by ENERGY STAR® roughly approximates the wattage matching that KEMA observed in the field.

Table 4. Incandescent Bulbs Replaced by CFLs from the KEMA CFL Metering Study

Original Incandescent Wattage	Number of Monitored Fixtures with Replacement CFLs	Percent of Monitored Fixtures	Typical CFL Replacement Wattage
60	250	57%	13-17
75	84	19%	18-22
40	55	12%	9-12
100	53	12%	23-26

Table 5. Summary of Market Parameters

Measure Parameter	Ex-Ante Value	Revised Ex-Ante Value
ΔkW	**ENERGY STAR® lumen equivalents**	No change
Hours of Operation	2.34 hrs/day	2.34 hrs/day
Net-to-Gross Ratio	0.80	0.75
Effective Useful Life	9.4 years	9.4 years
In-service Rate	90%	90%

1.5 Base Cases for Savings Estimates: Existing and Above Code

The existing equipment replaced by these measures are incandescent lamps in the range of 15 watts through 500 watts. Base measures are mapped to replacement CFLs as described in Table 6

Table 6. Mapping of Base Wattages to CFLs by Lumen Equivalency

BASE WATTS	LUMEN RANGE		SOURCE
	≤	≥	
≥24	0	249	extrapolated
25	250	449	extrapolated
40	450	799	Energy Star®
60	800	1,099	Energy Star®
75	1,100	1,399	Energy Star®
90	1,400	1,599	interpolated
100	1,600	1,999	Energy Star
120	2,000	2,599	interpolated
150	2,600	3,599	Energy Star®
200	3,600	4,599	extrapolated
500	4,600		extrapolated

Table 6 is an expansion of the Energy Star® CFL/Incandescent Equivalency Chart reproduced below in Table 7[7].

Table 7. Energy Star® Light Output Equivalent

LIGHT OUTPUT EQUIVALENCY

To determine which ENERGY STAR qualified light bulbs will provide the same amount of light as your current incandescent light bulbs, consult the following chart:

INCANDESCENT LIGHT BULBS	MINIMUM LIGHT OUTPUT	COMMON ENERGY STAR QUALIFIED LIGHT BULBS
WATTS	LUMENS	WATTS
40	450	9-13
60	800	13-15
75	1,100	18-25
100	1,600	23-30
150	2,600	30-52

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1.6 Base Cases and Measure Effective Useful Lives

A measure Effective Useful Life (EUL) of 9.4 years is used for these measures are based on EULs for DEER MeasureIDs D03-801 to D03-818 All Screw-in CFLs – Residential located in Table 11-4: Non-Weather Sensitive – Lighting EULs, in Section 11 of the *2004-2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report*[8]. See Section 1.4 EM&V, Market Potential, and Other Studies for discussion.

1.7 Net-to-Gross Ratios for Different Program Strategies

Table 8 summarizes all applicable net-to-gross ratios for programs that may be used by this measure.

Table 8. Net-to-Gross Ratios

Program Approach	NTG
Upstream Lighting	0.75

The net-to-gross (NTG) ratio used for these measures is based on Edison's evaluation of actual measure distributions in combination with the methodology outlined in the *2004/2005 Statewide Residential Retrofit Single Family Energy Efficiency Rebate Evaluation,* June 29, 2007.

Section 2. Calculation Methods

2.1 Energy Savings Estimation Methodologies

The annual energy savings and demand reduction formulas follow the calculation methods used in Section 2 of the *2004–2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report, December 2005*[9], specifically:

ΔWatts/unit:

The demand difference (watts per unit) is simply the difference between the electric demand of the base unit and the electric demand of the energy efficient unit.

ΔWatts/unit = *Base Watts/unit - Energy Efficient Unit Watts*

Example: *ΔWatts/unit = 100 Watts/unit - 54 Watts / units = 46 Watts*

Annual Energy Savings:

$$\text{Energy Savings [kWh/Unit]} = \frac{(\Delta\text{Watts/unit}) \times (\text{hours/day}) \times (\text{days/year}) \times (\text{In Service Rate})}{1{,}000 \text{ Watts / kW}}$$

$$\text{Example: Energy Savings} = \frac{(46 \text{ Watts})(2.34/\text{hrs / day})(365 \text{ days / year}) \times .90}{1{,}000 \text{ Watt / kW}} = 35.4 \text{ kWh}$$

2.2 Demand Reduction Estimation Methodologies

The annual energy savings and demand reduction formulas follow the calculation methods used in Section 2 of the *2004–2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report, December 2005*[10], specifically:

ΔWatts/unit:

The demand difference (watts per unit) is simply the difference between the electric demand of the base unit and the electric demand of the energy efficient unit.

ΔWatts/unit = *Base Watts/unit - Energy Efficient Unit Watts*

Example: *ΔWatts/unit = 100 Watts/unit - 54 Watts / units = 46 Watts*

Demand Reduction:

$$\text{Demand Reduction [kW/Unit]} = \frac{(\Delta\text{Watts/unit}) \times (\text{In Service Rate}) \times (\text{Peak Hour Load Share})}{1{,}000 \text{ Watts s/ kW}}$$

Example:

$$\text{Demand Reduction} = \frac{46 \text{ Watts} \times (0.90) \times (0.075)}{1{,}000 \text{ Watt s /kW}} = 0.0031 \text{ kW}$$

Peak Hour Load Share: The Peak Hour Load Share represents the portion of energy demand produced by a lighting measure during an on peak period expressed as a percentage. The Peak Hour Load Share serves the same purpose for residential lighting as the Coincident Diversity Factor does for nonresidential lighting.

The load shape used for these measures is based on a simple average of the three usage periods between the hours of 2:00 pm and 5:00 pm summer weekdays as required by California Public Utilities Commission Interim Opinion 2006 Update of Avoided Costs and Related Issues Pertaining to Energy Efficiency Resources, Decision 06-06-063, June 29, 2006[11] which states "Until further notice of this Commission, the definition of peak kilowatt (kW) contained in the 2005 Database for Energy Efficient Resources (DEER) shall be used for the purpose of verifying energy efficiency program and portfolio performance. As discussed in this decision, DEER defines peak demand as the average grid level impact for a measure between 2 p.m. and 5 p.m. during the three consecutive weekday period containing the weekday temperature with the hottest temperature of the year." This results in a Peak Hour Load Share of 7.5%. This revision is based on the underlying data supporting the load shapes presented in Figure 4-13 Indoor CFL Load Shapes by Day Type, contained in Section 4 of the CFL Metering Study Final Report, KEMA, February 25, 2005. The information is reproduced here as Table 9. This is an update or revision to the 8.1% Peak Demand Savings factor embedded in the energy savings presented in Table 2-2: 2004-05 DEER Residential CFL Measure IDs and Savings Estimates, Section 2 of the *2004–2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report, December 2005*[12].

Table 9. CFL Percent On by Day Type and Season

Percent On by Day Type and Season					
Average of 2:00 PM to 5:00 PM Summer Weekdays:					
From	**To**	**Winter***		**Summer****	
Hour	**Hour**	**Weekday**	**Weekend**	**Weekday**	**Weekend**
0	**1**	6.7%	7.9%	4.9%	5.7%
1	**2**	4.2%	5.1%	3.2%	3.8%
2	**3**	3.3%	4.2%	2.6%	2.8%
3	**4**	3.4%	3.8%	2.6%	2.6%
4	**5**	3.6%	3.3%	2.8%	2.3%
5	**6**	5.1%	4.1%	4.0%	2.8%
6	**7**	6.9%	5.6%	5.9%	4.1%
7	**8**	7.7%	7.2%	6.3%	5.6%
8	**9**	8.2%	8.8%	6.4%	6.6%
9	**10**	9.3%	10.9%	7.1%	7.9%
10	**11**	10.2%	12.0%	7.5%	8.5%
11	**12**	10.4%	12.6%	7.3%	8.4%
12	**13**	10.3%	12.1%	7.3%	8.2%
13	**14**	10.1%	12.0%	7.4%	8.1%
14	**15**	9.9%	12.2%	7.5%	8.2%
15	**16**	9.6%	11.8%	7.4%	8.3%
16	**17**	9.7%	11.9%	7.7%	8.4%
17	**18**	11.2%	13.0%	8.1%	8.7%
18	**19**	16.0%	17.2%	10.0%	10.1%
19	**20**	22.2%	22.3%	14.4%	12.9%
20	**21**	25.3%	25.3%	19.2%	17.8%
21	**22**	22.8%	23.3%	18.8%	17.1%
22	**23**	17.2%	18.5%	14.1%	13.4%
23	**24**	11.2%	12.5%	8.7%	8.7%

*Winter refers to the month with the highest usage, which is December.

**Summer refers to the lowest usage month, which is June.

Section 3 Load Shapes

Load shapes are a graphic representation of electrical load over time and are an important part of the life-cycle cost analysis of any energy efficiency program portfolio. The net benefits associated with a measure are based on the amount of energy saved and the avoided cost per unit of energy saved. For electricity, the avoided cost varies hourly over an entire year. Thus, the net benefits calculation for a measure requires both the total annual energy savings (kWh) of the measure and the distribution of that savings over the year. The distribution of savings over the year is represented by the measure's load shape. The measure's load shape indicates what fraction of annual energy savings occurs in each time period of the year. An hourly load shape indicates what fraction of annual savings occurs for each hour of the year. A time-of-use (TOU) load shape indicates what fraction occurs within five or six broad time-of-use periods, typically defined by a specific utility rate tariff. Formally, a load shape is a set of fractions summing to unity, one fraction for each hour or for each TOU period. Multiplying the measure load shape with the hourly avoided cost stream determines the average avoided cost per kWh for use in the life cycle cost analysis that determines a measure's total resource cost (TRC) benefit.

3.1 Base Cases Load Shapes

The base case indoor lighting system's demand would be expected to follow a typical residential indoor lighting end use load shape as illustrated in Figures 1 and 2.

3.2 Measure Load Shapes

To estimate net benefits in the E3 calculator, a demand load shape is required. The demand load shape ideally represents the *difference* between the base equipment and the installed energy efficiency measure. This *difference* load profile is what is called the Measure Load Shape and would be the preferred load shape for use in the net benefits calculations.

The Load Shape Update Initiative Study determined that for load-following measures, the end-use load shape can be substituted for the measure shape:

> "It can be argued that for measures that are roughly load-following (have a similar pattern to the end-use itself), substituting the end-use load shape for the measure shape is a reasonable simplification. Errors introduced by this substitution may be minor compared to other uncertainties in the savings valuation process. Distinguishing measure shape from end-use shape may be an unnecessary complication except for measures that are not load-following. This perspective was suggested by some workshop participants and interviewees."[13]

Since CFLs are direct replacements for incandescent lamps with no change in their operational characteristics, Southern California Edison (SCE) uses the lighting end use load shape in the E3 calculator for residential lighting. The E3 Calculator contains a fixed set of load shapes selections that are the combination of the hourly avoided costs and whatever load shape data were available at the time of the tool's creation. In the case of SCE's E3 Calculator, the majority of the load shape data at the time were TOU End Use load shapes and not Hourly Measure load shapes. Figure 3and Figure 4 represent the TOU End Use Energy and Peak Demand factors for indoor lighting measures that are embedded within the SCE E3 Calculator.

The "CFL-RC" load shape in the SCE E3 calculator was derived from the KEMA CFL metering study and compressed into the TOU factors shown in Figure 3 and Figure 4. The same end use load shape is used for both the measure and the base case.

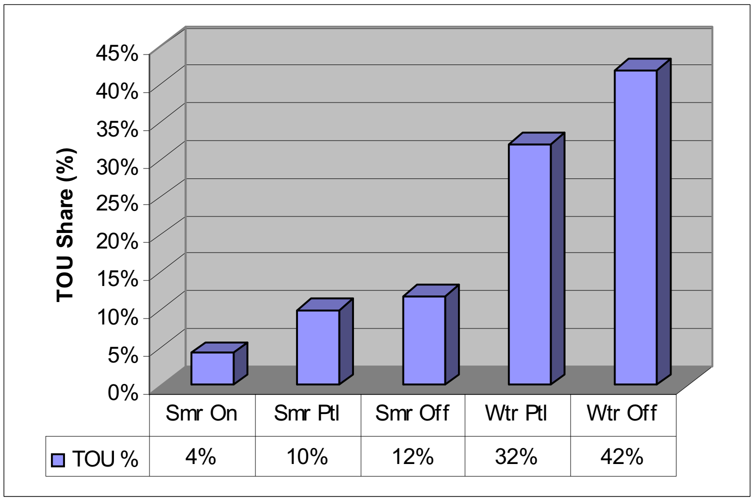

Figure 3. Time of Use Energy Factors for Residential CFLs

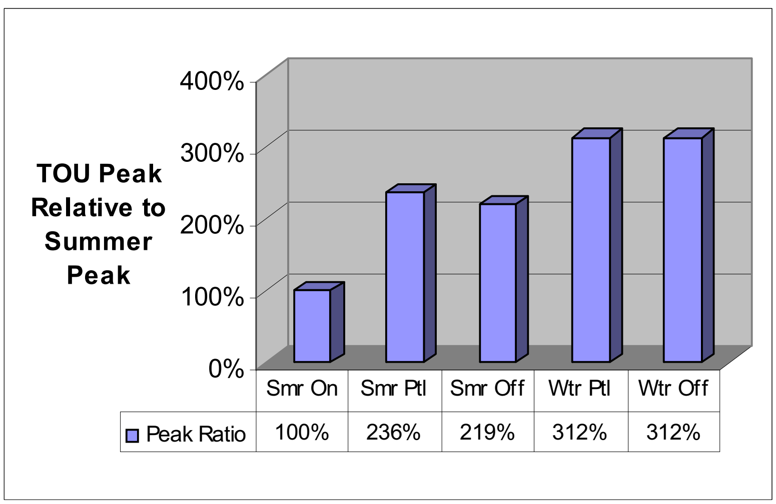

Figure 4. Time of Use Demand Factors for Residential CFLs

Section 4. Base Case and Measure Costs

Measure costs were obtained directly from *Table C-4: DEER Non-Weather Sensitive Measure List*[14] in most instances. As explained in Section 4.3 below, for certain measures that were not represented in the DEER tables, bulb wattages were extrapolated to match available cost data.

4.1 Base Case Costs

Base equipment costs were obtained from the DEER for this work paper as listed in Table 9.

4.2 Measure Costs

For screw-in compact fluorescent lamps, measure costs were extracted from the *2004-2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report, Appendix C, Table C-4 DEER Non – Weather Sensitive Measure List*[14]. Wattages of CFLs measures were matched to those in the DEER table and the incremental measure costs were used. In instances where direct mappings of wattages were not possible, costs from the closest available DEER wattages were used. For example, Table C-4 in DEER did not have costs for 9 Watt, 10 Watt, or 11 Watt CFLs. The first available costs in the DEER table were for a 13 Watt CFL. So the costs presented for the 13 Watt CFLs were used for the 9, 10, and 11 watt CFLs. Using the above example, 9 Watt, 10 Watt, 11 Watt, and 13 Watt CFLs would all be priced at the next available cost of $4.98/unit.

4.3 Incremental and Full Measure Costs

For screw-in compact fluorescent lamps, incremental costs were extracted from the *2004-2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report, Appendix C, Table C-4 DEER Non – Weather Sensitive Measure List*[115]. Wattages of CFLs measures were matched to those in the DEER table and the incremental measure costs were used as presented here as Table 10. Where direct mappings of wattages were not possible, costs from the closest available DEER wattages were used. For example, Table C-4 in the DEER update study did not have costs for a 9 Watt, 10 Watt, or 11 Watt CFLs. The first available costs in the DEER table were for a 13 Watt CFL. So the costs presented for the 13 Watt CFLs were used for the 9, 10, and 11 watt CFLs. Using the above example, 9 Watt, 10 Watt, 11 Watt, and 13 Watt CFLs would all be priced at the next available cost of $4.40/unit.

The DEER measure installation costs were not used for these measures for the following reasons. The participants in this program are home owners or renters who would install these units as part of their normal maintenance routines and not incur any additional operating expense over and above the level of effort in replacing a standard incandescent lamp. An argument could be made that due to the longer life on CFLs those installations would occur less frequently and that an installation credit due to the reduced frequency of replacement could be easily calculated. However, SCE has decided not to calculate and claim an installation credit at this time.

Table 10. DEER Table C-4: Non-Weather Sensitive Measure List

MeasureID	Measure Name	Energy Common Units	Cost Common Units	Base Equipment Cost ($)	Measure Equipment Cost ($)	Incremental Equipment Cost ($)	Labor Cost ($)	Installed Cost ($)
D03-801	13 Watt CFL < 800 Lumens - screw-in	LAMP	Lamp	$0.57	$4.98	$4.40	$3.77	$8.18
D03-802	13 Watt CFL =800 Lumens - screw-in	LAMP	Lamp	$0.61	$4.87	$4.26	$3.77	$8.04
D03-803	14 Watt CFL - screw-in	LAMP	Lamp	$0.61	$5.25	$4.64	$3.77	$8.41
D03-804	15 Watt CFL - screw-in	LAMP	Lamp	$0.61	$5.62	$5.01	$3.77	$8.79
D03-805	16 Watt CFL - screw-in	LAMP	Lamp	$0.61	$6.00	$5.39	$3.77	$9.16
D03-806	18 Watt CFL < 1,100 Lumens - screw-in	LAMP	Lamp	$0.61	$6.74	$6.14	$3.77	$9.91
D03-807	18 Watt CFL =1,100 Lumens - screw-in	LAMP	Lamp	$0.61	$6.37	$5.77	$3.77	$9.54
D03-808	19 Watt CFL =1,100 Lumens - screw-in	LAMP	Lamp	$0.61	$6.73	$6.12	$3.77	$9.89
D03-809	20 Watt CFL - screw-in	LAMP	Lamp	$0.61	$7.08	$6.47	$3.77	$10.25
D03-810	23 Watt CFL - screw-in	LAMP	Lamp	$0.61	$6.66	$6.05	$3.77	$9.82
D03-811	25 Watt CFL <1,600 Lumens - screw-in	LAMP	Lamp	$0.61	$8.85	$8.24	$3.77	$12.02
D03-812	25 Watt CFL =1,600 Lumens - screw-in	LAMP	Lamp	$0.61	$7.24	$6.63	$3.77	$10.40
D03-813	26 Watt CFL <1,600 Lumens - screw-in	LAMP	Lamp	$0.61	$9.21	$8.60	$3.77	$12.37
D03-814	26 Watt CFL =1,600 Lumens - screw-in	LAMP	Lamp	$0.61	$7.52	$6.92	$3.77	$10.69
D03-815	28 Watt CFL - screw-in	LAMP	Lamp	$0.61	$8.10	$7.50	$3.77	$11.27
D03-816	30 Watt CFL - screw-in	LAMP	Lamp	$0.61	$9.26	$8.65	$3.77	$12.43
D03-817	36 Watt CFL - screw-in	LAMP	Lamp	$2.22	$9.19	$6.97	$3.77	$10.75
D03-818	40 Watt CFL - screw-in	LAMP	Lamp	$2.22	$12.77	$10.55	$3.77	$14.32
D03-819	13 Watt CFL < 800 Lumens - pin based	LAMP	Lamp	$0.00	$17.88	$0.00	$27.14	$45.02
D03-820	13 Watt CFL =800 Lumens - pin based	LAMP	Lamp	$0.00	$17.88	$0.00	$27.14	$45.02
D03-821	14 Watt CFL - pin based	LAMP	Lamp	$0.00	$18.38	$0.00	$27.14	$45.51
D03-822	15 Watt CFL - pin based	LAMP	Lamp	$0.00	$18.87	$0.00	$27.14	$46.01
D03-823	16 Watt CFL - pin based	LAMP	Lamp	$0.00	$19.36	$0.00	$27.14	$46.50
D03-824	18 Watt CFL < 1,100 Lumens - pin based	LAMP	Lamp	$0.00	$20.35	$0.00	$27.14	$47.49
D03-825	18 Watt CFL =1,100 Lumens - pin based	LAMP	Lamp	$0.00	$20.35	$0.00	$27.14	$47.49
D03-826	19 Watt CFL =1,100 Lumens - pin based	LAMP	Lamp	$0.00	$20.84	$0.00	$27.14	$47.98
D03-827	20 Watt CFL - pin based	LAMP	Lamp	$0.00	$21.34	$0.00	$27.14	$48.48
D03-828	23 Watt CFL - pin based	LAMP	Lamp	$0.00	$22.82	$0.00	$27.14	$49.96
D03-829	25 Watt CFL <1,600 Lumens - pin based	LAMP	Lamp	$0.00	$23.80	$0.00	$27.14	$50.94
D03-830	25 Watt CFL =1,600 Lumens - pin based	LAMP	Lamp	$0.00	$23.80	$0.00	$27.14	$50.94
D03-831	26 Watt CFL <1,600 Lumens - pin based	LAMP	Lamp	$0.00	$24.30	$0.00	$27.14	$51.44
D03-832	26 Watt CFL =1,600 Lumens - pin based	LAMP	Lamp	$0.00	$24.30	$0.00	$27.14	$51.44
D03-833	28 Watt CFL - pin based	LAMP	Lamp	$0.00	$25.28	$0.00	$27.14	$52.42
D03-834	30 Watt CFL - pin based	LAMP	Lamp	$0.00	$26.27	$0.00	$27.14	$53.41
D03-835	40 Watt CFL - pin based	LAMP	Lamp	$0.00	$31.20	$0.00	$27.14	$58.34
D03-836	55 Watt CFL - pin based	LAMP	Lamp	$0.00	$38.60	$0.00	$27.14	$65.74
D03-837	65 Watt CFL - pin based	LAMP	Lamp	$0.00	$43.54	$0.00	$27.14	$70.68
D03-838	20W CFL Table Lamp	Fixture	Fixture	$50.43	$50.43	$0.00	$0.00	$0.00
D03-839	25W CFL Table Lamp	Fixture	Fixture	$61.13	$61.13	$0.00	$0.00	$0.00
D03-840	32W CFL Table Lamp	Fixture	Fixture	$63.20	$63.20	$0.00	$0.00	$0.00
D03-841	50W CFL Table Lamp	Fixture	Fixture	$122.96	$122.96	$0.00	$0.00	$0.00
D03-842	55W CFL Torchiere	Fixture	Torchiere	$59.39	$59.39	$0.00	$0.00	$0.00
D03-843	70W CFL Torchiere (two LAMPs)	Fixture	Torchiere	$55.76	$55.76	$0.00	$0.00	$0.00
D03-844	50W Metal Halide	Fixture	Fixture	$0.00	$113.85	$0.00	$100.51	$214.36
D03-845	75W Metal Halide	Fixture	Fixture	$0.00	$120.09	$0.00	$100.51	$220.60
D03-846	100W Metal Halide	Fixture	Fixture	$0.00	$126.66	$0.00	$100.51	$227.17
D03-847	175W PS Metal Halide	Fixture	Fixture	$0.00	$129.01	$0.00	$67.84	$196.86
D03-848	175W PS Metal Halide	Fixture	Fixture	$0.00	$129.01	$0.00	$67.84	$196.86
D03-849	250W PS Metal Halide	Fixture	Fixture	$0.00	$152.08	$0.00	$67.84	$219.92
D03-850	200W HPS	Fixture	Fixture	$0.00	$91.05	$0.00	$67.84	$158.89
D03-851	180W LPS	Fixture	Fixture	$0.00	$74.62	$0.00	$67.84	$142.46
D03-852	Premium T8 El Ballast	Fixture	Fixture	$19.23	$23.42	$4.19	$0.00	$0.00
D03-853	T8 32W Dimming El Ballast	Fixture	Fixture	$16.54	$72.89	$56.34	$16.96	$89.85
D03-854	De-lamp from 4', 4 lamp/fixture	Fixture	Fixture	$0.00	$3.08	$0.00	$22.63	$25.71
D03-855	De-lamp from 8', 4 lamp/fixture	Fixture	Fixture	$0.00	$3.28	$0.00	$22.63	$25.91
D03-856	Occ-Sensor - Wall box	Sensor	Sensor	$0.00	$42.28	$0.00	$35.00	$77.28
D03-857	Occ-Sensor - Plug loads	Sensor	Sensor	$0.00	$82.25	$0.00	$35.00	$117.25
D03-858	Timeclock:	Timeclock	Timeclock	$0.00	$123.01	$0.00	$116.88	$239.89
D03-859	Photocell:	Photocell	Photocell	$0.00	$12.06	$0.00	$47.75	$59.81
D03-860	LED Exit Sign (New)	Exit Sign	Sign	$0.00	$31.52	$0.00	$33.92	$65.44
D03-861	LED Exit Sign Retrofit Kit	Exit Sign	Sign	$0.00	$16.66	$0.00	$33.92	$50.58
D03-862	Electroluminescent Exit Sign (New)	Exit Sign	Sign	$0.00	$73.42	$0.00	$33.92	$107.34
D03-863	Electroluminescent Exit Sign Retrofit Kit	Exit Sign	Sign	$0.00	$70.14	$0.00	$33.92	$104.06
D03-901	High Efficiency Copier	Copy Machine	copier	$1,616.38	$1,773.14	$156.76	$0.00	$0.00
D03-902	High Efficiency Copier	Copy Machine	copier	$4,686.00	$7,654.69	$2,968.69	$0.00	$0.00
D03-903	High Efficiency Copier	Copy Machine	copier	$0.00	$10,924.63	$0.00	$0.00	$0.00
D03-904	High Efficiency Gas Fryer	Fryer	Fryer	$1,520.61	$4,103.15	$2,582.54	$0.00	$0.00
D03-905	High Efficiency Gas Griddle	Griddle	Griddle	$1,758.36	$3,860.67	$2,102.31	$0.00	$0.00
D03-906	High Efficiency Electric Fryer	Fryer	Fryer	$3,326.73	$12,088.62	$8,761.89	$0.00	$0.00
D03-907	Hot Food Holding Cabinet	Cabinet	Cabinet	$1,545.67	$2,589.81	$1,044.13	$0.00	$0.00
D03-908	Connectionless Steamer	Steamer	Steamer	$5,128.24	$3,206.64	-$1,921.61	$0.00	$0.00
D03-909	Point of Use Water Heat	1000 sqft building	WtrHtr	$492.96	$863.60	$370.64	$250.90	$1,114.50

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Attachments

Attachment 1. Integral Screw-In Residential Compact Fluorescent Worksheet.

WPSCRELG0017.1 Summary.xls

References

Work Paper WPSCRELG0022
Revision 0

Southern California Edison Company
Design & Engineering Services

Integral (Screw-In) Compact Fluorescent Lamp (CFL) – Non-Residential

At a Glance Summary

Measure Description	Screw-in Compact Fluorescent Lamps Nonresidential , upstream
Savings Impacts Common Units	kWh/unit
Customer Base Case Description	Incandescent Lamp
Code Base Case Description	Screw-in Compact Fluorescent Lamp
Costs Common Units	Lamp
Measure Equipment Cost ($/unit)	Various – See table below
Measure Incremental Cost ($/unit)	Various – See table below
Measure Installed Cost ($/unit)	Various – Same as Equipment Cost
Measure Load Shape	Indoor Lt
Effective Useful Life (years)	2.1 years
Program Type:	Replace on Burnout (ROB)
TOU AC Adjustment	0%
Net-to-Gross Ratio	75% (Subject to completion of the study referenced in this work paper and in accordance with any direction provided by the Commission in the final decision on energy efficiency incentives)
Building Type	Miscellaneous Commercial
Building Vintage	All
Climate Zone	All
Important Comments	Values in the "At a Glance Summary" table below are rounded representations of full decimal values. The full values will be used when calculating program results for reporting purposes.

Work Paper RunID: WPSCRELG0022.0-	Measure Name	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)	Measure Equipment Cost ($/unit)	Measure Incremental Cost ($/unit)
001	Screw-in CFL 5 Watt <450 Lumens (Nonres.)	59.4	0.015	59.4	0.015	$4.98	$4.40
002	Screw-in CFL 7 Watt 450 to 799 Lumens (Nonres.)	97.9	0.024	97.9	0.024	$4.98	$4.40
003	Screw-in CFL 9 Watt 450 to 799 Lumens (Nonres.)	92.0	0.023	92.0	0.023	$4.98	$4.40
004	Screw-in CFL 10 Watt <450 Lumens (Nonres.)	44.5	0.011	44.5	0.011	$4.98	$4.40
005	Screw-in CFL 10 Watt 450 to 799 Lumens (Nonres.)	89.0	0.022	89.0	0.022	$4.98	$4.40
006	Screw-in CFL 10 Watt 800 to 1,099 Lumens (Nonres.)	148.4	0.036	148.4	0.036	$4.87	$4.26
007	Screw-in CFL 11 Watt <450 Lumens (Nonres.)	41.6	0.010	41.6	0.010	$4.98	$4.40
008	Screw-in CFL 11 Watt 450 to 799 Lumens (Nonres.)	86.1	0.021	86.1	0.021	$4.98	$4.40
009	Screw-in CFL 11 Watt 800 to 1,099 Lumens (Nonres.)	145.4	0.036	145.4	0.036	$4.87	$4.26
010	Screw-in CFL 12 Watt <450 Lumens (Nonres.)	38.6	0.009	38.6	0.009	$4.98	$4.40
011	Screw-in CFL 12 Watt 450 to 799 Lumens (Nonres.)	83.1	0.020	83.1	0.020	$4.98	$4.40
012	Screw-in CFL 12 Watt 800 to 1,099 Lumens (Nonres.)	142.5	0.035	142.5	0.035	$4.87	$4.26
013	Screw-in CFL 13 Watt <450 Lumens (Nonres.)	35.6	0.009	35.6	0.009	$4.98	$4.40
014	Screw-in CFL 13 Watt 450 to 799 Lumens (Nonres.)	80.1	0.020	80.1	0.020	$4.98	$4.40
015	Screw-in CFL 13 Watt 800 to 1,099 Lumens (Nonres.)	139.5	0.034	139.5	0.034	$4.87	$4.26
016	Screw-in CFL 14 Watt 450 to 799 Lumens (Nonres.)	77.2	0.019	77.2	0.019	$5.25	$4.64

Work Paper RunID: WPSCRELG0022.0-	Measure Name	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)	Measure Equipment Cost ($/unit)	Measure Incremental Cost ($/unit)
017	Screw-in CFL 14 Watt 800 to 1,099 Lumens (Nonres.)	136.5	0.033	136.5	0.033	$5.25	$4.64
018	Screw-in CFL 15 Watt 450 to 799 Lumens (Nonres.)	74.2	0.018	74.2	0.018	$5.62	$5.01
019	Screw-in CFL 15 Watt 800 to 1,099 Lumens (Nonres.)	133.6	0.033	133.6	0.033	$5.62	$5.01
020	Screw-in CFL 15 Watt 1,100 to 1,399 Lumens (Nonres.)	178.1	0.044	178.1	0.044	$5.62	$5.01
021	Screw-in CFL 16 Watt 800 to 1,099 Lumens (Nonres.)	130.6	0.032	130.6	0.032	$6.00	$5.39
022	Screw-in CFL 16 Watt 1,100 to 1,399 Lumens (Nonres.)	175.1	0.043	175.1	0.043	$6.00	$5.39
023	Screw-in CFL 17 Watt 450 to 799 Lumens (Nonres.)	68.3	0.017	68.3	0.017	$6.74	$6.14
024	Screw-in CFL 17 Watt 800 to 1,099 Lumens (Nonres.)	127.6	0.031	127.6	0.031	$6.74	$6.14
025	Screw-in CFL 17 Watt 1,100 to 1,399 Lumens (Nonres.)	172.1	0.042	172.1	0.042	$6.37	$6.14
026	Screw-in CFL 18 Watt 450 to 799 Lumens (Nonres.)	65.3	0.016	65.3	0.016	$6.74	$6.14
027	Screw-in CFL 18 Watt 800 to 1,099 Lumens (Nonres.)	124.7	0.031	124.7	0.031	$6.74	$6.14
028	Screw-in CFL 18 Watt 1,100 to 1,399 Lumens (Nonres.)	169.2	0.041	169.2	0.041	$6.37	$5.77
029	Screw-in CFL 19 Watt 450 to 799 Lumens (Nonres.)	62.3	0.015	62.3	0.015	$6.73	$6.12
030	Screw-in CFL 19 Watt 800 to 1,099 Lumens (Nonres.)	121.7	0.030	121.7	0.030	$6.73	$6.12
031	Screw-in CFL 19 Watt 1,100 to 1,399 Lumens (Nonres.)	166.2	0.041	166.2	0.041	$6.73	$6.12
032	Screw-in CFL 20 Watt 800 to 1,099 Lumens	118.7	0.029	118.7	0.029	$7.08	$6.47

Work Paper RunID: WPSCRELG0022.0-	Measure Name	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)	Measure Equipment Cost ($/unit)	Measure Incremental Cost ($/unit)
	(Nonres.)						
033	Screw-in CFL 20 Watt 1,100 to 1,399 Lumens (Nonres.)	163.2	0.040	163.2	0.040	$7.08	$6.47
034	Screw-in CFL 21 Watt 800 to 1,099 Lumens (Nonres.)	115.7	0.028	115.7	0.028	$6.66	$6.05
035	Screw-in CFL 21 Watt 1,100 to 1,399 Lumens (Nonres.)	160.3	0.039	160.3	0.039	$6.66	$6.05
036	Screw-in CFL 22 Watt 800 to 1,099 Lumens (Nonres.)	112.8	0.028	112.8	0.028	$6.66	$6.05
037	Screw-in CFL 22 Watt 1,100 to 1,399 Lumens (Nonres.)	157.3	0.039	157.3	0.039	$6.66	$6.05
038	Screw-in CFL 23 Watt 800 to 1,099 Lumens (Nonres.)	109.8	0.027	109.8	0.027	$6.66	$6.05
039	Screw-in CFL 23 Watt 1,100 to 1,399 Lumens (Nonres.)	154.3	0.038	154.3	0.038	$6.66	$6.05
040	Screw-in CFL 23 Watt 1,400 to 1,599 Lumens (Nonres.)	198.9	0.049	198.9	0.049	$6.66	$6.05
041	Screw-in CFL 23 Watt 1,600 to 1,999 Lumens (Nonres.)	228.5	0.056	228.5	0.056	$6.66	$6.05
042	Screw-in CFL 24 Watt 800 to 1,099 Lumens (Nonres.)	106.8	0.026	106.8	0.026	$8.85	$6.63
043	Screw-in CFL 24 Watt 1,100 to 1,399 Lumens (Nonres.)	151.4	0.037	151.4	0.037	$7.24	$6.63
044	Screw-in CFL 24 Watt 1,400 to 1,599 Lumens (Nonres.)	195.9	0.048	195.9	0.048	$7.24	$6.63
045	Screw-in CFL 24 Watt 1,600 to 1,999 Lumens (Nonres.)	225.6	0.055	225.6	0.055	$7.24	$6.63
046	Screw-in CFL 25 Watt 800 to 1,099 Lumens (Nonres.)	103.9	0.025	103.9	0.025	$8.85	$6.63
047	Screw-in CFL 25 Watt 1,100 to 1,399 Lumens (Nonres.)	148.4	0.036	148.4	0.036	$7.24	$6.63

Work Paper RunID: WPSCRELG0022.0-	Measure Name	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)	Measure Equipment Cost ($/unit)	Measure Incremental Cost ($/unit)
048	Screw-in CFL 25 Watt 1,400 to 1,599 Lumens (Nonres.)	192.9	0.047	192.9	0.047	$7.24	$6.63
049	Screw-in CFL 25 Watt 1,600 to 1,999 Lumens (Nonres.)	222.6	0.055	222.6	0.055	$7.24	$6.63
050	Screw-in CFL 26 Watt 800 to 1,099 Lumens (Nonres.)	100.9	0.025	100.9	0.025	$9.21	$6.92
051	Screw-in CFL 26 Watt 1,100 to 1,399 Lumens (Nonres.)	145.4	0.036	145.4	0.036	$7.52	$6.92
052	Screw-in CFL 26 Watt 1,400 to 1,599 Lumens (Nonres.)	189.9	0.047	189.9	0.047	$7.52	$6.92
053	Screw-in CFL 26 Watt 1,600 to 1,999 Lumens (Nonres.)	219.6	0.054	219.6	0.054	$7.52	$6.92
054	Screw-in CFL 27 Watt 800 to 1,099 Lumens (Nonres.)	97.9	0.024	97.9	0.024	$8.10	$7.50
055	Screw-in CFL 27 Watt 1,100 to 1,399 Lumens (Nonres.)	142.5	0.035	142.5	0.035	$8.10	$7.50
056	Screw-in CFL 27 Watt 1,400 to 1,599 Lumens (Nonres.)	187.0	0.046	187.0	0.046	$8.10	$7.50
057	Screw-in CFL 27 Watt 1,600 to 1,999 Lumens (Nonres.)	216.7	0.053	216.7	0.053	$8.10	$7.50
058	Screw-in CFL 28 Watt 1,100 to 1,399 Lumens (Nonres.)	139.5	0.034	139.5	0.034	$8.10	$7.50
059	Screw-in CFL 28 Watt 1,400 to 1,599 Lumens (Nonres.)	184.0	0.045	184.0	0.045	$8.10	$7.50
060	Screw-in CFL 28 Watt 1,600 to 1,999 Lumens (Nonres.)	213.7	0.052	213.7	0.052	$8.10	$7.50
061	Screw-in CFL 29 Watt 1,100 to 1,399 Lumens (Nonres.)	136.5	0.033	136.5	0.033	$9.26	$8.65
062	Screw-in CFL 29 Watt 1,400 to 1,599 Lumens (Nonres.)	181.0	0.044	181.0	0.044	$9.26	$8.65
063	Screw-in CFL 29 Watt 1,600 to 1,999 Lumens	210.7	0.052	210.7	0.052	$9.26	$8.65

Work Paper RunID: WPSCRELG0022.0-	Measure Name	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)	Measure Equipment Cost ($/unit)	Measure Incremental Cost ($/unit)
	(Nonres.)						
064	Screw-in CFL 30 Watt 1,100 to 1,399 Lumens (Nonres.)	133.6	0.033	133.6	0.033	$9.26	$8.65
065	Screw-in CFL 30 Watt 1,400 to 1,599 Lumens (Nonres.)	178.1	0.044	178.1	0.044	$9.26	$8.65
066	Screw-in CFL 30 Watt 1,600 to 1,999 Lumens (Nonres.)	207.8	0.051	207.8	0.051	$9.26	$8.65
067	Screw-in CFL 30 Watt 2,000 to 2,599 Lumens (Nonres.)	267.1	0.065	267.1	0.065	$9.26	$8.65
068	Screw-in CFL 31 Watt 1,100 to 1,399 Lumens (Nonres.)	130.6	0.032	130.6	0.032	$9.19	$6.97
069	Screw-in CFL 31 Watt 1,400 to 1,599 Lumens (Nonres.)	175.1	0.043	175.1	0.043	$9.19	$6.97
070	Screw-in CFL 31 Watt 1,600 to 1,999 Lumens (Nonres.)	204.8	0.050	204.8	0.050	$9.19	$6.97
071	Screw-in CFL 32 Watt 1,100 to 1,399 Lumens (Nonres.)	127.6	0.031	127.6	0.031	$9.19	$6.97
072	Screw-in CFL 32 Watt 1,400 to 1,599 Lumens (Nonres.)	172.1	0.042	172.1	0.042	$9.19	$6.97
073	Screw-in CFL 32 Watt 1,600 to 1,999 Lumens (Nonres.)	201.8	0.049	201.8	0.049	$9.19	$6.97
074	Screw-in CFL 33 Watt 1,100 to 1,399 Lumens (Nonres.)	124.7	0.031	124.7	0.031	$9.19	$6.97
075	Screw-in CFL 33 Watt 1,400 to 1,599 Lumens (Nonres.)	169.2	0.041	169.2	0.041	$9.19	$6.97
076	Screw-in CFL 33 Watt 1,600 to 1,999 Lumens (Nonres.)	198.9	0.049	198.9	0.049	$9.19	$6.97
077	Screw-in CFL 34 Watt 1,100 to 1,399 Lumens (Nonres.)	121.7	0.030	121.7	0.030	$9.19	$6.97
078	Screw-in CFL 34 Watt 1,400 to 1,599 Lumens (Nonres.)	166.2	0.041	166.2	0.041	$9.19	$6.97

Work Paper RunID: WPSCRELG0022.0-	Measure Name	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)	Measure Equipment Cost ($/unit)	Measure Incremental Cost ($/unit)
079	Screw-in CFL 34 Watt 1,600 to 1,999 Lumens (Nonres.)	195.9	0.048	195.9	0.048	$9.19	$6.97
080	Screw-in CFL 35 Watt 1,400 to 1,599 Lumens (Nonres.)	163.2	0.040	163.2	0.040	$9.19	$6.97
081	Screw-in CFL 35 Watt 1,600 to 1,999 Lumens (Nonres.)	192.9	0.047	192.9	0.047	$9.19	$6.97
082	Screw-in CFL 35 Watt 2,000 to 2,599 Lumens (Nonres.)	252.3	0.062	252.3	0.062	$9.19	$6.97
083	Screw-in CFL 36 Watt 1,400 to 1,599 Lumens (Nonres.)	160.3	0.039	160.3	0.039	$9.19	$6.97
084	Screw-in CFL 36 Watt 1,600 to 1,999 Lumens (Nonres.)	189.9	0.047	189.9	0.047	$9.19	$6.97
085	Screw-in CFL 36 Watt 2,000 to 2,599 Lumens (Nonres.)	249.3	0.061	249.3	0.061	$9.19	$6.97
086	Screw-in CFL 37 Watt 1,400 to 1,599 Lumens (Nonres.)	157.3	0.039	157.3	0.039	$12.77	$10.55
087	Screw-in CFL 37 Watt 1,600 to 1,999 Lumens (Nonres.)	187.0	0.046	187.0	0.046	$12.77	$10.55
088	Screw-in CFL 37 Watt 2,000 to 2,599 Lumens (Nonres.)	246.3	0.060	246.3	0.060	$12.77	$10.55
089	Screw-in CFL 38 Watt 1,400 to 1,599 Lumens (Nonres.)	154.3	0.038	154.3	0.038	$12.77	$10.55
090	Screw-in CFL 38 Watt 1,600 to 1,999 Lumens (Nonres.)	184.0	0.045	184.0	0.045	$12.77	$10.55
091	Screw-in CFL 38 Watt 2,000 to 2,599 Lumens (Nonres.)	243.4	0.060	243.4	0.060	$12.77	$10.55
092	Screw-in CFL 38 Watt 2,600 to 3,599 Lumens (Nonres.)	332.4	0.081	332.4	0.081	$12.77	$10.55
093	Screw-in CFL 39 Watt 1,400 to 1,599 Lumens (Nonres.)	151.4	0.037	151.4	0.037	$12.77	$10.55
094	Screw-in CFL 39 Watt 1,600 to 1,999 Lumens	181.0	0.044	181.0	0.044	$12.77	$10.55

Work Paper RunID: WPSCRELG0022.0-	Measure Name	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)	Measure Equipment Cost ($/unit)	Measure Incremental Cost ($/unit)
	(Nonres.)						
095	Screw-in CFL 39 Watt 2,000 to 2,599 Lumens (Nonres.)	240.4	0.059	240.4	0.059	$12.77	$10.55
096	Screw-in CFL 39 Watt 2,600 to 3,599 Lumens (Nonres.)	329.4	0.081	329.4	0.081	$12.77	$10.55
097	Screw-in CFL 40 Watt 1,600 to 1,999 Lumens (Nonres.)	178.1	0.044	178.1	0.044	$12.77	$10.55
098	Screw-in CFL 40 Watt 2,000 to 2,599 Lumens (Nonres.)	237.4	0.058	237.4	0.058	$12.77	$10.55
099	Screw-in CFL 40 Watt 2,600 to 3,599 Lumens (Nonres.)	326.5	0.080	326.5	0.080	$12.77	$10.55
100	Screw-in CFL 41 Watt 1,600 to 1,999 Lumens (Nonres.)	175.1	0.043	175.1	0.043	$12.77	$10.55
101	Screw-in CFL 41 Watt 2,000 to 2,599 Lumens (Nonres.)	234.5	0.057	234.5	0.057	$12.77	$10.55
102	Screw-in CFL 41 Watt 2,600 to 3,599 Lumens (Nonres.)	323.5	0.079	323.5	0.079	$12.77	$10.55
103	Screw-in CFL 42 Watt 1,600 to 1,999 Lumens (Nonres.)	172.1	0.042	172.1	0.042	$12.77	$10.55
104	Screw-in CFL 42 Watt 2,000 to 2,599 Lumens (Nonres.)	231.5	0.057	231.5	0.057	$12.77	$10.55
105	Screw-in CFL 42 Watt 2,600 to 3,599 Lumens (Nonres.)	320.5	0.078	320.5	0.078	$12.77	$10.55
106	Screw-in CFL 43 Watt 1,600 to 1,999 Lumens (Nonres.)	169.2	0.041	169.2	0.041	$12.77	$10.55
107	Screw-in CFL 43 Watt 2,000 to 2,599 Lumens (Nonres.)	228.5	0.056	228.5	0.056	$12.77	$10.55
108	Screw-in CFL 43 Watt 2,600 to 3,599 Lumens (Nonres.)	317.6	0.078	317.6	0.078	$12.77	$10.55
109	Screw-in CFL 44 Watt 1,600 to 1,999 Lumens (Nonres.)	166.2	0.041	166.2	0.041	$12.77	$10.55

Work Paper RunID: WPSCRELG0022.0-	Measure Name	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)	Measure Equipment Cost ($/unit)	Measure Incremental Cost ($/unit)
110	Screw-in CFL 44 Watt 2,000 to 2,599 Lumens (Nonres.)	225.6	0.055	225.6	0.055	$12.77	$10.55
111	Screw-in CFL 44 Watt 2,600 to 3,599 Lumens (Nonres.)	314.6	0.077	314.6	0.077	$12.77	$10.55
112	Screw-in CFL 45 Watt 1,600 to 1,999 Lumens (Nonres.)	163.2	0.040	163.2	0.040	$12.77	$10.55
113	Screw-in CFL 45 Watt 2,000 to 2,599 Lumens (Nonres.)	222.6	0.055	222.6	0.055	$12.77	$10.55
114	Screw-in CFL 45 Watt 2,600 to 3,599 Lumens (Nonres.)	311.6	0.076	311.6	0.076	$12.77	$10.55
115	Screw-in CFL 46 Watt 1,600 to 1,999 Lumens (Nonres.)	160.3	0.039	160.3	0.039	$12.77	$10.55
116	Screw-in CFL 46 Watt 2,000 to 2,599 Lumens (Nonres.)	219.6	0.054	219.6	0.054	$12.77	$10.55
117	Screw-in CFL 46 Watt 2,600 to 3,599 Lumens (Nonres.)	308.7	0.076	308.7	0.076	$12.77	$10.55
118	Screw-in CFL 47 Watt 1,600 to 1,999 Lumens (Nonres.)	157.3	0.039	157.3	0.039	$12.77	$10.55
119	Screw-in CFL 47 Watt 2,000 to 2,599 Lumens (Nonres.)	216.7	0.053	216.7	0.053	$12.77	$10.55
120	Screw-in CFL 47 Watt 2,600 to 3,599 Lumens (Nonres.)	305.7	0.075	305.7	0.075	$12.77	$10.55
121	Screw-in CFL 48 Watt 1,600 to 1,999 Lumens (Nonres.)	154.3	0.038	154.3	0.038	$12.77	$10.55
122	Screw-in CFL 48 Watt 2,000 to 2,599 Lumens (Nonres.)	213.7	0.052	213.7	0.052	$12.77	$10.55
123	Screw-in CFL 48 Watt 2,600 to 3,599 Lumens (Nonres.)	302.7	0.074	302.7	0.074	$12.77	$10.55
124	Screw-in CFL 49 Watt 1,600 to 1,999 Lumens (Nonres.)	151.4	0.037	151.4	0.037	$12.77	$10.55
125	Screw-in CFL 49 Watt 2,000 to 2,599 Lumens	210.7	0.052	210.7	0.052	$12.77	$10.55

Work Paper RunID: WPSCRELG0022.0-	Measure Name	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)	Measure Equipment Cost ($/unit)	Measure Incremental Cost ($/unit)
	(Nonres.)						
126	Screw-in CFL 49 Watt 2,600 to 3,599 Lumens (Nonres.)	299.8	0.073	299.8	0.073	$12.77	$10.55
127	Screw-in CFL 50 Watt 2,000 to 2,599 Lumens (Nonres.)	207.8	0.051	207.8	0.051	$12.77	$10.55
128	Screw-in CFL 50 Watt 2,600 to 3,599 Lumens (Nonres.)	296.8	0.073	296.8	0.073	$12.77	$10.55
129	Screw-in CFL 50 Watt 3,600 to 4,599 Lumens (Nonres.)	445.2	0.109	445.2	0.109	$12.77	$10.55
130	Screw-in CFL 51 Watt 2,000 to 2,599 Lumens (Nonres.)	204.8	0.050	204.8	0.050	$12.77	$10.55
131	Screw-in CFL 51 Watt 2,600 to 3,599 Lumens (Nonres.)	293.8	0.072	293.8	0.072	$12.77	$10.55
132	Screw-in CFL 51 Watt 3,600 to 4,599 Lumens (Nonres.)	442.2	0.108	442.2	0.108	$12.77	$10.55
133	Screw-in CFL 52 Watt 2,000 to 2,599 Lumens (Nonres.)	201.8	0.049	201.8	0.049	$12.77	$10.55
134	Screw-in CFL 52 Watt 2,600 to 3,599 Lumens (Nonres.)	290.9	0.071	290.9	0.071	$12.77	$10.55
135	Screw-in CFL 52 Watt 3,600 to 4,599 Lumens (Nonres.)	439.3	0.108	439.3	0.108	$12.77	$10.55
136	Screw-in CFL 53 Watt 2,000 to 2,599 Lumens (Nonres.)	198.9	0.049	198.9	0.049	$12.77	$10.55
137	Screw-in CFL 53 Watt 2,600 to 3,599 Lumens (Nonres.)	287.9	0.070	287.9	0.070	$12.77	$10.55
138	Screw-in CFL 53 Watt 3,600 to 4,599 Lumens (Nonres.)	436.3	0.107	436.3	0.107	$12.77	$10.55
139	Screw-in CFL 54 Watt 2,000 to 2,599 Lumens (Nonres.)	195.9	0.048	195.9	0.048	$12.77	$10.55
140	Screw-in CFL 54 Watt 2,600 to 3,599 Lumens (Nonres.)	284.9	0.070	284.9	0.070	$12.77	$10.55

Work Paper RunID: WPSCRELG0022.0-	Measure Name	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)	Measure Equipment Cost ($/unit)	Measure Incremental Cost ($/unit)
141	Screw-in CFL 54 Watt 3,600 to 4,599 Lumens (Nonres.)	433.3	0.106	433.3	0.106	$12.77	$10.55
142	Screw-in CFL 55 Watt 2,000 to 2,599 Lumens (Nonres.)	192.9	0.047	192.9	0.047	$12.77	$10.55
143	Screw-in CFL 55 Watt 2,600 to 3,599 Lumens (Nonres.)	282.0	0.069	282.0	0.069	$12.77	$10.55
144	Screw-in CFL 55 Watt 3,600 to 4,599 Lumens (Nonres.)	430.3	0.105	430.3	0.105	$12.77	$10.55

Document Revision History

Revision 0	September 2007	• Split original work paper short form WPSCRELG0017.0 into CFL groups • Expanded to final WP template format • Measure equipment costs added • Net to Gross Ration Reduced from 80% to 75% (Subject to completion of the study referenced in this work paper and in accordance with any direction provided by the Commission in the final decision on energy efficiency incentives) • In Service Rate Changed from 90% to 92%

Note: The information provided in this work paper was developed using the best available technical resources at the time this document was prepared.

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Section 1. General Measure and Baseline Data

1.1 Measure Description and Background

A compact fluorescent lamp (CFL) consists of two main parts: a gas-filled tube and an electronic ballast. Electric current flows from the ballast through the gas, causing it to emit ultraviolet light. The ultraviolet light then excites a white phosphor coating on the inside of the tube, making it emit visible light. This measure replaces incandescent lamps. An incandescent lamp is also a source of artificial light that works through a different process known as incandescence. In the incandescent process an electrical current passes through a thin filament, heating it and causing it to become excited and release photons.

The fluorescent process is approximately four times more efficient at converting electricity into light. Modern CFLs typically have a life span of between 6,000 and 15,000 hours. CFL wattages covered by this work paper range in values from 5 watts through 55 watts with lumen rages from under 450 lumens through 4,599 lumens replacing incandescent lamps with wattages that range from under 24 watts through 500 watts with matching lumen rages.

The measures discussed in this work paper are integral (screw-in) compact fluorescent lamps.

1.2 DEER Differences Analysis

The Non-Residential Sector Non-Weather Sensitive section (Section 3) of the *2004-2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report*, *December 2005(Itron, 2005)*[16]contains the DEER methodology for calculating energy savings for screw-in compact fluorescent lamps (CFL) measures. A lumen equivalency table is also presented for compact fluorescent lamps (CFLs) that range from less than 13 watts through 40 watts that are mapped to incandescent wattages that range from a 40 Watt incandescent lamp through a 150 Watt incandescent lamp. The report does not present tables with a complete set of lighting savings estimates for all of the market sectors but, instead, explains their methodology, presents examples, and includes a table that contains interior lighting savings estimates for the primary school market sector under program delivery methods.

Two methodologies for calculating demand savings are presented in this section of the DEER report. A methodology for Standard Performance Contracts (SPC) which are considered to have strict measure verification requirements and second methodology for Express Efficiency which is considered to have limited or no measure verification requirements. The significant difference between the two methodologies is the inclusion of an installation rate adjustment factor in the Express Efficiency algorithm. The Express Efficiency methodology, which includes a downward adjustment factor installation rate, is used for the measures covered by this work paper and is discussed in greater detail in the following sections on demand and energy savings.

Demand Savings: The methodology presented in the DEER Report for the calculation of demand saving is based on several factors that include the calculation of wattage reductions resulting from replacing a base technology (incandescent lamp), matching the lumen output of the base technologies with the lumen output of a CFL measures, calculating the delta watts, then multiplying the result by an Installation Rate (the equivalent of an In Service Rate in the residential calculation) and Peak Coincidence Factor (the equivalent of a Peak Hour Load Share in the residential calculation) and applying an interactive effect[17] (Demand Interactive Effect from Table 3-2)[18].

$$\textbf{Demand Savings}\left[\frac{Watts}{unit}\right] = (\Delta Watts\ /\ unit) \times (Installation\ Rate) \times (Peak\ Coincidence\ Factor) \times (Interactive\ Effects)$$

Below is an example calculation done for a 14W CFL screw-in lamp replacing a 60W incandescent base lamp.

Energy savings are calculated in DEER following a simple formula that captures wattage level changes, hours of daily use, and estimates of lamp installation rate identified as an In Service Rate.

$$\textbf{Energy Savings}\left[\frac{kWh}{unit \cdot year}\right] = \frac{(\Delta Watts\ /\ unit) \times (annual\ hours\ of\ use) \times (Installation\ Rate) \times (Interactive\ Effects)}{1{,}000\ Watt\ hours\ /\ kWh}$$

As presented in greater detail in Section 2 of this work paper, the methodology used to calculate energy and demand saving are the same as those used in the DEER Report subject to the modification discussed below.

Interactive effects: When more efficient light sources are installed, the wattage of new lamps is lower. This lower wattage produces less heat. The lower heat emissions result in cooler air and reduced air conditioning requirements. The purpose of including demand- and energy-interactive effects in the DEER calculation algorithm is to a capture the energy and demand reductions from the avoided air conditioning load resulting from the reduction of internal heat gains produced by the more efficient lighting sources. The impact of accounting for these interactive effects is to increase calculated energy and demand savings by as much as 26% in some market types, based on the tables in the DEER Report. However, SCE is concerned that the interactive effects used in the DEER Report are not appropriate for these measures for the following reasons. The DEER interactive factors do not vary by climate zone and are not scalable to account for differences in air conditioning systems and operational differences. It is unclear if the interactive factor appropriately accounts for increases in heating requirements (including fan loads) which may offset some of these savings. It is also unclear if the interactive effects presented in DEER are appropriate for the small businesses that tend to participate in this type of program. Program participants tend to be small businesses, which may not use air conditioning to the extent necessary to produce the interactive effects that are presented in the DEER Report. It should be noted that the interactive effects presented in the DEER Report are the same for large customer types and small customer types. Due to these concerns, SCE does not use interactive effects in the calculation of energy and demand savings for the measures in this work paper.

Effective Useful Life: The Effective Useful Life (EUL) used for the measures in this work paper is based on the EUL for Small Retail from *Table 11-4: Non-Weather Sensitive – Lighting EULs* of the DEER Report[19]. This is a deviation from the methodology used for calculating the annual hours of operation and coincidence factors discussed above. This deviation is due to recent concern over the true operating hours of CFL that are being purchased under this program that could impact the calculation of effective useful lives dictating a more conservative approach. Therefore, instead of using an EUL of 2.5 years based on the average EUL of the market sectors participating in the program [small retail, small office, and sit down restaurants], SCE uses an **EUL of 2.1 years**, which is the lowest effective useful life of these three market sectors, when calculating the energy and demand impact for the measures in this program.

Installation Rate: For the measures in this work paper as explained below in Section 1.4 on EM&V Market Potential, Edison has determined that the DEER installation Rate of 92% (0.92) that is used for Express Efficiency type programs that have limited or no measure verification requirements is more appropriate for these measures.

1.3 Codes and Standards Requirements Analysis

There are currently no known codes or standards applicable to this measure.

1.4 EM&V, Market Potential, and Other Studies

Although not directly applicable for nonresidential upstream lighting, the *2004/2005 Statewide Residential Retrofit Single-Family Energy Efficiency Rebate Evaluation* (Itron 2007)[20] examines the upstream lighting program through which bulbs are rebated. Sections 5 & 6 of this study provide an updated analysis of the upstream CFL program covered by this work paper. Itron gathered general energy efficiency data from a telephone survey (n=4,718), with a portion being asked in-depth questions about residential lighting (n=1000), an on-site inspection (n=100) and surveys of manufacturers and retailers.

Delta Wattage Assumption (ΔW): The Itron 2007 study developed ΔkW assumptions based on lumens using data from the on-site inspections[1]. Rather than determining a base wattage from which to calculate the ΔkW for each bulb, they calculated an average ΔkW for various lumen ranges. That is, a 13W and a 14W CFL of the same luminosity would be assumed to have the same average ΔkW. Unfortunately, lamps with output of 1,100 to 2,599 lumens were considered as one category, even though that range includes the lumen output of 75W, 100W, and 150W incandescent bulbs replacements. The study results were used, together with the number of non specialty CFLs from each lumen category sold under the 2006 SCE Residential Upstream Lighting Program to determine a base-wattage assumption. The ΔW assumptions were drawn from the study. Using program data, the wattages of all the bulbs in each lumen category were summed to find the average wattage of CFLs in that category. The average wattage was added to the ΔW to find a base wattage for each lumen category as shown in the Equation 1.

[Equation 1]

$$\overline{\Delta W} = \frac{\Sigma(W_{base} - W_{new})}{n} \rightarrow \overline{W_{base}} = \frac{\Sigma W_{new}}{n} + \overline{\Delta W} = \overline{W_{new}} + \overline{\Delta W}$$

In addition, the same calculations were done for all of the bulbs in the 1100-2599 lumen range, using weighted averages based on the number of bulbs that were sold under the 2006 program in each category. The results are contained in Table 11:

Table 11. Base Wattage Assumptions

Lumen Range	SCE Base Wattage (Energy Star)	Average CFL Wattage (SCE 2006 Program)	SCE Average Delta W	SFEER Delta W	Inferred Base Wattage
0-799	40	9.0	31.0	46.8	55.8

800-1099	60	13.8	46.2	51.3	65.1
1100-1599	75	19.2	55.8	68.5	87.7
1600-2000	100	23.9	76.1	68.5	92.4
2000-2599	150	30.0	120.0	68.5	98.5
1100-2599	96.6	23.2	73.4	68.5	91.7

*This category is based on weighted averages for the three smaller categories

In each case the ENERGY STAR® wattage equivalence used in the DEER report and the program assumptions is more conservative, except for the 1600-1999 and 2000-2599 lumen range. This is most likely due to the fact that such a large lumen range was used. For the grouped 1100-2599 lumen category, the difference between the effective SCE base wattage and the inferred base wattage based on SFEER is 5.3%, well within an expected 10% error bound on the SFEER estimate. This exercise was only meant to demonstrate that the program assumptions, based on ENERGY STAR®, are reasonable and somewhat conservative. The survey relied on self-reported data about what light bulb had preceded an existing light bulb, which may not be highly reliable data. This exercise is not meant to support an increase in the base wattage assumption. We recommend maintaining the DEER equivalence over the Itron finding because it is more conservative and more specific to the lumen range of a bulb.

Net-to-Gross Assumption: To determine the Net-To-Gross (NTG) ratio, the study relied on surveys of retailers and manufacturers. This was due to the fact that in the telephone survey only 24% of respondents who had purchased CFLs during the program were aware they had received a discount, and so direct self-report data were scarce. This is a characteristic nature of upstream programs where it is difficult to adopt standard end-use-based survey methodologies for determining a net-to-gross ratio. Hence, in the surveys of retailers and manufacturers, the study asked respondents to estimate free-ridership based on their sales data for various retail channels. Although the number of respondents was very small in many cases, we accept this because the respondents represented a large portion of the sales volume in that retail channel. The study found distinct free-ridership rates for different retail channels, and then calculated a weighted average of these based on rebated sales volume during 2004-05. The overall free-ridership for SCE was calculated to be 33%, yielding a .67 NTG for 2004-05. Of the 24% of those surveyed who remembered receiving a discount, 63% were somewhat likely, not very likely, or very unlikely to purchase a CFL in the absence of the discount, and thus demonstrated some influence by the program[21]. This value is close to the value determined by the retailer and manufacturer survey data and we deem that the two different methodologies corroborate one another. Because the study NTG results are retail channel specific and the Upstream Lighting program retail channel distribution of CFLs has shifted, we calculated the NTG using weights developed from 2006 program data. We calculated weights using proportions of sales volume, dollar amount paid by the utility, and energy savings for the utility. The results are shown in Table 12.

Table 12. Net-to-Gross Values by Distribution Channel

Channel	Units	Dollars	kWh	SFEER 04/05	Channel Free-ridership

Big Box	8.5%	6.6%	6.2%	18.0%	75%
Discount	19.2%	20.2%	20.4%	12.0%	3%
Drug	5.5%	5.6%	5.4%	4.0%	41%
Grocery	56.4%	57.4%	57.6%	51.0%	16%
Home Improvement	8.1%	7.8%	8.1%	12.0%	66%
Small Hardware	1.4%	1.3%	1.3%	2.0%	52%
Other	0.9%	0.9%	1.0%	1.0%	38%
Total	100.0%	100.0%	100.0%	100.0%	
Parameter					
Free-ridership	24.8%	23.4%	23.2%	33.4%	
NTG	0.75	0.77	0.77	0.67	

Weighting by dollars or by energy saved yields a slightly higher NTG, but the figures are quite similar and SCE recommends using the **0.75 net to gross ratio** determined using the methodology used in the study. Because the data represent the program as a whole, and not solely the residential data, we are assuming the NTG for the residential and non-residential portions of savings are the same.

Installation rate: For the measures in this work paper, Edison has determined that the DEER **Installation Rate of 92%** (0.92) that is used for Express Efficiency-type programs[22] that have limited or no measure verification requirements would be more appropriate for these program measures than the 100 % installation rate for programs with strict measure verification requirements. The 92% installation rate is expected to also account for bulbs that are installed at a later time. There are no EM&V studies available that have yet calculated the future installation and savings for stored bulbs.

Hours of Operation: The "SDG&E 2004-05 Express Efficiency Lighting Program Time of Use Study" (RLW Analytics 2007)[23] sought to determine an hours of operation figure for non-residential applications. Unfortunately, because we assume that the non-residential portion of the bulbs purchased through the Residential Upstream Lighting Program tend only to go to specific applications, the general non-residential number was not applicable. RLW did have measurements for the applications we assume, but the sample size was too small (n=1 in one case) to justify a change in program assumptions. Therefore, we recommend retaining the number that was calculated from DEER.

Effective Useful Life: We recommend retaining the value of 2.1 years as no new data is available to suggest another value.

Residential/Non-Residential Split: Currently there are no studies available that directly measure the proportion of upstream rebated lighting products purchased for commercial use. This work paper assumes 10% of the measure purchased are for commercial applications. To validate this assumption, we used data gathered in a previous manufacture buy-down program. The 1994 Compact Fluorescent Lamp Manufacturers' Rebate Program provided financial incentives directly to CFL manufacturers to sell compact fluorescent equipment in Southern California Edison territory at discounted prices. As part of the program, consumer bounce–back cards collected basic information for the CFL product usage. The bounce back card included a question on use of the purchased product for business or home use. The responses to this question are provided in Table3 as both unweighted and weighted proportions, where the weights are based on the number of CFLs purchased. Two questions were used to calculate the weighted proportions: weighted proportions based on responses to either question on "number of CFL bulbs purchased" (Q7) or "number of CFLs by location used(Q5 a-g)"; and weighted proportions based on "number of bulbs purchased (Q7) where information on location was unknown. Thus column X in Table 13 is based on an amalgam of weight proportions sensitive to location and records that could only be weighted with respect to bulb count.

Table 13. 1994 CFL Manufacturers Bounce Back Card Survey

1994 CFL Manufacturer's Bounce Back Card Survey						
Is this Compact Fluorescents Bulb for your home or business?						
Source Question * :	Column X: No. of bulbs and bulbs with location		Column Y: No. of bulbs		Column Z: No. of Cards	
	CFL(c)	Wtd.Percent	CFL(b)	Wtd.Percent	CFL(a)	Percent
Business	5,860	16%	122	11%	1,931	10%
Household	30,567	81%	934	86%	16,424	88%
Household/Business	1,350	4%	33	3%	272	1%
TOTAL	37,777		1,089		18,627	
Percent Business		19%		14%		12%

*
Column X: Q7- How Many CFLs Purchased or Q5A-Q5G - No. of CFLs in a different location
Colum Y: Q7- How Many CFLs Purchased
CFL(c) and CFL(b) are weighted counts by number of CFLs purchased.CFL(a) is unweighted count of cards

As shown in Table 13, at least 12% or as high as 19% bulbs purchased through the Manufacturers' Rebate program were for commercial use, hence supporting the conservative program planning estimate of 10%. Future EM&V study needs to update this proportion for the Upstream lighting program measures assumed to be used in commercial application as well.

Incandescent Equivalency: We can validate the CFL to incandescent equivalency assumptions made in this work paper by creating a metric using available data from field observations. This metric is the CFL to incandescent ratio, which tells us the observed relationship between the wattages of CFLs and wattages of incandescent lamps they replaced. The equivalence need not be based on wattage alone but rather can be based on lumen output, as is assumed in this work paper. SCE compared the CFL to incandescent ratio implied by the ENERGY STAR Light Output Equivalency Table (Section 1.5 below) to the ratio calculated using the results of the KEMA CFL Metering Study[7](reproduced below for ease of reference). For the ENERGY STAR equivalence, the categories are based on lumen levels; for the CFL Metering Study they are based on incandescent base wattage. In each case, a range of CFL wattages fall into each category and so minimum and maximum values were calculated for each category and the mean was chosen. The weighted average was then calculated based on 2006 program volume for the ENERGY STAR equivalence and from KEMA's reported relative frequency. The aggregated CFL to incandescent ratio from the ENERGY STAR chart is 0.267 and that for the CFL Metering Study was 0.254. This is a difference of 5%. This suggests that the lumen mapping method recommended by ENERGY STAR roughly approximates the wattage matching that KEMA observed in the field.

Table 14. KEMA CFL Metering Study

Table 5-4
Incandescent Bulbs Replaced by CFLs

Original Incandescent Wattage	Number of Monitored Fixtures with Replacement CFLs	Percent of Monitored Fixtures	Typical CFL Replacement Wattage
60	250	57%	13-17
75	84	19%	18-22
40	55	12%	9-12
100	53	12%	23-26

Table 15. Summary of Market Parameters

Measure Parameter	*Ex-ante* Value	Revised *Ex-ante* Value
ΔkW	ENERGY STAR® lumen equivalents	No change
Hours of Operation	3,220	3,220
Net-to-Gross Ratio	0.80	0.75
Effective Useful Life	2.1	2.1
In-service Rate	90%	92%

1.5 Base Cases for Savings Estimates: Existing and Above Code

The existing equipment replaced by these measures are incandescent lamps in the range of 15 watts through 500 watts. Base measures are mapped to replacement CFLs as described in Table 16.

Table 16: Mapping of Base Wattages to CFLs by Lumen Equivalency

BASE WATTS	LUMEN RANGE ≤	≥	SOURCE
≥ 24	0	249	extrapolated
25	250	449	extrapolated
40	450	799	Energy Star®
60	800	1,099	Energy Star®
75	1,100	1,399	Energy Star®
90	1,400	1,599	interpolated
100	1,600	1,999	Energy Star
120	2,000	2,599	interpolated
150	2,600	3,599	Energy Star®
200	3,600	4,599	extrapolated
500	4,600		extrapolated

This table is an expansion of the Energy Star® CFL/Incandescent Equivalency Chart which can be found at http://www.energystar.gov/index.cfm?c=cfls.pr_cfls[24], which is also shown in Table 17 for ease of reference.

Table 17. Energy Star Light Output Equivalency

LIGHT OUTPUT EQUIVALENCY

To determine which ENERGY STAR qualified light bulbs will provide the same amount of light as your current incandescent light bulbs, consult the following chart:

INCANDESCENT LIGHT BULBS WATTS	MINIMUM LIGHT OUTPUT LUMENS	COMMON ENERGY STAR QUALIFIED LIGHT BULBS WATTS
40	450	9-13
60	800	13-15
75	1,100	18-25
100	1,600	23-30
150	2,600	30-52

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Table 5-4 of the 2005 CFL Metering Study[25] also provides self-reported base incandescent replacement wattage for various CFL wattages. This is based on self-reported data on the monitored fixtures in the study.

1.6 Base Cases and Measure Effective Useful Lives

Measure effective useful lives (EULs) used for these measures are based on those found under MeasureID for D03-801 to D03-818 All Screw-in CFLs –Retail Small located in Table 11-4: Non-Weather Sensitive – Lighting EULs, p.11-8: *2004-2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report, December 2005*[26].

Table 18. Non-Weather Sensitive - Lighting EULs (DEER Table 11-4)

MeasureID	Measure Name	EUL	EUL Source
D03-801 to D03-818	All Screw-in CFLs - Health/Medical - Hospital	0.9	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Health/Medical - Nursing Home	0.9	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Lodging - Hotel	0.9	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Lodging - Motel	0.9	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Restaurant - Fast-Food	1.3	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Grocery	1.4	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Retail - Single-Story Large	1.8	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Retail - 3-Story Large	1.9	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Education - Community College	2.1	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Retail - Small	2.1	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Restaurant - Sit-Down	2.3	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Education - University	2.6	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Manufacturing - Light Industrial	2.8	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Storage - Conditioned	2.8	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Storage - Unconditioned	2.8	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Office - Large	2.9	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Warehouse - Refrigerated	3.1	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Office - Small	3.2	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Education - Secondary School	3.5	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Education - Primary School	5.6	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Lodging - Guest Rooms	7.0	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Residential	9.4	DEER/Metering Study 2005
D03-819 to D03-837	All pin based CFLs - Commercial Buildings	12.0	SERA Report - May 2005/07-14-05
D03-819 to D03-837	All pin based CFLs - Residential Buildings	16.0	SERA Report - May 2005/07-14-05
D03-838	20W CFL Table Lamp: Residential	16.0	SERA Report - May 2005/07-14-05
D03-839	25W CFL Table Lamp: Residential	16.0	SERA Report - May 2005/07-14-05
D03-840	32W CFL Table Lamp: Residential	16.0	SERA Report - May 2005/07-14-05
D03-841	50W CFL Table Lamp: Residential	16.0	SERA Report - May 2005/07-14-05
D03-842	55W CFL Torchiere: Residential	9.0	CALMAC Report - September 2000
D03-843	70W CFL Torchiere (two LAMPs): Residential	9.0	CALMAC Report - September 2000
D03-844	50W Metal Halide	16.0	CALMAC Report - September 2000
D03-845	75W Metal Halide	16.0	CALMAC Report - September 2000
D03-846	100W Metal Halide	16.0	CALMAC Report - September 2000
D03-847	175W PS Metal Halide	16.0	CALMAC Report - September 2000
D03-848	175W PS Metal Halide	16.0	CALMAC Report - September 2000
D03-849	250W PS Metal Halide	16.0	CALMAC Report - September 2000
D03-850	200W HPS	16.0	CALMAC Report - September 2000
D03-851	180W LPS	16.0	CALMAC Report - September 2000
D03-852	Premium T8 El Ballast	11.0	SERA Report - May 2005/07-14-05
D03-853	T8 32W Dimming El Ballast	11.0	SERA Report - May 2005/07-14-05
D03-854	De-lamp from 4', 4 lamp/fixture	11.0	SERA Report - May 2005/07-14-05
D03-855	De-lamp from 8', 4 lamp/fixture	11.0	SERA Report - May 2005/07-14-05
D03-856	Occ-Sensor - Wall box	8.0	CALMAC Report - September 2000
D03-857	Occ-Sensor - Plug loads	10.0	CALMAC Report - September 2000
D03-858	Timeclock:	8.0	CALMAC Report - September 2000
D03-859	Photocell:	8.0	CALMAC Report - September 2000
D03-860	LED Exit Sign (New)	16.0	CALMAC Report - September 2000
D03-861	LED Exit Sign Retrofit Kit	16.0	CALMAC Report - September 2000
D03-862	Electroluminescent Exit Sign (New)	16.0	CALMAC Report - September 2000
D03-863	Electroluminescent Exit Sign Retrofit Kit	16.0	CALMAC Report - September 2000

1.7 Net-to-Gross Ratios for Different Program Strategies

Table 19 summarizes all applicable Net-to-Gross ratios for programs that may be used by this measure.

Table 19. Net-to-Gross Ratios

Program Approach	NTG
Upstream Non Residential Lighting	0.75

As explained above in Section 1.4 EM&V Market Potential, the Net-to-Gross (NTG) ratio used for these measures is based on Edison's evaluation of actual measure distributions in combination with the methodology outlined in the *2004/2005 Statewide Residential Retrofit Single Family Energy Efficiency Rebate Evaluation,* June 29, 2007.

Section 2. Calculation Methods

2.1 Energy Savings Estimation Methodologies

The annual energy savings formulas follow the calculation methods used in the *2004–2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report, December 2005*[15], modified to exclude energy and interactive effects as explained in the DEER Difference Analysis section of these of these work papers found in Section 1.2, specifically:

[Equation 2] ΔWatts/unit:

The demand difference (watts per unit) is simply the difference between the electric demand of the base unit and the electric demand of the energy efficient unit:

ΔWatts/unit = *Base Watts/unit - Energy Efficient Unit Watts*
Example: *ΔWatts/unit = 100 Watts/unit - 54 Watts / units = 46 Watts*

[Equation 3] Annual Energy Savings:

$$\text{Energy Savings [kWh/Unit]} = \frac{(\Delta\text{Watts/unit}) \times (\text{annual hours of operation}) \times (\text{Installation Rate})}{1{,}000 \text{ Watts / kW}}$$

$$\text{Example: Energy Savings} = \frac{(46 \text{ Watts})(3{,}226 \text{ annual hour of operation}) \times (0.92 \text{ Installation Rate})}{1{,}000 \text{ Watt / kW}} = 136.52 \text{ kWh}$$

Annual hours of operation: The DEER Report employs a methodology that is oriented toward using operating hours for specific market sectors when calculating energy and demand impacts. However, at this time there is insufficient data to determine specific allocation of measures to specific market sectors. It is however generally understood that the primary nonresidential participants in this program are small businesses. Accordingly, SCE uses a simple average of the annual operating hours for small retail, small office, and sit-down restaurants. The annual hours of operation used in this work paper are based on a simple average of the DEER operating hours for three building types that are considered to be the primary participants in this program: small retail, small office, and sit-down restaurants. The operating hours are obtained from *Table 3-2: Annual Lighting Hours, energy and demand Diversity Factors, and Coincident Diversity Factors by Building Type for CFL Lighting*[16]. Current assumptions are that the most likely participants in this program will the owners and operators of small businesses. The market sectors that most closely represent this general category are small offices, sit-down restaurants, and small retail establishments. A simple average of these market segments was calculated as follows:

[Equation 4]
$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i = \frac{1}{n}(x_1 + \cdots + x_n).$$

3226 average operating hours = (2,492 office-small + 3,444 restaurant-sit down + 3,742 retail-small)/3 observations

2.2 Demand Reduction Estimation Methodologies

The demand reduction formulas follow the calculation methods used in the *2004–2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report, December 2005*[27], on page 3-6, modified to exclude energy and interactive effects, as explained in the DEER Difference Analysis section of these work papers, found in Section 1.2, specifically:

[Equation 5] ΔWatts/unit:

The demand difference (watts per unit) is simply the difference between the electric demand of the base unit and the electric demand of the energy efficient unit.

ΔWatts/unit = *Base Watts/unit - Energy Efficient Unit Watts*

Example: *ΔWatts/unit = 100 Watts/unit - 54 Watts / units = 46 Watts*

[Equation 6] Demand Reduction:

$$\text{Demand Reduction [kW/Unit]} = \frac{(\Delta\text{Watts/unit}) \times (\text{Installation Rate}) \times (\text{Peak Coincidence Factor})}{1{,}000 \text{ Watts/kW}}$$

Example:

$$\text{Demand Reduction} = \frac{46 \text{ Watts} \times (0.92) \times (0.79)}{1{,}000 \text{ Watts/kW}} = 0.03343 \text{ kW}$$

Coincident Diversity Factors: Section 3, the non residential section of the 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, uses a coincident diversity factor in place of the peak load share used in the residential section to calculate the portion of energy demand produced by a lighting measure that occurs during an on peak period. For reasons elaborated on in the above discussion on hours of operation, the Coincident Diversity Factors used in this work paper are based on a simple average of the DEER coincident diversity factors for the same three building types: small retail, small office, and sit-down restaurants, which are considered to be the primary participants in this program. These factors were obtained from *Table 3-2: Annual Lighting Hours, Energy and Demand Diversity Factors, and Coincident Diversity Factors by Building Type for CFL Lighting*[28]. Using the same formula as cited above for the calculation of average operating hours, an average coincident factor is calculated as follows.

0.79 Coincident Diversity Factor = (0.81 office-small + 0.68 restaurant-sit down + 0.88 retail-small)/3 observations

In all cases, the values were extracted directly from Table 3-2, which is reproduced below.

- **Table 1. Annual Lighting Hours and Demand Diversity Factors, and Coincident Diversity Factors by Building Type for CFL Lighting (DEER Table 3-2)**

Market Sector	Annual Operating Hours	Energy Interactive Effects	Coincident Diversity Factors	Demand Interactive Effects
Education - Primary School	1,440	1.15	0.42	1.23
Education - Secondary School	2,305	1.15	0.42	1.23
Education - Community College	3,792	1.15	0.68	1.22
Education - University	3,073	1.15	0.68	1.22
Grocery	5,824	1.13	0.81	1.25
Health/Medical - Hospital	8,736	1.18	0.74	1.26
Health/Medical - Clinic	8,736	1.18	0.74	1.26
Lodging - Hotel	8,736	1.14	0.67	1.14
Lodging - Motel	8,736	1.14	0.67	1.14
Lodging - Guest Rooms	1,145*	1.14	0.67	1.14
Manufacturing - Light Industrial	2,860	1.04	0.99	1.08
Office - Large	2,739*	1.17	0.81	1.25
Office - Small	2,492*	1.17	0.81	1.25
Restaurant - Sit-Down	3,444*	1.15	0.68	1.26
Restaurant - Fast-Food	6,188	1.15	0.68	1.26
Retail - 3-Story Large	4,259	1.11	0.88	1.19
Retail - Single-Story Large	4,368	1.11	0.88	1.19
Retail - Small	3,724*	1.11	0.88	1.19
Storage - Conditioned	2,860	1.06	0.84	1.09
Storage - Unconditioned	2,860	1.06	0.84	1.09
Warehouse - Refrigerated	2,600	1.06	0.84	1.09

* Different from the values used in Table 3-5

Section 3 Load Shapes

Load Shapes are a graphic representation of electrical load over a period of time and are an important part of the life-cycle cost analysis of any energy efficiency program portfolio. The net benefits associated with a measure are based on the amount of energy saved and the avoided cost per unit of energy saved. For electricity, the avoided cost varies hourly over an entire year. Thus, the net benefits calculation for a measure requires both the total annual energy savings (kWh) of the measure and the distribution of that savings over the year. The distribution of savings over the year is represented by the measure's load shape. The measure's load shape indicates what fraction of annual energy savings occurs in each time period of the year. An hourly load shape indicates what fraction of annual savings occurs for each hour of the year. A Time-of-Use (TOU) load shape indicates what fraction occurs within five or six broad time-of-use periods, typically defined by a specific utility rate tariff. Formally, a load shape is a set of fractions summing to unity, one fraction for each hour or for each TOU period. Multiplying the measure load shape with the hourly avoided cost stream determines the average avoided cost per kWh for use in the life cycle cost analysis that determines a measure's total resource cost (TRC) benefit.

3.1 Base Cases Load Shapes

The base case indoor lighting system's demand would be expected to follow an indoor lighting end-use load shape for each market sector as shown in the E3 Calculator.

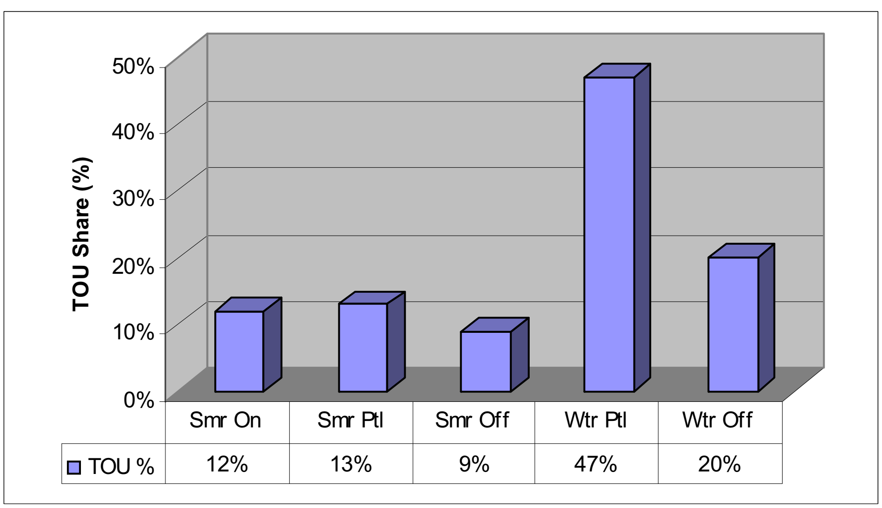
3.2 Measure Load Shapes

For purposes of the net benefits estimates in the E3 calculator, what is required is the demand load shape that ideally represents the *difference* between the base equipment and the installed energy efficiency measure. This *difference* load profile is what is called the Measure Load Shape and would be the preferred load shape for use in the net benefits calculations. The measure equipment and controls may alter the typical commercial indoor lighting hourly demand profile differently, making it difficult to select a single demand profile to represent the category. The commercial indoor lighting measures demand profile under this Direct Install measure category (fluorescent lighting system) is expected to be slightly lower when compared to the base system.

The Load Shape Update Initiative Study determined that for load-following measures, the end-use load shape can be substituted for the measure shape:

> "It can be argued that for measures that are roughly load-following (have a similar pattern to the end-use itself), substituting the end-use load shape for the measure shape is a reasonable simplification. Errors introduced by this substitution may be minor compared to other uncertainties in the savings valuation process. Distinguishing measure shape from end-use shape may be an unnecessary complication except for measures that are not load-following. This perspective was suggested by some workshop participants and interviewees."[29]

The E3 Calculator contains a fixed set of load shapes selections that are the combination of the hourly avoided costs and whatever load shape data were available at the time of the tool's creation. In the case of SCE's E3 Calculator, the majority of the load shape data at the time were TOU End Use load shapes and not Hourly Measure load shapes. Figure 5 and Figure 6 represent the TOU End Use Energy and Peak Demand factors for indoor lighting measures that are embedded within the SCE E3 Calculator.



- **Figure 5. TOU energy Factors - Indoor Lighting End Use**

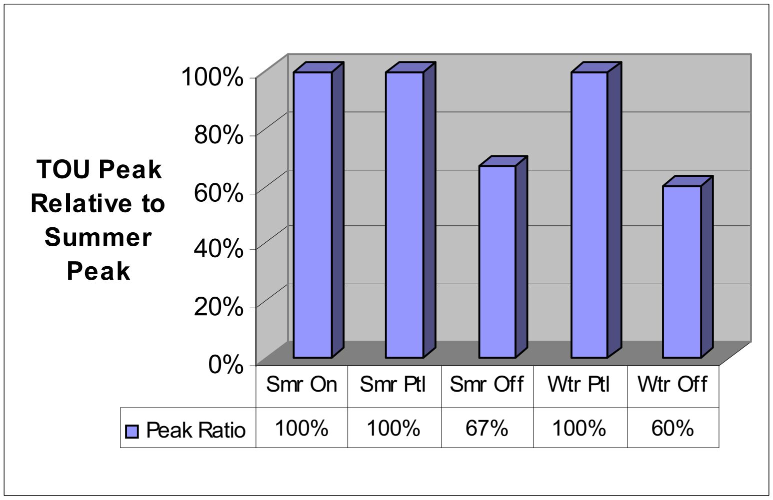


Figure 6. TOU Demand Factors - Indoor Lighting End Use

In the E3 Calculator, for the "Measure Electric End Use Shape" selection, the "Indoor Lighting" (Indoor LT) load shape is the only appropriate selection for the Commercial Indoor Lighting System Replacement measure category. The "Indoor Lighting" selection is enabled for most of the nonresidential Target Sectors in Version 3c3-2000 of the E3 Calculator. The exceptions are:

- Grocery Store, select Food Store to enable the IndoorLT load shape,
- Fast Food Restaurant, select Restaurant to enable the IndoorLT load shape,
- Sit Down Restaurant, select Restaurant to enable the IndoorLT load shape,
- Storage Building, select Non-Refrigerated Warehouse to enable the IndoorLT load shape,
- School, select K-12 School to enable the IndootLT load shape, and
- Assembly, select Miscellaneous Commercial to enable the IndoorLT load shape.

Section 4. Base Case and Measure Costs

Measure costs were obtained directly from Table C-4: DEER Non-Weather Sensitive Measure List, in most instances. As explained in section 4.3 below, for certain measures that were not represented in the DEER tables, lamp wattages were extrapolated to match available cost data.

4.1 Base Cases Costs

Base equipment costs were obtained from the DEER for this work paper as listed in Table 21 below.

4.2 Measure Costs

For screw-in compact fluorescent lamps, measure costs were extracted from the *2004-2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report, Appendix C, Table C-4 DEER Non – Weather Sensitive Measure List*[30]. Wattages of CFLs measures were matched to those in the DEER table and the incremental measure costs were used as presented in the table. In instances where direct mappings of wattages were not possible, costs from the closest available DEER wattages were used. For example, Table C-4 in DEER did not have costs for a 9 Watt, 10 Watt, or 11 Watt CFLs. The first available costs in the DEER table were for a 13 Watt CFL. So the costs presented for the 13 Watt CFLs were used for the 9, 10, and 11 watt CFLs. Using the above example, 9 Watt, 10 Watt, 11 Watt, and 13 Watt CFLs would all be priced at the next available cost of $4.98/unit.

4.3 Incremental and Full Measure Costs

For screw-in compact fluorescent lamps, incremental costs were extracted from the *2004-2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report, Appendix C, Table C-4 DEER Non – Weather Sensitive Measure List*[20]. Wattages of CFLs measures were matched to those in the DEER table and the incremental measure costs were used as presented. In instances where direct mappings of wattages were not possible, costs from the closest available DEER wattages were used. For example, Table C-4 in DEER did not have costs for a 9 Watt, 10 Watt, or 11 Watt CFLs. The first available costs in the DEER table were for a 13 Watt CFL. Therefore, the costs presented for the 13 Watt CFLs were used for the 9, 10, and 11 watt CFLs. Using the above example, 9 Watt, 10 Watt, 11 Watt, and 13 Watt CFLs would all be priced at the next available cost of $4.40/unit.

Installation costs were not used for these measures for the following reason: the participants in this non residential program are most likely small business owners that would install these units as part of their normal maintenance routines and not incur any additional expense over and above the level of effort in replacing a standard incandescent lamp. An argument could be made that due to the longer life on CFLs, those installations would occur less frequently and that an installation credit due to the reduced frequency of replacement could be easily calculated. However, SCE has decided not to calculate and claim an installation credit at this time.

Table 21. DEER Non-Weather Sensitive Measure List (DEER Table C-4)

MeasureID	Measure Name	Energy Common Units	Cost Common Units	Base Equipment Cost ($)	Measure Equipment Cost ($)	Incremental Equipment Cost ($)	Labor Cost ($)	Installed Cost ($)
D03-801	13 Watt CFL < 800 Lumens - screw-in	LAMP	Lamp	$0.57	$4.98	$4.40	$3.77	$8.18
D03-802	13 Watt CFL =800 Lumens - screw-in	LAMP	Lamp	$0.61	$4.87	$4.26	$3.77	$8.04
D03-803	14 Watt CFL - screw-in	LAMP	Lamp	$0.61	$5.25	$4.64	$3.77	$8.41
D03-804	15 Watt CFL - screw-in	LAMP	Lamp	$0.61	$5.62	$5.01	$3.77	$8.79
D03-805	16 Watt CFL - screw-in	LAMP	Lamp	$0.61	$6.00	$5.39	$3.77	$9.16
D03-806	18 Watt CFL < 1,100 Lumens - screw-in	LAMP	Lamp	$0.61	$6.74	$6.14	$3.77	$9.91
D03-807	18 Watt CFL =1,100 Lumens - screw-in	LAMP	Lamp	$0.61	$6.37	$5.77	$3.77	$9.54
D03-808	19 Watt CFL =1,100 Lumens - screw-in	LAMP	Lamp	$0.61	$6.73	$6.12	$3.77	$9.89
D03-809	20 Watt CFL - screw-in	LAMP	Lamp	$0.61	$7.08	$6.47	$3.77	$10.25
D03-810	23 Watt CFL - screw-in	LAMP	Lamp	$0.61	$6.66	$6.05	$3.77	$9.82
D03-811	25 Watt CFL <1,600 Lumens - screw-in	LAMP	Lamp	$0.61	$8.85	$8.24	$3.77	$12.02
D03-812	25 Watt CFL =1,600 Lumens - screw-in	LAMP	Lamp	$0.61	$7.24	$6.63	$3.77	$10.40
D03-813	26 Watt CFL <1,600 Lumens - screw-in	LAMP	Lamp	$0.61	$9.21	$8.60	$3.77	$12.37
D03-814	26 Watt CFL =1,600 Lumens - screw-in	LAMP	Lamp	$0.61	$7.52	$6.92	$3.77	$10.69
D03-815	28 Watt CFL - screw-in	LAMP	Lamp	$0.61	$8.10	$7.50	$3.77	$11.27
D03-816	30 Watt CFL - screw-in	LAMP	Lamp	$0.61	$9.26	$8.65	$3.77	$12.43
D03-817	36 Watt CFL - screw-in	LAMP	Lamp	$2.22	$9.19	$6.97	$3.77	$10.75
D03-818	40 Watt CFL - screw-in	LAMP	Lamp	$2.22	$12.77	$10.55	$3.77	$14.32
D03-819	13 Watt CFL < 800 Lumens - pin based	LAMP	Lamp	$0.00	$17.88	$0.00	$27.14	$45.02
D03-820	13 Watt CFL =800 Lumens - pin based	LAMP	Lamp	$0.00	$17.88	$0.00	$27.14	$45.02
D03-821	14 Watt CFL - pin based	LAMP	Lamp	$0.00	$18.38	$0.00	$27.14	$45.51
D03-822	15 Watt CFL - pin based	LAMP	Lamp	$0.00	$18.87	$0.00	$27.14	$46.01
D03-823	16 Watt CFL - pin based	LAMP	Lamp	$0.00	$19.36	$0.00	$27.14	$46.50
D03-824	18 Watt CFL < 1,100 Lumens - pin based	LAMP	Lamp	$0.00	$20.35	$0.00	$27.14	$47.49
D03-825	18 Watt CFL =1,100 Lumens - pin based	LAMP	Lamp	$0.00	$20.35	$0.00	$27.14	$47.49
D03-826	19 Watt CFL =1,100 Lumens - pin based	LAMP	Lamp	$0.00	$20.84	$0.00	$27.14	$47.98
D03-827	20 Watt CFL - pin based	LAMP	Lamp	$0.00	$21.34	$0.00	$27.14	$48.48
D03-828	23 Watt CFL - pin based	LAMP	Lamp	$0.00	$22.82	$0.00	$27.14	$49.96
D03-829	25 Watt CFL <1,600 Lumens - pin based	LAMP	Lamp	$0.00	$23.80	$0.00	$27.14	$50.94
D03-830	25 Watt CFL =1,600 Lumens - pin based	LAMP	Lamp	$0.00	$23.80	$0.00	$27.14	$50.94
D03-831	26 Watt CFL <1,600 Lumens - pin based	LAMP	Lamp	$0.00	$24.30	$0.00	$27.14	$51.44
D03-832	26 Watt CFL =1,600 Lumens - pin based	LAMP	Lamp	$0.00	$24.30	$0.00	$27.14	$51.44
D03-833	28 Watt CFL - pin based	LAMP	Lamp	$0.00	$25.28	$0.00	$27.14	$52.42
D03-834	30 Watt CFL - pin based	LAMP	Lamp	$0.00	$26.27	$0.00	$27.14	$53.41
D03-835	40 Watt CFL - pin based	LAMP	Lamp	$0.00	$31.20	$0.00	$27.14	$58.34
D03-836	55 Watt CFL - pin based	LAMP	Lamp	$0.00	$38.60	$0.00	$27.14	$65.74
D03-837	65 Watt CFL - pin based	LAMP	Lamp	$0.00	$43.54	$0.00	$27.14	$70.68
D03-838	20W CFL Table Lamp	Fixture	Fixture	$50.43	$50.43	$0.00	$0.00	$0.00
D03-839	25W CFL Table Lamp	Fixture	Fixture	$61.13	$61.13	$0.00	$0.00	$0.00
D03-840	32W CFL Table Lamp	Fixture	Fixture	$63.20	$63.20	$0.00	$0.00	$0.00
D03-841	50W CFL Table Lamp	Fixture	Fixture	$122.96	$122.96	$0.00	$0.00	$0.00
D03-842	55W CFL Torchiere	Fixture	Torchiere	$59.39	$59.39	$0.00	$0.00	$0.00
D03-843	70W CFL Torchiere (two LAMPs)	Fixture	Torchiere	$55.76	$55.76	$0.00	$0.00	$0.00
D03-844	50W Metal Halide	Fixture	Fixture	$0.00	$113.85	$0.00	$100.51	$214.36
D03-845	75W Metal Halide	Fixture	Fixture	$0.00	$120.09	$0.00	$100.51	$220.60
D03-846	100W Metal Halide	Fixture	Fixture	$0.00	$126.66	$0.00	$100.51	$227.17
D03-847	175W PS Metal Halide	Fixture	Fixture	$0.00	$129.01	$0.00	$67.84	$196.86
D03-848	175W PS Metal Halide	Fixture	Fixture	$0.00	$129.01	$0.00	$67.84	$196.86
D03-849	250W PS Metal Halide	Fixture	Fixture	$0.00	$152.08	$0.00	$67.84	$219.92
D03-850	200W HPS	Fixture	Fixture	$0.00	$91.05	$0.00	$67.84	$158.89
D03-851	180W LPS	Fixture	Fixture	$0.00	$74.62	$0.00	$67.84	$142.46
D03-852	Premium T8 El Ballast	Fixture	Fixture	$19.23	$23.42	$4.19	$0.00	$0.00
D03-853	T8 32W Dimming El Ballast	Fixture	Fixture	$16.54	$72.89	$56.34	$16.96	$89.85
D03-854	De-lamp from 4', 4 lamp/fixture	Fixture	Fixture	$0.00	$3.08	$0.00	$22.63	$25.71
D03-855	De-lamp from 8', 4 lamp/fixture	Fixture	Fixture	$0.00	$3.28	$0.00	$22.63	$25.91
D03-856	Occ-Sensor - Wall box	Sensor	Sensor	$0.00	$42.28	$0.00	$35.00	$77.28
D03-857	Occ-Sensor - Plug loads	Sensor	Sensor	$0.00	$82.25	$0.00	$35.00	$117.25
D03-858	Timeclock:	Timeclock	Timeclock	$0.00	$123.01	$0.00	$116.88	$239.89
D03-859	Photocell:	Photocell	Photocell	$0.00	$12.06	$0.00	$47.75	$59.81
D03-860	LED Exit Sign (New)	Exit Sign	Sign	$0.00	$31.52	$0.00	$33.92	$65.44
D03-861	LED Exit Sign Retrofit Kit	Exit Sign	Sign	$0.00	$16.66	$0.00	$33.92	$50.58
D03-862	Electroluminescent Exit Sign (New)	Exit Sign	Sign	$0.00	$73.42	$0.00	$33.92	$107.34
D03-863	Electroluminescent Exit Sign Retrofit Kit	Exit Sign	Sign	$0.00	$70.14	$0.00	$33.92	$104.06
D03-901	High Efficiency Copier	Copy Machine	copier	$1,616.38	$1,773.14	$156.76	$0.00	$0.00
D03-902	High Efficiency Copier	Copy Machine	copier	$4,686.00	$7,654.69	$2,968.69	$0.00	$0.00
D03-903	High Efficiency Copier	Copy Machine	copier	$0.00	$10,924.63	$0.00	$0.00	$0.00
D03-904	High Efficiency Gas Fryer	Fryer	Fryer	$1,520.61	$4,103.15	$2,582.54	$0.00	$0.00
D03-905	High Efficiency Gas Griddle	Griddle	Griddle	$1,758.36	$3,860.67	$2,102.31	$0.00	$0.00
D03-906	High Efficiency Electric Fryer	Fryer	Fryer	$3,326.73	$12,088.62	$8,761.89	$0.00	$0.00
D03-907	Hot Food Holding Cabinet	Cabinet	Cabinet	$1,545.67	$2,589.81	$1,044.13	$0.00	$0.00
D03-908	Connectionless Steamer	Steamer	Steamer	$5,128.24	$3,206.64	-$1,921.61	$0.00	$0.00
D03-909	Point of Use Water Heat	1000 sqft building	WtrHtr	$492.96	$863.60	$370.64	$250.90	$1,114.50

Index

Attachments

Attachment 1. Non-Residential CFL Integral Screw-In Fixtures Worksheet.

WPSCRELG0022.0 Summary.xls

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[2] Itron, Inc., 2004/2005 Statewide Residential Retrofit Single Family Energy Efficiency Rebate Evaluation, June 29, 2007, Sections 5 and 6.

[3] Ibid., 6-6.

[4] Ibid., 5-23.

[5] Ibid., 6-6

[6] Ibid., 6-9

[7] Energy Star® CFL/Incandescent Equivalency Chart which can be found at http://www.energystar.gov/index.cfm?c=cfls.pr_cfls

[8] Itron 2005, 11-8

[9] Ibid., 2-2, 2-3

[10] Ibid., 2-2, 2-3

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[12] Decision 06-06-063, June 29, 2006, Interim Opinion: 2006 Update of Avoided Costs and Related Issues Pertaining to Energy Efficiency Resources.

[13] KEMA Inc., Final Report Load Shape Initiative, November 17, 2006

[14] Itron 2005, 2-5

[15] Itron 2005, C-

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[29] KEMA, Final Report Load Shape Initiative, Revised November 17, 2006.
[30] Ibid., C-5
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[30]. Ibid: Note **Error! Bookmark not defined.**, page 132.
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Agricultural Measures

Agricultural Measures

Introduction

This section provides supporting documents for the following Customized Measures:

Summary Issues

- The following measures in the Dairy Farms Target Market have the following NTFR values adopted for 2009-2011 Planning from CPUC.
    - Milk Pump VSD - 50%
    - Scroll Compressor - 50%
    - Plate Cooler - 26%
    - Compressor Heat Recovery Unit - 50%
    - Vacuum Pump VSD - 75%
    - All Other - 50%
- The above listed measures values are from the EM&V Report of 2004-05 California Multi Measure Farm Program that pertains to PG&E's 3rd Parties (EnSave), CALMAC ID: ENS0002.01, March 2007. www.calmac.org
- This study is targeted for dairy farms only. Please see page 1 of the executive summary of the attached report.

Recommendations

- For agriculture measures other than the dairy farm measures as listed above, the NTFR of 0.7 (default value) is recommended

Evaluation, Measurement and Verification Report
California Multi Measure Farm Program
1354-04 and 1360-04

prepared for

California Public Utilities Commission
EnSave, Inc.

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CALMAC ID: ENS0002.01

March 15, 2007

Table of Contents

1.0
EXECUTIVE SUMMARY

This report summarizes the approach, data collection and results for the Evaluation, Measurement and Verification of EnSave, Inc's *California Multi Measure Farm Program (354-04 and 1360-04)*. All activities, with the exception of the Process Questionnaire and survey, were developed and conducted by kW Engineering, an independent energy engineering firm based in Oakland, CA.

The objective of the program was to promote and provide incentives for the installation of high efficiency options for five measures associated with milking at dairies. The program was implemented in Pacific Gas and Electric and Southern California Edison's service territories, California's two largest Investor Owned Utilities (IOUs). The program targeted small, independent dairies that have typically been underserved by energy efficiency programs in the past.

Evaluation results are based on calculations completed using comprehensive data collected through end-use metering and telephone surveys. A summary of the program results is provided in Exhibit 1 below. This exhibit shows the ex-ante estimate of savings as provided by EnSave, the program implementer. Also provided in the table are the ex-post, evaluation based savings reflecting both gross and net adjustments to the ex-ante values. As discussed in the M&V plan, four of the five energy efficiency measures offered under the program were explicitly evaluated under this study. The fifth measure, variable speed drives for vacuum pumps, is reported using both gross and net adjustments from previous studies.

Exhibit 1: Energy Impacts Reporting Tables for 2004-2005 Programs

Sum Of Energy Impacts for This 2004-2005 Program

2004-2005 form

	Year	Calendar Year	Ex-ante Gross Program-Projected Program MWh Savings (1)	Ex-Post Net Evaluation Confirmed Program MWh Savings (2)	Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)	Ex-Post Evaluation Projected Peak MW Savings (2**)	Ex-Ante Gross Program-Projected Program Therm Savings (1)	Ex-Post Net Evaluation Confirmed Program Therm Savings (2)
Program IDs*:	354-04 and 1360-04							
Program Name:	California Multi-Measure Farm Program							
	1	2004	5,177.07	2,620.90	0.952	0.504	0	0
	2	2005	5,177.07	2,620.90	0.952	0.504	0	0
	3	2006	5,177.07	2,620.90	0.952	0.504	0	0
	4	2007	5,177.07	2,620.90	0.952	0.504	0	0
	5	2008	5,177.07	2,620.90	0.952	0.504	0	0
	6	2009	5,177.07	2,620.90	0.952	0.504	0	0
	7	2010	5,177.07	2,620.90	0.952	0.504	0	0
	8	2011	5,177.07	2,620.90	0.952	0.504	0	0
	9	2012	5,177.07	2,620.90	0.952	0.504	0	0
	10	2013	5,177.07	2,620.90	0.952	0.504	0	0
	11	2014	5,177.07	2,620.90	0.952	0.504	0	0
	12	2015	5,177.07	2,620.90	0.952	0.504	0	0
	13	2016	5,177.07	2,620.90	0.952	0.504	0	0
	14	2017	5,177.07	2,620.90	0.952	0.504	0	0
	15	2018	5,177.07	2,620.90	0.952	0.504	0	0
	16	2019	5,177.07	2,620.90	0.952	0.504	0	0
	17	2020	5,177.07	2,620.90	0.952	0.504	0	0
	18	2021	5,177.07	2,620.90	0.952	0.504	0	0
	19	2022	5,177.07	2,620.90	0.952	0.504	0	0
	20	2023	5,177.07	2,620.90	0.952	0.504	0	0
	TOTAL	**2004-2023**	103,541.48	52,418.03	0.952	0.504	0	0

Exhibit 2 below provides ex-ante, gross and net ex-post estimates of energy and demand savings, and associated realization rates. The ex-ante savings values are estimated savings from EnSave, taken from their final program database of participants. Gross ex-post savings values are the result of savings estimates based on the measured data collected to support this evaluation and associated analysis. The Gross Realization Rate is simply the ratio of the gross ex-post savings estimate to the ex-ante savings estimate. The ex-ante estimate of savings for the compressor heat recovery measure was accepted at 100% because the total savings for the measures was less than 1% of the program total and the sample frame (three participants) did not warrant primary data collection. As mentioned above, the gross realization rate of 100% is used for the Vacuum pump VSD measure per the evaluation plan.

For the four measures evaluated under this study, the net-to-gross analysis resulted in a net realization rate of 42%. This net realization rate was estimated based on telephone survey data and subsequent analysis conducted by Dr. Phil Willems. Please see Section 5, Process Survey, for a complete discussion of how this value was derived. For the last measure, the vacuum pump VSD, the ex-ante net realization rate of 75% applied.

Exhibit 2: Energy and Demand Impacts by Measure

Measure	Ex-Ante Energy Savings (kWh/yr)	Gross Ex-Post Energy Savings (kWh/yr)	Gross Realization Rate	Net Realization Rate	Net Ex-Post Energy Savings (kWh/yr)	Overall Ex-Post Realization Rate
Milk Pump VSD	1,004,682	385,709	38%	42%	161,998.0	16%
Scroll Compressor	631,928	365,634	58%	42%	153,566.1	24%
Plate Cooler	570,773	220,221	39%	42%	92,493.0	16%
Compressor Heat Recovery Unit	43,705	43,705	100%	42%	18,356.0	42%
Vaccum Pump VSD	2,925,985	2,925,985	100%	75%	2,194,488.4	75%
Total	**5,177,073**	**3,941,254**	**76.1%**		**2,620,901.5**	**50.6%**

Measure	Ex-Ante Demand Savings (kW)	Gross EM&V Demand Savings (kW)	Gross Realization Rate	Net Realization Rate	Net Ex-Post Demand Savings (kW)	Overall Ex-Post Realization Rate
Milk Pump VSD	178.41	85.32	48%	42%	35.84	20%
Scroll Compressor	106.72	80.88	76%	42%	33.97	32%
Plate Cooler	112.11	48.72	43%	42%	20.46	18%
Compressor Heat Recovery Unit	7.26	7.26	100%	42%	3.05	42%
Vaccum Pump VSD	547.38	547.38	100%	75%	410.53	75%
Total	**951.88**	**769.56**	**80.8%**		**503.85**	**52.9%**

2.0
PROGRAM DESCRIPTION

2.1. Program Overview

EnSave, Inc.'s (EnSave) California Multi Measure Farm Program (1354-04 and 1360-04) was designed to provide peak demand and energy savings to Agricultural (Dairy) customers in Pacific Gas and Electric's (PG&E) and Southern California Edison's (SCE) service territories. These are the two largest Investor Owned Utilities (IOU's) whose customers contribute the Public Goods Charge (PGC), which provides funding for this program.

Savings were to be achieved through the installation of five measures. Measures include the following:

- The installation of variable speed drives (VSD) for vacuum pumps used for milking
- The installation of plate and frame heat exchangers (plate coolers) used to pre-cool milk using ground water before it enters refrigerated bulk storage tanks
- The installation of VSDs for milk transfer pumps used to transport milk to the storage tanks
- The installation of compressor heat recovery units used to capture heat rejected from refrigeration compressor in order to heat water used in equipment washing
- The installation of scroll compressors which provide more efficient means of cooling milk

2.2 Measure Descriptions

There are five measures included in the program: Variable speed drives (VSD) on milking vacuum pumps; plate coolers; VSDs on milk pumps; compressor heat recovery units; and scroll compressors. Each of these measures provides significant energy (kWh) and demand (kW) savings to participants. The vacuum pump VSD measure was previously offered under the 2002-2003 California Variable Speed Drive Farm Program. The four additional measures that complete the portfolio under this program complement the VSD on the milking vacuum pump measure by saving energy on other aspects of the milk production process.

Standard equipment for milk production in dairy farms typically consists of one or more electrically powered vacuum pumps, one or more refrigeration compressors, and one or more milk transfer pumps per farm. While the loading of refrigeration compressors varies substantially over the process, a standard refrigeration compressor operates primarily to cool milk as it enters a bulk storage tank, and secondarily to maintain a temperature setpoint for stored milk. Vacuum pumps and milk transfer pumps operate during milking hours only. The baseline refrigeration compressor type is an air cooled reciprocating compressor. Both vacuum pump and milk transfer pump baseline equipment consists of constant speed pumps with constant energy consumption. The vacuum pump runs at full speed and a mechanical regulator creates an intentional air leak or "bleed" to regulate the pressure of the system regardless of the amount of milk being pumped. When the system requires a higher level of vacuum, the regulator closes and the vacuum level increases. Milk transfer pumps are enabled during milking and provide a constant flow of milk to bulk storage tanks.

Of the five energy efficiency measures, it is important to note that energy and demand savings for the plate cooler, milk pump VSD and scroll compressor all come from reduced energy consumption for cooling the milk. This cooling can be accomplished with either refrigeration associated with the bulk tank or a milk chiller. The point is that direct measurement of usage and calculation of savings for all of these measures came from measurement of the refrigeration energy. Following is a more detailed description of each of the measures.

Measure 1: Vacuum Pump VSD

The VSD electronically senses the vacuum need of the system at all times and adjusts the speed at which the pump runs to deliver only that amount of vacuum required. This is accomplished by using a pressure sensor to eliminate the regulator. The baseline for this measure is a constant speed/constant pressure pump. While the baseline pump always provides enough vacuum to satisfy the highest load, the VSD pump only runs at a speed required to meet the current milking load. This reduction in pump motor speed results in electrical energy and demand savings over the constant speed situation. This measure has been evaluated in a previous study. Per the program implementation plan, no M&V was conducted for this measure.

Measure 2: Milk Plate Cooler

The plate cooler consists of a two stream plate and frame heat exchanger that uses cool ground water to reduce the temperature of milk before it enters a bulk tank. The savings resulting from this measure are incurred at the refrigeration compressor in the form of reduced thermal load. Typical dairy refrigeration systems consist of direct exchange compressors used to cool milk in bulk storage tanks. The reduced heat content of milk entering the bulk storage tanks results directly in a reduced refrigeration load. The baseline for the plate cooler measure is a system that does not utilize a plate cooler.

Measure 3: Milk Pump VSD

The milk removed by the vacuum pump system is captured in small tanks before it is transferred to the bulk storage tank by the milk transfer pump. The baseline for the Milk Pump VSD measure is a constant speed milk transfer system including a plate cooler. A variable speed milk pump optimizes milk flow through the plate cooler to regulate the water-to-milk flow ratio and enhance the performance of the milk plate cooler. This optimized flow further reduces the amount of refrigeration needed in the bulk tank. The baseline for this measure is a system that uses a plate cooler without a VSD on the milk pump.

It should be noted that there is a small amount of pumping savings associated with operating the pump at a slower speed. This savings is small relative to a more typical application of a VSD (such as the vacuum pump application or a variable volume chilled water system) where the mass flow is reduced, and was not estimated as part of the evaluation.

Measure 4: Compressor Heat Recovery

The installation of a compressor heat recovery system captures heat rejected from refrigeration compressors to be used for pre-heating of hot water. Hot water is used throughout the milking process for equipment cleaning. The unit is composed of a storage tank lined with heat exchangers through which hot refrigerant gas condenses, giving up heat to the water. The pre-heated water is then introduced to a conventional water heater as needed. As indicated in the program filing, this measure is limited to farms using electric water heating. The baseline for this measure is a conventional electric water heater without heat recovery.

Measure 5: Scroll Compressor

Compared to a conventional reciprocating (positive displacement) compressor, scroll compressors use about 30% less electricity for the same refrigeration effect. Scroll compressors also tend to run more quietly, have fewer breakdowns and last longer. This measure replaces older reciprocating compressors with new scroll compressors. The baseline for a scroll compressor is an existing reciprocating compressor.

3.0 EM&V APPROACH, SAMPLE DESIGN, AND DATA COLLECTION

In this section we provide a discussion of the evaluation approach, the sample design for selecting metered sites, and the process used to collect data. The general approach was founded in the idea that savings are relatively constant day-to-day, but the daily total is difficult to estimate accurately without measurement.

3.1 Approach

Direct measurement was a driving requirement for the evaluation. Based on this approach, kW Engineering developed a data collection and analysis plan consistent with that outlined by the International Performance Measurement and Verification Protocol (IPMVP), Option B, Retrofit Isolation. In the EM&V plan, it was assumed that the sample design would initially be evenly divided between measures with five metered sites for each of the four measures. The approach was to directly measure the energy consumption for a representative sample of participants for each of the measures and estimate site-specific demand and energy savings. These site specific estimates of savings were then to be used to develop savings metrics that could be applied to individual non-metered participants.

3.2 Sample Design and Adjustments to the Analysis Approach

Per the EM&V plan, the sample design began with the assumption that five occurrences of each measure would be metered. This plan was qualified with the idea that as participation in the program advanced, metered sites would be redistributed to reflect participation. One of the difficulties faced in the selection and recruitment of sites, was that the participation process made it impossible to identify participating sites prior to measure installation. Basically the program operated on a first come, first served basis, so there was no guarantee that a potential site would ultimately participate.

Given the understanding that obtaining significant pre-installation data would not be possible, the analysis approach was revisited. The revised approach assumed that the majority of the data collected would come from post-installation monitoring and that secondary data would be used to estimate the pre condition. The plan had already allowed for some level of thermal monitoring, and that data would serve as the means for estimating the pre condition for the sample.

The pre condition for these sites was estimated using the following procedure. In all cases, the compressor cooling electrical usage was monitored. Thermal monitoring was used to track the temperature of the milk entering and leaving the plate coolers. According to the National Dairy Council, milk is required to be cooled to a minimum of 45 °F for storage and transportation. Since the cooling of milk is 100% sensible, the cooling energy required is directly proportional to the temperature change of the milk. Said another way, if the temperature of the milk exiting the plate cooler is halfway between the entering temperature and the storage temperature, then 50% of the energy required to cool the milk can be attributed to the plate cooler and the other 50% to the refrigeration system. Since we know the electrical consumption of the refrigeration system from the monitoring, and can estimate the percentage of heat that the refrigeration system is removing, we can calculate the electrical consumption that would have been required in the absence of the plate cooler as a ratio of the observed electrical consumption and percentage of heat removed by the refrigeration system. This approach assumes that the refrigeration system consumption is constant over the range of milk temperatures, which isn't a perfect assumption but reasonably close relative to other independent variables such as changes in outdoor temperature.

To calculate the single baseline consumption value to be used in the population estimate of savings, the estimated "pre condition" value discussed above were combined with monitored sites that ultimately did not install measures and the sites which used the plate coolers with chilled water. The chilled water sites could be used since 100% of the cooling effect was provided by the refrigeration system.

3.3 Data Collection

The primary data for the analysis were collected through direct metering of electricity consumption of refrigeration equipment as well as temperature variables associated with the milk production process. There were three main areas of data collection accomplished by kW Engineering: 1) Interval electricity consumption, 2) Baseline equipment and operating data, 3) Temperature data. Electrical consumption data were collected by kW Engineering using ElitePro data loggers temporarily installed at each of the metered sites. Temperature data were collected using Pace Scientific XR440 Pocket Loggers. Each of the selected farms was contacted and arrangements were made to visit the farm and install data loggers. Some baseline data were collected via telephone. The resulting data provides a census of the participant population. Milk production data, in gallons[1] of milk produced per year, were collected. A discussion of data collection and analysis for multiple measures can be found in the next section.

<u>Measure 1: Vacuum Pump VSD</u>

The vacuum pump VSD measure was previously offered under the 2002-2003 California Variable Speed Drive Farm Program. This measure has been evaluated in a previous study. Per the program implementation plan, no M&V was conducted for this measure.

<u>Measure 2: Milk Plate Cooler</u>

Both electric and thermal metering was completed for this measure. Since the savings for this measure are generated through reduced heat load on the refrigeration system, pre- and post-installation electrical consumption of the refrigeration system were monitored. Electrical monitoring was accomplished using a true three-phase interval meter. In addition, thermal monitoring was used to quantify the amount of heat removed from the production cycle. Determining the heat removed was accomplished by using high accuracy (12-bit) data loggers in tandem with high accuracy thermisters.

[1] When the M&V plan was developed, our understanding was that this milk production data would be provided in pounds both for annual and daily data. In actuality it is provided in gallons. From an analysis standpoint, this was easily reconciled with standard unit conversions.

Measure 3: Milk Pump VSD

Because this measure is an enhancement to a Milk Plate Cooler, the savings are also realized through reduced refrigeration. Therefore an identical monitoring approach to the milk plate cooler was used, with the exception that pre-installation thermal monitoring was also accomplished.

Measure 4: Compressor Heat Recovery
kW Engineering was only able to monitor one pre-retrofit water heater. The metering consisted of the total power consumption of the water heater.

Measure 5: Scroll Compressor

Monitoring for this measure involved Post-installation electrical consumption of the refrigeration system. If the system included both a milk chiller and DX refrigeration on the bulk tank, both were metered.

While the requirement for analysis was total daily electricity usage, electrical consumption and temperature data were logged at 15-minute intervals in order to be able to collect operating hours as well as consumption. Based on the recommendations of the IPMVP, Option B, the metering duration was set as a minimum of 14 days. At the end of the monitoring period the loggers were retrieved and the data downloaded. A discussion of data collection and analysis for multiple measures can be found in the next section.

4.0 RESULTS

4.1 Calculation of Savings

The estimates for demand and energy savings for the program were completed in a series of steps working with the metered and participant data. Ex-ante savings estimates for the program participants were developed by EnSave based on experience and data collected from previous programs. As mentioned above, EnSave has developed proprietary software, which estimates energy savings given baseline data. This software was used to develop the ex-ante demand and energy savings estimates for each participant using baseline information provided in the application.

Using the data downloaded from each logger, spreadsheets for each site were developed to compute daily usage, annual usage, and savings. This was accomplished by first screening the raw data so that only full days are included in the analysis.

Next, using a pivot table, average daily kWh, kW, and kWh/100 Gallons of milk were calculated for each full day. In a similar fashion the daily runtime was computed. Daily, total kWh and runtime are averaged over all of the complete days to yield a final estimate of daily electricity usage and runtime.

The metric used for savings is kWh per 100 gallons of milk produced. Using the metered data a baseline energy usage was determined as discussed in Section 3.2. In order to leverage metered sites with the total population, energy usage adjustment factors were calculated for each measure. The adjustment factors were used to predict energy savings for non-metered participants.

The last step in the process was to estimate the annual verified savings values and compare them to the ex-ante estimates. For demand this is simply the baseline demand computed by EnSave and the average daily demand discussed above. The energy savings were estimated by subtracting the average post-installation production specific energy usage (kWh/100 Gal) from the baseline and then multiplying by the average daily milk production and 365 days per year. The result is then compared to the ex-ante estimate generated by EnSave's software.

For both demand and energy impacts, the ratio of the verified savings to the ex-ante estimate is termed the gross realization rate. This realization rate is the percentage of the ex-ante estimate that is realized (or actual) gross savings based on the verified savings values without adjustment for net effects. The following is a description of the Adjustment factors used to calculate participant energy savings.

<u>Baseline</u>

Baseline site equipment consists of a constant speed milk transfer pump and bulk tank refrigeration only. Due to the lack of sites in which to meter the baseline equipment, the baseline energy usage, as applied to all participant farms, is based on the kWh /100 gallons for metered sites adjusted to reflect operation without energy efficient equipment. As discussed in Section 3.2, these adjustments were accomplished using thermal data to isolate the impacts of the plate coolers and milk pump VSD's. The energy use for each measure was determined using the adjustment factors described below.

Chilled Water Plate Cooler System – CW

It was noted that some sites incorporate a mechanically cooled water stream with the installation of plate coolers. The use of chilled water in plate coolers significantly reduces the milk exit temperature. However, because the cooling is provided by the facility's refrigeration system no energy savings result from the addition of a plate cooler or variable speed drive milk pumps. The reduced flow advantage of a variable speed milk pump is unable to produce further heat transfer due to the temperature difference of the chilled water and the milk streams. Monitoring of plate cooler inlet and outlet temperatures show an average of 71% of the heat removed from incoming milk is removed by the plate cooler. Systems using ground water plate cooler systems removed an average of 28% of the milk's heat. Sites with chilled water plate cooler systems will not provide energy savings from either the plate cooler measure or the variable speed milk pump measure.

In the discussion of the Plate Cooler and Milk Transfer VSD measures below we present two realization rates, an overall realization rate for program level delivery of savings and also a realization rate to reflect the removal of the chilled water sites. We include the second realization rate to provide a better technical potential estimate of measure savings given that the program can be modified to eliminate the installation of chilled water with these measures.

Plate Cooler – PC

The plate cooler adjustment factor is based on monitored kWh/100 gallon values from dairy farms with and without the installed equipment and the percent of heat removed from milk by the plate cooler. Temperature data gathered from farms with existing plate cooler systems were used to determine the percent of total heat removed by the plate cooler for both full and reduced milk flow rates. The heat removal was used to determine the plate cooler adjustment factor. The sample used for the plate cooler adjustment factor is provided Exhibit 3, as well as the heat removal data.

Exhibit 3: Summary of Plate Cooler Metered Sites

Sample Sites	Approx. Daily Milk Production (Gal)	kWh/100 Gal	Plate Cooler	Chilled Water	VSD Milk Pump	Scroll Compressor	Plate Cooler Heat Removal	Baseline (kWh/100 Gal)	Post-Retrofit (kWh/100 Gal)	Plate Cooler Savings	PC
Metered Site 3	2,000	2.95	X	0	0	0	21.3%	3.58	2.95	0.63	18%
Metered Site 4	1,000	3.25	X	0	0	0	20.2%	3.91	3.25	0.66	17%
Metered Site 5	5,000	3.55	X	0	0	0	21.3%	4.30	3.55	0.76	18%
Metered Site 6	2,000	1.69	X	0	0	0	ND				.
Metered Site 12	1,000	2.51	X	0	0	0	26.6%	3.18	2.51	0.67	21%
Average		2.79						3.74	3.07	0.68	

ND - No Data: Logger Failure

Savings Ratio:	18.1%
Usage Ratio:	81.9%

Only dairy farms using ground water through the plate cooler were included in the sample. The Plate Cooler adjustment factor sample consists of monitored sites having installed only a plate cooler as compared to the baseline sites. The factor is applied as a multiplicative function of baseline energy usage. The average usage factor, 81.9%, was applied to the baseline kWh/100 gallon for all sites having installed a ground water plate cooler system, to determine the post-retrofit energy usage as follows:

Post Plate Cooler Energy Usage = Baseline Energy Usage * PC Usage Factor (81.9%)

The table below provides realization rates for the Plate Cooler measure with and without the chilled water sites included. The lower realization rate for all sites reflects the fact the chilled water sites did not achieve savings. The higher realization rate reflects a more realistic savings value (relative to the ex ante estimate) for the measure given that the program could be modified to eliminate the installation of chilled water sites.

Exhibit 4: Gross Plate Cooler Savings
All Sites and Non-Chilled Water Sites

Plate Cooler	Ex-Ante Energy Savings (kWh/yr)	Gross Ex-Post Energy Savings (kWh/yr)	Gross Realization Rate
Energy (kWh)			
All Sites	570,773	220,221	39%
Non-Chilled Water Sites	400,596	220,221	55%
Demand (kW)			
All Sites	112.11	48.72	43%
Non-Chilled Water Sites	83.60	48.72	58%

Milk Transfer Pump VSD – MP

The Milk Transfer Pump VSD adjustment factor is based on a sample of monitored sites having installed a variable speed drive on a milk transfer pump with an existing plate cooler as compared to the baseline sites. The sample is provided below. Because the baseline for the installation of a milk transfer pump VSD is a milk cooling system including a plate cooler, the plate cooler heat removal data for systems with reduced milk flow was used to isolate the energy savings due to the installation of a milk transfer pump VSD. The factor is applied as a multiplicative function of baseline energy usage. The post-installation sample includes both pre and post-installation metering and post only metering of farms with variable frequency milk transfer pumps. The usage factor, 88.6%, was applied to the baseline kWh/100 gallon for all sites having installed a variable speed milk transfer pump, to determine the post-retrofit energy usage.

Exhibit 5: Summary of Milk Pump Metered Sites

Sample Sites	Approx.Daily Milk Production (Gal)	kWh/100 Gal	Plate Cooler	Chilled Water	VSD Milk Pump	Plate Cooler Heat Removal	Baseline	Post	Savings Ratio
Metered Site 8	3,000	2.96	X	0	X	33.2%	3.94	3.49	0.11
Metered Site 10	2,000	4.21	X	0	X	34.1%	5.65	4.97	0.12
Metered Site 13	4,000	1.75	X	0	X	36.9%	2.39	2.06	0.14
Metered Site 14	2,000	2.07	X	0	X	43.9%	2.97	2.44	0.18
Metered Site 15	4,000	2.06	X	0	X	17.8%	2.43	2.43	(0.00)

Baseline	3.47
Post Retrofit	3.08
Savings	0.39
Savings Ratio	10.9%
Usage Ratio	88.6%

The Milk Transfer Pump VSD measure had the same issue regarding the chilled water installations as discussed in the Plate Cooler measure above, and similar results are presented below.

Exhibit 6: Gross Milk Pump Savings
All Sites and Non-Chilled Water Sites

Milk Pump	Ex-Ante Energy Savings (kWh/yr)	Gross Ex-Post Energy Savings (kWh/yr)	Gross Realization Rate
Energy (kWh)			
All Sites	1,004,682	385,709	38%
Non-Chilled Water Sites	696,859	385,709	55%
Demand (kW)			
All Sites	178.41	85.32	48%
Non-Chilled Water Sites	129.10	85.32	66%

<u>Compressor Efficiency – CE</u>

Because the Scroll Compressor measure will reduce energy usage over all compressor operating periods, the Compressor Efficiency adjustment factor is applied as a multiplicative function of baseline energy usage. The sample for this measure includes sites with baseline reciprocating compressors as compared to sites using scroll type compressors without chilled water plate cooler systems. The adjustment factor was determined by adjusting the kWh/100 gallon values for each farm to isolate the baseline and post-retrofit compressor specific energy usage without other installed measures. The usage factor, 64.1%, was applied to the baseline kWh/100 gallon for all sites having installed the scroll compressor measure, to determine the post-retrofit energy usage.

4.2 Results for Metered Sample

Using the process described above, metered results of energy usage, operating hours, demand and energy savings were developed for each of the metered sites based on the data collected. A summary of results for all of the metered sites can be found in Table-7, Summary of Site Specific Results, below.

Exhibit 7: Site Specific Measurement Results

Site	Gal/Day	kWh/Day		kWh/ 100 Gal		Milk ΔT (Deg F)		Water ΔT (Deg F)	
	(kGals)	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Metered Site 9	N/A	480.8	441.0	3.9	3.7	37.0	35.8	0.5	0.6
Metered Site 8	4,000	264.0	261.5	6.2	6.1	52.7	51.9	1.4	1.7
Metered Site 1	1,000	44.6	-	5.8	-	-	-	-	-
Metered Site 4	1,000	35.9	-	3.3	-	11.4	-	4.8	-
Metered Site 13	2,000	-	82.0	-	4.2	-	19.2	-	21.5
Metered Site 14	2,000	-	82.7	-	4.4	-	19.9	-	12.6
Metered Site 15	1,000	16.5	10.4	2.5	2.1	15.0	5.1	9.2	11.2
Metered Site 21	1,000	27.7	31.6	4.2	4.9	25.8	25.0	4.8	2.8
Metered Site 23	0	-	19.2	-	5.7	-	1.3	-	3.2
Metered Site 3	2,000	59.3	-	3.0	-	12	-	8.1	-
Metered Site 6	2,000	26.2	-	1.7	-	-	-	-	-
Metered Site 2	2,000	159.6	-	6.4	-	-	-	-	-
Metered Site 18	4,000	-	68.6	-	2.1	-	10	-	1.2
Metered Site 22	1,000	-	35.3	-	3.6	-	-	-	-
Metered Site 19	2,000	-	112.4	-	7.2	-	-	-	-
Metered Site 11	3,000	-	89.4	-	3.0	-	-	-	-
Metered Site 17	2,000	-	112.8	-	2.1	-	24.7	-	3.4
Metered Site 5	5,000	-	79.5	-	3.5	-	12	-	8.8
Metered Site 16	4,000	-	73.0	-	1.7	-	20.8	-	6.8
Metered Site 24	N/A	-	1,058.5	-	0.4	-	47.9	-	40.6

Exhibit 8: Site Summary of Measures Installed at Metered Sites

Sample Sites	Pre-Installation Data Collected	Chilled Water	Plate Cooler	VSD Milk Pump	Scroll Compress-or
Metered Site 1	X				
Metered Site 2	X				
Metered Site 3			X		
Metered Site 4			X		
Metered Site 5			X		
Metered Site 6			X		
Metered Site 7		X	X		
Metered Site 8			X	X	
Metered Site 9	X	X	X		
Metered Site 10			X	X	
Metered Site 11			X	X	
Metered Site 12			X		
Metered Site 13			X	X	X
Metered Site 14			X	X	X
Metered Site 15			X	X	X
Metered Site 16		X	X	X	X
Metered Site 17	X	X	X		
Metered Site 18	X	X	X		
Metered Site 19					X

4.3 Participant Population Results

Total program level results for the participant population were computed by applying the measure-specific savings factors determined in the above mentioned process to the final database of participants. A summary of program level savings by measure is presented in Exhibit 9 below.

Exhibit 9: Energy and Demand Impacts by Measure

Measure	Ex-Ante Energy Savings (kWh/yr)	Gross Ex-Post Energy Savings (kWh/yr)	Gross Realization Rate	Net Realization Rate	Net Ex-Post Energy Savings (kWh/yr)	Overall Ex-Post Realization Rate
Milk Pump VSD	1,004,682	385,709	38%	42%	161,998.0	16%
Scroll Compressor	631,928	365,634	58%	42%	153,566.1	24%
Plate Cooler	570,773	220,221	39%	42%	92,493.0	16%
Compressor Heat Recovery Unit	43,705	43,705	100%	42%	18,356.0	42%
Vaccum Pump VSD	2,925,985	2,925,985	100%	75%	2,194,488.4	75%
Total	**5,177,073**	**3,941,254**	**76.1%**		**2,620,901.5**	**50.6%**

Measure	Ex-Ante Demand Savings (kW)	Gross EM&V Demand Savings (kW)	Gross Realization Rate	Net Realization Rate	Net Ex-Post Demand Savings (kW)	Overall Ex-Post Realization Rate
Milk Pump VSD	178.41	85.32	48%	42%	35.84	20%
Scroll Compressor	106.72	80.88	76%	42%	33.97	32%
Plate Cooler	112.11	48.72	43%	42%	20.46	18%
Compressor Heat Recovery Unit	7.26	7.26	100%	42%	3.05	42%
Vaccum Pump VSD	547.38	547.38	100%	75%	410.53	75%
Total	**951.88**	**769.56**	**80.8%**		**503.85**	**52.9%**

A total of 118 farmers participated in the program. As illustrated in Exhibit 10 below, the majority of the participants and savings were attained in Pacific Gas and Electric Company's service territory.

Exhibit 10: Participants, Energy and Demand Impacts by Utility

Measure	Number of Participants	Ex-Ante Savings	Gross EM&V Savings	Gross Realization Rate	Net Ex-Post Savings	Overall Ex-Post Realization Rate
PG&E						
Energy (kWh)	99	3,966,668	2,968,406	75%	1,958,424	49.4%
Demand (kW)	99	769.96	611.67	79%	399.97	51.9%
SCE						
Energy (kWh)	19	1,210,406	972,848	80%	662,478	54.7%
Demand (kW)	19	181.93	157.89	87%	103.88	57.1%
Total						
Energy (kWh)	118	5,177,074	3,941,254	76%	2,620,901	50.6%
Demand (kW)	118	951.88	769.56	81%	503.85	52.9%

Please note that full versions of the required Energy Impacts Reporting Tables can be found in Appendix A.

5.0 PROCESS SURVEY

The following section contains the process analysis for the program. The process analysis was conducted by Philippus Willems, PhD. Inc, based on telephone survey data collected from participants and non-participants by Quantum Market Research, Inc.

I. Introduction

This report summarizes the results of a process evaluation of EnSave's California Multi Measure Farm Program, which was funded by the California Public Utilities Commission (CPUC) for PY2004-2005. EnSave offered the program to 2,120 dairy producers throughout Pacific Gas and Electric's (PG&E's) and Southern California Edison's (SCE's) service territories, with the objective of achieving energy and demand savings through the installation of five energy efficiency measures at dairy farms. These installations were accomplished by educating farmers on the benefits of the energy efficient measures and offering cash incentives.

The goals of the process evaluation were to:

- identify market barriers to the installation of the program measures
- assess the effectiveness of program outreach and delivery
- estimate a Net-to-Gross ratio for the program

Note that the present evaluation only addresses four of the five measures covered by the program, since the VSD Vacuum Pump measure (previously offered under the 2002-2003 California Variable Speed Drive Farm Program) was addressed in a previous study.

Evaluation Tasks

The evaluation goals were addressed through the following tasks:

- A telephone survey conducted with 51 program participants out of a total of 118.
- A telephone survey conducted with 32 non-participants, defined as farmers who were informed about the program but chose not to participate. The 32 surveys were successfully completed from a sample of 45 non-participants.
- Analysis and reporting.

The phone surveys were conducted by Quantum Market Research from April through June of 2006.

II. Evaluation Findings

Program Awareness

Data on the timing and source of awareness of the program were collected from both participants and non-participants. The year in which survey respondents reported becoming aware of the program is shown in Exhibit 1.

Exhibit 1. Year Respondents Became Aware of the Program

	Parts	Non-Parts
2002	8.0%	9.4%
2003	18.0%	18.8%
2004	42.0%	31.3%
2005	28.0%	25.0%
2006	2.0%	6.3%
DK	2.0%	9.4%
Total	100.0%	100.0%

While 70% of participants and 56% of non-participants said they learned of the program in 2004 or 2005 (the program years), 26% of participants and 28% of non-participants said they learned of the program during 2002 or 2003, when EnSave offered the Vacuum Pump VFD Program.

Sources of program awareness are summarized in Exhibit 2, which shows participant and non-participants responses to the question: "How did you find out about the California Multi Measure Farm Program?"

Exhibit 2. Sources of Program Awareness

	Participants (N=51)	Non-Parts (N=32)
Equipment vendor	72.5%	25.0%
Direct mail	19.6%	34.4%
Newspaper/newsletter	3.9%	9.4%
Utility rep	0.0%	9.4%
Word of mouth	2.0%	6.3%
EnSave program rep	2.0%	0.0%
DK	0.0%	15.6%
Total	100.0%	100.0%

The survey results indicate the importance of vendors and to a lesser extent direct mail in effectively reaching California dairy farmers with this program and encouraging them to participate:

- More than 70% of participants said they learned of the program from equipment vendors, compared to just 25% of non-participants. In contrast, only a single participant and no non-participants became aware of the program through an EnSave Program representative.

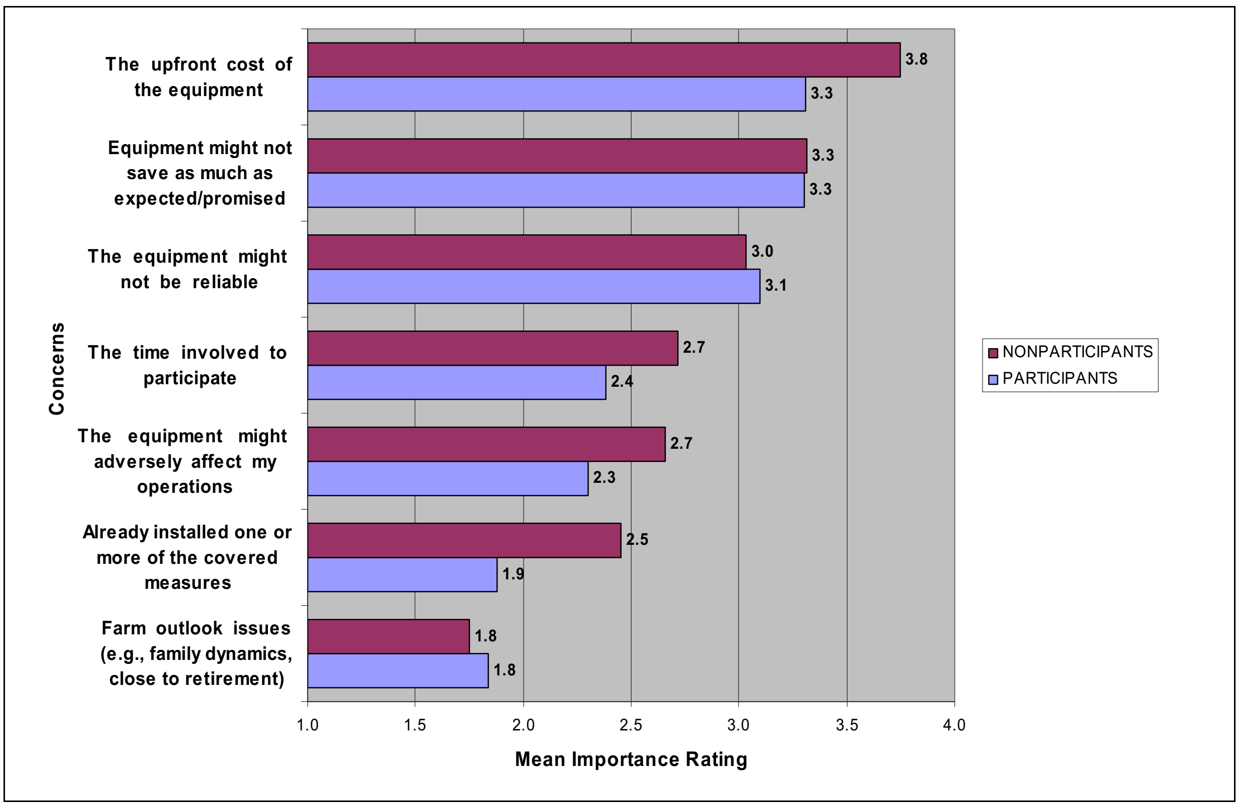
- Direct mail was also a significant source of program awareness, and was cited by more than one-third of non-participants as well as 20% of participants.

While only 4% of participants said they learned of the program through newsletters or newspapers, more than 9% of non-participants became aware through this channel. Moreover, 8% of participants offered the suggestion that the program should have been announced or advertised in dairy magazines when asked what recommendations they had to improve the California Multi Measure program, suggesting that these magazines could have been an effective way to reach the program's targeted audience.

Barriers to Participation

Both participants and non-participants were asked about the importance of various concerns regarding their participation in the program. Results are presented in Exhibit 3.

Exhibit 3. Concerns Regarding Participation

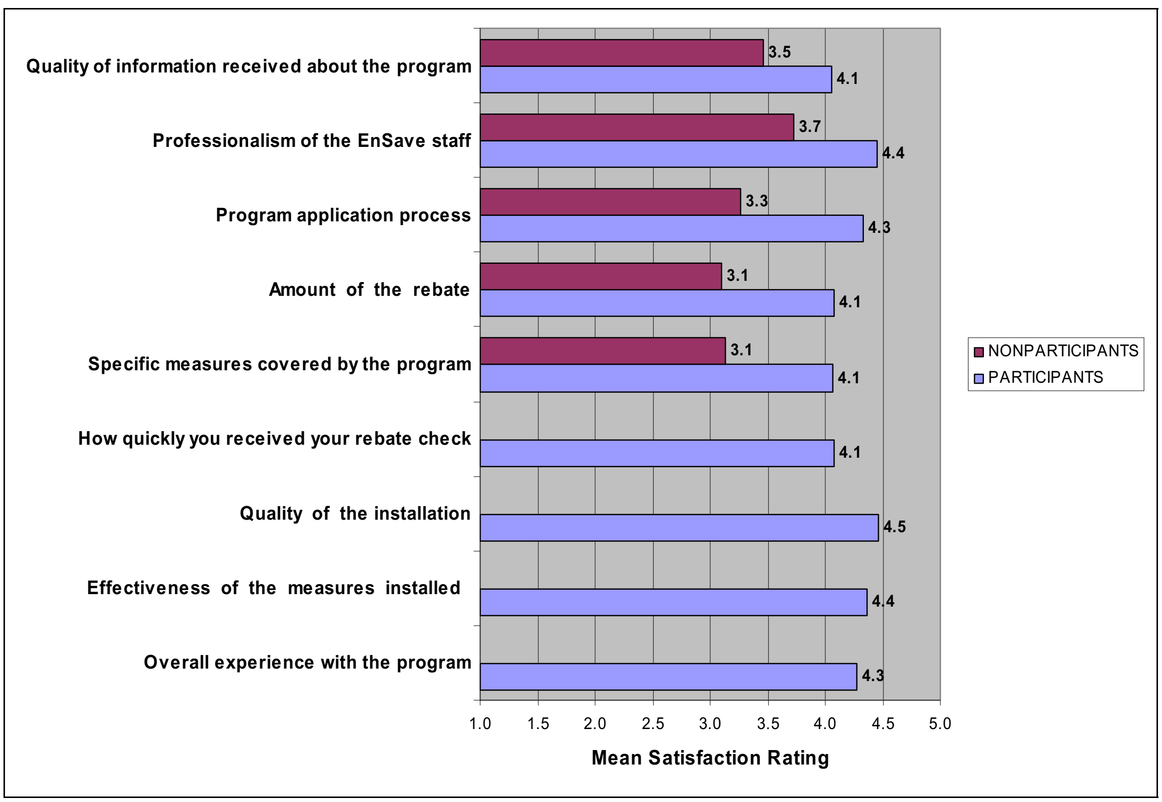


Participants generally assigned somewhat lower levels of importance to concerns they may have had about participating in the program, although none of the differences between the two sets of means were statistically significant. For both groups, the biggest issues were the upfront cost of the equipment, concerns that the equipment might not save as much as promised, and concerns that it might not be reliable. The biggest difference between participants and non-participants was in whether they already had one or more program measures installed. For both groups, farm outlook issues, such as family dynamics or a farmer nearing retirement, were the least significant concern affecting the decision to participate.

Program Satisfaction

To assess program performance, both participants and non-participants were asked about their satisfaction with those elements of the California Multi Measure Farm program dealing with awareness and enrollment. Program participants were also asked about their satisfaction with various aspects of program participation after they had signed up for the program. Results are summarized in Exhibit 4 and discussed below.

Exhibit 4. Satisfaction with Program Elements



Participants were more satisfied than non-participants with all elements related to learning about and deciding whether to participate in the program, with all of the differences statistically significant at the 95% confidence level. The differences between participants and non-participants were greatest for satisfaction with the program application process, the measures covered by the program, and the amount of the rebate – suggesting that non-participants may have chosen not to participate because of their perception of the steps involved in the process. Farmers who did participate were generally very satisfied with both the application process and their actual participation, assigning all of the program elements a mean rating of greater than 4 on a 1 to 5 scale.

Respondents who assigned a satisfaction rating of 1 or 2 to any element were asked to explain why they did so. The resulting explanations or comments are summarized below, first for participants, then for non-participants.

Participant Explanations for Ratings of 1 or 2

- Information
  - There wasn't very much information; it could have been more detailed
  - I didn't receive any information
- EnSave staff professionalism
  - I had a hard time getting hold of anyone
- Application process
  - Hard to get hold of anyone, and when I did they turned me down
- Rebate
  - Because of how long it took to process everything. I was involved in two programs. It took 6 months until I got the rebate on the fans.
  - I didn't get any rebate.
  - The amount was too low, $2200 on an $8000 unit
  - The cost of the equipment compared to the rebate
  - Because it was too low
- Length of time to receive the rebate
  - My check was delayed by some person's negligence
  - I didn't get a rebate
  - It took too long
- Quality of the installation
  - There were problems with the installation
- Equipment performance
  - We're still having a problem with our milk being too hot
- Program overall
  - It is silly for them to say you have to get it approved before installation. Sometimes you have to get the equipment put in quickly.
  - The installation had problems

Non-participants Explanations for Ratings of 1 or 2

- Information
  - The whole process took too long
  - It didn’t accurately reflect what I could get
  - It was unclear the way they put it
- EnSave staff professionalism
  - They were friendly but not expert enough on the technical side of the program.
  - I didn't think I'd get paid. Payback or rebate was promised on original vacuum pump install but never came through. (Someone) at EnSave said they'd be able to pay but after installing the equipment and calling her back she said there was no money left.
  - Because I didn't really get the help I needed to actually get the rebate.
- Application process
  - Took too long
  - Bad past experiences
  - They didn't explain what was covered and what wasn't. I installed the unit and they didn't give me credit for it saying it didn't meet requirements.
  - There was no guarantee that if the equipment was put in the rebate would be paid..
  - They were slow getting back to me; need to get back quicker.
  - Too much paperwork, it became a burden.
  - Too many forms to fill out.
- Rebate
  - Because of maintenance, it would not be worth it.
  - Because of the concern about the vendor raising price in view of the program, so no real savings were available.
  - Amount of the rebate offered was too low for both rebate and payback time.
  - Would like a higher percent offer.
  - Because I never got the rebate.
  - By the time the company that installed finished the paperwork, they had run out of money.
  - Would like a higher rebate offer.
  - They were too low, should have been 20 percent.
  - Wanted more money (rebate).
  - Regardless of what we save we still pay a lot for electricity, so the rebates should be higher.
- Measures covered by the program
  - Somehow I was misled about what equipment I could get.
  - They never got back to me about offering to rebate on any piece of equipment.
  - Lack of information regarding measures and effects of them.
  - Should have been more measures.

One of the underlying factors contributing to the low satisfaction ratings offered by non-participants appears to be the fact that the program ran out of money before the end of 2005, a point that was raised by six non-participants when they were asked to offer suggestions for program improvement. The following comments were offered:

- If I enroll in the program I'd like to be guaranteed that a rebate will be paid after investing in expensive equipment.
- If the program has an end date for a year then the money should be available for anybody who applies.
- We bought an air compressor, did the paperwork to get a rebate, then got a letter saying that EnSave was out of money. I think that if we agree to take part in the program and purchase equipment then the money for the rebate should be set aside for us.
- Have more funds available, so that those who wish to participate can do so.
- Make more effort to communicate regarding ongoing paperwork needed from the farmer. Should not be a reason to be deprived of rebate when money runs out.
- The application was easy to fill out but as the communication process happened it was not very good. I still have copies of applications and I still haven't received any rebates. One time when I called EnSave they said they had run out of funds.

Other recommendations from non-participants included better program communication (4 respondents), more or higher rebates (3), better technical information/support (3), rebates to manufacturers (1), financing (1), and providing a list of other farmers who have this equipment (1).

Among participants, most said they had no suggestions or offered positive comments, reflecting the high level of satisfaction with program elements and with the program overall. Those comments that were offered focused on better communication, including advertising of the program in dairy magazines and via direct mail (7), higher rebates (4), an improved, shorter application process (4), and a wider range of measures covered by the program (3).

Net-to-Gross Estimates

Several questions were asked of program participants to determine the extent to which measures installed through the program would have been installed anyway. While the intent was to estimate a program-level NTG, the best way to do this would be through the calculation of NTG numbers for each individual measure and the application of these individual numbers to the number of each measure installed through the program. However, because many of the participants surveyed had installed the Vacuum Pump VSD measure that was excluded from this evaluation, the number of respondents having installed each of the other individual measures was relatively small, ranging from 3 for the compressor heat recovery unit to 32 for milk pump VSDs.

For each measure, all survey respondents were asked whether they had installed that measure through the program (for participants only), through another program, or outside any program. Results are presented in Exhibit 5.

Exhibit 5. Actions Taken by Program Measure

Action Taken \ Measure	Milk plate cooler		Milk pump VSD		Scroll compressor		Compressor Heat Recovery Unit	
	N=50 PARTS	N=32 NPs	N=50 PARTS	N=32 NPs	N=50 PARTS	N=32 NPs	N=50 PARTS	N=32 NPs
Installed through the program	14.0%	0.0%	64.0%	0.0%	16.0%	0.0%	6.0%	0
Installed through another program	0.0%	6.3%	2.0%	25.0%	0.0%	3.1%	0.0%	6.3%
Installed, but not through any program	74.0%	78.1%	18.0%	25.0%	20.0%	18.8%	40.0%	40.6%
Have not installed	12.0%	12.5%	14.0%	40.6%	60.0%	56.3%	52.0%	50.0%
Other		3.1%	0.0%	3.1%	0.0%	6.3%	0.0%	0.0%
DK		0.0%	2.0%	6.3%	4.0%	15.6%	2.0%	3.1%

For all measures except milk pump VSDs, more participants had installed the measure outside any program than had installed through the Multi measure Farm program. The percentage installing outside any program was similar for participants and non-participants, while the percentage who had not installed the measure was roughly equal for all measures except milk pump VSDs.

The implication for the program NTG is that at all but the milk pump VSD measure were more likely to have been installed outside the program than through the program. Moreover, milk plate coolers appear to be standard practice, with roughly three-fourths of all respondents having installed them without using any program. While about 20% of milk coolers installed outside the program by both participants and non-participants use cooled water (and therefore do not obtain energy savings,) all seven[2] of the milk plate coolers installed through the program, use ground water.

Both participants and non-participants were also asked why they had not installed the measures targeted by the program. Results are presented in Exhibit 6.

Exhibit 6. Reasons for Not Installing Program Measures

[2] This refers to the sample of program participants that also participated in the telephone survey

Reason for Not Installing \ Measure	Milk plate cooler		Milk pump VSD		Scroll compressor		Compressor Heat Recovery Unit	
	N=6	N=4	N=7	N=13	N=30	N=18	N=26	N=16
	PARTS	NPs	PARTS	NPs	PARTS	NPs	PARTS	NPs
Costs too much/payback too long	33.3%	75.0%	28.6%	46.2%	36.7%	38.9%	38.5%	37.5%
Didn't know /wasn't told about it	33.3%		14.3%		40.0%	27.8%	26.9%	18.8%
No need/already have/equipment still good	33.3%	25.0%	14.3%	15.4%	16.7%	11.1%	7.7%	31.3%
Might not save as much as expected			14.3%	15.4%				
Didn't think about it							7.7%	
Might not be reliable							3.8%	
Other			28.6%	15.4%	3.3%		7.7%	
DK				7.7%	3.3%	22.2%	7.7%	12.5%

While the number of respondents who had not installed the measure was low for both milk plate coolers and milk pumps VSDs, more than 40 farmers said they had not installed scroll compressors or compressor heat recovery units. Upfront costs/payback concerns were the main reason these measures had not been installed, followed by lack of information or knowledge about the measures. Fully 40% of participants said they did not know or had not been told about scroll compressors, while 26.9% offered that response for compressor heat recovery units. To the extent that this may have happened because compressors are offered by a different set of vendors, participating suppliers should be encouraged to make farmers aware of other measures offered through the program. They may not have done so because demand for other measures would reduce the availability of program funds for their own product line.

Finally, the extent to which the Multi Measure Farm Program encouraged participants to take actions they would otherwise not have taken was addressed by a survey question asking participants who installed a measure through the program what they would have done if the program had not been available. Results are presented in Exhibit 7.

Exhibit 7. Actions in the Absence of the Program

Action Without Program \ Measure	Milk plate cooler	Milk pump VSD	Scroll compressor	Compressor Heat Recovery Unit	All Measures Combined
	N=7	N=32	N=8	N=3	N=50
would not have installed	14.3%	25.0%	12.5%	33.3%	22.0%
would have installed anyway	28.6%	34.4%	62.5%	66.7%	40.0%
would have installed, but not as soon	57.1%	40.6%	25.0%	0.0%	38.0%

Note first that the number of participants who installed each measure was fewer than 10 for all but milk pump VSDs, making the results statistically invalid at the individual measure level. For milk pump VSDs, 32 participants installed the measure, and 34% of those said they would have installed the measure anyway, while 41% said they would have installed, but not as soon. Combining the percentage who said they would not have installed the measure and the percentage who would not have installed at this time, we calculate the NTG for this measure as .25 plus .41, or .66. More conservatively, if the percentage who would have installed the measure later is weighted at 50% to account for deferred free-ridership, the NTG for this measure would be .25 plus .20, or .45.

Ideally, we would estimate the program NTG by calculating measure-specific NTG values and calculating a weighted program mean based on the number of each measure installed. However, as noted above, there are too few observations for measure-specific calculation. Instead, we combined the observations for all measures, as shown in the last column in Exhibit 7. For the surveyed participants, this yields an aggregate NTG of 0.42 across all 50 measures for which respondents provided data (.22 + 50% of .4).

The high market penetration for most of the measures covered by the program stands in contrast to the results of a 2002 survey conducted by EnSave, which indicated that less than 20 percent of California dairy producers were currently adopting the energy efficiency measures to be offered under the program. It appears that several of the program technologies have gained widespread market acceptance since then, suggesting that there is no strong continuing need for a program targeting the installation of these measures.

At least some of the non-participants who said they installed one of the program measures did so in anticipation of receiving a rebate through the Multi Measure Farm Program but ultimately found that the program had run out of money. Such installation of measures outside a program would normally be considered a spillover effect. However, we did not quantify this effect because there was no statistically sound way to do so. As noted previously, non-participant questions asked about the installation of program measures through other programs or outside any program, but did not explicitly ask whether a measure had been installed in anticipation of a rebate that was never received. Instead, nonparticipants provided this information in comments at the end of the survey. A total of six non-participants both installed one or more measures outside any program and offered comments on the program running out of money, sometimes (but not always) with reference to specific measures. Thus, while it is clear that some non-participants undertook measure installations that were induced by the program, we do not know which measures and how many non-participant installations were affected.

We do know from non-participant comments that the funding shortfall appears to have been perceived as bait and switch by a number of (involuntary) non-participants, that this led to negative perceptions of the program, and that this may make it more difficult to encourage participation targeted to this generally skeptical market segment.

IV. Summary of Key Findings

- More than two thirds of participants and 56% of non-participants said they learned of the program in 2004 or 2005 (the program years), while 26% of participants and 28% of non-participants said they learned of the program during 2002 or 2003, when EnSave offered the Vacuum Pump VSD Program.

- More than 70% of participants learned of the program from equipment vendors, compared to 25% of non-participants. Direct mail was also a significant source of program awareness, cited by more than one-third of non-participants and 20% of participants. While only 4% of participants said they learned of the program through newsletters or newspapers, more than 9% of non-participants became aware through this channel, and 8% of participants offered the suggestion that the program should have been announced or advertised in dairy magazines – a relatively high percentage for an unprompted response.

- Participants generally assigned somewhat lower levels of importance to concerns about participating in the program, although none of the differences between the two sets of means were statistically significant. For both groups, the biggest issues were the upfront cost of the equipment, concerns that the equipment might not save as much as promised, and concerns that it might not be reliable.

- Participants were statistically significantly (at the 95% confidence level) more satisfied than non-participants with all elements related to learning about and deciding whether to participate in the program.
  - The differences between participants and non-participants were greatest for satisfaction with the program application process, the measures covered by the program, and the amount of the rebate – suggesting that non-participants may have chosen not to participate because of their perception of the steps involved in the process.
  - On the other hand, farmers who did participate were generally very satisfied with both the application process and their actual participation, assigning all of the program elements a mean rating of greater than 4 on a 1 to 5 scale.
  - One of the underlying factors contributing to the low satisfaction ratings offered by non-participants appears to be the fact that the program ran out of money before the end of 2005, a point that was raised by six non-participants when they were asked to offer suggestions for program improvement.

- All but the milk pump VSD measure were more likely to have been installed outside the program than through the program. Moreover, milk plate coolers appear to be standard practice, with roughly three-fourths of all respondents having installed them without using any program.
  - While the number of respondents who had not installed the measure was low for both milk plate coolers and milk pumps VSDs, more than 40 farmers said they had not installed scroll compressors or compressor heat recovery units.

  - Upfront costs/payback concerns were the main reason these measures had not been installed, followed by lack of information or knowledge about the measures.

- NTG estimates were calculated based on the percentage of participants who said they would not have installed the program measure without the program in place or would not have installed it until later.
  - Because so few participants installed other measures, milk pump VSDs were the only measure for which an individual NTG value could be calculated: 0.66.
  - Making the same calculation using all 50 measures installed by survey respondents yields an aggregate NTG of 0.6 for the program based on survey results.

- The high market penetration for most program measures stands in contrast to the results of a 2002 survey conducted by EnSave indicating that less than 20 percent of California dairy farms were adopting these measures.
  - It appears that several of the program technologies have gained widespread market acceptance since then, suggesting that there is no strong continuing need for a program targeting the installation of these measures.
  - At least some non-participants installed program measures in anticipation of receiving a rebate through the Multi Measure Farm Program but ultimately found that the program had run out of money. This is perceived as bait-and-switch marketing by the effected farmers, discredits the current program, and will make it more difficult for future programs to succeed with this target market. Ensuring that participants who install program measures in anticipation of incentives do in fact receive those incentives is a fundamental requirement of program implementation. Program managers should avoid these unexpected (but not unpredictable) shortfalls through, suggesting that there is no strong continuing need for a program targeting the installation of these measures better communication and the commitment of funds before a project is initiated.

APPENDIX A
REQUIRED ENERGY IMPACTS REPORTING TABLES

Sum Of Energy Impacts for This 2004-2005 Program

2004-2005 form

Program IDs*:	354-04 and 1360-04						
Program Name:	California Multi-Measure Farm Program						
Year	**Calendar Year**	**Ex-ante Gross Program-Projected Program MWh Savings (1)**	**Ex-Post Net Evaluation Confirmed Program MWh Savings (2)**	**Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)**	**Ex-Post Evaluation Projected Peak MW Savings (2**)**	**Ex-Ante Gross Program-Projected Program Therm Savings (1)**	**Ex-Post Net Evaluation Confirmed Program Therm Savings (2)**
1	2004	5,177.07	2,620.90	0.952	0.504	0	0
2	2005	5,177.07	2,620.90	0.952	0.504	0	0
3	2006	5,177.07	2,620.90	0.952	0.504	0	0
4	2007	5,177.07	2,620.90	0.952	0.504	0	0
5	2008	5,177.07	2,620.90	0.952	0.504	0	0
6	2009	5,177.07	2,620.90	0.952	0.504	0	0
7	2010	5,177.07	2,620.90	0.952	0.504	0	0
8	2011	5,177.07	2,620.90	0.952	0.504	0	0
9	2012	5,177.07	2,620.90	0.952	0.504	0	0
10	2013	5,177.07	2,620.90	0.952	0.504	0	0
11	2014	5,177.07	2,620.90	0.952	0.504	0	0
12	2015	5,177.07	2,620.90	0.952	0.504	0	0
13	2016	5,177.07	2,620.90	0.952	0.504	0	0
14	2017	5,177.07	2,620.90	0.952	0.504	0	0
15	2018	5,177.07	2,620.90	0.952	0.504	0	0
16	2019	5,177.07	2,620.90	0.952	0.504	0	0
17	2020	5,177.07	2,620.90	0.952	0.504	0	0
18	2021	5,177.07	2,620.90	0.952	0.504	0	0
19	2022	5,177.07	2,620.90	0.952	0.504	0	0
20	2023	5,177.07	2,620.90	0.952	0.504	0	0
TOTAL	**2004-2023**	103,541.48	52,418.03	0.952	0.504	0	0

*This form is for the total energy impacts for the program across all IOU territories in which the program was implemented.
May be multiple ID numbers if implemented in more than one territory.
**Please include the definition of Peak MW used in the evaluation.

Definition of Peak MW as used in this evaluation: The average demand reduction achieved between 12:00 PM and 6:00 PM when the equipment is operating.

1. Gross Program-Projected savings are those savings projected by the program before NTG adjustments.
2. Net Evaluation Confirmed savings are those documented via the evaluation and include the evaluation contractor's NTG adjustments.

Note:
Peak MW is defined as average annual peak demand reduction.

SCE Program Energy Impact Reporting for 2004-2005 Programs

Program ID*:	1360-04							
Program Name:	California Multi-Measure Farm Program							
Year	**Calendar Year**	**Ex-ante Gross Program-Projected Program MWh Savings (1)**	**Ex-Post Net Evaluation Confirmed Program MWh Savings (2)**	**Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)**	**Ex-Post Evaluation Projected Peak MW Savings (2**)**	**Ex-Ante Gross Program-Projected Program Therm Savings (1)**	**Ex-Post Net Evaluation Confirmed Program Therm Savings (2)**	
1	2004	1,210.4	662.5	0.182	0.104	0	0	
2	2005	1,210.4	662.5	0.182	0.104	0	0	
3	2006	1,210.4	662.5	0.182	0.104	0	0	
4	2007	1,210.4	662.5	0.182	0.104	0	0	
5	2008	1,210.4	662.5	0.182	0.104	0	0	
6	2009	1,210.4	662.5	0.182	0.104	0	0	
7	2010	1,210.4	662.5	0.182	0.104	0	0	
8	2011	1,210.4	662.5	0.182	0.104	0	0	
9	2012	1,210.4	662.5	0.182	0.104	0	0	
10	2013	1,210.4	662.5	0.182	0.104	0	0	
11	2014	1,210.4	662.5	0.182	0.104	0	0	
12	2015	1,210.4	662.5	0.182	0.104	0	0	
13	2016	1,210.4	662.5	0.182	0.104	0	0	
14	2017	1,210.4	662.5	0.182	0.104	0	0	
15	2018	1,210.4	662.5	0.182	0.104	0	0	
16	2019	1,210.4	662.5	0.182	0.104	0	0	
17	2020	1,210.4	662.5	0.182	0.104	0	0	
18	2021	1,210.4	662.5	0.182	0.104	0	0	
19	2022	1,210.4	662.5	0.182	0.104	0	0	
20	2023	1,210.4	662.5	0.182	0.104	0	0	
TOTAL	**2004-2023**	24,208.13	13,249.56	0.182	0.104	0	0	

*Please complete this form for the SCE program ID included in the evaluation.
**Please include the definition of Peak MW used in the evaluation.
Definition of Peak MW as used in this evaluation: The average demand reduction achieved between 12:00 PM and 6:00 PM when the equipment is operating.

Note, change the Program ID Number on the worksheet tabs (below), so that it matches the Program ID Number of the program being evaluated.

1. Gross Program-Projected savings are those savings projected by the program before NTG adjustments.
2. Net Evaluation Confirmed savings are those documented via the evaluation and include the evaluation contractor's NTG adjustments.

Note:
Peak MW is defined as average annual peak demand reduction.

Program ID*:	354-04							
Program Name:	California Multi-Measure Farm Program							
	Year	**Calendar Year**	**Ex-ante Gross Program-Projected Program MWh Savings (1)**	**Ex-Post Net Evaluation Confirmed Program MWh Savings (2)**	**Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)**	**Ex-Post Evaluation Projected Peak MW Savings (2**)**	**Ex-Ante Gross Program-Projected Program Therm Savings (1)**	**Ex-Post Net Evaluation Confirmed Program Therm Savings (2)**
	1	2004	3,966.7	1,958.4	0.770	0.400	0	0
	2	2005	3,966.7	1,958.4	0.770	0.400	0	0
	3	2006	3,966.7	1,958.4	0.770	0.400	0	0
	4	2007	3,966.7	1,958.4	0.770	0.400	0	0
	5	2008	3,966.7	1,958.4	0.770	0.400	0	0
	6	2009	3,966.7	1,958.4	0.770	0.400	0	0
	7	2010	3,966.7	1,958.4	0.770	0.400	0	0
	8	2011	3,966.7	1,958.4	0.770	0.400	0	0
	9	2012	3,966.7	1,958.4	0.770	0.400	0	0
	10	2013	3,966.7	1,958.4	0.770	0.400	0	0
	11	2014	3,966.7	1,958.4	0.770	0.400	0	0
	12	2015	3,966.7	1,958.4	0.770	0.400	0	0
	13	2016	3,966.7	1,958.4	0.770	0.400	0	0
	14	2017	3,966.7	1,958.4	0.770	0.400	0	0
	15	2018	3,966.7	1,958.4	0.770	0.400	0	0
	16	2019	3,966.7	1,958.4	0.770	0.400	0	0
	17	2020	3,966.7	1,958.4	0.770	0.400	0	0
	18	2021	3,966.7	1,958.4	0.770	0.400	0	0
	19	2022	3,966.7	1,958.4	0.770	0.400	0	0
	20	2023	3,966.7	1,958.4	0.770	0.400	0	0
	TOTAL	**2004-2023**	79,333.35	39,168.47	0.770	0.400	0	0

*Please complete this form for the PG&E program ID included in the evaluation.
**Please include the definition of Peak MW used in the evaluation.
Definition of Peak MW as used in this evaluation: The average demand reduction achieved between 12:00 PM and 6:00 PM when the equipment is operating.

Note, change the Program ID Number on the worksheet tabs (below), so that it matches the Program ID Number of the program being evaluated.

1. Gross Program-Projected savings are those savings projected by the program before NTG adjustments.
2. Net Evaluation Confirmed savings are those documented via the evaluation and include the evaluation contractor's NTG adjustments.

Note:
Peak MW is defined as average annual peak demand reduction.

APPENDIX B
EM&V PLAN REVIEW COMMENTS & RESPONSES

CPUC/Policy Manual Evaluation Goal		How the plan addresses the Policy Manual or justification for not doing so:	Issues of concern, if any:
Measure energy and peak savings per year over the life of the measures (kWh, kW & therms for each year)	Installation verification	Sample of 10% of sites (20) receive M&V	
	Gross impact analysis	Based off realization rate adjustments to sites from M&V analysis	
	Impact units of measure (program or measure)	Measure and program level savings estimates, with estimates per pound of milk production	
	Measurement and Verification approach	IPMVP Option B, 2 week pre and post metering with 15-minute interval, electric and thermal (logger thermisters and ultrasonic flow meter, measure entering & exiting milk and cooling water temperatures for milk plate cooler & milk pump VSDs	
	Sampling and uncertainty	85% confidence on a measure-basis assuming a 20% standard deviation	
	Peak demand analysis	Pre-Evaluation Comments: Will update EM&V plan in appropriate sections. Not difficult, all data available. Post-Evaluation Comments: Demand impacts for all measures were developed and reported as part of the evaluation.	Need to include in EM&V Plan (should be relatively simple off of 15-minute interval data)
	Net-to-Gross	Pre-Evaluation Comments: The simplest approach will be to	Needs to be added.

		stipulate 75% which is consistent with the PIP and the Policy manual. We will state that a comprehensive Net-to-gross analysis is more suited to the statewide evaluation of the IOU programs that involve the dairy industry. Post-Evaluation Comments: A net to gross analysis was conducted and incorporated in the final report, see Section 5.	
Measure cost-effectiveness		Pre-Evaluation Comments: Cost-effectiveness will be computed using the program workbook with updated savings and costs to reflect the EM&V findings and actual costs. Post-Evaluation Comments: Given the low overall realization rates for the four measures evaluated, a detailed review and analysis does not seem to be useful or warranted.	Needs to be addressed.
Provide upfront market assessment and baseline analysis		Pre-Evaluation Comments: Based on EnSave's experience with the 2002 program, and that small dairies have traditionally been under served, there is a clear need for energy efficiency programs targeted toward the dairy industry. Given the timeframe of the program, the hard to reach aspect, and identified need, an upfront market assessment was not reasonable. With the exception of Vacuum pump VSD's (which are not part of the evaluation), baseline data do not exist for the other measures. As a	Needs to be addressed.

		component of the process survey, participating farmers will be polled regarding the installation of measures outside of the program. Also, all participating farmers will be asked if any of the qualifying measures have already been installed and if any incentive was received. Results will be provided in a tabular format.	
Provide ongoing feedback and guidance		Pre-Evaluation Comments: EnSave will receive quarterly progress reports of the evaluation effort detailing what was found at the site and effectiveness of the measures installed and evaluated to date. EnSave can then incorporate those comments in progress reports to the Commission.	Needs to be addressed.
Measure indicators of effectiveness and testing program theory (PT/LM) and approach		Post-Evaluation Comments Detailed measurement and testing of the program theory was not completed under the evaluation, given the relatively small size of the program and the established need for the program based on results from the 2002-2003 VSD Vacuum pump program.	Needs to be addressed.
Assess the overall levels of performance and success **(Process eval)**	Process evaluation approach	Pre-Evaluation Comments: A process evaluation will be conducted in a similar fashion to the 2002 program.	Needs to be addressed.
	Sampling plan for process evaluation	Since this market sector is hard to reach, the process evaluation will be conducted as a census.	Needs to be addressed.
Inform decisions regarding		Verification on sample of 10%.	

compensation and final payments **(Measure counts)**			
Help assess the continuing need for the program **(Gen assessment)**		Pre-Evaluation Comments: Will update EM&V Plan. We will base this on the response rate to marketing activities and how fast the program becomes subscribed. Post-Evaluation Comments: See Section 5, Process Survey of the final report.	Needs to be addressed.

CUSTOMIZED MEASURES

WORKPAPERS

- LIGHTING
- ALL HVAC
- CUSTOM ELECTRIC MEASURES
- CUSTOM GAS MEASURES
- NON-RES NEW CONSTRUCTION (DAY LIGHTING/OTHER LIGHTING CONTROLS)
- RES NEW CONSTRUCTION (WHOLE BUILDING)
- RES MULTIFAMILY NEW CONSTRUCTION (WHOLE BUILDING)

Customized Measures

Introduction

This section provides supporting documents for the following Customized Measures:

- Large Non-Residential customized incentive measures NTFR value
- Residential Single Family New Construction Whole Building measures NTFR value
- Residential Single Family New Construction Lighting measure NTFR value
- Residential Multifamily New Construction Whole Building measure NTFR value
- Non-Residential New Construction Daylighting Controls measure NTFR value
- Non-Residential New Construction Other Lighting Controls measure NTFR value

Summary Issues

- Large Non-Residential customized incentive measures have the following NTFR values adopted for 2009-2011 Planning from CPUC.
  - All Lighting - 64%
  - All HVAC - 64%
  - Custom Electric Measures - 64%
  - Custom Gas Measures - 64%
- The DEER Update NTGR excludes savings from non-incented energy efficiency measures and practices that are part of an SPC project as well as ignores correction to the measurable self report bias contrary to the recommendation of the EM&V studies. Please see attached Joint Utilities workpaper on Standard Performance Program All Measures Net-to-Gross Ratios.

- The Residential Single Family New Construction Whole Building measure has NTFR of 48% for 2009-2011 Planning from CPUC. Please see 2004-05 CA Statewide Energy Star New Homes Program evaluation study, page 15, Table 3. The NTFR values do not include spillover, to be appropriate must be applied to meter-adjusted gross savings. The meter adjustments are shown on page 65, Table 23. Please see EM&V Study ID - PGE0218 (July 18, 2007). www.calmac.org

- The Residential Single Family New Construction Lighting measure has NTFR of 62% for 2009-2011 Planning from CPUC. This measure is for a prescriptive lighting rebate application and there are no evaluations has completed for this measure in RNC. Although the DEER team referenced two studies for this measure, neither study evaluated lighting savings or lighting free ridership.

- The Residential Multifamily New Construction Whole Building measure has NTFR of 50% for 2009-2011 Planning from CPUC.See attached email from Douglas Mahone, dated June 12, 2008.

- The Non-Residential New Construction Daylighting Controls measure has NTFR of 64% for 2009-2011 Planning from CPUC. Please see 2004-05 Evaluation of the SBD Program, August 2007, page 31, Table 32, go to the following CALMAC link, http://calmac.org/publications/Final_Report_SBD_2004-2005.pdf

- The Non-Residential New Construction Other Lighting Controls measure has NTFR of 81% for 2009-2011 Planning from CPUC. Please see 2004-05 Evaluation of the SBD Program, August 2007, page 31, Table 32, go to the following CALMAC link, http://calmac.org/publications/Final_Report_SBD_2004-2005.pdf

Recommendations

- Large Non-Residential customized incentive measures NTFR value of 69%
- Residential Single Family New Construction Whole Building measures NTFR of 123% for kwh and 40% for therm
- Residential Single Family New Construction Lighting measure NTFR of 70% (default value)
- Residential Multifamily New Construction Whole Building measure NTFR of 100%.
- Non-Residential New Construction Daylighting Controls measure NTFR of 97%
- Non-Residential New Construction Other Lighting Controls measure NTFR of 90%

All Lighting

Work Paper

Joint IOU

Standard Performance Contract Program — All Measures

Net-to-Gross Ratios

May 16, 2008

At a Glance Summary

Measure Names	All Measures
Program Type	Retrofit
Market Segment	Nonresidential
Delivery Type	Customized Incentives, Performance Contracting
Net-to-Gross Ratios	0.69
Important Comments	

Note: The information provided in this work paper was developed using the best available technical resources at the time this document was prepared.

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List of Tables

Section 1.

1.1 General Measure and Program Description

This work paper documents the net-to-gross ratio (NTGR) for all measure categories in the 2006-2008 nonresidential Standard Performance Contract (SPC) program. The SPC program offers customized incentives that are calculated on the basis of project performance related to energy efficiency for equipment retrofits or replacements.

1.2 DEER 2008 NTG Update Differences Analysis

For the NTGRs for this program, the 2008 update to the Database for Energy Efficiency Resources (DEER)[1] draws on the recent measurement and evaluation study[2] of the 2004-2005 statewide nonresidential Standard Performance Contract Program. That study reports an overall NTGR of 0.69. The DEER Update proposes a value of 0.54. The difference lies in the disregard for adjustments to the raw measurement of the net-to-gross ratio.

1.3 EM&V, Market Potential, and Other Studies

In the 2004-2005 statewide nonresidential Standard Performance Contract Program evaluation study[2], the independent evaluation contractor calculated a net-to-gross ratio of 0.69 for the program.

Total Project Savings.

The unit of analysis in the SPC program should be the project, not a large number of separate measures. The term “participant spillover” has been used inaccurately in the assessment of net savings of the Standard Performance Contract programs, resulting in the inappropriate reduction of the NTGR value by 0.05 in the DEER Update.

The DEER Update NTGR excludes savings from non-incented energy efficiency measures and practices that are part of an SPC project. Customers do file applications for SPC projects that include measures for which incentives are not available. These measures are undertaken as part of the SPC project and do result in savings. In addition, during the course of the project, the customer may enlarge the project’s scope and not bother to change the application because the project as a whole, with the project incentive offered, can still meet their financial criteria. In the loose language that has grown common among some California evaluations of calculated savings programs in the last few years, these measures have inappropriately been labeled “participant spillover.”

Spillover is defined in the *California Energy Efficiency Evaluation Protocols*[3] as “reductions in energy consumption and/or demand in a utility’s service area caused by the presence of the DSM program, beyond *program related* gross or net savings of participants” (emphasis added). Participant spillover is then the additional energy savings achieved from some separate activity that the customer later undertakes as a result of learning about energy efficiency through their initial project participation. When evaluating a prescriptive rebate program, a customer’s subsequent purchase of additional measures or different measures outside the program is appropriately identified as participant spillover. But in a calculated savings program, the whole project or building **is** the unit of measurement. The net-to-gross ratio should be focused on

identifying the savings that were "program related," that is, related to the project that the SPC program encouraged.

By estimating project savings only as incented-measure savings, this inappropriate methodology ignores one of the major arguments for customized project-level programs — they reduce lost opportunities and help customers to undertake more comprehensive retrofits, achieving greater savings from more measures than a prescriptive widget-by-widget approach. The project level incentive allows customers to put together a project that "pencils out" for them as a whole, even though some parts of the project will not be eligible for financial incentives from an energy efficiency program.

This perspective is consistent with the Commission's direction that spillover impacts should not be counted as part of the goal achievement for 2006-08 programs. The rationale for that directive is that spillover savings do not occur as part of program participation and must therefore have inherently greater uncertainty of measurement. What has been incorrectly labeled "participant spillover" in the SPC program evaluation does not fit this rationale.

Adjustment for Self-Report Methodology Bias.

Self-report bias is a widely recognized flaw of the customer decision-maker survey approach to estimating freeridership. In the research plan for the evaluation of the 2004-05 SPC Program, Itron proposed, and the ED and the study advisory committee approved, to measure freeridership using a survey-based measurement tool with an accepted self-report bias adjustment. This same approach has used in previous SPC evaluations. By understanding the bias of the self-report approach and correcting for it (see XENERGY, 2001), the self-report approach's measurement accuracy can be improved the same way that a rifle's sights can be made more accurate by adjusting for windage. Ignoring this measurement correction is simply poor research technique.

This measurement bias, like any other measurement bias, should be corrected, especially when it is measurable. The key factor in this instance is that it has been measured in a previous study; other programs may have not been able to measure it or did not make any attempt to measure it. For large nonresidential programs where multiple decisions makers are involved, such measurement bias exists and needs to be identified and corrected.

Section 2. Calculation Methods

2.1 NTG Estimation Methodology

Net-to-Gross Ratios for Different Program Strategies

The applicable net-to-gross ratio for this measure is 0.69, based on the evaluation study for the 2004-05 program. The self-reported survey-based estimate of 0.54 is adjusted by adding 0.10 to offset the downward bias that was recommended in the XENERGY study. It is further adjusted by adding 0.05 for the technique's underreporting of total project savings. Thus:

$$\text{SPC NTGR} = 0.54 + 0.10 + 0.05 = 0.69$$

Section 3. Summary

Table 1. Net to Gross Ratio (NTGR) Values

Program Approach	NTGR
Standard Performance Contract	0.69

References

1. Database for Energy Efficient Resources (DEER), DEER Net-to-Gross Update 2008, May 2008

2. 2004-2005 Statewide Nonresidential Standard Performance Contract Program Measurement and Evaluation Study: Impact, Process and Market Evaluation – Final Report. Itron, March 19, 2008 (First Draft).

3. California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals. The TecMarket Works Team, April 2006, p. 241.

All HVAC

Work Paper

Joint IOU

Standard Performance Contract Program — All Measures

Net-to-Gross Ratios

May 16, 2008

At a Glance Summary

Measure Names	All Measures
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1.2 DEER 2008 NTG Update Differences Analysis

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1.3 EM&V, Market Potential, and Other Studies

In the 2004-2005 statewide nonresidential Standard Performance Contract Program evaluation study[2], the independent evaluation contractor calculated a net-to-gross ratio of 0.69 for the program.

Total Project Savings.

The unit of analysis in the SPC program should be the project, not a large number of separate measures. The term “participant spillover” has been used inaccurately in the assessment of net savings of the Standard Performance Contract programs, resulting in the inappropriate reduction of the NTGR value by 0.05 in the DEER Update.

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Net-to-Gross Ratios for Different Program Strategies

The applicable net-to-gross ratio for this measure is 0.69, based on the evaluation study for the 2004-05 program. The self-reported survey-based estimate of 0.54 is adjusted by adding 0.10 to offset the downward bias that was recommended in the XENERGY study. It is further adjusted by adding 0.05 for the technique's underreporting of total project savings. Thus:

$$\text{SPC NTGR} = 0.54 + 0.10 + 0.05 = 0.69$$

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Table 1. Net to Gross Ratio (NTGR) Values

Program Approach	NTGR
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References

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Custom Electric Measures

Work Paper

Joint IOU

Standard Performance Contract Program — All Measures

Net-to-Gross Ratios

May 16, 2008

At a Glance Summary

Measure Names	All Measures
Program Type	Retrofit
Market Segment	Nonresidential
Delivery Type	Customized Incentives, Performance Contracting
Net-to-Gross Ratios	0.69
Important Comments	

Note: The information provided in this work paper was developed using the best available technical resources at the time this document was prepared.

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This work paper documents the net-to-gross ratio (NTGR) for all measure categories in the 2006-2008 nonresidential Standard Performance Contract (SPC) program. The SPC program offers customized incentives that are calculated on the basis of project performance related to energy efficiency for equipment retrofits or replacements.

1.2 DEER 2008 NTG Update Differences Analysis

For the NTGRs for this program, the 2008 update to the Database for Energy Efficiency Resources (DEER)[1] draws on the recent measurement and evaluation study[2] of the 2004-2005 statewide nonresidential Standard Performance Contract Program. That study reports an overall NTGR of 0.69. The DEER Update proposes a value of 0.54. The difference lies in the disregard for adjustments to the raw measurement of the net-to-gross ratio.

1.3 EM&V, Market Potential, and Other Studies

In the 2004-2005 statewide nonresidential Standard Performance Contract Program evaluation study[2], the independent evaluation contractor calculated a net-to-gross ratio of 0.69 for the program.

Total Project Savings.

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Non-Residential New Construction (Day Lighting/Other Lighting Controls)

Final Report

An Evaluation of the 2004-2005 Savings By Design Program

CPUC Numbers: 1127-04, 1261-04, 1183-04, 1249-04, 1346-04, and 1323-04

PO #: V2016912

Prepared for the California Public Utilities Commission

and the following California Investor Owned Utilities:

Pacific Gas and Electric

San Diego Gas and Electric

Southern California Edison

Southern California Gas

August 2007

Prepared by:

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Acknowledgements

The evaluation of the 2004-2005 Savings By Design program (previously known as the Building Efficiency Assessment Study) was performed on behalf of the California Public Utilities Commission. The study was managed by Southern California Edison Company, under the direction of Cathy Chappell of the Heschong Mahone Group. RLW would like to thank Marian Brown and Richard Pulliam of SCE for helping to make the study a success. RLW would also like to acknowledge Mary Sutter and Mary Anderson for their insights and assistance in helping RLW conduct and complete the SBD study. For further information on this report please contact Marian Brown at SCE.

Dr. Roger Wright of RLW Analytics directed the evaluation Matt Brost was the initial project manager, replaced by Dr. John L. Stoops during the project execution phase. RLW would also like to thank our sub-contractors for their excellent contributions to the project. Pete Jacobs of Architectural Energy Corporation led the engineering simulation modeling efforts, and both Architectural Energy Corporation and Eskinder Berhanu and Associates staff assisted in the on-site data collection and end-use metering tasks.

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Executive Summary

This document is the final report for the Savings By Design (SBD) study for the statewide Non-Residential New Construction (NRNC) program area for 2004-2005. This report contains summary results for program participants of Savings By Design (SBD). Savings By Design is the statewide NRNC energy efficiency program administered and implemented by Pacific Gas and Electric Company, San Diego Gas and Electric Company, Southern California Edison Company, and Southern California Gas Company, also known as the California investor-owned utilities (IOUs). Previously this evaluation was also called the Building Efficiency Assessment study.

The key objectives of the study are to:

- Develop gross and net impact estimates for the gross whole building energy and demand savings resulting from the Savings By Design program,
- Develop gross and net energy and demand impact estimates of both incented and non-incented measure categories,
- Develop estimates of free-ridership,
- Develop net energy and demand impacts, and
- Provide process findings of the SBD program from the perspective of the program participants.

The SBD program has included industrial projects participating at varying levels at each utility. As of Program Year 2002, all four utilities allowed industrial projects to participate in their program and to receive incentive payments. The industrial results have been reported separately due to the unique considerations of these process specific measures.

The sample was not stratified by project type (i.e. commercial, industrial); instead an overall evaluation sample was selected using energy savings as the stratification variable. The sampling plan was designed to over-sample the large customers, increasing the variance captured by the sample and improving the overall precision.

The 2004-2005 SBD Evaluation Study is an evaluation of Savings By Design projects that were paid incentives in calendar year 2004-2005. Though this study is restricted to projects paid in 2004-2005, the evaluated projects may have initially signed onto the program several years ago, or as late as 2005. The basis of the gross energy and demand savings methodology were DOE-2 engineering models and engineering calculations that are informed by detailed onsite surveys, end-use metered data and monthly billing data. The output of the engineering models is statistically projected to the program population to show program impacts at the 90% confidence level. The study is further informed by in-depth telephone surveys with the building owners and/or designers regarding the energy design choices made for these buildings. The results of the decision-maker data not only produce process findings, they are also used to adjust the engineering models for estimating the program's net energy impacts.

The following sections describe the high-level findings identified by the evaluators in the course of the 2004-2005 SBD Study. When compared to prior SBD evaluations for years 2002 and 2003, the overall savings numbers in this report are higher because this evaluation covers two years, while the prior evaluations were for a single year.

Gross Impact Findings

This section presents gross impact findings for the statewide Savings By Design program, including both commercial and industrial projects. Impact findings have been calculated at the utility level, and then aggregated to the statewide level. A limitation of the study is that the sample was designed to optimize the precision at the *statewide* level in order to achieve a relative precision of 8% at the 90% level of confidence for *statewide* kBtu savings estimates. However, CPUC mandated reporting requires savings estimates at the utility level. When samples that are optimized for statewide precision are used to predict utility specific savings, the number of sites per utility is smaller than optimal in some cases, resulting in higher uncertainty around the utility level savings estimates.

The evaluation results show that the utilities' tracking estimates are slightly exceeded by the gross energy savings estimates developed from our evaluation methodology, resulting in about a 103% realization rate for electrical energy savings, kWh, as shown in Table 1. These findings are based on a sample of sites that comprise roughly 42% of the program estimated electrical energy savings, almost 40% of the program estimated electrical demand savings, and approximately 48% of the program estimated natural gas savings. Gas savings were driven largely by HVAC measures, which account for almost six million therms (over 67%) of savings and have a relative precision of 114%.[1]

	Ex-Ante Gross Savings	Sampled Savings	% Savings Sampled	Ex-Post Gross Savings	Gross Realization Rate
Energy(MWh)	344,748	144,339	41.9%	355,453	103.1%
Demand(MW)	68.7	27.3	39.7%	56.4	82.1%
Gas (therms)	8,662,541	4,194,603	48.4%	8,478,008	97.9%

Table 1: Gross Energy and Demand Impacts – Combined Total

Energy, demand, and gas findings presented in Table 2 show the impacts attributed to commercial projects and industrial projects separately. The table shows the estimated gross realization rate for industrial projects is approximately 80%, 104%, and 32% respectively for energy, demand, and gas savings respectively.

The natural gas savings for the industrial sector were driven down largely by one site with an estimated tracking saving of 1,400,000 therms per year, accounting for over 67% of total gross savings. During the evaluation team's phone survey with the facility representative it was found that the measure, an incented heat exchanger had failed prematurely and was returned to the factory. This resulted in a gross and net savings of zero for this project.

		Ex-Ante Gross Savings	Ex-Post Gross Savings	Gross Realization Rate
Commercial	**Energy(MWh)**	228,003	268,758	117.9%
	Demand(MW)	58.5	45.0	77.0%
	Gas (therms)	2,878,393	6,489,318	225.4%
Industrial	**Energy(MWh)**	116,744	86,696	74.3%
	Demand(MW)	10.3	11.4	110.8%
	Gas (therms)	5,784,148	1,988,690	34.4%

Table 2: Gross Energy and Demand Impacts – Commercial and Industrial

[1] An explanation of statistical terms, such as relative precision and error bounds, can be found in the appendix.

Net Impact Findings

In this study, RLW prepared a decision-maker survey that asked measure specific questions of program participants. We used self-reported decision-maker survey responses to calculate the estimates of free-ridership by measure category and end-use. The survey questions elicited information describing why the efficiency choices were made and the various influences on these decisions. The purpose of the measure/end-use questions was to reconstruct what might have happened absent program influences. Using a scoring methodology developed early in the study, the surveys were scored and then given to the surveyor responsible for the project DOE-2 modeling. Using a "net savings report" furnished by the analysts, the surveyor adjusted the DOE-2 model to reflect program influences. The models were then re-simulated and compared to the as-built and baseline parametric models to develop end-use and measure level estimates of participant free-ridership. A comprehensive explanation of the net savings methodology can be found in the appendix.

The net impact findings for the 2004-2005 program cycle are presented in Table 3 below including both commercial and industrial projects. The results indicate a net-to-gross ratio of roughly 75% for commercial energy savings and 77% for commercial demand savings. The industrial net-to-gross ratio is approximately 65% and 66% for energy and demand savings, respectively. While lower than the commercial net-to-gross, these industrial results are an improvement over 2003 results (59% energy N-T-G and 55% demand N-T-G) and significantly improved over the 2002 results (35% energy N-T-G and 33.3% demand N-T-G).

		Ex-Post Net Savings	Ex-Post Gross Savings	Net-to-Gross Realization Rate
Commercial	Energy(MWh)	203,409	268,758	75.7%
	Demand(MW)	34.7	45.0	77.1%
	Gas(therms)	6,801,954	6,489,318	104.8%
Industrial	Energy(MWh)	56,121	86,696	64.7%
	Demand(MW)	7.6	11.4	66.4%
	Gas(therms)	1,114,771	1,988,690	56.1%

Table 3: Net Savings and Demand Reduction – Commercial & Industrial

The participant net-to-gross is an estimate of program-induced savings, less what the participants would have done absent the program (i.e., free-ridership), as a percentage of participant gross savings. The participant net-to-gross ratio is most closely comparable to net-to-gross ratios calculated for past NRNC program evaluations conducted in California. Table 4, Table 5, and Table 6 present ex-ante gross savings, ex-post gross savings, ex-post net savings, and the net to gross ratios for each end use. Referring to Table 4, the commercial participant net-to-gross ratio is around 76%, which represents the percentage of the energy savings that are a direct result of the SBD program, while the remainder (~24%) is considered program free-ridership. Industrial participant net-to-gross ratio is nearly 65%.

	Commercial Energy Impacts (MWh)	Industrial Energy Impacts (MWh)	Calculation
Ex-Ante Gross Savings	228,003	116,744	A
Ex-Post Gross Savings	268,758	86,696	B
Gross Realization Rate	117.9%	74.3%	(A/B)
Ex-Post Net Savings	203,409	56,121	C
Net-to-Gross Ratio	75.7%	64.7%	(C/B)

Table 4: Program Net Electrical Energy Savings

	Commercial Energy Impacts (MW)	Industrial Energy Impacts (MW)	Calculation
Ex-Ante Gross Savings	58.5	10.3	A
Ex-Post Gross Savings	45.0	11.4	B
Gross Realization Rate	77.0%	110.8%	(A/B)
Ex-Post Net Savings	34.7	7.6	C
Net-to-Gross Ratio	77.1%	66.4%	(C/B)

Table 5: Program Net Electrical Demand Reduction

	Commercial Energy Impacts (Therms)	Industrial Energy Impacts (Therms)	Calculation
Ex-Ante Gross Savings	2,878,393	5,784,148	A
Ex-Post Gross Savings	6,489,318	1,988,690	B
Gross Realization Rate	225.4%	34.4%	(A/B)
Ex-Post Net Savings	6,801,954	1,114,771	C
Net-to-Gross Ratio	104.8%	56.1%	(C/B)

Table 6: Program Net Natural Gas Savings

Table 7 reports the electrical energy net-to-gross ratios from the past three NRNC evaluation studies. The commercial net-to-gross ratio of 74% for the 2004-2005 SBD compares favorably with past results, but does indicate a small continued increase in free-ridership percentage. The industrial program continues to improve its net-to-gross ratio, but at levels lower than the commercial program.

Sector	Program Year	Net-to-gross Ratio
Commercial	1999-2001	82%
Commercial	2002	75%
Commercial	2003	76%
Commercial	2004-2005	75%
Industrial	2002	35%
Industrial	2003	59%
Industrial	2004-2005	64%

Table 7: Historic Electrical Energy Net to Gross Ratios for NRNC Studies

CPUC Reporting Tables

The following 5 tables are what have been reported to the CPUC for net program lifecycle savings of the Savings By Design program. The first table lists the "statewide" savings, which is the aggregate of all four utilities; the subsequent four tables are the utility specific net program lifecycle savings.

Program IDs*: 1161-04 1183-04 1506-04 1127-04 1323-04 1346-04 1249-04
Program Name: Savings By Design

Year	Calendar Year	Ex-ante Gross Program-Projected Program MWh Savings (1)	Ex-Post Net Evaluation Confirmed Program MWh Savings (2)	Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)	Ex-Post Net Evaluation Projected Peak MW Savings (2**)	Ex-Ante Gross Program-Projected Program Therm Savings (1)	Ex-Post Net Evaluation Confirmed Program Therm Savings (2)
1	2004	344,748	259,530	68.74	42.27	8,662,541	7,916,725
2	2005	344,748	259,530	68.74	42.27	8,662,541	7,916,725
3	2006	344,748	259,530	68.74	42.27	8,662,541	7,916,725
4	2007	344,748	259,530	68.74	42.27	8,662,541	7,916,725
5	2008	344,748	259,530	68.74	42.27	8,662,541	7,916,725
6	2009	344,748	259,530	68.74	42.27	8,662,541	7,916,725
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15	2018	326,693	259,530	64.91	42.27	7,644,619	7,916,725
16	2019	204,517	178,367	39.73	28.34	5,040,455	1,408,227
17	2020	37,386	53,381	7.12	7.37	672,450	1,114,771
18	2021	37,386	53,381	7.12	7.37	672,450	1,114,771
19	2022	37,386	53,381	7.12	7.37	672,450	1,114,771
20	2023	37,386	53,381	7.12	7.37	672,450	1,114,771
TOTAL	2004-2023	5,469,833	4,231,455			135,977,998	123,503,414

Table 8: Overall 2004-2005 Net Program Lifecycle Savings

Program ID*: 1506-04(proc) 1127-04
Program Name: Savings By Design

Year	Calendar Year	Ex-ante Gross Program-Projected Program MWh Savings (1)	Ex-Post Net Evaluation Confirmed Program MWh Savings (2)	Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)	Ex-Post Net Evaluation Projected Peak MW Savings (2**)	Ex-Ante Gross Program-Projected Program Therm Savings (1)	Ex-Post Net Evaluation Confirmed Program Therm Savings (2)
1	2004	108,856	74,989	23.11	13.84	6,137,245	1,421,523
2	2005	108,856	74,989	23.11	13.84	6,137,245	1,421,523
3	2006	108,856	74,989	23.11	13.84	6,137,245	1,421,523
4	2007	108,856	74,989	23.11	13.84	6,137,245	1,421,523
5	2008	108,856	74,989	23.11	13.84	6,137,245	1,421,523
6	2009	108,856	74,989	23.11	13.84	6,137,245	1,421,523
7	2010	108,856	74,989	23.11	13.84	6,137,245	1,421,523
8	2011	108,856	74,989	23.11	13.84	6,137,245	1,421,523
9	2012	108,856	74,989	23.11	13.84	6,137,245	1,421,523
10	2013	108,856	74,989	23.11	13.84	6,137,245	1,421,523
11	2014	108,856	74,989	23.11	13.84	6,137,245	1,421,523
12	2015	108,856	74,989	23.11	13.84	6,137,245	1,421,523
13	2016	108,856	74,989	23.11	13.84	6,137,245	1,421,523
14	2017	108,856	74,989	23.11	13.84	6,137,245	1,421,523
15	2018	90,801	74,989	19.28	13.84	5,119,323	1,421,523
16	2019	84,811	75,171	18.00	13.22	4,781,623	1,424,005
17	2020	10,912	23,753	2.32	4.87	615,207	1,114,771
18	2021	10,912	23,753	2.32	4.87	615,207	1,114,771
19	2022	10,912	23,753	2.32	4.87	615,207	1,114,771
20	2023	10,912	23,753	2.32	4.87	615,207	1,114,771
TOTAL	**2004-2023**	1,732,334	1,271,269			97,667,996	26,091,158

Table 9: PG&E 2004-2005 Net Program Lifecycle Savings.

Program ID*: 1183-04(procurement) and 1161-04
Program Name: Savings By Design

Year	Calendar Year	Ex-ante Gross Program-Projected Program MWh Savings (1)	Ex-Post Net Evaluation Confirmed Program MWh Savings (2)	Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)	Ex-Post Net Evaluation Projected Peak MW Savings (2**)	Ex-Ante Gross Program-Projected Program Therm Savings (1)	Ex-Post Net Evaluation Confirmed Program Therm Savings (2)
1	2004	153,610	126,964	27.87	18.76	332,143	4,129,443
2	2005	153,610	126,964	27.87	18.76	332,143	4,129,443
3	2006	153,610	126,964	27.87	18.76	332,143	4,129,443
4	2007	153,610	126,964	27.87	18.76	332,143	4,129,443
5	2008	153,610	126,964	27.87	18.76	332,143	4,129,443
6	2009	153,610	126,964	27.87	18.76	332,143	4,129,443
7	2010	153,610	126,964	27.87	18.76	332,143	4,129,443
8	2011	153,610	126,964	27.87	18.76	332,143	4,129,443
9	2012	153,610	126,964	27.87	18.76	332,143	4,129,443
10	2013	153,610	126,964	27.87	18.76	332,143	4,129,443
11	2014	153,610	126,964	27.87	18.76	332,143	4,129,443
12	2015	153,610	126,964	27.87	18.76	332,143	4,129,443
13	2016	153,610	126,964	27.87	18.76	332,143	4,129,443
14	2017	153,610	126,964	27.87	18.76	332,143	4,129,443
15	2018	153,610	126,964	27.87	18.76	332,143	4,129,443
16	2019	119,705	103,196	22	15.12	258,832	(15,778)
17	2020	26,474	29,628	5	2.50	57,243	-
18	2021	26,474	29,628	5	2.50	57,243	-
19	2022	26,474	29,628	5	2.50	57,243	-
20	2023	26,474	29,628	5	2.50	57,243	-
TOTAL	**2004-2023**	2,503,278	2,096,540			5,412,706	61,925,861

Table 10: SCE Net Program Lifecycle Savings

Program ID*:	1323-04 (proc) 1346-04							
Program Name:	Savings By Design							
	Year	Calendar Year	Ex-ante Gross Program-Projected Program MWh Savings (1)	Ex-Post Net Evaluation Confirmed Program MWh Savings (2)	Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)	Ex-Post Net Evaluation Projected Peak MW Savings (2**)	Ex-Ante Gross Program-Projected Program Therm Savings (1)	Ex-Post Net Evaluation Confirmed Program Therm Savings (2)
	1	2004	63,959	42,240	14.26	7.31	2,121,796	2,362,047
	2	2005	63,959	42,240	14.26	7.31	2,121,796	2,362,047
	3	2006	63,959	42,240	14.26	7.31	2,121,796	2,362,047
	4	2007	63,959	42,240	14.26	7.31	2,121,796	2,362,047
	5	2008	63,959	42,240	14.26	7.31	2,121,796	2,362,047
	6	2009	63,959	42,240	14.26	7.31	2,121,796	2,362,047
	7	2010	63,959	42,240	14.26	7.31	2,121,796	2,362,047
	8	2011	63,959	42,240	14.26	7.31	2,121,796	2,362,047
	9	2012	63,959	42,240	14.26	7.31	2,121,796	2,362,047
	10	2013	63,959	42,240	14.26	7.31	2,121,796	2,362,047
	11	2014	63,959	42,240	14.26	7.31	2,121,796	2,362,047
	12	2015	63,959	42,240	14.26	7.31	2,121,796	2,362,047
	13	2016	63,959	42,240	14.26	7.31	2,121,796	2,362,047
	14	2017	63,959	42,240	14.26	7.31	2,121,796	2,362,047
	15	2018	63,959	42,240	14.26	7.31	2,121,796	2,362,047
	16	2019						
	17	2020						
	18	2021						
	19	2022						
	20	2023						
	TOTAL	2004-2023	959,385	633,597			31,826,940	35,430,705

Table 11: SDG&E Net Program Lifecycle Savings

Program ID*:	1249-04							
Program Name:	Savings By Design							
	Year	Calendar Year	Ex-ante Gross Program-Projected Program MWh Savings (1)	Ex-Post Net Evaluation Confirmed Program MWh Savings (2)	Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)	Ex-Post Net Evaluation Projected Peak MW Savings (2**)	Ex-Ante Gross Program-Projected Program Therm Savings (1)	Ex-Post Net Evaluation Confirmed Program Therm Savings (2)
	1	2004	18,322	15,337	3.50	2.35	71,357	3,713
	2	2005	18,322	15,337	3.50	2.35	71,357	3,713
	3	2006	18,322	15,337	3.50	2.35	71,357	3,713
	4	2007	18,322	15,337	3.50	2.35	71,357	3,713
	5	2008	18,322	15,337	3.50	2.35	71,357	3,713
	6	2009	18,322	15,337	3.50	2.35	71,357	3,713
	7	2010	18,322	15,337	3.50	2.35	71,357	3,713
	8	2011	18,322	15,337	3.50	2.35	71,357	3,713
	9	2012	18,322	15,337	3.50	2.35	71,357	3,713
	10	2013	18,322	15,337	3.50	2.35	71,357	3,713
	11	2014	18,322	15,337	3.50	2.35	71,357	3,713
	12	2015	18,322	15,337	3.50	2.35	71,357	3,713
	13	2016	18,322	15,337	3.50	2.35	71,357	3,713
	14	2017	18,322	15,337	3.50	2.35	71,357	3,713
	15	2018	18,322	15,337	3.50	2.35	71,357	3,713
	16	2019						
	17	2020						
	18	2021						
	19	2022						
	20	2023						
	TOTAL	2004-2023	274,836	230,048			1,070,355	55,690

Table 12: SoCalGas Net Program Lifecycle Savings

Total Resource Cost Results

Total resource cost (TRC) is a cost-effectiveness metric for utility energy efficiency programs. If a program has a TRC value greater than one, it is considered cost effective. Table 13 shows each utility's projected TRC based upon project goals that were calculated before 2004. The ex ante TRC is based upon actual project activities recorded during 2004-2005. The ex post TRCs are the calculated based upon the evaluated savings and our net-to-gross analysis values. Due to project scope, ex post TRCs used utility budgets as reported, incremental measure cost, and utility estimates of effective useful measure life without question.

Due to the long project cycles of new construction projects, this is not an exact comparison of activities. The utility estimates were solely based on 2004-2005 program efforts, while the ex post TRC considers only projects paid in 2004-2005, many of which were result of projects committed in prior program years. Similarly, many projects committed in 2004-2005 have not been completed or paid, and the savings associated with these projects are not counted in the evaluation estimates.

Utility	Utility Projected TRC Ratio	Utility Ex-Ante TRC Ratio	Ex-Post TRC Ratio
PGE	* 2.10	* 2.60	2.06
SCE	* 2.56	* 2.45	3.29
SDGE	* 1.91	* 3.37	2.34
SoCalGas	2.59	2.89	2.64
Overall	2.27	2.60	2.65

Table 13: Total Resource Cost (TRC) by Utility[2]

Process Findings

RLW designed and completed decision-maker (DM) surveys to help determine the net savings attributable to the program.[3] The questions were formulated to learn more about program awareness and attitudes, specific building characteristics, and design and construction practices. The process questions addressed several general categories of interest:

- **General Building Information** – General building information such as ownership type and type of project.
- **Program Attitudes and Awareness** – The importance of energy efficiency to the company and other factors which influenced them to participate.

[2] *Combined TRC of utility's SBD public goods and procurement funded projects

[3] The same sites used in the gross savings estimation were included in the net savings decision maker interviews.

- **Dollar Incentives, Design Assistance and Design Analysis** – Value of services offered by the Savings by Design Program. [4]

General Building Information

This portion of the survey addressed the types of projects, types of building, ownership intent, etc. Many of these results are as expected, such as the finding that over 70% of the surveyed projects were new construction, while the others were major renovations, also allowed in the SBD program. Similarly, almost 70% of the buildings were privately owned and the remainder was publicly owned. Table 14 shows building ownership by occupancy intent. All publicly owned buildings were intended to be occupied by the owner while only 81.7% of privately owned buildings were intended to be owner occupied.

Ownership of Building	Occupancy Intent			Total
	Owner Occupied	Lease Space	Developer Occupied	
Private	81.7%	17.8%	0.5%	100.0%
Public	100.0%	0.0%	0.0%	100.0%

Table 14: Building Ownership by Occupancy Intent (q8 & q9)

SBD Attitudes and Awareness

The program participants were generally satisfied with the program. This is indicated by the frequent “no changes needed” responses when asked what the program should improve. This is shown in Table 15. Some of the requests for change came in the following areas: making the program easier and faster to use, involving the utilities earlier in the projects, increasing marketing efforts, and increasing interaction with the design team. Respondents were allowed to give multiple recommendations; therefore the sum of the percentages is greater than 100%.

[4] Design analysis includes energy modeling and engineering calculations. Design assistance includes the identification of energy efficiency opportunities, resources and design development support to aid building owners and design teams with energy-efficient facility design.

Recommendations	% of Respondents
No Changes Needed	50.8%
Other	21.5%
More marketing to increase awareness of program	9.8%
Increase Incentives	9.5%
Utilities should try to get involved earlier in projects	9.0%
Don't Know	7.2%
More interaction with design team	7.0%
Review and response from utility needs to be more timely	5.1%
Utility Reps need to present benefits more clearly	1.7%
Less paperwork and red tape	1.3%
Increase post project feedback, better "closure"	0.6%
Refused	-
Sample Size	191

Table 15: Recommended Changes to Savings by Design (q20)

The majority of the participants became aware of the program through a utility representative or previous utility program participation. At the same time, the owner was the biggest advocate for participating in the program, representing 62.3% of the primary supporters.

Importance of Incentives, Design Assistance and Design Analysis

In each of the categories of incentives, and design assistance or design analysis, the majority of the respondents indicated that these items were very or somewhat valuable. Figure 1 shows the results. Additionally, over three-quarters of the respondents indicated that they had changed their construction practices to include more energy efficient designs as a result of participation in the program. These factors combine to show that participants rely greatly on the program's offerings and the effects of these services go beyond the SBD project.

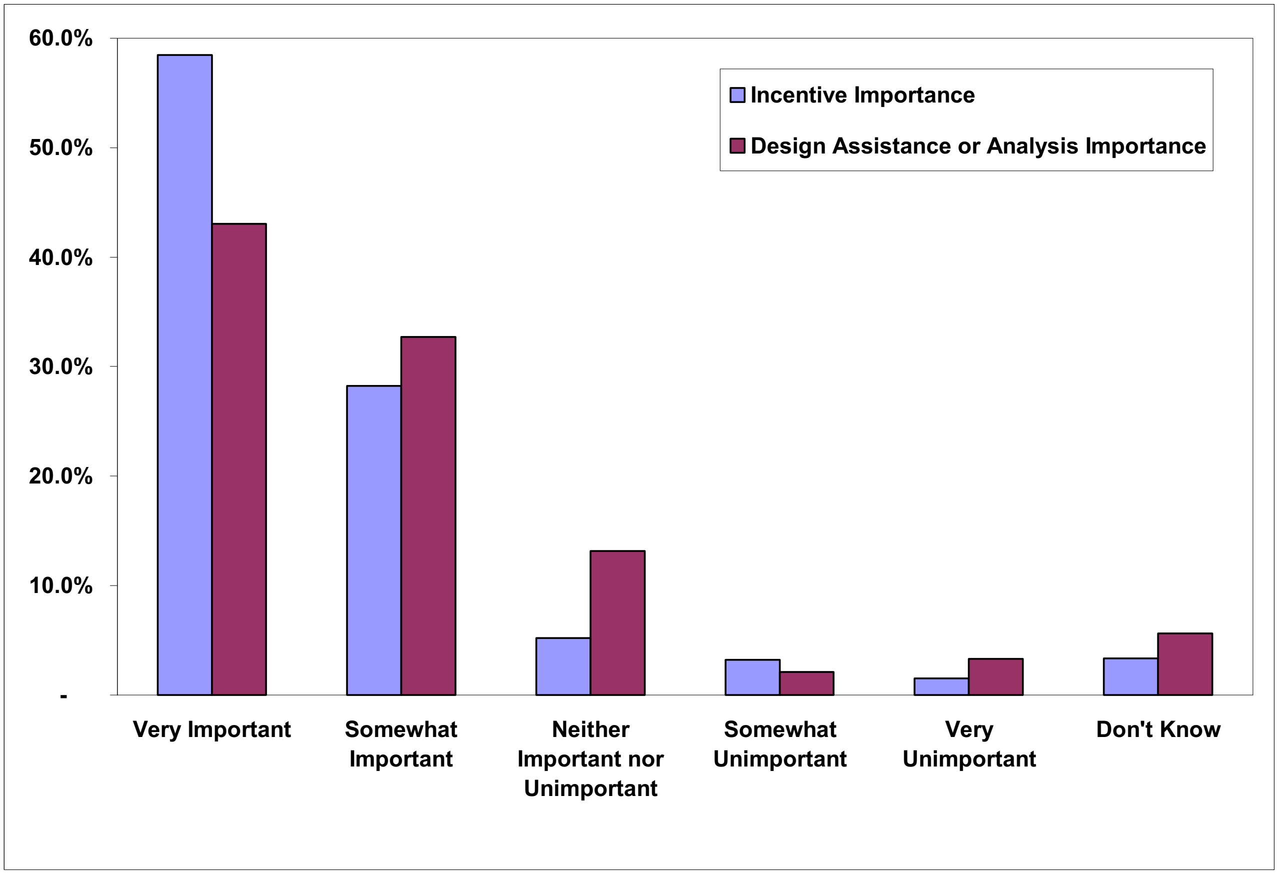

Figure 1: Importance of Incentive and Design Assistance/Analysis

Introduction

RLW Analytics, Inc. (RLW) conducted an evaluation of the 2004-2005 Savings By Design (SBD) Program, California's statewide non-residential new construction (NRNC) energy efficiency program administered by PG&E (CPUC #1127-04), SCE (CPUC #1261-04 and 1183-04), SoCalGas (CPUC #1249-04), and SDG&E (CPUC # 1346-04 and 1323-04). Prior evaluations of this program were called the Building Efficiency Assessment (BEA) study. A separate report was written that was paid for out of PG&E Procurement funding for SBD (CPUC #1506-04).

This document is the final report for the Savings By Design (SBD) study for the statewide Non-Residential New Construction (NRNC) program area, covering calendar years 2004 and 2005. This report contains summary results for program participants over multiple years that received their incentive payments in 2004 and 2005. The key objectives of the study are to:

- Develop on-going gross whole-building energy and demand impact estimates for the SBD program,
- Develop on-going impact estimates of both incented and non-incented measure categories,
- Develop on-going estimates of both free-ridership at the measure and end-use level,
- Develop net energy and demand impacts, and
- Provide on-going process findings of the SBD program from the perspective of the program participants.

Evaluation Overview

RLW Analytics (RLW) is the prime contractor on this project and carried out all statistical analysis for this report. Architectural Energy Corporation (AEC) of Boulder Colorado participated in the on-site data collection, and is the lead on the engineering simulation work. Eskinder Berhanu & Associates (EBA), located in Southern California, assisted RLW and AEC in the data collection and engineering modeling.

The RLW Team has developed a sound and reliable process for estimating the energy impact of the Statewide Non-residential New Construction (NRNC) program. Our methodology builds on our prior experience evaluating the 1994, 1996, 1998, and 1999 NRNC programs for PG&E and SCE, our work on the CBEE California Statewide Non-residential New Construction Baseline study, as well as our work on the 1999-2001, 2002 and 2003 BEA studies (Savings By Design evaluations have been titled "Building Efficiency Assessment Studies" (BEA) in the past). Moreover, the same approach was applied to the last five years of program activities, including 1999 through 2003. Findings from these studies are presented in the previous four Building Efficiency Assessment Study reports. This is the fourth in a series of Savings By Design evaluation reports. The participant population for this study consisted of 1096 sites paid in the statewide SBD program during 2004-2005.

The Savings By Design evaluation defines participants by the year in which they were paid their incentive. Alternatively, the utilities define program participation year based upon the year the participant signed a contract to receive program incentives. Therefore the 2004-2005 SBD study is not a true study of PY 2004-2005 program activities. However, because this is an on-going evaluation of SBD, a complete picture of SBD and corresponding non-participant projects is evolving over time.

The selection of the participant sites was guided by a model-based statistical sampling plan as in each of the last studies dating back to the 1994 NRNC evaluation. We used a participant sample that was efficiently stratified by utility and the tracking estimate of annual energy savings, with proportional representation of building types and climate zones in the combined participant population. The final participant sample size was 180 sites.

This study and the two previous studies are different from prior NRNC program and SBD evaluations in that they include industrial projects. Although the industrial projects do not conform to the standardized evaluation methods developed by the evaluation team for commercial projects, all sampled industrial projects did undergo rigorous evaluation and review. This study, unlike prior years, did not examine non-participants.

The gross savings evaluation is based on DOE-2 engineering models and engineering calculations that are informed by detailed on-site surveys statistically projected to the program population. Title 24 is the baseline used by the Model-IT software for generating gross savings estimates for the whole building and at the measure level. To refine the engineering models, short term monitoring was conducted at a sample of sites and the models were calibrated to the empirical field measurements.

The net savings component of the evaluation considers free-ridership (i.e., savings that would have occurred even if the customer had not participated in the program), at the measure and end-use level. Free-ridership values are calculated by revising the DOE-2 site specific engineering models to reflect the efficiency choices of the owner absent the program, or any previous interactions with the program. DOE-2 model adjustments are determined through in-depth interviews with the project decision-makers. This approach results in net savings at the end-use level for program participants

The SBD study also includes an analysis of process findings as reported by the participant decision-makers. In-depth telephone surveys are conducted with participant building owners and designers in order to assess the effectiveness of the program, reasons for participation, satisfaction with the program, and other areas of program influence. This aspect of the evaluation also includes questions for participants regarding design and construction decisions made in the process of the project. The responses from these surveys are tabulated and expanded back to the population of participants. Results are used to assess the attitudes, decision-making processes and beliefs of NRNC market actors for use in improving program delivery of the Savings By Design program.

Savings By Design Program Description

The Savings By Design program offered by California's Investor Owned Utilities includes design assistance and financial incentives to improve the energy efficiency of commercial new construction and industrial projects. The incentive program has two participation paths, the Systems approach and the Whole Building approach. Within the Systems approach, there are commercial and industrial projects. The incentive structure targets both the building owner and the building design team.

Systems Approach

Commercial Projects

The Systems Approach used "CaNCCalc" which is a specially designed savings estimation tool to provide savings values for efficient systems that are broadly available, though not currently standard practice. Since mid-2001, SBD has used an evolved version of CaNCCalc that uses a DOE-2 simulation engine with an eQUEST front-end that provides detailed results for custom inputs.

Building Systems covered under this approach include the following:

Shell Measures

Buildings incorporating high performance glazing into their building designs are eligible for incentives. Energy savings are based on the number of glazing layers, visible transmittance (Tvis), and solar heat gain coefficient (SHGC).

Daylighting Systems

Buildings incorporating control systems to take advantage of sidelighting from windows and toplighting from skylights are both eligible for incentives. The energy savings estimates are based on the lighting power (kW) controlled, the Performance Index (PI) of the glazing (visible light transmittance/solar heat gain coefficient), and the total area of high performance glazing.

Interior Lighting Systems

To qualify for owner incentives, projects need to achieve at least a 10% reduction in the building's lighting power density (LPD). The system must still provide adequate light levels as recommended by the Illuminating Engineering Society. At least two of the following lighting measures must be included in an efficient lighting system design to qualify for incentives:

- High-efficiency lamps
- Efficient ballasts
- Occupancy sensors
- Improved lighting design

HVAC Systems

The HVAC systems component includes high-efficiency equipment and controls that regulate the system. The HVAC Systems component addresses the following measures:

- High-efficiency packaged units
- High-efficiency heat pumps
- High-efficiency water-cooled chillers
- High-efficiency boilers
- Variable-speed motor drives on system fans and pumps
- Demand-controlled ventilation
- Premium-efficiency motors
- Low solar heat gain coefficient (SHGC) glazing
- Cool roofs

Service Hot Water Systems

- High efficiency instantaneous and storage water heaters

Refrigeration Systems

The following efficient supermarket refrigeration system improvements are eligible for incentives in SBD:

- Floating head pressure
- Variable-speed drive condensers fans
- Variable suction pressure
- High efficiency evaporator fans
- Mechanical subcooling
- Timers on case lighting

Industrial Process or Other Systems

The Other Systems or Processes portion of Savings By Design offers financial incentives to facility owners for energy efficient measures utilized in a wide range of unique industrial applications. These projects mostly utilize the Systems Approach, except for refrigerated warehouses as discussed below, and rely on calculations outside of CaNCCalc provided by utility engineers or independent consultants. In most cases, the industrial measures are completely isolated from any commercial building.

The incented industrial measures include the following:

- Carbon monoxide sensors for parking garage fans
- Compressed air measures –
    - VSD compressors, efficient air dryers, system pressure reduction, loss control
- Premium efficiency motors and VSDs on pumping, fan, and blower applications
- Lighting measures in dairy barns
- Heat exchangers
- Groundwater cooled condensers
- Efficient injection molding machines
- Low pressure UV wastewater treatment
- Efficient specialized process equipment and design
- High volume low speed fans

Refrigerated Warehouses

The refrigerated warehouse component of the industrial process measures utilized a customized approach using DOE-2.2R simulation models. The measures found in the sampled projects included the following:

- Efficient condensers
- Floating head pressure, variable condenser set point, VFD on condenser fan
- VFDs on motors and pumps

- Efficient motors- compressors, supply fans, conveyor motors
- Low lighting power density (LPD)
- Occupancy sensor lighting controls- freezers, warehouses
- Waste water heat exchanger
- Increased insulation
- Evaporator fan run time strategy
- Floating suction pressure
- Hot gas defrost
- Mechanical sub cooling

Whole Building Approach

The Whole Building Approach offers a comprehensive package of services designed to analyze energy-efficient, cost-effective design alternatives. The Whole Building Approach is not limited to particular measures, but provides incentives based on reduced energy consumption relative to Title-24. This program component provides Design Assistance and Design Analysis to help provide an optimized "whole-building" design.

Design Assistance

Design assistance is available to building owners and to their design teams, regardless of the design approach, and is matched to the needs of the project. Under the Systems Approach, design assistance may include recommendations for efficient equipment, consultation on enhanced design strategies, or provision of sample specifications. Under the Whole Building Approach, design assistance may involve support to the design team in developing a building energy simulation model, preparing a report for the owner on recommended design modifications, and facilitating the integration of any modifications into the final building design. In this report, we refer to these activities as Design Analysis.

One of the purposes of design assistance is to provide resources for the development of new skills and capabilities that design team members can apply to their future projects. Design assistance may include training services for design team members on new techniques or analysis tools.

Owner Incentives

Financial incentives are available to building owners when the efficiency of the new building exceeds the minimum SBD thresholds, generally 10% better than Title-24 standards. These incentives encourage owners to make energy efficiency a priority in their new buildings and help to defray the additional costs associated with increased efficiency. Owner incentives are determined in different ways, depending on whether the Whole Building or the Systems Approach is used.

Under the Whole Building Approach, the overall efficiency of the building is evaluated using a computer simulation program. If the building is at least 10% better than baseline, incentives are available. The incentives range from $0.06 to $0.18/annualized kWh savings and $0.34 to $0.80/ annualized therm savings, depending on the amount of savings relative to Title-24. The maximum incentive is $150,000 per freestanding building or individual meter and may not exceed 50% of the incremental cost.

Under the Systems Approach, energy savings and incentives are calculated system-by-system, based on the quantities and efficiencies of qualifying components. Owner incentives are calculated at a rate of $0.10/annualized kWh and $0.60/ annualized therm savings depending on the end-use system type, with a maximum incentive of $75,000 per freestanding building or individual meter and may not exceed 50% of the incremental cost.

Design Team Incentives

To support the extra effort required for integrated energy design and to reward exceptional design accomplishments, SBD offers financial incentives to design teams. To qualify for design team incentives, the team must use the Whole Building Approach and a computer simulation model to optimize their design. The model calculates the energy savings of the building relative to Title-24 standards. If the building design saves at least 15% relative to Title-24, the design team qualifies for incentives.

Incentives range from $0.03 - $0.06/annualized kWh savings and $0.15 - $0.27/annualized therm savings as the design becomes more efficient, with a maximum of $50,000 per project. Design team incentives are paid directly to the design team and are in addition to the incentives the building owner receives.

Program Activity and Sample Summary

This section provides an overview of the statewide Savings By Design (SBD) program for projects paid in 2004-2005. Only projects that were paid incentives within the evaluation years 2004-2005 were considered although the evaluated projects initially signed onto the program as early as 2000, or as late as 2005. The following tables demonstrate the variation of results due to sponsoring utility, project size and participation path. Analysis of these differences provides insight into the underlying patterns and trends within the program delivery history, and provides a foundation for future program modifications.

Ex-Ante Gross Savings

Table 16 shows the number of projects, the total associated ex-ante gross energy savings and the average energy savings by utility for the Savings By Design program. PG&E and SDG&E projects are larger on average than the average SCE and SoCalGas projects. Together, PGE and SCE dominate the program, accounting for over 77% of the projects and 76% the energy savings.

Utility	Number of Projects	Total MBtu	Average MBtu	kBtu/ SQFT
PG&E	419	1,728,302	4,125	45
SCE	428	1,606,028	3,752	54
SoCal Gas	70	194,738	2,782	53
SDG&E	179	874,296	4,884	83
Statewide	**1,096**	**4,403,365**	**4,018**	**54**

Table 16: Savings By Design Ex-Ante Gross Savings

Table 17 presents the energy savings[5] and participation rates for the Savings By Design program, and previous NRNC programs, by year and by utility. In the two year period 2004-2005, the SBD program completed roughly 1,096[6] projects, a little more than twice the number achieved in 2003 indicating that the program was operating in a relatively stable mode.

Utility	2005			2004			2003		2002		Q4 1999-2001	
	# Projects	Total MWh	Total Therms	# Projects	Total MWh	Total Therms	# Projects	Total MWh	# Projects	Total MWh	# Projects	Total MWh
PG&E	231	61,305	459,980	188	47,551	5,677,265	165	47,158	133	16,877	127	19,418
SCE	212	71,680	154,261	216	81,930	177,882	198	65,855	198	77,467	169	53,835
SoCalGas	42	7,424	36,396	28	10,898	34,961	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
SDG&E	80	18,376	251,492	99	46,208	1,878,701	104	16,414	95	27,187	190	17,034
Statewide	**565**	**158,785**	**902,129**	**531**	**186,588**	**7,768,809**	**467**	**129,428**	**426**	**121,531**	**486**	**90,287**

[5] Energy Savings are reported in both MWh and MBtu for 2004-05. MBtu savings includes both electricity and gas savings. Gas savings were not reported in previous years.

[6] Out of 1,096 projects in the population, two were split into two separate projects for evaluation purposes since two different approaches (Systems Approach and Whole Building) were found in the data for the same site. One site was dropped later in the analysis due to insufficient on-site survey information. The tracking database was not always internally consistent – savings reported in the site and the measures tables did not add up exactly all the time. Corrections made to the database due to these discrepancies resulted in negligible differences in energy savings.

Table 17: Savings By Design Participation Rates and Energy Savings

Program Participation Approach

The Savings By Design program has an integrated design philosophy that intends to move the NRNC market toward a more holistic approach to building design and construction. The *Whole Building Approach,* as it is termed in the SBD program, takes advantage of the integrated design philosophy. In some instances in this report we make comparisons between Whole Building and Systems projects.

Table 18 shows the number of projects paid in 2004-2005, the associated energy savings (MBtu) and savings per square foot (kBtu) by participation approach. During 2004-05, Savings By Design paid for a total of 351 Whole Building projects, or 32% of the total. PG&E had the most Whole Building Approach projects of any utility, with 140. SDG&E had the highest Whole Building total energy savings and the highest energy savings per project.

Statewide, Whole Building projects are expected to save more energy per square foot than are system projects. This holds true for SCE, SoCalGas, and SDG&E, but not for PG&E which had a higher savings ratio for system projects - 46 kBtu/sqft. On average, the SBD program-tracking database estimates 54 kBtu savings per square foot for all participants.

Approach	PG&E			SCE			SoCal Gas			SDG&E			Statewide		
	# Projects	MBtu Savings	kBtu/ Sqft	# Projects	MBtu Savings	kBtu/ Sqft	# Projects	MBtu Savings	kBtu/ Sqft	# Projects	MBtu Savings	kBtu/ Sqft	# Projects	MBtu Savings	kBtu/ Sqft
Systems Approach	279	1,172,059	46	335	1,129,411	46	41	79,530	47	90	301,681	63	745	2,682,681	47
Whole Building Approach	140	556,244	44	93	476,616	74	29	115,208	59	89	572,616	98	351	1,720,684	65
Overall	**419**	**1,728,302**	**45**	**428**	**1,606,028**	**54**	**70**	**194,738**	**53**	**179**	**874,296**	**83**	**1,096**	**4,403,365**	**54**

Table 18: Savings By Design Participation Approach: System vs. Whole Building

Program Participation & SBD Sample Size

Table 19 shows the Savings By Design program installations and evaluation sample sizes by utility. Also, note that the large projects were over-sampled for each utility, which resulted in a higher than average sampled MBtu savings per project.

	PG&E		SCE		SoCalGas		SDG&E		Statewide	
	Population	Sample	Population	Sample	Population	Sample	Population	Sample	Population	Sample
Number of Projects	419	65	428	65	70	15	179	35	1,096	180
MBtu Savings	1,728,302	594,749	1,606,028	578,495	194,738	80,073	874,296	534,270	4,403,365	1,787,586
Savings per Project (MBtu)	4,125	9,150	3,752	8,900	2,782	5,338	4,884	15,265	4,018	9,931

Table 19: Savings By Design Program Participation by Utility

Table 20 shows SBD program population and sample sizes by stratum and utility service territory. Stratum 1 is for small sites, in terms of ex-ante gross energy savings and Stratum 5 is for large sites. For a complete description of the stratum definitions, see Sample Design (Page 60) section of this report. The sample was designed by utility; therefore each utility has different cut points for each stratum. PG&E funded an additional 20 sites listed in Table 20 as procurement. The primary purpose of adding end-use metering is to improve the site level engineering measurements of energy and demand savings. This is accomplished since end-use metering increases the site level rigor of the engineering approach used for non-metered sites. A specific investigation of the impact of these additional sites will be provided in a future report for PG&E.

	PG&E			SCE		SoCalGas		SDG&E	
Stratum	Population	Sample	Procurement	Population	Sample	Population	Sample	Population	Sample
1	206	13	4	219	13	35	3	94	7
2	81	13	4	83	13	15	3	37	7
3	60	13	4	56	13	8	3	24	7
4	47	13	4	44	13	7	3	16	7
5	25	13	4	26	13	5	3	8	7
Overall	419	65	20	428	65	70	15	179	35

Table 20: Savings By Design Program Participation by Stratum and Utility

Gross Savings Results

This section presents the gross energy savings and peak demand reduction results. These include the findings for the shell, lighting power density, daylighting controls, other lighting controls, motors, HVAC, and refrigeration measures as well as the combined building total. Projects that were incented under the Whole Building Approach are reported under the measure group labeled “Whole Building”. The combined total energy savings and demand reduction are defined to be the difference between the energy use or demand for the entire building under the T24 baseline and as-built simulations. The results were determined for each sample site both on a whole building basis as well as within each end use. Positive savings indicate that the building was more efficient – used less energy or demanded less – than its baseline case. As in the 2002 and 2003 Building Efficiency Assessments, we have reported industrial measures in a separate category named “Industrial” due to the unique nature of industrial measures such as those installed in waste water facilities and dairies. Some commercial projects included industrial measures, labs with fume hoods for example. As mentioned in the previous section, the modeling results for these sites were disaggregated into commercial and industrial measures for the analysis, and the resulting industrial findings are included within the industrial results tables.

Two different approaches were taken in analyzing the energy savings and demand reduction data. The fundamental difference between the two approaches is the determination of savings constituents. Previous studies have included both approaches, whereas this year’s study focuses on the “All Measures” approach explained below.

The “All Measures” approach, listed below, aggregates savings from all measure categories regardless of the specific measures for which a site received an incentive. For example, if a site received an incentive for HVAC but also achieved savings due to increased LPD efficiency, the total savings for that site would be the sum of both HVAC and LPD savings. The reason that this approach was adopted was to prevent trade-offs where sites could receive incentives for increased efficiency in one measure category while having sub-code efficiency in other measure categories.

The “Incented Measure” approach, listed in the appendix, only considers savings for each measure category for which a site received an incentive. In the “All Measures” example where both HVAC and LPD measures were better than baseline, the savings for that site would only consist of the HVAC measure for which the site received a rebate. These estimates of savings can be useful to show how cost effective certain measures are, but in order to prevent trade-off between measures the SBD program has established the “All Measures” as the approach used to report savings for the program.

Statewide Energy Findings

Table 21 shows the estimated combined total gross energy savings relative to the energy savings from the program tracking databases, calculated at the utility level. For all program participants, the combined total annual gross energy savings were estimated in this evaluation to be 355,453 MWh, representing a gross realization rate of 103.1%.

Utility	Ex-Ante Gross Energy Savings (MWh)	Sampled Energy Savings (MWh)	% Sampled Energy Savings	Ex-Post Gross Energy Savings (MWh)	Error Bound	Relative Precision	Gross Realization Rate
PGE	108,856	44,534	40.9%	103,222	7,962	7.7%	94.8%
SCE	153,610	56,096	36.5%	164,540	24,135	14.7%	107.1%
SoCalGas	18,322	7,582	41.4%	16,862	2,537	15.0%	92.0%
SDGE	63,959	36,127	56.5%	70,829	8,909	12.6%	110.7%
Total	344,748	144,339	41.9%	355,453	27,050	7.6%	103.1%

Table 21: Combined Total Annual Gross Energy Savings

Figure 2 and Table 23 show the composition of annual gross energy savings by measure type at the statewide level. The analysis of the SBD program was conducted using ratio estimation. For a statewide analysis one ratio is calculated and applied to all utilities. For a utility specific evaluation separate ratios are calculated for each utility. Depending on how much variation there is among utility ratios, utility ratio estimates can vary greatly from the statewide ratio. For annual energy savings the statewide and utility specific ratios were very similar. The statewide estimate of savings shown in Table 22 is 355,771 MWh with a relative precision of 7.7%, yielding a difference of less than 300 MWh in savings and 0.01% relative precision from Table 1 and Table 21.

Utility specific compositions are provided in the appendix. Whole Building Approach projects continue to comprise nearly 40% of the annual energy savings among program participants as it did in the 2003 evaluation. This is a significant increase over the 2002 findings (23%)[7] and 2001 (20%)[8]. The industrial measures account for 26% of the annual energy savings up slightly from 22% in 2003. Lighting power density grew to 18% from 10% in 2003 while all of the other saving categories fell with only HVAC and motors exceeding 10% of the total.

Program Estimated Energy Savings (MWh)	Sampled Energy Savings (MWh)	% Energy Savings Sampled	Ex-Post Gross Energy Savings (MWh)	Relative Precision	Realization Rate
344,748	144,339	42%	355,771	7.7%	103.2%

Table 22: Statewide Annual Gross Energy Savings

[7] 2002 Building Efficiency Assessment, An Evaluation of the Savings By Design Program, RLW Analytics, Inc., July 2004, page 19.

[8] 1999-2001 Building Efficiency Assessment, An Evaluation of the Savings By Design Program, RLW Analytics, Inc., April 2003, page 20.

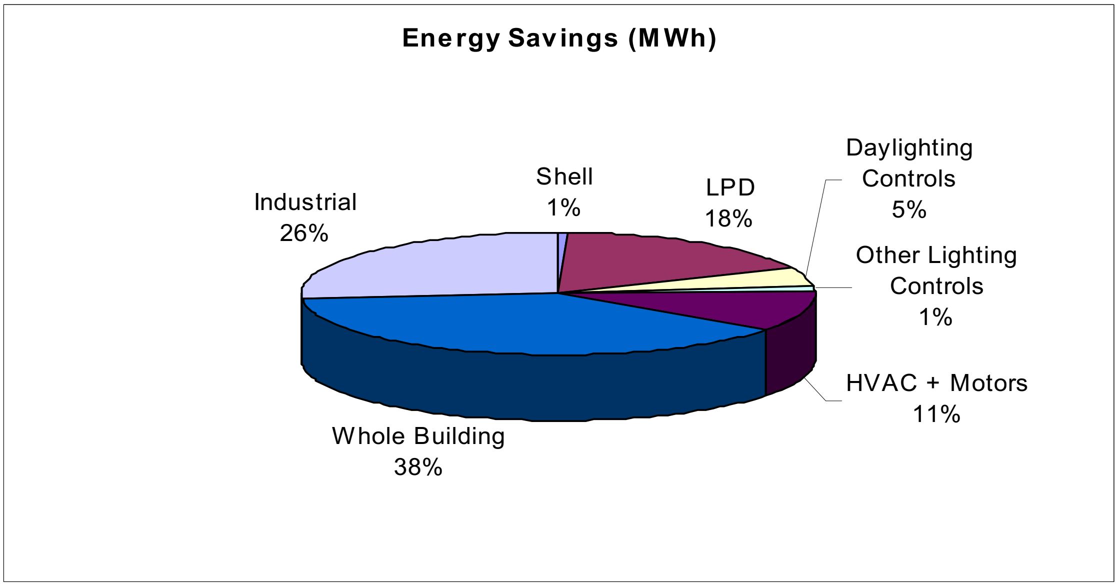

Figure 2: Composition of Annual Ex-Post Gross Energy Savings as a Percent of Combined Total

Table 23 shows the estimated energy savings and error bound by measure type as well as for the combined commercial total. The combined commercial total energy savings were 265,080 MWh, with an error bound of 31,189 MWh, yielding a 90% confidence interval of 233,891 to 296,269 MWh. Industrial measures achieved gross energy savings of 90,691 MWh, with an error bound of 15,505 MWh, yielding a 90% confidence interval of 75,186 to 106,196 MWh.

Each end use is a category of energy consuming measures that contribute to the total energy consumption of a building. The "measure categories" in this report refer to the measures that define each of the DOE-2 parametrics. The "shell" measure category has no value in the final column labeled "Savings as % of End Use Baseline" because shell measures do not directly consume energy and thus have no associated baseline consumption. The industrial measure category also has no value in this column because industrial measures utilize measure specific standard practice for determining energy savings, as opposed to a predefined Title 24 baseline.

	Measure Category	Ex-Post Gross Energy Savings (MWh)	Error Bound	Relative Precision	End Use % Savings
Systems Approach	Shell	1,663	1,757	105.7%	NA
	LPD	60,596	19,739	32.6%	30.6%
	Daylighting Controls	17,643	10,959	62.1%	8.9%
	Other Lighting Controls	4,916	2,050	41.7%	2.5%
	HVAC + Motors	39,875	16,246	40.7%	17.9%
	Refrigeration	-	-	-	-
	Domestic Hot Water	(9)	13	155.4%	NA
	Whole Building	140,395	11,725	8.4%	17.5%
	Combined Commercial Total	**265,080**	**31,189**	**11.8%**	**20.9%**
	Industrial	90,691	15,505	17.1%	NA

Table 23: Annual Gross Energy Savings by Measure

Statewide Demand Reduction Findings

This section presents the gross summer peak demand reduction for the program participants.

Table 24 shows the estimated combined total summer peak gross demand reduction relative to the summer peak demand reduction from the program tracking databases, calculated at the utility level. For all program participants, the combined total summer peak gross demand reduction is estimated to be 56.4 MW, representing a gross realization rate of 82.1%.

Utility	Ex-Ante Gross Demand Reduction (MW)	Sampled Demand Reduction (MW)	% Sampled Demand Reduction	Ex-Post Gross Demand Reduction (MW)	Error Bound	Relative Precision	Gross Realization Rate
PGE	23.1	9.5	40.9%	19.0	2.8	14.5%	82.1%
SCE	27.9	8.9	32.1%	23.7	8.3	35.1%	84.9%
SoCalGas	3.5	1.6	46.9%	2.8	0.4	12.6%	80.3%
SDGE	14.3	7.2	50.8%	11.0	1.9	17.4%	76.9%
Total	68.7	27.3	39.7%	56.4	9.0	15.9%	82.1%

Table 24: Combined Total Summer Peak Gross Demand Reduction

Table 25 shows the demand reduction calculated using a statewide ratio. The ex-post gross demand savings are 57.1 MW, which is 0.7 MW greater than the estimate calculated with utility specific ratios. The demand saving estimate calculated with the statewide ratio has a relative precision that is 1.7% higher than the utility specific ratios shown in Table 24. The reason that the overall relative precision improved with the utility specific ratios when compared to the estimate calculated statewide ratio, is that the statewide utilized a single ratio which it applied to all utilities. The statewide ratio that was applied to each utility was had more variation than a separate ratio calculated for each individual utility, showing that some utilities over predict tracking savings and others under predict.

Program Estimated Demand Reduction (MW)	Sampled Demand Reduction (MW)	% Demand Reduction Sampled	Ex-Post Gross Demand Reduction (MW)	Relative Precision	Realization Rate
68.7	27.3	40%	57.1	17.6%	83.1%

Table 25: Statewide Summer Peak Gross Demand Reduction

Figure 3 shows the breakdown of summer peak demand reduction by measure category at the statewide level. As with the energy savings results, Whole Building Approach projects account for almost 45% of the summer peak demand reduction among program participants. About 23% of the reduction is due to lighting measures (i.e. lighting power density, daylighting controls, and other lighting controls), while HVAC + Motors measures comprise an additional 13% of the reduction. Industrial accounts for 19% of the summer peak demand reduction.

The comparison of Figure 2 and Figure 3 reveals that the demand savings contribution by end use for Whole Building is larger than the corresponding energy savings. Lighting in total has similar demand and energy savings but the impact of daylighting controls has a larger demand impact and LPD has a larger energy savings impact. The Industrial measure category is experiencing the largest differential between the demand and energy savings percentage at 19% and 26%, respectively.

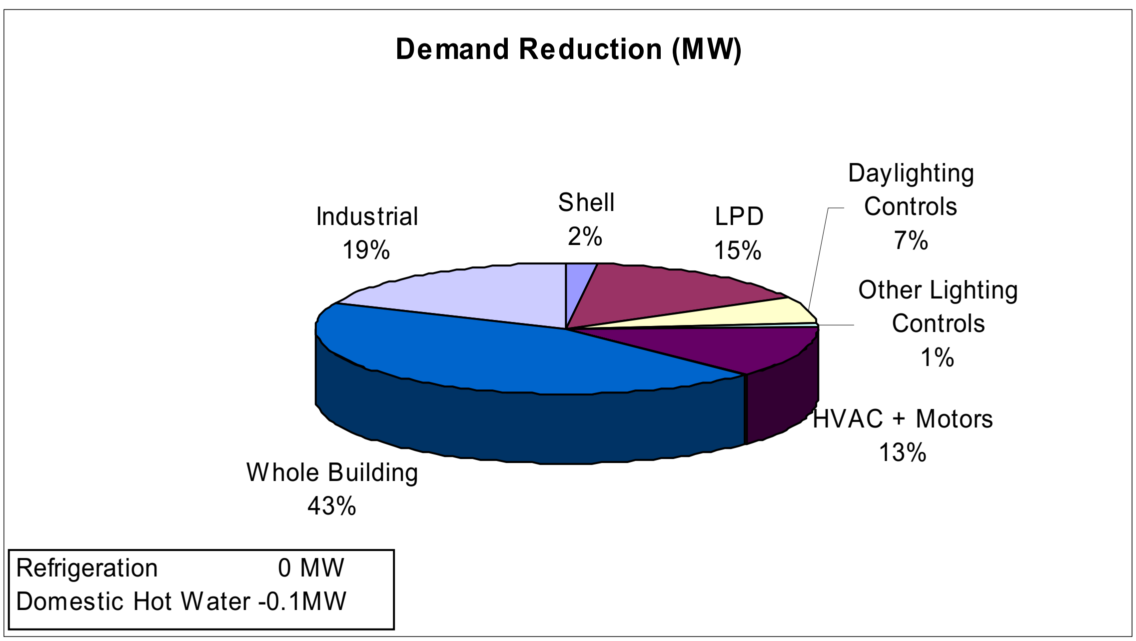

Figure 3: Composition of Summer Ex-Post Gross Peak Demand Reduction as a Percent of Combined Total

Table 26 shows the estimated gross summer peak demand reduction and error bound by measure type, as well as for combined commercial total, calculated at the statewide level. The combined commercial total gross summer peak demand reduction was 46.5 MW, with an error bound of 7.9 MW, yielding a 90% confidence interval of 38.6, 54.4 MW. Industrial measures achieved summer peak demand reduction of 10.6 MW, with an error bound of 3.7 MW, yielding a 90% confidence interval of 6.9, 14.3 MW.

In general, the demand reduction for each measure category as a percentage of its end use baseline demand is very similar to the energy savings as a percentage of its end use baseline consumption. LPD measures are producing the most demand reduction for any systems measures (8.7 MW). Whole Building projects are producing over one-half of the demand savings for all commercial measures, accounting for 25.2 MW out of a total 46.5 MW.

	Measure Category	Ex-Post Gross Demand Reduction (MW)	Error Bound	Relative Precision	End Use % Reduction
Systems Approach	Shell	1.1	0.5	49.3%	NA
	LPD	8.7	3.7	42.7%	27.9%
	Daylighting Controls	3.9	2.4	61.6%	12.5%
	Other Lighting Controls	0.3	0.5	130.9%	1.1%
	HVAC + Motors	7.3	3.2	43.7%	14.9%
	Refrigeration	-	-	-	-
	Domestic Hot Water	(0.1)	0.1	155.3%	NA
	Whole Building	25.2	3.1	12.5%	18.8%
	Combined Commercial Total	**46.5**	**7.9**	**17.0%**	**20.1%**
	Industrial	10.6	3.7	34.9%	NA

Table 26: Summer Peak Gross Demand Reduction By Measure

Statewide Gas Savings Findings

Note: Prior Savings By Design Evaluations did not include an analysis of gas savings. Due to the small sample size including gas savings and large percentage of sample sites with tracking or evaluated savings of zero, it was discovered that ratio analysis could not be used on certain measure categories. As a result of this finding, mean per unit estimation was used for all utility specific measure categories where ratio analysis was not a viable option. Because of the combination of ratio analysis and weighted mean per unit estimation, an overall error bound and relative precision could not be calculated for gas savings.

The 2004-2005 impact evaluation includes for the first time the evaluation of natural gas savings. Since natural gas is predominately a heating fuel, measures which reduce internal heat gain from losses, such as lighting, show negative gas savings. In addition, interactive effects result in small gas savings attributable to measures which do not have a direct gas component such as refrigeration.

As shown in Table 27 the total ex-ante gross gas savings for the program is 8,662,541 therms with a realization rate of 97.9%. The evaluation is based on a sample representing around 48% of the ex-ante gross gas savings. SCE's large realization rate was driven by HVAC savings which accounted for 98% of the total savings and had a relative precision of 138%, which means that the prediction has a large amount of uncertainty. SCE's HVAC/Motors savings also accounts for 47% of the total gas savings of the program, but has little meaning as a result of the high degree of uncertainty associated with such a large relative precision.

Utility	Ex-Ante Gross Energy Savings (Therms)	Sampled Energy Savings (Therms)	% Sampled Energy Savings	Ex-Post Gross Energy Savings (Therms)	Gross Realization Rate
PGE	6,137,245	2,539,961	41.4%	2,207,486	36.0%
SCE	332,143	61,467	18.5%	4,082,376	1229.1%
SoCalGas	71,357	24,769	34.7%	14,777	20.7%
SDGE	2,121,796	1,568,406	73.9%	2,173,369	102.4%
Total	8,662,541	4,194,603	48.4%	8,478,008	97.9%

Table 27: Combined Total Annual Gross Gas Savings

Table 28 shows that the statewide gross therms savings of 9,100,000 therms, a difference of 6.5% from the by utility estimate of 8,700,000 therms. Ratio analysis could be used to estimate statewide overall savings because the ex-Ante gross estimates and ex-post Gross estimates of savings had consistent signs (both were positive or both were negative); therefore an overall relative precision was able to be calculated. However, the utility specific estimates of savings used a combination of ratio analysis and mean per unit estimation and as a result an overall relative precision could not be calculated for these estimates.

Program Estimated Energy Savings (Therms)	Sampled Energy Savings (Therms)	% Energy Savings Sampled	Ex-Post Gross Energy Savings (Therms)	Relative Precision	Realization Rate
8,662,541	4,194,603	48%	9,111,514	74.9%	105%

Table 28: Statewide Annual Gross Gas Savings

Table 29 and Figure 4 illustrate the total gas program savings by measure category, at the statewide level. The interactive effects are particularly obvious in the table with negative gas savings attributable to lighting energy efficiency measures. The largest percentage of gas savings are from HVAC specific measures representing almost 62% of all measures categories with positive savings. Most of the remaining savings are attributable to industrial and whole building measures. For gas measures with negative savings, denoted with a (*), weighted mean per unit analysis was used. When attempting to use ratio estimation, the denominator (total ex-ante gross savings) was positive and numerator (total ex-post gross savings) was negative which caused incorrect results.

One reason that the relative precisions are poor for gas measure categories is that the ex-ante gross savings or ex-post gross savings are often zero. Ratio analysis develops a trend line to best fit the data, where the precision is determined by the variance of each point from that trend line. If a large percentage of those points are on the axis then the trend line will be a poor predictor of actual savings and thus have a low relative precision.

	Measure Category	Ex-Post Gross Energy Savings (Therms)	Error Bound	Relative Precision	End Use % Savings
Systems Approach	Shell	443,196	355,655	80.2%	NA
	LPD*	(206,545)	NA	NA	NA
	Daylighting Controls*	(78,534)	NA	NA	NA
	Other Lighting Controls*	(18,232)	NA	NA	NA
	HVAC + Motors	5,852,558	6,517,364	111.4%	47.7%
	Refrigeration	38,937	29,370	75.4%	0.3%
	Domestic Hot Water	37,164	23,922	64.4%	1.2%
	Whole Building	1,213,583	268,907	22.2%	31.1%
	Combined Commercial Total	**7,282,128**	NA	NA	NA
	Industrial	1,829,386	1,054,771	57.7%	NA

Table 29: Annual Gross Gas Savings by Measure[9]

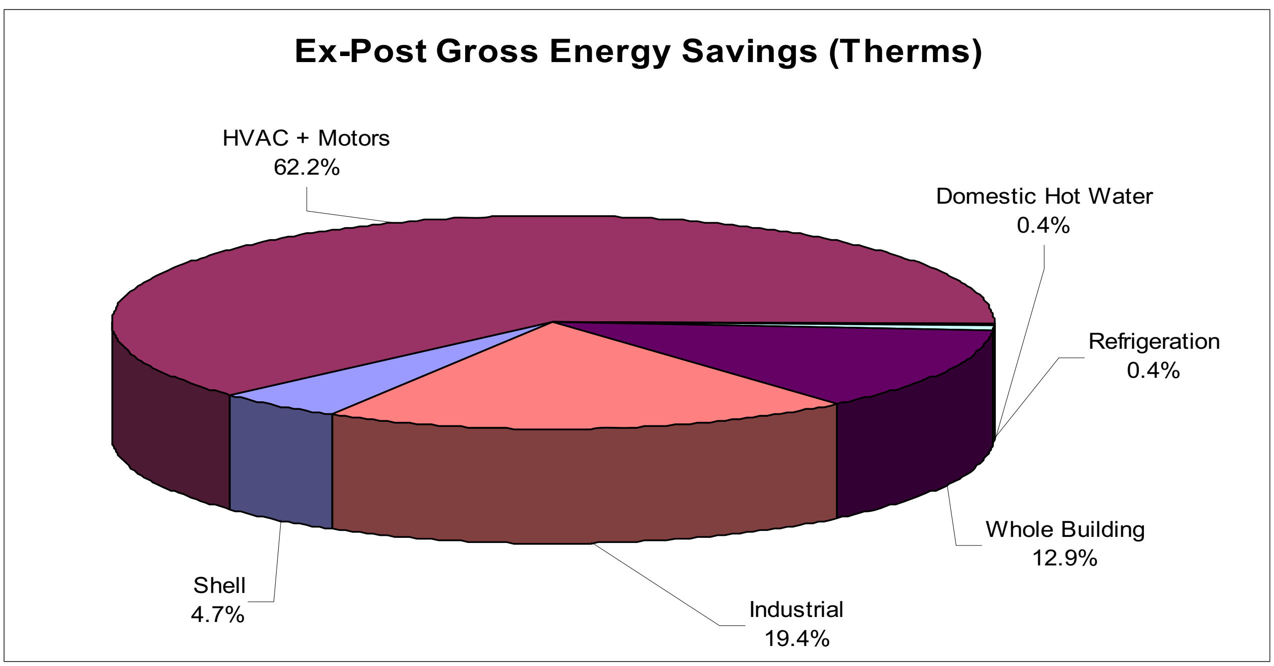

Figure 4: Composition of Annual Ex-Post Gross Gas Savings

[9] For gas measures denoted with a (*), weighted mean per unit analysis was used.

as a Percent of Combined Total (Therms)[10]

[10] Figure 4 shows each measure as a percentage of total savings for all measures with positive savings.

Net Savings Results

Net savings results for both annual energy savings and summer peak demand reduction are presented in this chapter. Furthermore, results are shown by end-use and System vs. Whole Building projects. Assessments of free-ridership by measure category are shown, where possible.

Energy Findings

Free-ridership Net Savings Results

To calculate free-ridership RLW surveyed decision-makers on their efficiency choices for incented measures. Based on the survey responses the engineering simulation models were adjusted to reflect these efficiency choices absent the Savings By Design program. The engineering models were then re-simulated. The results of these simulations were analyzed to obtain the net savings for participants.

Table 30 shows the combined total annual net and gross savings by utility, calculated at the utility level. Across the four utilities the SBD program had an ex-post net savings of approximately 260,000 MWh and a 73% net to gross ratio. SoCalGas had the largest net to gross ratio at 91%, though it also had the lowest ex-post net savings at slightly over 15,000 MWh.

Utility	Ex-Post Net Energy Savings (MWh)	Relative Precision	Ex-Post Gross Energy Savings (MWh)	Relative Precision	Net-to-Gross Ratio
PGE	74,989	10.4%	103,222	7.7%	72.6%
SCE	126,964	18.7%	164,540	14.7%	77.2%
SoCalGas	15,337	25.2%	16,862	15.0%	91.0%
SDGE	42,240	19.2%	70,829	12.6%	59.6%
Total	259,530	49.1%	355,453	46.4%	73.0%

Table 30: Combined Total Net Savings by Utility

Table 31 shows the total net program impacts taking into account participant free-ridership. Using this methodology, the commercial ex-post net participant savings are 203,409 MWh, which corresponds to a net-to-gross ratio of 75.7%. Industrial measures achieved net savings 56,121 MWh, corresponding to a net-to-gross ratio of 64.7%.

	Commercial Energy Impacts (MWh)	Industrial Energy Impacts (MWh)	Calculation
Ex-Ante Gross Savings	228,003	116,744	A
Ex-Post Gross Savings	268,758	86,696	B
Gross Realization Rate	117.9%	74.3%	(A/B)
Ex-Post Net Savings	203,409	56,121	C
Net-to-Gross Ratio	75.7%	64.7%	(C/B)

Table 31: Total Net Energy Program Impacts

Table 32 shows the total net program impacts by measure type, calculated at the statewide level. Savings estimates in Table 32 differ from Table 30 and Table 31, because they are calculated using different ratio estimates (statewide versus utility specific estimates). Since the whole building approach accounts for over half the net savings, its net-to-gross ratio of 70.2% has a large impact on the ratio for the entire program. Similarly the large contributions to total savings from LPD and HVAC + Motors (NTGR of 73.6% and 84.2%, respectively) also have a significant impact on the total program net-to-gross ratio. The higher ratios from other measures do not have a significant effect on total program ratio because they account for a small fraction of total program savings.

	Measure Category	Ex-Post Net Savings (MWh)	Relative Precision	Ex-Post Gross Savings (MWh)	Relative Precision	Net-to-Gross Ratio
Systems Approach	Shell	1,626	107.5%	1,871	91.4%	86.9%
	LPD	45,604	34.8%	61,954	32.4%	73.6%
	Daylighting Controls	17,486	62.8%	18,079	62.0%	96.7%
	Other Lighting Controls	4,503	45.0%	5,028	41.6%	89.6%
	HVAC + Motors	31,493	50.3%	37,402	43.0%	84.2%
	Refrigeration	-	0.0%	-	0.0%	N/A
	Domestic Hot Water	(9)	155.5%	(9)	155.3%	N/A
	Whole Building	95,831	11.0%	136,500	10.0%	70.2%
	Combined Commercial Total	**196,534**	**14.5%**	**260,826**	**12.3%**	**75.4%**
	Industrial	59,209	18.9%	93,138	18.0%	63.6%

Table 32: Total Net Energy Program Impacts by Measure Type

Industrial projects represent 30.6% of the overall net energy savings, up from 22% in the 2003 SBD study. In the 1999-2001 SBD study, there were no industrial projects, whereas in the 2002 and 2003 studies the energy savings due to industrial measures were considerable.

Industrial measures were diverse and the net savings analysis often called for in-depth qualitative questioning that went beyond the scope of the original survey questionnaire. Many of the industrial measures were extremely large in terms of energy savings; therefore it was extremely important to have comprehensive discussions regarding the decision making that occurred at the time of the measure installation. However, these measures were typically important to the customer's process, large in terms of energy consumption, and expensive to procure. Therefore decision-makers were easily able to recall and discuss the decision making process that led them to install the equipment incented by Savings By Design. These issues also contributed to the relatively high free-ridership of 36.4%.

The final industrial net to gross ratio of 63.6% represents an improvement over 2003 (59%). Further information on each industrial site evaluated is available in the industrial sites write-ups provided in the appendix. Some specific findings that contributed to the low NTG included:

- Decisions to install energy efficient equipment were sometimes made before initial contact with the SBD representative, and
- The industrial site with the largest savings was only partially influenced by Savings By Design.

Summer Peak Demand Findings

Free-ridership Net Savings Results

Table 33 shows the combined summer net and gross peak demand reduction by utility. The overall net participant savings is 42.3 MW. SoCalGas had the largest net to gross ratio at 83.5% but had the lowest net demand reduction at 2.3 MW.

Utility	Ex-Post Net Demand Reduction (MW)	Relative Precision	Ex-Post Gross Demand Reduction (MW)	Relative Precision	Net-to-Gross Ratio
PGE	13.8	17.8%	19.0	14.5%	73.0%
SCE	18.8	36.2%	23.7	35.1%	79.3%
SoCalGas	2.3	28.7%	2.8	12.6%	83.5%
SDGE	7.3	23.5%	11.0	17.4%	66.7%
Total	42.3	45.8%	56.4	43.0%	74.9%

Table 33: Combined Total Net Demand Reduction by Utility

Table 34 shows the total net program impacts for summer peak demand reduction, taking into account participant free-ridership. The commercial net participant reduction is 34.7 MW, which corresponds to a participant net-to-gross ratio of roughly 77%. Industrial measures achieved a net reduction of 7.6 MW, corresponding to a net-to-gross ratio of approximately 66%.

	Commercial Energy Impacts (MW)	Industrial Energy Impacts (MW)	Calculation
Ex-Ante Gross Savings	58.5	10.3	A
Ex-Post Gross Savings	45.0	11.4	B
Gross Realization Rate	77.0%	110.8%	(A/B)
Ex-Post Net Savings	34.7	7.6	C
Net-to-Gross Ratio	77.1%	66.4%	(C/B)

Table 34: Total Net Demand Program Impacts

Table 35 shows the total net program demand reduction by measure type, calculated at the statewide level. The dominate measure category is whole building (accounting for 52% of net program demand reduction) which has a 72.7% net-to-gross ratio. The other large contributors to total demand reduction, LPD and HVAC + Motors, have similar net-to-gross ratios of 78.3 and 72.4%, respectively. The remaining measure categories have net-to-gross ratios closer to 100% but they are not sufficiently large in total savings to significantly impact the total program net-to-gross value of 74.9%. The industrial measure category has a net-to-gross ratio of 65.9%, which is similar to energy findings.

	Measure Category	Ex-Post Net Demand Reduction (MW)	Relative Precision	Ex-Post Gross Demand Reduction (MW)	Relative Precision	Net-to-Gross Ratio
Systems Approach	Shell	1.1	48.6%	1.1	49.3%	99.9%
	LPD	6.8	44.4%	8.7	42.7%	78.3%
	Daylighting Controls	3.9	61.5%	3.9	61.6%	100.8%
	Other Lighting Controls	0.5	65.0%	0.3	130.9%	143.0%
	HVAC + Motors	5.3	48.6%	7.3	43.7%	72.4%
	Refrigeration	-	0.0%	-	0.0%	
	Domestic Hot Water	(0.1)	155.3%	(0.1)	155.3%	NA
	Whole Building	18.3	16.2%	25.2	12.5%	72.7%
	Combined Commercial Total	**35.9**	**19.4%**	**46.5**	**17.0%**	**77.2%**
	Industrial	7.0	35.5%	10.6	34.9%	65.9%

Table 35: Total Net Demand Program Reduction by Measure Type

Gas Findings

Free-ridership Net Savings Results

Table 36 shows the total net program impacts for annual gas savings, taking into account participant free-ridership. The overall ex-post net participant savings are close to 8,000,000 therms, which correspond to a participant net-to-gross ratio of approximately 93%. Table 36 provides utility level estimates of savings, whereas the Table 38 estimates for specific measure categories are produced at the statewide level. Individual utility estimates of savings by measure category are provided in the appendix. Table 37 separates out gross and net savings by commercial and industrial projects. As mentioned previously, since two different approaches were employed in evaluating savings (ratio analysis and mean per unit estimation) an overall relative precision and error could not be calculated.

Net savings estimates for commercial sites were estimated via manipulation of sample site simulation models. Using this technique, there are occurrences where interactive effects will indicate a net-to-gross ratio greater than 100%. For example, when the glazing solar heat gain coefficient is de-rated for free-ridership, the cooling electrical usage increases, thus decreasing the electrical energy savings relative to baseline. However, the de-rated glazing allows more passive solar heating thereby reducing the building heating load, and increasing the gas savings relative to gross. This type of interactive effect occurred often enough to produce net to gross ratios greater than 100% for some of the market sectors below.

Utility	Ex-Post Net Energy Savings (Therms)	Ex-Post Gross Energy Savings (Therms)	Net-to-Gross Ratio
PGE	1,421,523	2,207,486	64.4%
SCE	4,129,443	4,082,376	101.2%
SoCalGas	3,713	14,777	25.1%
SDGE	2,362,047	2,173,369	108.7%
Total	7,916,725	8,478,008	93.4%

Table 36: Net Therm Savings by Utility

	Commercial Energy Impacts (Therms)	Industrial Energy Impacts (Therms)	Calculation
Ex-Ante Gross Savings	2,878,393	5,784,148	A
Ex-Post Gross Savings	6,489,318	1,988,690	B
Gross Realization Rate	225.4%	34.4%	(A/B)
Ex-Post Net Savings	6,801,954	1,114,771	C
Net-to-Gross Ratio	104.8%	56.1%	(C/B)

Table 37: Total Net Gas Savings Impacts

	Measure Category	Ex-Post Net Savings (Therms)	Relative Precision	Ex-Post Gross Savings (Therms)	Relative Precision	Net-to-Gross Ratio
Systems Approach	Shell	413,706	96.8%	443,196	80.2%	93.3%
	LPD*	(150,598)	NA	(206,545)	NA	72.9%
	Daylighting Controls*	(65,862)	NA	(78,534)	NA	83.9%
	Other Lighting Controls*	(16,317)	NA	(18,232)	NA	89.5%
	HVAC + Motors	5,881,387	114.5%	5,852,558	111.4%	100.5%
	Refrigeration	36,147	75.3%	38,937	75.4%	92.8%
	Domestic Hot Water	37,012	64.5%	37,164	64.4%	99.6%
	Whole Building	1,407,273	22.5%	1,213,583	22.2%	116.0%
	Combined Commercial Total	**7,542,748**	NA	**7,282,128**	NA	**103.6%**
	Industrial	1,025,472	70.9%	1,829,386	57.7%	56.1%

Table 38: Gas Net Savings by Measure[11]

[11] For gas measures with negative savings, denoted with a (*), weighted mean per unit analysis was used. When attempting to use ratio estimation, the denominator (total ex-ante gross savings) was positive and the numerator (total ex-post gross savings) was negative which caused incorrect results.

Process Findings

RLW designed decision-maker (DM) surveys to help determine the net savings attributable to the program. The questions were designed to learn more about program awareness and attitudes, specific building characteristics, and design and construction practices. The following sections report these results and correlate directly with the flow of the decision-maker survey. This section addresses the following areas of interest:

- Interviewee information,
- Building descriptive statistics,
- Savings By Design program attitudes and awareness,
- Importance of Dollar Incentives, Design Assistance and Design Analysis,
- Prototype Modules.

Survey Respondents

The target number of total interviews was approximately 200. The final dataset, however, contained survey responses from 197 participants. Out of the 197, 11 surveys were incomplete. In other words, not all questions were answered because either the decision-maker wasn't with the company for a long enough time to answer questions appropriately or the primary respondent was not available. Sometimes the interviewee was also found to be non-responsive; he or she did not complete the survey [left the interview midway] and later was not available to answer questions despite the repeated attempts to reach him or her. The industrial participants were also administered the standard decision-maker survey, however some survey questions were omitted if they were not applicable.

All of the decision-maker responses have been weighted to the population. Case weights were developed (in the same way as the gross savings analysis) so that the 197 survey participants were representative of the entire population.

The goal of the sample was to infer information about SBD participants. The information was gathered from interviewing the decision-makers, which included the building owners and, in many cases, members of the design team for the buildings in the sample. Frequently multiple people were interviewed to complete a single survey. For example, numerous interviews included the mechanical engineer responsible for designing the HVAC system in addition to the building owner or facilities manager who answered the less technical questions.

Many of the SBD program participants were responsible for multiple buildings within our sample, especially where a set of prototype plans were used. In some cases, one person answered several surveys, one survey for each of the sampled projects under their control. In fact, the same questions were asked multiple times in order to get project specific information since different projects may have required different responses. For example, one participant may have had two HVAC projects, each in a different climate. Therefore some responses would be considerably different and thus require independent answers for each project.

Methodology

Weighted Responses

In order to produce an unbiased extrapolation to the population, all responses have been weighted to the population. Each survey (sample element) has a weight, calculated using MBSS techniques, and associated with the responses which tell how many individuals a single sample element represents. Qualitatively, the weights say how much each survey "counts" toward representing the population.

Results are reported by "% of respondents," calculated using the following equation:

(Weighted number of respondents) ÷ (Total weighted sample).

Percentage of Respondents

Due to the design of the survey and response categories, all column totals equal 100%, except where noted otherwise.

Sample Size

"Sample size", as reported in all tables in this section, represents the actual un-weighted number of respondents who answered the question, and is reported separately for each question. This is necessary since not every question was answered by every person, due to refusal or inapplicability.

Survey Responses

Often times, not every question was answered with a specific response and some questions even went unanswered due to refusal, non-applicability, skip patterns, or other reasons. "Don't know" answers are included in the sample size for each question and are considered a legitimate category of response. Each answer with non-responses (missing values) has been eliminated and the sample size for that question has been appropriately reduced. The variation in the sample sizes for various questions can be explained by this. For example, the questions on prototype plans have smaller sample sizes because not all buildings used prototype plans.

For non-quantitative, or qualitative, results, verbatim responses are provided throughout this report. Some questions list all responses, while other questions provide only a sample of responses. In some cases, sample responses were selected for their content and may not be representative of all the responses for that question. A complete list of responses for each question can be made available upon request.

Survey Results

Interviewee Information

This subsection provides information on the interviewee. Table 39 shows that 94.4% of the people who were interviewed were either the owner of the building or the owner's representative. The last line of Table 39 shows that responses for this question were recorded from a total of 194 people.

Interviewee	% of Respondents
Owner or Owner's Representative	94.4%
Others	5.6%
Don't Know	-
Refused	-
Sample Size	194

Table 39: Interviewee Information (q1)

The interviewees were also asked if they recalled participation in the SBD program. As Table 40 shows, 96.3% of all interviewees recalled participation.

Interviewee	% of Respondents
Recalled Participation in SBD Program	96.3%
Didn't Recall Participation in SBD Program	2.6%
Don't Know	1.0%
Refused	-
Sample Size	194

Table 40: If Interviewee Recalled Participation in SBD Program (q2)

Building Descriptive Statistics

This subsection focuses on descriptive statistics of the surveyed buildings. Table 41 shows that 82.6% of the buildings matched the correct building descriptions exactly as specified in the program. For the remaining buildings there were two possible scenarios. First, the building descriptions didn't match exactly because the buildings were mixed occupancies, which led to multiple descriptions of the building. Second, the buildings were described as something different from what was specified in the program. All building types are shown in Table 42.

Type of Building	% of Respondents
Description Same as Program	82.6%
Description Not Exactly Same as Program	17.4%
Sample Size	192

Table 41: Type of Building (q3)

The descriptions of the buildings[12] are listed in Table 42. This also shows that 21.2% of the buildings were retail and wholesale stores, 13.6% were General C&I Work, 14.3% were schools and 9.3% were offices.

Type of Building	% of Respondents
Retail and Wholesale Store	21.2%
School	14.3%
General C&I Work	13.6%
Other	9.6%
Office	9.3%
C&I Storage	5.7%
Grocery Store	5.2%
Fire/Police/Jails	2.6%
Medical/Clinical	2.1%
Community Center	2.0%
Library	1.6%
Hotels/Motels	1.3%
Government Training, Office/Detention Facility, Primarily Jail & Office	1.1%
Religious Worship, Auditorium, Convention	1.1%
Restaurant	1.1%
Storage	1.1%
Administrative Offices	1.1%
Residential, Retail, & Parking Garage	0.9%
Office, Gym, Portable classrooms, & Media Center	0.8%
Warehouse/Office	0.8%
Warehouse/Distribution Center	0.8%
Miscellaneous	0.5%
Wastewater Treatment Plant	0.3%
Other-General C&I Work	0.3%
Refrigerated Storage	0.3%
Processing produce - General C&I Work	0.3%
C&I Work	0.2%
Milk Storage	0.2%
Refrigerated Warehouse	0.2%
C&I storage, Distribution Warehouse	0.1%
Other-Bio tech R&D	0.1%
Research & Development(60%) and Administrative bldg(40%)	0.1%

Table 42: Building Description (q3)

Table 43 classifies the buildings by project type. Over 70% of all SBD projects were new buildings.

[12] If an interviewee reported a building description different from what is stated by the program, the updated response provided by the interviewee is listed in Table 42.

Type of Project	% of Respondents
New Building (Brand New Construction)	70.2%
Renovation or remodel of an existing building	9.1%
Addition to an existing building	6.9%
First Tenant improvement or newly conditioned space in an existing shell building	6.1%
Gut rehabilation of existing building	4.2%
Renovation and addition	3.4%
Sample Size	195

Table 43: Type of Project (q4)

Some of the buildings were additions to existing buildings or renovations. A small fraction of interviewees (16 surveys) also provided details as to where in the building the additions or renovations took place. Below are some chosen responses.

Selected Participant Responses (q4a)

Central Plant

Ethanol Plant Constructed on Existing Site

Manufacturing Area

New Part is the gym and the other special purpose buildings plus five classrooms and the other classrooms were renovated

The building completion year ranged from 2001 to 2006. Figure 5 shows that over 88.4% of the buildings were completed in 2003, 2004 or 2005. In total, almost half (48.9%) of the buildings were completed in the year 2004. Table 44 shows that the sample size was 155. The interviewees also reported that almost all (approximately 99%) opened for occupancy immediately (within a month) after completion. Buildings completed in 2006 were measures installed prior to building completion. Some in this category were industrial sites where measures were installed before the final construction dates of the building. For example, in a wastewater treatment plant, secondary effluent pumps were installed outside the building, prior to final completion of building construction. Similarly, buildings completed in 2001-02 where additions to buildings were constructed later. For example, an existing school had a gymnasium and special purpose building constructed as well as renovation on five existing classrooms.

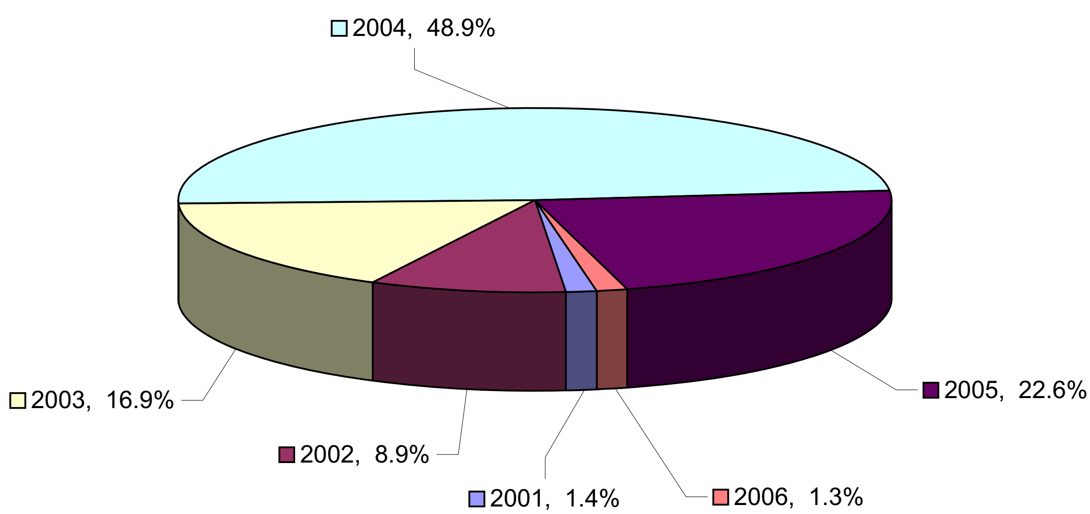

Figure 5: Building Completion Year

Building Completion Year	% of Respondents
2001	1.4%
2002	8.9%
2003	16.9%
2004	48.9%
2005	22.6%
2006	1.3%
Sample Size	155

Table 44: Building Completion Year (q5)

Table 45 shows that over 97% of all buildings were completely built out. Construction was not complete for the remaining 3%.

Building Completely Built Out	% of Respondents
Yes	97.0%
No	3.0%
Sample Size	193

Table 45: Building Completely Built Out (q6)

Table 46 shows that 92.6% of all buildings were fully occupied at the time of the survey.

Building Completely Occupied	% of Respondents
Yes	92.6%
No	7.2%
Sample Size	192

Table 46: Building Occupancy (q7)

Table 47 provides information on building ownership. Approximately 69% of all buildings were owned by private companies, whereas the remainders were owned by public agencies.

Ownership of Building	% of Respondents
Private	68.9%
Public	31.1%
Don't Know	-
Refused	-
Sample Size	197

Table 47: Ownership Intent (q8)

The reason for the construction or renovation of these buildings is summarized in Table 48. As can been seen from this table, 87.4% were built to be owner occupied. Approximately 12.2% of the buildings were built by a developer with the intent to lease space. Findings from previous SBD studies have shown that owner occupied buildings are more likely to make construction decisions using more sophisticated investment decision making procedures, such as return on investment (ROI) or lowest lifecycle cost, whereas speculative building decision-makers more frequently used lowest first cost decision making.

Occupancy Intent	% of Respondents
Built to be Owner occupied	87.4%
Built by a developer with the intent to lease space	12.2%
Built and Occupied By Developer with intent not lease remaining space	0.3%
Don't Know	-
Refused	-
Sample Size	197

Table 48: Occupancy Intent during Construction (q9)

As expected, all public agencies built their buildings to be owner occupied, while only 81.7% of private companies built their buildings to be owner occupied. The results are shown in Table 49.

Ownership of Building	Occupancy Intent			Total
	Owner Occupied	Lease Space	Developer Occupied	
Private	81.7%	17.8%	0.5%	100.0%
Public	100.0%	0.0%	0.0%	100.0%

Table 49: Building Ownership by Occupancy Intent (q8 & q9)

Table 50 shows that the building plans were available for 61% of the projects. The plans were not available for the 27% of the respondents.

Availability of Building Plans	% of Respondents
Yes	61.0%
No	27.0%
Don't Know	12.0%
Refused	-
Sample Size	196

Table 50: Availability of Building plans (q10)

Savings by Design Program Attitudes and Awareness

All SBD program participants were asked how they first became aware of the SBD program, services, and owner incentives that were available. As can be seen from Table 51, about 77% of the respondents heard of the program through utility representatives or previous utility program participation. This percentage is very similar to last year's findings.

The large proportion of participants that previously participated in utility programs (44.6%) suggests that the program may need to change its marketing strategy to attract a broader audience and get more customers that have not previously participated. However, the percentage for "learning from utility representatives" (32.1%) is higher than the 2002 results (26.1%) but lower than 2003 results (35.5%). The lack of responses in support of web sites or marketing materials suggests that the utilities need to revisit the intent and content of these sources.

Source	% of Respondents
Previous Utility Program Participation	44.6%
Utility Representative	32.1%
Architect	4.9%
Manufacturer Rep.	4.9%
Other	4.0%
Don't Know	2.5%
Marketing Material	2.2%
Utility Seminar PEC Center or SCE	1.6%
Engineer	1.4%
Construction Manager	1.1%
Web Site	0.4%
Energy Manager	0.3%
Sample Size	194

Table 51: Source of Awareness of Savings by Design (q11)

When asked whether the interviewee worked directly with SBD representative, 82.4% said yes. The remaining 17.6% did not work directly with SBD representatives. These results are shown in Table 52.

Worked Directly With SBD Representative	% of Respondents
Yes	82.4%
No	17.6%
Don't Know	-
Refused	-
Sample Size	194

Table 52: If Worked Directly With SBD Representative (q12)

All SBD participants were asked at what stage of the design and construction process they became actively involved with the SBD representatives. Interviewees were read the list of options in Table 53. The results indicate that 75.8% became involved with the program early in the design process (16.4% during project conception, 18.1% during project development, 13% during schematic design, and 28.3% during the design development phase). SBD involvement began during the construction documents phase for only 6.1% of respondents. However, 9.9% of projects involved SBD representatives late in the process, 9.2% during construction, and 0.7% following completion of construction, suggesting that design and equipment decisions were made prior to SBD involvement. These participants could be considered free riders. Figure 6 presents the results.

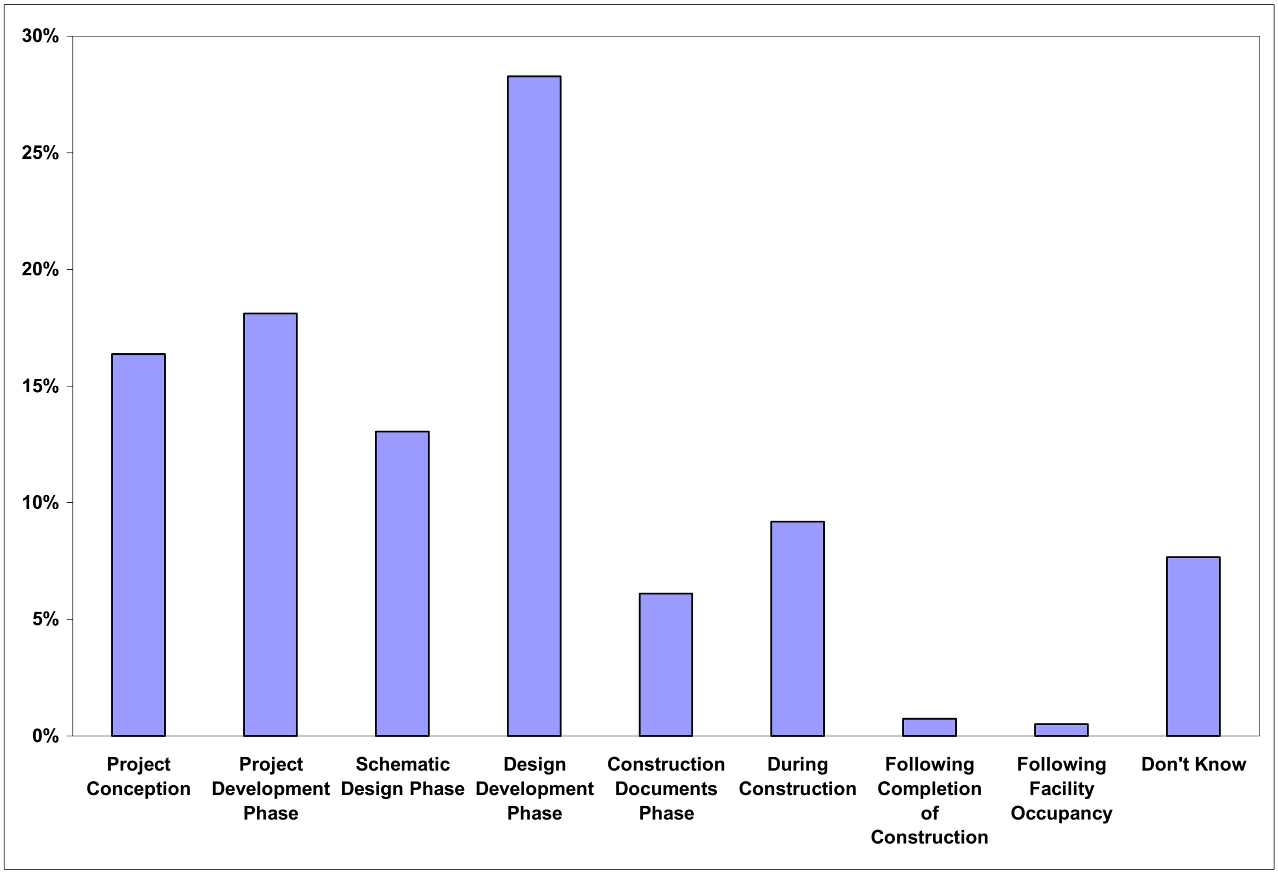

Figure 6: Stage of Involvement with SBD representatives (q13)

Stage	% of Respondents
Design Development Phase	28.3%
Project Development Phase	18.1%
Project Conception	16.4%
Schematic Design Phase	13.0%
During Construction	9.2%
Don't Know	7.7%
Construction Documents Phase	6.1%
Following Completion of Construction	0.7%
Following Facility Occupancy	0.5%
Sample Size	192

Table 53: Stage of Involvement with SBD representatives (q13)

Table 54 summarizes the responses given when SBD participants were asked (unprompted) which member of their project team was the single biggest advocate for participating in the program. Over 60% of the participants said that the owners or the developers were the biggest advocates for SBD participation. This supports the finding of the NRNC baseline study[13] that asserts that architects and engineers feel that the owners are the key decision-makers. Other notable advocates were architects, energy managers and mechanical engineers. The interviewees who chose the option “other” in Table 54 were asked to name or describe who they consider to be the biggest advocate. Their responses included Assistant VP of Energy, Public Works Director, employees of the Finance Department and some other specific designations or names.

Single Biggest Advocate	% of Respondents
Owner/Developer	62.3%
Architect	10.5%
Mechanical Engineer	6.1%
Other	5.5%
Energy Manager	4.6%
Construction Manager	4.2%
Electrical Engineer	2.8%
Manufacturer Rep.	2.0%
Don't Know	1.5%
Lighting Designer	0.5%
Sample Size	191

Table 54: Single Biggest Advocate for Participating in SBD (q14)

Importance of Dollar Incentives, Design Assistance, and Design Analysis

All SBD participants were asked to rate the level of importance of the incentives paid to the owner in motivating their organization to participate. As shown in Table 55 and Figure 7, approximately 86.8% said the incentive was either “very important” or “somewhat important”, while only 4.7% rated the incentive very unimportant or somewhat unimportant. This suggests that incentives are a critical tool for engaging program participation of building owners.

[13] 1999 Non-Residential New Construction Baseline Study.

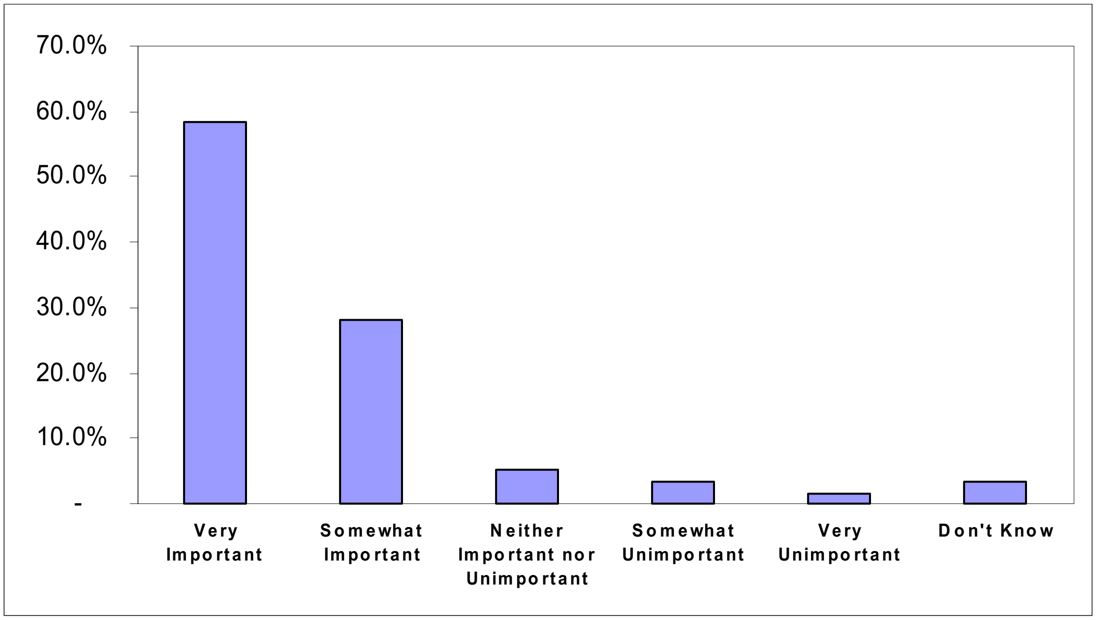

Figure 7: Importance of Owner Incentive in Participation (q15)

Importance of Dollar Incentive	% of Respondents
Very Important	58.5%
Somewhat Important	28.3%
Neither Important nor Unimportant	5.2%
Somewhat Unimportant	3.2%
Very Unimportant	1.5%
Don't Know	3.4%
Sample Size	192

Table 55: Importance of Owner Incentive in Participation (q15)

All SBD participants were asked to rate the level of importance of the design assistance provided by SBD in motivating their participation in the program. Table 56 and Figure 8 show that 75.7% of respondents rated the assistance as very or somewhat important, while only 5.4% rated the assistance as very or somewhat unimportant.

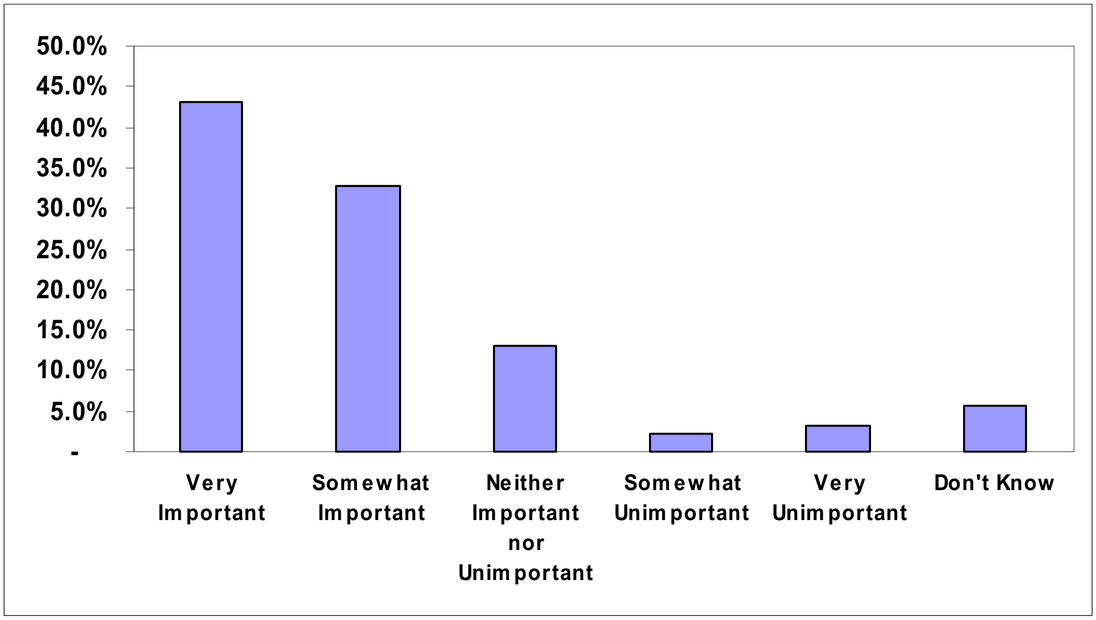

Figure 8: Importance of Design Assistance for Participation (q16)

Importance of Design Assistance and Analysis	% of Respondents
Very Important	43.0%
Somewhat Important	32.7%
Neither Important nor Unimportant	13.2%
Somewhat Unimportant	2.1%
Very Unimportant	3.3%
Don't Know	5.6%
Sample Size	190

Table 56: Importance of Design Assistance for Participation (q16)

As shown in Table 57, 77.4% of the participants stated that SBD participation influenced them to change their standard building practices to construct more efficient buildings in the future. 15.5% of the respondents answered that SBD participation did not influence changes in their standard practice. Almost 2% said that they had no plans to build any more buildings in future.

If Participation Changed Standard Building Practice	% of Respondents
Yes	77.4%
No	15.5%
No Plans to build any more buildings	1.7%
Don't Know	5.4%
Sample Size	191

Table 57: Changed Standard Practice to Higher Energy Efficiency due to SBD Participation (q17)

Participants who answered “yes” in Table 57 were asked about the changes they have made to the standard practice that would lead to a more energy efficient building design. Their diverse comments are below.

All Participant Responses (q18)

The program has influenced us to improve the HVAC EER, lighting watts per fixture as well as add occupancy sensors. (COMMON RESPONSE)

This was a flagship building and now we are installing VFDs in new projects. (COMMON RESPONSE)

Due to our participation we now have policies that we must exceed T24 by 20% across the board.

The changes we made (during the program) realigned our thinking to incorporate all facilities, design, maintenance and construction operations. We have now set the standard for LEED certification.

Over the last three years, many of the measures have become standard practice by either market transformation or utility influence.

The biggest thing it's changed is our mind set; we are now more inclined to consider different ideas to conserve energy and in turn save money.

Had we know about the program sooner we would have installed a more efficient boiler and lighting system rather than buying used equipment.

SBD has provided us a greater awareness of managing our day to day operations of the VSD and lighting.

The program reinforced good decision making. PG&E saying, "this is a good thing to do,” validates our decisions and shows our management that energy efficiency features are important and not excessive.

SBD is a tremendous resource for us. It provides our engineers with the framework to contemplate how the plants are going to operate efficiently early on. It pulls our whole team together to consider the conceptual design. Our SBD rep comes a few times a year to refine our projects and by the time they are ready to be submitted to those that allocate the *funding, we know we have the best design possible. My job would be a lot more difficult without the resources of SBD. We are very concerned they have proposed moving us to Standard Performance Contracts as we don't want to loose our SBD rep he does an excellent job quantifying the benefits and researching for us things we don’t know.*

They have provided a lot of insight on things we could be doing. The problem is equipment manufacturers are not keeping up with the technology. We have implemented many items because of the program such as anti-sweat heater controls, increased insulation, efficient ventilation and lighting along with energy management controls on case and evaporative and condenser fans.

We are still referring to the design analysis for all new projects we do. The analysis was done for a prototype building and although Colma was not a prototype project, we still are benefiting from the analysis and using it at our other buildings.

We are trying to incorporate time of use and peak loads into our operations.

Without this kind of program, dairy owners would buy the cheapest thing on the market.

We continue to install tank insulation in our other winery locations

We have started using more EE lighting fixtures in our warehouses and we encourage our tenants to use light colored paint on the interiors to reflect the light from the skylights.

We have implemented Cool ducts - 100% seal, R-40 roof insulation, green sandwich panels, and biomass materials.

Similarly, the participants who answered “No” in Table 57 were asked to give reasons in support of their response. Some of their comments are below.

Selected Participant Responses (q17 why)

This (energy efficiency) is standard practice for us because…we need to be efficient. (COMMON RESPONSE)

We try and have efficient designs already in place; it's part of our culture. (COMMON RESPONSE)

The program didn't directly influence us; the influence comes from doing that which is sustainable.

Early on we were looking at more efficient lighting (we've done a $10mil energy conservation project) and gone to T-5 fixtures with instant on/off and higher EER for HVAC units.

Energy efficiency was not a priority as much as making sure the building could meet our process demands.

Our O&M department keeps us up to date on the most recent technological developments. For instance we are using Novar EMS to control our HVAC and Lighting.

Our design simply meets the SBD criteria there was no influence beyond that.

We are a large company; those that allocate the funds are note always in tune with the savings associated with energy efficiency upgrades. SBD input helps to ensure we get better equipment.

Participants were asked to rate the value of SBD “Incentives”, “Design Assistance”, and “Design Analysis”. The results, shown in Table 58, indicate high satisfaction with all three components. A significant majority of respondents gave a rating of 1 or 2, where a rating of 1 is “very valuable”. The ratings in 2004-05 are the highest for “Incentives” where over 83% rated this service 1 or 2. The ratings are the lowest for “Design Analysis” where around 40% rated the service 1 or 2. This is in contrast to what we found in the 2003 analysis - the ratings in 2003 were highest for “Design Analysis” where 75% rated this service a 1 or 2. In 2003, only 64% chose a 1 or 2 for “Design Assistance” and 69% for Incentives.

% of Participants 1="Very Valuable" 5="Not at all Valuable"	Incentives	Design Assistance	Design Analysis
1	47.3%	26.5%	24.8%
2	35.8%	32.7%	15.6%
3	7.4%	15.0%	8.3%
4	4.0%	12.0%	8.6%
5	2.5%	2.3%	1.5%
Don't Know	3.0%	7.3%	5.9%
NA	-	4.0%	19.1%
Not Provided	-	0.3%	16.3%
Total	100.0%	100.0%	100.0%
Sample Size	191	191	189
Average Score	1.75	2.22	2.09
Standard Deviation	2.21	2.52	2.56

Table 58: Value of Incentives, Design Assistance, and Design Analysis (q19)

All participants were asked to provide recommendations for changes to the SBD program in order to improve its delivery to customers. These answers were unprompted, and multiple responses were accepted. The answers have been categorized based on common responses. Percentages reported were calculated using the following equation:

(weighted number of respondents with a particular answer) ÷

(total weighted number of respondents who answered the question).

One hundred ninety-one survey respondents answered this question. Table 59 shows that almost 51% of the participants felt that no changes were needed. Suggestions that received support included “more marketing to increase awareness of program” (9.8%), “utilities should try to get involved earlier in projects” (9%) and “other” (21.5%). Interestingly, only 9.5% of the respondents recommended an “increase (in) incentives,” while most others seemed to be pleased with the incentives. This is a significant change from the 2002 results where 27.5% of respondents recommended increased incentives. However, in 2003 this percentage was only 2.9%. As multiple answers were accepted on this question, the percentages in Table 59 do not add up to 100%.

Recommendations	% of Respondents
No Changes Needed	50.8%
Other	19.0%
More marketing to increase awareness of program	9.8%
Increase Incentives	9.5%
Utilities should try to get involved earlier in projects	9.0%
Don't Know	7.2%
More interaction with design team	7.0%
Review and response from utility needs to be more timely	5.1%
Utility Reps need to present benefits more clearly	1.7%
They could have been more involved and also had a little quicker response time	1.4%
It would be nice if we could… get design assistance earlier in the project	1.1%
Less paperwork and red tape	1.3%
Increase post project feedback, better "closure"	0.6%
Refused	-
Sample Size	191

Table 59: Recommended Changes to Savings by Design (q20)

Respondents who chose "Other" in Table 59 were asked to state their specific recommendation(s). Selected "Other" comments and recommendations are listed below.

Other Selected Recommendations (q20 Other)

Develop a check list of participant actions, timing, etc. for all phases, from design to construction. Guarantee funding; often there is uncertainty over funding.

Provide a check list or outline of key considerations for products and services such as the correct application for parking lot lighting. Ideally the list would provide a preliminary cost/benefit analysis.

Assign more staff to the SBD program. Although their people did a great job, it took a long time to process the project and we can see they are stretched really thin.

We would like to have more face to face interaction with the utility. They should come see us and talk about our up-and-coming projects.

SBD could be a lot more aggressive. They are too passive in the role they play now. For example, they should attend design meetings.

We are open to any support they can provide us to increase energy savings as long as it doesn't interfere with the guests' experience in our hotels.

It would be good to know, now that the building has been operating for a few years, what other things we can do to make our building more efficient. The new construction services department knows so much about our building that it would be nice to have the utility return and provide additional suggestions.

Provide a list of companies to work with other than [vendor]. We were forced to use [vendor] and felt they have very poor customer service and very unresponsive. We are *now spending $20,000 to upgrade the computer algorithms since we learned the design did not minimize our impact during peak load. (reworded)*

Increase marketing to architects.

The SBD program ought to provide incentives and design assistance according to facility type, like restaurants. Then we can get better assistance and more innovative ideas to improve the efficiency of our projects.

The missing piece is that they need to give more incentives for PV. Our air quality is really bad out here in the central valley, so we could win on two counts by reducing pollution from power plants (and saving energy). Without financial incentives, it is too expensive.

The post-measurement team that verified the installation made it an awkward process because afterwards they took 3-4 months to calculate the incentive and 2 or 3 times before they got the amount right. We think they should send people out that know about the systems in advance.

The technology was hard to work with. Analysis software EnergyPro was a hassle.

Work with manufacturers to get energy efficient equipment on the market readily available.

2005 building energy codes are more difficult to meet much less exceeds. The requirements set by SBD in light of the Title-24 changes are getting far too difficult to meet and the incentive amounts are not clear enough.

One might expect the customers that value the incentives to recommend an increase in incentive amounts. Yet, of all the respondents that valued incentives, only 7.8% of them recommended an increase in the incentive amount. Even though this number is still similar to the overall population (Table 59, 9.5%), it indicates that participants who are most influenced by the incentive are generally satisfied with the incentive amount. Table 60 shows the results.

Importance of Dollar Incentive	Recommendation		Total
	Increase Incentive	Other	
Very Important	4.2%	95.8%	100.0%
Somewhat Important	3.6%	96.4%	100.0%

Table 60: Importance of Incentive by Recommendation to Increase Incentive

Prototype Projects

Prototype plans refer to a master set of plans that are used for construction of multiple buildings. This is common practice among large retail and restaurant chains, many of which participated in the SBD program. The questions in this section were developed in order to provide program planners with some basic information regarding prototype projects.

The Program's rules for prototypes have evolved since 1999, and led to a "prototype building" policy targeted to chain accounts with centralized design authority being defined and implemented. Up until 2002 some utilities allowed all buildings to qualify for the incentive, while others applied Whole Building incentives to the initial project, with subsequent projects receiving the Systems Approach rate incentives. Currently, all three utilities allow all prototype buildings to qualify for Whole Building incentives.

Participants were first asked if they used a set of prototype plans or master specifications in the design and construction of their building – only 16.9% responded yes as shown in Table 61. Figure 9 presents the results.

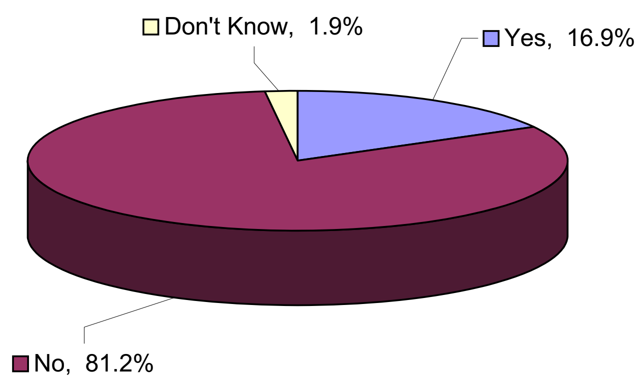

Figure 9: Used Prototype Plans (q21)

Prototype Plans Used	% of Respondents
Yes	16.9%
No	81.2%
Don't Know	1.9%
Refused	-
Sample Size	193

Table 61: Used a set of Prototype Plans (q21)

Participants who used a set of prototype plans were asked if at any time SBD was actively involved with design assistance or design analysis in the development, refinement and/or enhancement of the prototype plans. As shown in Table 62 94.7% responded yes. As noted in the beginning of this chapter, all percentages listed are weighted percentages, and as such 16.9% is the weighted percentage of the population that used prototype plans, not the percentage of the sample. As a result, the sample sizes of 39 in Table 62 & Table 63 are 20.2% of the 193 sample size from Table 61, which is slightly higher than the stated 16.9%.

	% of Respondents
Yes	94.7%
No	3.5%
Don't Know	1.8%
Sample Size	39

Table 62: Received Design Assistance or Analysis through SBD (q28)

Participants who used a set of prototype plans were also asked if future SBD incentives would be an important consideration in the development, refinement, and/or enhancement of the prototype plans for these projects. The answers of the participants are summarized in Table 63. Almost 90% considered future SBD incentives important.

	% of Respondents
Yes	89.7%
No	8.6%
Don't Know	1.8%
Sample Size	39

Table 63: Future SBD incentives Important (q29)

Conclusions

The survey results indicate that a little over two-thirds of the buildings were owned by private companies and the remaining were owned by public companies. The results also show that a majority of the interviewees heard of the program through utility representatives or utility program participations.

The program participants were generally satisfied with the program. This is indicated by the frequent “no changes needed” responses when asked what the program should improve. Also, there were encouraging scores on the value of incentives, design assistance and analysis (Table 58 and Table 59). Some of the requests for change came in the following areas: making the program easier and faster to use, involving the utilities earlier in the projects, increasing marketing efforts, and increasing interaction with the design team.

The issue of incentives came up directly in multiple questions. While it is reasonable to conclude that everyone values financial incentives, the degree to which those incentives are influencing measure implementation is not clear. In other words, while the incentives may be necessary for enlisting program participation, when standard practice exceeds the minimum code compliance, an incentive is not necessary. This may explain situations where the respondent expressed the importance of incentives while stating that their measure choices were standard practice. Even still, the majority of respondents indicated the program influenced them to change their standard building practice. This is illustrated in Figure 10. Along with incentives, design assistance and analyses were also found to be very valuable by the program participants.

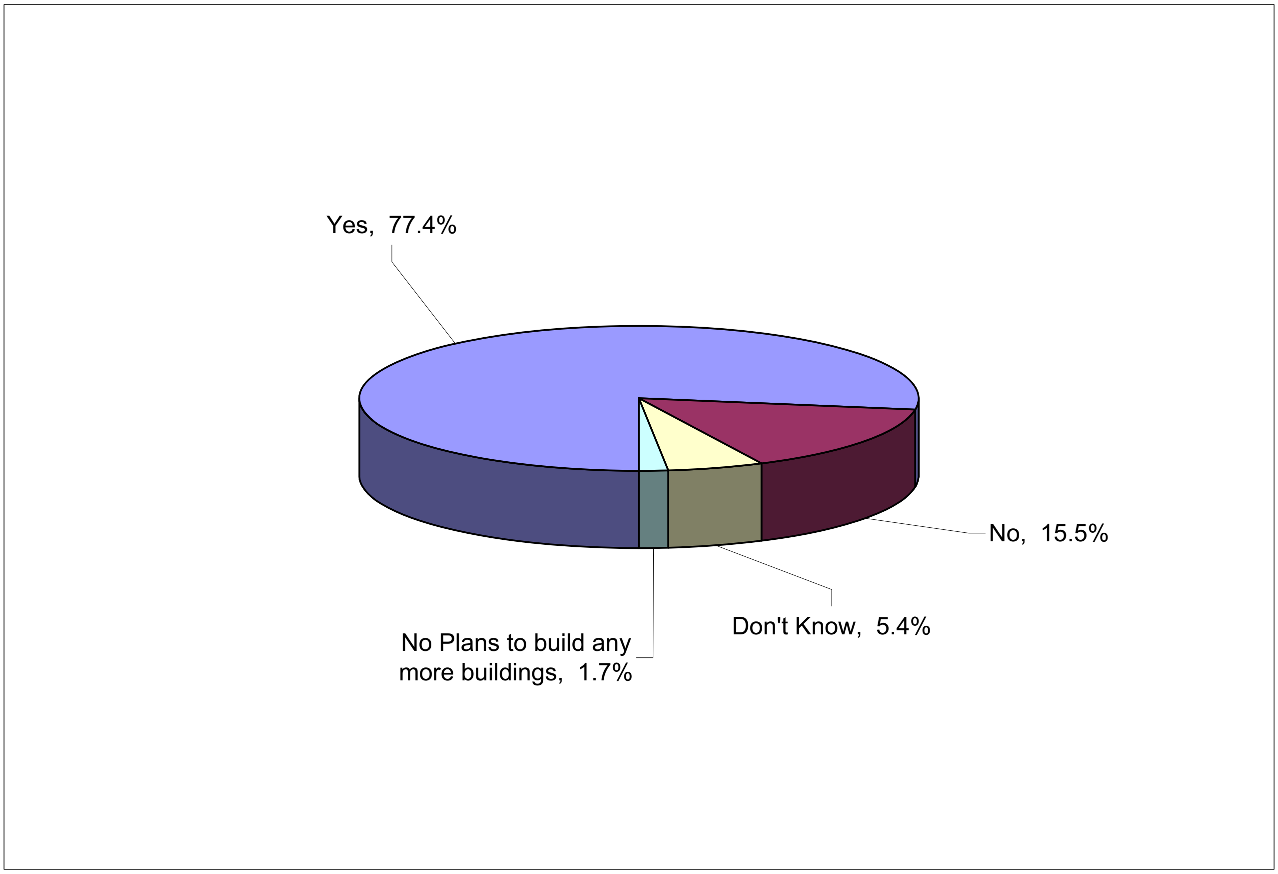

Figure 10: Changed Standard Practice to Higher Energy Efficiency due to SBD Participation (q17)

A small percentage (16.9%) of participants used a set of prototype plans or master specifications in the design and construction of their building. The majority of survey respondents for these prototype plans were actively involved with SBD design assistance or design analysis. The majority also feels that future SBD incentives are an important consideration in the development, refinement, and/or enhancement of the prototype plans used for new projects.

Finally, there were several instances last year where non-participants indicated to the interviewer that they would like to learn more about the SBD program for possible future participation, indicating an opportunity for SBD program marketing. This corresponds to the narrow range of responses about the source of awareness of Savings By Design and the lack of mention of marketing material and web sites by respondents. These results indicate that a broader marketing program would be beneficial.

Data Sources and Sampling Plan

Data Sources

RLW Analytics and AEC used several secondary and primary data sources to complete this project. The secondary data sources include:

- Statewide SBD program databases and files
- Engineering and manufacturers' reference material, and
- California Energy Commission weather data

California's Investor Owned Utilities (IOU) databases, Title-24 compliance certificates, and program files are used to identify participating buildings, estimated savings, and incented measures. The other secondary sources were used to support the modeling and calibration effort.

Primary data sources include:

- New construction decision-makers, and
- Newly constructed buildings

Data were obtained from the primary sources through quantitative interviews and surveys. Buildings were surveyed and simulated. The new construction decision-makers include building owners/managers, architects, and specifying engineers.

Sampling Plan

The selection of the sites was guided by a model-based statistical sampling plan as in the 1994-96 evaluation studies, the 1998 baseline study, and the 1999-2001, 2002 and 2003 SBD studies.

Model-based sampling methods were also used to analyze the data, i.e., to extrapolate the findings from the sample sites to the target population of all program participants and to evaluate the statistical precision of the results. MBSS™ methods of statistical sampling and analysis were completed in substantially the same way as in the 1994, 1996 and 1998 NRNC evaluations and the 1999-2001, 2002 and 2003 SBD studies.

Once the program tracking data were available, model-based methods were used to combine the tracking data with the findings from prior studies about the sample design parameters – the error ratio and gamma parameter. Using these data, we determined the statistical precision to be expected on gross annual energy savings from the planned sample size for the participant sample.

Once the sample size had been determined, we developed the sample design. We used a sample that was efficiently stratified by the tracking estimate of annual energy savings, with proportional representation of utilities in the combined participant population.

Theoretical Foundation

MBSS™ methodology was used to develop efficient sample designs and to assess the likely statistical precision. The target variable of analysis, denoted y, is the energy savings of the project. The primary stratification variable, the estimated energy savings of the project, is denoted *x*. A ratio model was formulated to describe the relationship between *y* and *x* for all units in the population, e.g., all program participants.

The MBSS™ ratio model consists of two equations called the primary and secondary equations:

$$\begin{aligned} y_k &= \beta x_k + \varepsilon_k \\ \sigma_k &= sd(y_k) = \sigma_0 x_k^{\gamma} \end{aligned}$$

Here $x_k > 0$ is known throughout the population. *k* denotes the sampling unit, i.e., the project. $\{\varepsilon_1, \ldots, \varepsilon_N\}$ are independent random variables with *an* expected value of zero, and β, σ_0, and γ (gamma) are parameters of the model. The primary equation can also be written as

$$\mu_k = \beta x_k$$

Under the MBSS ratio model, it is assumed that the expected value of *y* is a simple ratio or multiple of *x.*

Here, y_k is a random variable with expected value μ_k and standard deviation σ_k. Both the expected value and standard deviation generally vary from one unit to another depending on x_k, following the primary and secondary equations of the model. In statistical jargon, the ratio model is (usually) a heteroscedastic regression model with zero intercept.

One of the key parameters of the ratio model is the error ratio, denoted *er*. The error ratio is a measure of the strength of the association between *y* and *x*. The error ratio is suitable for measuring the strength of a heteroscedastic relationship and for choosing sample sizes. It is *not* equal to the correlation coefficient. It *is* somewhat analogous to a coefficient of variation except that it describes the association between two or more variables rather than the variation in a single variable.

Using the model discussed above, the error ratio, *er*, is defined to be:

$$er = \frac{\sum_{k=1}^{N} \sigma_k}{\sum_{k=1}^{N} \mu_k} = \frac{\frac{1}{N}\sum_{k=1}^{N} \sigma_k}{\frac{1}{N}\sum_{k=1}^{N} \mu_k}$$

Figure 11 gives some typical examples of ratio models with different error ratios. An error ratio of 0.2 represents a very strong association between *y* and *x*, whereas an error ratio of 0.8 represents a weak association. Loosely speaking, an error ratio of .75 implies that the measured savings is typically within ±75% of the tracking estimate of savings adjusted for the realization rate. The smaller the error ratio, the stronger the association between tracking and measured savings, and the smaller the sample size needed to estimate the program realization rate with a fixed precision.

As Figure 11 indicates, the error ratio is the principle determinant of the sample size required to satisfy the 90/10 criteria for estimating *y*. If the error ratio is small, then the required sample is correspondingly small.

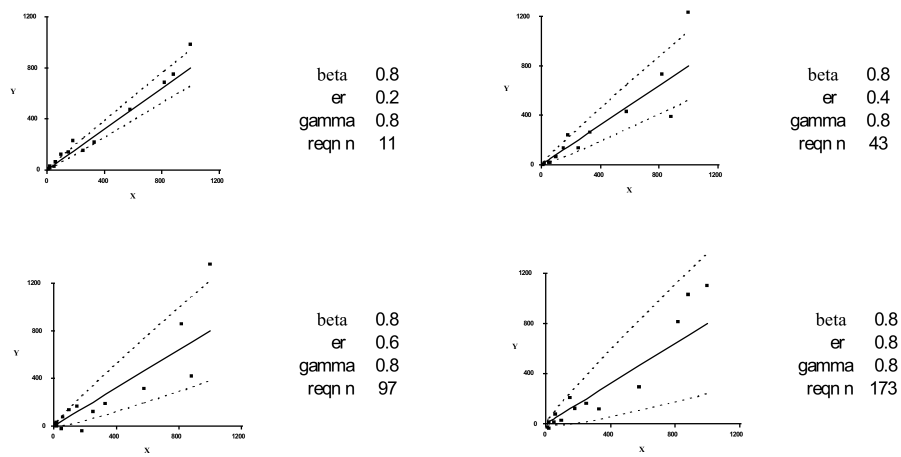

Figure 11: Examples of MBSS Ratio Models

The model parameters – b, g, and the error ratio -- were calculated from the 2003 SBD study. The model parameters are shown in

Table 64. Based on the 2003 SBD sample projects, the error ratio is 0.69. *Using this value, our analysis indicated that a sample of 180 2004-05 SBD program participants would provide a relative precision of about ±7.8% at the 90% level of confidence*.

Parameter	Value
b	1.129
g	0.78
Error ratio	0.69

Table 64: Sample Design Model Parameters

In order to inform future sample designs, we have calculated the model parameters, b, g, and the error ratio, using the actual participant population and sample. Table 65 shows the results.

Parameter	Value
b	1.023
g	0.80
Error ratio	0.75

Table 65: Actual Model Parameters

Sample Design

Planned Statewide Participant Sample Design

For the purposes of this study, a building was defined to be a building that received an incentive through the Savings By Design program for installing energy efficient equipment during 2004-05. At the sample design stage, we found that there were 1,096 projects paid in 2004-05, combining for a total ex-ante gross savings of 4,403,365 MBtu. Considering all 1,096 projects, the average savings was 4,018 MBtu per project.

Table 66 shows the original sample design. As is typical in a non-residential program, there were a large number of small projects but the relatively few large projects yielded much of the total savings. Table 66 shows that for PG&E, there were 206 projects with annual savings of 440 MBtu or less, with a total ex-ante gross savings of 90,700 MBtu. The maximum MBtu in each stratum is called the stratum cut point. These 206 projects were 49% of all PG&E projects, but they represented only 5% of all savings. By contrast, the fifth stratum that contains 25 projects for PG&E represents only about 6% of all PG&E projects, but yielded 51% of the total ex-ante gross savings. Because the population distribution of savings is much skewed, the sample design was carefully stratified by utility and size to produce the appropriate mix of small and large projects among each utility.

Utility	Stratum	Population			Sample				
		Savings per Project (MBtu)	Total MBtu	Number of Projects	Max MBtu Savings	Savings per Project (MBtu)	Total MBtu	Sample Size	Sample Fraction
PG&E	1	440	90,700	206	1,257	592	7,699	13	0.06
	2	2,317	187,660	81	3,320	2,277	29,605	13	0.16
	3	4,165	249,886	60	5,339	4,232	55,021	13	0.22
	4	6,786	318,919	47	8,708	6,630	86,193	13	0.28
	5	35,245	881,136	25	143,546	32,018	416,230	13	0.52
	PG&E Subtotal	4,125	1,728,302	419		9,150	594,749	65	0.16
SCE	6	393	86,011	219	1,035	287	3,734	13	0.06
	7	2,371	196,807	83	3,593	2,300	29,897	13	0.16
	8	5,145	288,117	56	6,591	5,202	67,629	13	0.23
	9	8,552	376,270	44	10,733	8,315	108,093	13	0.30
	10	25,339	658,823	26	50,135	28,396	369,142	13	0.50
	SCE Subtotal	3,752	1,606,028	428		8,900	578,495	65	0.15
SoCalGas	11	272	9,527	35	491	361	1,082	3	0.09
	12	1,389	20,836	15	1,895	1,201	3,603	3	0.20
	13	4,332	34,658	8	4,912	4,490	13,470	3	0.38
	14	6,398	44,788	7	6,634	6,406	19,217	3	0.43
	15	16,986	84,929	5	26,406	14,233	42,700	3	0.60
	SoCalGas Subtotal	2,782	194,738	70		5,338	80,073	15	0.21
SDG&E	16	403	37,920	94	1,100	478	3,344	7	0.07
	17	2,279	84,325	37	3,618	2,533	17,728	7	0.19
	18	5,030	120,732	24	5,890	5,120	35,837	7	0.29
	19	11,979	191,663	16	19,408	12,653	88,573	7	0.44
	20	54,957	439,657	8	153,685	55,541	388,787	7	0.88
	SDG&E Subtotal	4,884	874,296	179		15,265	534,270	35	0.20
Statewide	**Total**	**4,018**	**4,403,365**	**1,096**		**9,931**	**1,787,586**	**180**	**0.16**

Table 66: Original Planned Sample Design

We applied the sample design to the projects that were paid in 2004-05. The sample was selected in three steps:

1. Classify each of the projects into one of the twenty strata according to the size of the savings and the utility.
2. Calculate the number of projects to be sampled from each stratum by multiplying the total number of projects by the sampling fraction for the stratum shown in Table 66.
3. Randomly select the specified number of projects.

Final Statewide Participant Sample Design

The participant case weights were calculated using model based stratification. In this approach, the population is sorted by increasing residual standard deviation, σ_k, or equivalently, by increasing x_k^γ, as x_k^γ and σ_k only differ by a constant under the ratio model. Then strata cut points are formed by dividing the sum of the x_k^γ equally among the strata, and the sample is allocated equally to each stratum. Then the population sizes are tabulated within each stratum. Finally the case weights are calculated in the usual way. The industrial sites were grouped in with the commercial sites in calculating the case weights because we were only able to identify mixed commercial and industrial savings in the sample and not in the population. We had to combine the groups since we could not make this distinction.

Table 67 shows the final participant sample design that was used to calculate the participant case weights. In this case, the sum of the population residual standard deviations has been divided equally among 20 strata. Within each utility, the sum of the residual standard deviations has been equally divided among the 5 strata. Then the stratum cut points shown in column three were calculated from the tracking estimates of MBtu for the population. Next, within each utility the sample was allocated equally to each stratum. The population sizes shown in column four were calculated from the stratum cut points. The final step was to calculate the case weights shown in the last column. For example, the case weight for the 31 sites in the first stratum is 268 / 31 = 8.65.

Utility	Stratum	Max MBtu Savings	# of Projects	Sample Size	Weight	Sample Fraction
PG&E	1	2,982,795	268	31	8.65	0.12
	2	4,761,125	72	19	3.79	0.26
	3	8,234,317	48	16	3.00	0.33
	4	22,140,507	27	16	1.69	0.59
	5	314,029,200	5	4	1.25	0.80
	PG&E Subtotal		420	86	4.88	0.20
SCE	6	3,129,257	283	24	11.79	0.08
	7	5,707,915	63	11	5.73	0.17
	8	9,038,560	44	13	3.38	0.30
	9	21,349,647	25	7	3.57	0.28
	10	50,134,506	13	9	1.44	0.69
	SCE Subtotal		428	64	6.69	0.15
SoCalGas	11	2,249,199	48	6	8.00	0.13
	12	4,912,124	9	3	3.00	0.33
	13	6,381,060	6	2	3.00	0.33
	14	11,876,094	5	3	1.67	0.60
	15	30,352,584	2	1	2.00	0.50
	SoCalGas Subtotal		70	15	4.67	0.21
SDG&E	16	3,390,599	126	12	10.50	0.10
	17	6,444,517	29	9	3.22	0.31
	18	14,718,728	15	7	2.14	0.47
	19	50,869,993	7	5	1.40	0.71
	20	153,684,692	3	3	1.00	1.00
	SDG&E Subtotal		180	36	5.00	0.20

Table 67: Final Sample Design

Table 68 presents the actual 2004-05 SBD population and sample by utility and the MBtu savings associated with these projects. In general, the larger projects in the program were SDG&E and PG&E projects. The SoCalGas projects tended to be smaller projects. Since the smaller projects have lower sampling fractions, SoCalGas had smaller sample sizes than SDG&E and PG&E.

	PG&E		SCE		SoCalGas		SDG&E		Statewide	
	Population	Sample	Population	Sample	Population	Sample	Population	Sample	Population	Sample
Number of Projects	419	65	428	65	70	15	179	35	1,096	180
MBtu Savings	1,728,302	594,749	1,606,028	578,495	194,738	80,073	874,296	534,270	4,403,365	1,787,586
Savings per Project (MBtu)	4,125	9,150	3,752	8,900	2,782	5,338	4,884	15,265	4,018	9,931

Table 68: Actual 2004-05 SBD Participation and Sample by Utility – MBtu Savings

The commercial and industrial projects were combined in the tracking data and a single sample design was performed on all of the projects. As Table 66 shows, the sample design was based on a stratified sampling plan that over-sampled projects with greater MBtu ex-ante gross savings, and under-sampled sites with fewer MBtu ex-ante gross savings. As a result, many of the larger industrial projects were captured in the sample. This approach allows for the inclusion of fewer sample points in the study since a greater amount of the program variation is captured in the sample, thereby improving the precision of the overall program estimates.

Once the sites were broken into strata by the amount of their MBtu ex-ante gross savings, they were randomly sorted and selected into the sample. This sampling procedure ensures that the sample contains a random representation of the projects in the population. Therefore, the various types of participants and program measures get the appropriate proportional distribution of the sample relative to the number in the population.

The weights for the industrial and commercial sites were calculated in a manner similar to the sample design. All commercial and industrial sites were combined into a sample file and projected to the entire program population. The random selection of sample points then ensured that the weights on the industrial sites approximate the number of industrial sites in the program population. Since many of the industrial sites were the larger projects, their weights were relatively low, meaning that the sites and their corresponding savings did not represent many projects in the population.

Gross Savings Methodology

This section describes the gross energy savings and demand reduction methodology. Energy savings and demand reduction results for the whole building as well as for shell, lighting power density, day lighting controls, other lighting controls, motors, HVAC, and refrigeration measure groups are presented in the next chapter.

Definitions

Some definitions would be helpful to clarify the discussion.

DOE-2 version The DOE-2.2 program version 44E3 was used in the project. The modeling tool was upgraded from DOE-2.1E to DOE-2.2 to take advantage of the latest DOE-2 modeling capabilities, and to provide consistency with the calculation engine used in the CA NCCalc tool. DOE-2.2 provides a more robust simulation of buildings with built-up HVAC systems. The grocery store refrigeration model is also more robust than the standard DOE2.1E model[14] We had custom modifications made to the 44E3 version to simulate daylighting controls using a "daylight factor" approach. The daylighting simulation strategy is identical to the strategy used in previous Savings by Design evaluations. Migrating the modeling tool from DOE-2.1 E to DOE-2.2 was a significant software development project, requiring many hours of software development and testing time.

Baseline A consistent standard of energy efficiency against which all buildings are measured. This is defined as the output of a DOE-2.2 simulation run of a building using either 1998 or 2001 Title-24 required equipment efficiencies (where applicable) and using the operating schedule found by the on-site surveyor. For building types where Title-24 does not apply (e.g. hospitals), or end-uses not covered by Title-24 (e.g. refrigeration systems), the baseline defined by the program for estimating the program savings are used.

As Built A DOE-2.2 simulation of a building using all equipment and operating parameters as found by an on-site surveyor.

Whole Building Savings The difference between the whole building energy use under the baseline and as-built simulations. Positive savings indicate that the building was more efficient – used less energy – than its baseline case.

End-Use Savings The difference between the whole building energy use under the baseline and as-built measures associated with a particular end use. For example, the lighting savings are the whole building savings associated with the lighting measures. Both direct and interactive savings are included in the lighting end use savings.

"Better than baseline" The as built simulation showed less energy consumption than the baseline simulation – more efficient than the base case. Positive savings.

"Worse than baseline" The as built simulation showed more energy consumption than the baseline simulation – less efficient than the base case. Negative savings.

[14] We used a "custom" version of DOE-2.1E in previous evaluations to work around the grocery store refrigeration limitations.

Model-Based Statistical Sampling

This project used a statistical methodology called Model-Based Statistical Sampling or MBSS™. MBSS™ has been used for many evaluation studies to select the sites or projects to be studied and to extrapolate the results to the target population. MBSS™ has been used for all of California's IOUs, NEES, Northeast Utilities, Consolidated Edison, The New York Power Authority, Wisconsin Electric, Sierra Pacific Power Company, and Washington Power and Light, among others. MBSS™ was used in the end-use metering component of the 1992 evaluation of PG&E's CIA program, the 1994, 1996, and 1998 NRNC evaluations for PG&E and Southern California Edison, and the 1998 NRNC Baseline Study for the CBEE. A complete description of MBSS™ methodology is available if further discussion of the methodology is required[15].

The general idea behind model-based statistics is that there is a relationship between the variable of interest – in this case, savings – and a variable that is known for the entire population – program estimate of savings. Using this prior information allows for greater precision with a given sample size because the prior information eliminates some of the statistical uncertainty.

The estimate of the total savings in the population can be expressed as the ratio of the sample average measured savings to the sample average estimated savings times the population total savings.

$$Y = y/x \; X$$

Where:

Y is the population total measured savings

y is the average measured savings in the sample

X is the population total ex-ante gross savings

x is the average ex-ante gross savings in the sample

The sample design discussion in the methodology section of this report described the sample designs used in this study. Therefore this section describes in more detail the methods used to extrapolate the results to the target population. Three topics are described:

- Case weights
- Balanced stratification to calculate case weights, and
- Stratified ratio estimation using case weights.

Statistical Terms Used in the Analysis

Standard Error

$$se = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \bar{y})^2}$$

[15] *Methods and Tools of Load Research, The MBSS System, Version V*. Roger L. Wright, RLW Analytics, Inc. Sonoma CA, 1996.

Standard error is the square root of the sum of the squares of the average difference between the expected value of a variable y (denoted $\bar{y}$ and the n actual values of y (y_i) of the sample. It is a measure of how much variation there is in the sample data relative to the estimated sample mean.

Error Bound

$$eb = 1.645 * se$$

If the underlying sample data is normally distributed, we expect the true value of y to be within 1.645*se of the estimate, $\bar{y}$, 90% of the time. In this report, this is often written as $\bar{y} +/- se$.

Relative Precision

$$rp = \frac{eb}{\bar{y}}$$

Relative precision expresses the error bound as a percentage of the estimated population mean, $\bar{y}$. Thus, a 10% relative precision means that there is a 90% probability that the true value of a variable we are predicting is within 10% of our predicted value. An rp of 25% implies that 90% of the time, the true value will be within 25% (plus or minus) of the estimated value.

Weighted Mean Per Unit Estimation of Total

Population Total = Sum of Stratum Totals

$$Y = \sum_{h=1}^{m} Y_h = \sum_{h=1}^{m} \left(\sum_{i=1}^{n} w_h y_{ih} \right)$$

Assumption: n_h **is known for every stratum** h **in the population**

Where: $w_h = \frac{N_h}{n_h}$

In our analysis, due to small sample size within each measure category at the utility level, we used a case weighted approach instead of a stratum based summation. This process is described in the following section.

Case Weights

Theoretical Foundation

Given observations of a variable *y* in a stratified sample, estimate the population total *Y*.

Note that the population total of *y* is the sum across the *H* strata of the subtotals of y in each stratum. Moreover each subtotal can be written as the number of cases in the stratum times the mean of *y* in the stratum. This gives the equation:

$$Y = \sum_{h=1}^{H} N_h \, \mu_h$$

Motivated by the preceding equation, we estimate the population mean in each stratum using the corresponding sample mean. This gives the conventional form of the stratified-sampling estimator, denoted $\hat{Y}$, of the population total *Y:*

$$\hat{Y} = \sum_{h=1}^{H} N_h \, \bar{y}_h$$

With a little algebra, the right-hand side of this equation can be rewritten in a different form:

$$\begin{aligned} \hat{Y} &= \sum_{h=1}^{H} N_h \, \bar{y}_h \\ &= \sum_{h=1}^{H} N_h \left(\frac{1}{n_h} \sum_{k \in s_h} y_k \right) \\ &= \sum_{k=1}^{n} \left(\frac{N_h}{n_h} \right) y_k \end{aligned}$$

Motivated by the last expression, we define the ***case weight*** of each unit in the sample to be $w_k = \frac{N_h}{n_h}$. Then the conventional estimate of the population total can be written as a simple weighted sum of the sample observations:

$$\hat{Y} = \sum_{k=1}^{n} w_k \, y_k$$

The case weight w_k can be thought of as the number of units in the population represented by unit *k* in the sample. The conventional sample estimate of the population total can be obtained by calculating the weighted sum of the values observed in the sample.

Case Weights

The case weights were calculated using model based stratification. In this approach, the population is sorted by increasing residual standard deviation, σ_k, or equivalently, by increasing x_k^γ, as x_k^γ and σ_k only differ by a constant under the ratio model. Then strata cut points are formed by dividing the sum of the x_k^γ equally among the strata, and the sample is allocated equally to each stratum. Then the population sizes are tabulated within each stratum. Finally the case weights are calculated in the usual way.

The industrial sites were grouped in with the commercial sites in calculating the case weights because we were only able to identify mixed commercial and industrial savings in the sample and not in the population. We had to combine the groups since we could not make this distinction.

Stratified Ratio Estimation

Ratio estimation is used to estimate the population total *Y* of the target variable *y* taking advantage of the known population total *X* of a suitable explanatory variable *x*. The ratio estimate of the population total is denoted $\hat{Y}_{ra}$ to distinguish it from the ordinary stratified sampling estimate of the population total, which is denoted as $\hat{Y}$.

Motivated by the identity $Y = BX$, we estimate the population total *Y* by first estimating the population ratio *B* using the sample ratio $b = \bar{y}/\bar{x}$, and then estimating the population total as the product of the sample ratio and the known population total *X.* Here the sample means are calculated using the appropriate case weights. This procedure can be summarized as follows:

$$
\begin{aligned}
\hat{Y}_{ra} &= b\,X \quad \text{where} \\
b &= \frac{\bar{y}}{\bar{x}} \\
\bar{y} &= \frac{1}{\hat{N}} \sum_{k=1}^{n} w_k\, y_k \\
\bar{x} &= \frac{1}{\hat{N}} \sum_{k=1}^{n} w_k\, x_k \\
\hat{N} &= \sum_{k=1}^{n} w_k
\end{aligned}
$$

The conventional 90 percent confidence interval for the ratio estimate of the population total is usually written as

$$
\begin{aligned}
&\hat{Y}_{ra} \pm 1.645\sqrt{V\left(\hat{Y}_{ra}\right)} \quad \text{where} \\
V\left(\hat{Y}_{ra}\right) &= \sum_{h=1}^{H} N_h^2 \left(1 - \frac{n_h}{N_h}\right) \frac{s_h^2(e)}{n_h} \\
s_h^2(e) &= \frac{1}{n_h - 1} \sum_{k \in s_h} \left(e_k - \bar{e}_h\right)^2 \\
e_k &= y_k - b\,x_k
\end{aligned}
$$

We can calculate the relative precision of the estimate $\hat{Y}_{ra}$ using the equation

$$rp = \frac{1.645\sqrt{V\left(\hat{Y}_{ra}\right)}}{\hat{Y}_{ra}}$$

MBSS theory has led to an alternative procedure to calculate confidence intervals for ratio estimation, called model-based domains estimation. This method yields the same estimate as the conventional approach described above, but gives slightly different error bounds. This approach has many advantages, especially for small samples, and has been used throughout this study.

Under model-based domains estimation, the ratio estimator of the population total is calculated as usual. However, the variance of the ratio estimator is estimated from the case weights using the equation

$$V\left(\hat{Y}_{ra}\right) = \sum_{k=1}^{n} w_k\left(w_k - 1\right)e_k^2$$

Here w_k is the case weight discussed above and e_k is the sample residual $e_k = y_k - b\,x_k$. Then, as usual, the confidence interval is calculated as

$$\hat{Y}_{ra} \pm 1.645\sqrt{V\left(\hat{Y}_{ra}\right)}$$

and the achieved relative precision is calculated as

$$rp = \frac{1.645\sqrt{V\left(\hat{Y}_{ra}\right)}}{\hat{Y}_{ra}}$$

The model-based domains estimation approach is often much easier to calculate than the conventional approach since it is not necessary to group the sample into strata. In large samples, there is generally not much difference between the case-weight approach and the conventional approach. In small samples the case-weight approach seems to perform better. For consistency, we have come to use model-based domains estimation in most work.

This methodology generally gives error bounds similar to the conventional approach. Equally, the model-based domains estimation approach can be derived from the conventional approach by making the substitutions:

$$\begin{aligned} \bar{e}_h &\approx 0 \\ s_h^2(e) &\approx \frac{1}{n_h}\sum_{k \in s_h} e_k^2 \end{aligned}$$

In the first of these substitutions, we are assuming that the within-stratum mean of the residuals is close to zero in each stratum. In the second substitution, we have replaced the within-stratum variance of the sample residual *e,* calculated with $n_h - 1$ degrees of freedom, with the mean of the squared residuals, calculated with n_h degrees of freedom.

Model-based domains estimation is appropriate as long as the expected value of the residuals can be assumed to be close to zero. This assumption is checked by examining the scatter plot of *y* versus *x*. It is important to note that the assumption affects only the error bound, not the estimate itself. $\hat{Y}_{ra}$ will be essentially unbiased as long as the case weights are accurate.

Gross Savings Expansions

Baseline, as-built, and savings estimates were developed for each project in the sample. The sample of baseline, as built, and savings estimates were projected to the population using the model-based statistical methods described above.

The end-use savings are the difference between the whole building energy use under the baseline and as-built measures associated with a particular end-use category of measures. Eight end-use measure groups were examined as part of this study:

- Shell – High performance glass
- Lighting Power Density– Lamps and ballasts
- Daylight Controls-Daylighting controls such as continuous dimming daylight controls and stepped dimming daylight controls
- Other Lighting Controls- Other lighting controls such as occupancy sensors and lumen maintenance controls
- Motors – All energy efficient motors, including HVAC fans. Also overall air distribution system design end-uses such as efficient cooling coils and oversized ducts
- HVAC – Compressor efficiency, VSDs, oversized cooling towers
- Refrigeration – Commercial refrigeration systems (condensers, compressors, cases)
- Industrial – Process pumps, CO sensors, VSD fume hoods
- DHW – Water Heaters

Net Savings Methodology

In this chapter, the methodology used to calculate the net savings results is presented. We have used a customer self-report methodology to calculate the net savings attributable to the SBD program. We also discuss our rationale for using this approach.

Background

In the 1994, 1996 and 1998 NRNC program evaluations, econometric techniques were used to model the efficiency choice of the sample sites in order to estimate the direct net impacts and spillover effects for demand and energy savings. Basically, the approach was to regress the observed energy efficiency of each site against decision-maker information regarding the degree of involvement and influence of the program. To the extent that a correlation was found between energy efficiency and involvement influence among either participants or non-participants, the program was given credit for either net savings or spillover.

This approach depended on self-reported decision-maker information as well as large samples to ferret out a statistically significant association. As in most exercises in econometric modeling, the results were somewhat sensitive to the specification of the econometric model (choice of variables) as well as the weight given to each observation (influential observations). Moreover, the results were not traceable to specific buildings, measures or respondents. Therefore, they were difficult to defend.

The present study has a significant advantage over the prior impact evaluations in that the data collection took place much closer to the time that the actual decisions were made about each project. In the prior studies, we were often talking to decision-makers about projects that were completed several years prior to the survey. In this study, we were discussing projects that have just been completed in the prior year. Moreover, the self-report methodology allows us to provide an estimate of the net savings.

The evolution of the free-ridership methodology is explored in greater detail in the attached white paper titled “Measuring the Net Impact of the Savings By Design Program”[16]. This paper also explores options for future “fine-tuning” of the net-to-gross analysis.

Net Savings Methodology

We used a methodology based on self-reported decision-maker survey responses. The self-report methodology is used to calculate the estimates of free-ridership.

In this study we prepared a decision-maker survey that asked measure specific questions of program participants. The survey questions elicited information describing why the efficiency choices were made and the various influences on these decisions.

The purpose of the measure/end-use questions was to reconstruct what might have happened absent program influences. Using a scoring methodology developed early in the study, the surveys were scored and then given to the surveyor responsible for the project DOE-2 modeling. Using a “net savings report” furnished by the analyst, the surveyor adjusted the DOE-2 model to reflect program influences. The models were then re-simulated and compared to the as-built and baseline gross parametric models to develop end-use and measure level estimates of participant free-ridership.

[16] Roger L. Wright, PhD, June 30, 2005.

We believe this technique produces reasonable estimates of free-ridership. Decision-makers often take credit for decisions made, even though in truth they may not have been responsible for the decision they now take credit for. Since the program participant may be more likely to take credit for a good decision than give credit to the program, we believe we are likely estimating net savings conservatively.

Decision-maker surveys were used to determine the measure-specific level of free-ridership occurring as a result of SBD. Free-ridership was quantified after the participant measures received a score for free-ridership. The scores were set using the methodology described in the appendix of this report. These scores were then applied by adjusting the corresponding measures in the "as surveyed" models to reflect free-ridership at the measure (end use) level. Results were calculated at the measure (end use) level in order to inform the SBD program staff of measures that were experiencing a high level of free-ridership.

Some definitions may be helpful.

Level of efficiency	The reduction in energy or demand of the as-built site as a percentage of the Title-24 baseline, determined from the onsite audit and DOE-2 simulation.
Program participants	Sites that received a program incentives.
Direct net impact	The savings of the program participants relative to the level of efficiency expected in the absence of the program.
Total net savings	Equal to the direct net savings.

Free-ridership Analysis Methodology

The self-reported Net-To-Gross (NTG) analysis estimated the portion of the savings that can be directly credited to the program. To accomplish this, it was necessary to understand the free-ridership rate associated with each participant. This NTG analysis estimated free-ridership and adjusted the site's gross savings using responses to a decision-maker survey. This process is described below.

Free-ridership is calculated as the difference between the baseline and what would have been installed absent the program, divided by the difference between baseline and what actually was installed. For example, assume a project used a lighting baseline of 2.0 watts/sqft, and the participant received incentives for and installed lighting equipment resulting in 1.3 watts/sqft. If the participant would have installed lighting at 2.0 watts/sqft in the absence of the program, then the baseline is accurate and free-ridership would be zero. If lighting equipment equaling 1.3 watts/sqft had been installed in the absence of the program, then the free-ridership would be 100 percent. In reality, however, such a project may have had 1.8 watts/sqft equipment installed without the program; this would result in a free-ridership rate of 28.5%.[17]

Quantifying free-ridership in this manner underscores the integral relationship between the measure baseline determination and what actually would have happened absent the program. Such a "partial free-ridership" is appropriate since measure savings vary directly and continuously with the efficiency level chosen for the equipment installed. We have found that this method is more robust than a dichotomous treatment of conservation and load management

[17] $\frac{2.0\ \mathrm{W/SF} - 1.8\ \mathrm{W/SF}}{2.0\ \mathrm{W/SF} - 1.3\ \mathrm{W/SF}} = 0.285$

free-riders, i.e., the participant either would or would not undertake a given conservation action in its entirety absent the program. While a dichotomous treatment is appropriate for some measures and some conservation programs, the researchers believe that in any performance-based program such as Savings By Design, probing the technical range of specifications and efficiencies provides a far more accurate picture of program-induced savings.

In this study, participants generally were willing and able to provide a sufficient level of detail for the analysis. This method of analysis relies on the ability of the survey respondent to recall information about the incented measures. However, it may be difficult for the survey respondents to respond accurately to a hypothetical question about what their actions would have been in the absence of the incentive and program support. In other words, some of the respondents may have had trouble 'backing out' knowledge about measures that they gained through the program. Therefore, our estimates of free ridership may be biased upward.

Senior level researchers conducted telephone and in-person interviews with the decision-makers directly involved with the project. The researchers used a series of questions designed to determine the important criteria to the owner in making the investment decision to install increasingly higher levels of energy efficiency. These questions are termed the financial aspect of free-ridership.

The specific energy conservation measure (ECM) or technology provided the analysis framework for the estimate of free-ridership. ECMs may be unique to each project. Some common ECMs are defined as follows:

- Lighting Controls (Occupancy Sensors, and Daylighting Controls),
- Lighting Systems w/reduced power density (LPD),
- High efficiency package units or heat pumps, and
- Premium Efficiency Motors.

Gross savings were determined by examining the difference between the actual efficiency level and the "baseline" efficiency level. Therefore, the net savings can be developed by examining the difference between a "modified" efficiency run and the "baseline" efficiency run. This modified efficiency was created by applying adjustments to the "as surveyed" models to reflect free-ridership at the measure level. Customer responses to the decision-maker interview were used according to the free-rider assessment methodology to create analogous modified or "free-rider" models.

The detailed methodology used to conduct the free-ridership assessment is presented in the appendix of this report.

Engineering Models

Overall Modeling Approach

The data requirements of the evaluation include kW, kWh and Therm savings for program and non-program measures during specific costing periods, including end-use interactions. Based on the California protocols and the prior NRNC evaluations, the gross impact analysis is conducted using the DOE-2.2 building energy simulation program. The DOE-2 program is well suited to analyzing the impacts of most measures included in the SBD new construction program. DOE-2 is a very flexible modeling tool, allowing the calculation of energy savings and demand reduction for lighting, lighting controls, shell measures, HVAC efficiency improvements and many HVAC control measures, among others. DOE-2.2 version 44E3 was used to take advantage of its abilities to model commercial refrigeration.

The keys to efficiently developing accurate and defensible DOE-2 models are:

1. Collection of appropriate building information during the on-site survey. This relies on competent, well-trained surveyors focused on collecting key building data. The team places the responsibility for creating and controlling for quality of the DOE-2 models in the hands of the surveyors responsible for data collection, i.e., the person most familiar with each site.
2. Quality control over the on-site data collection and data entry, including range, internal consistency, and reasonableness checks. These are incorporated into the data-entry software provided to the surveyors.
3. Computerized tools to calculate model input parameters from the on-site survey databases and automatically generate as-built and Title-24 DOE-2 input files.
4. A second level of model review and quality control by an experienced DOE-2 engineer. Senior engineering staff review and check the models after surveyor has constructed and checked the models for quality and validity.
5. For a large fraction of the simulated sites, focused short-term monitoring was conducted for the purpose of calibrating the engineering model. In addition concurrent weather and utility billing data was collected to improve the model match with real world site conditions in the model calibration process.
6. Automated data validation of model outputs and energy savings projections.
7. Computerized tools to automatically perform the required parametric runs and store the results in an electronic database.

The models were responsive to both the measures installed under the program and the building attributes covered under Title-24. High-quality DOE-2 models were generated from the on-site survey databases by providing input files with the following attributes:

Loads

Space definition and model zoning. The building was defined in terms of a series of spaces that represent the principal uses of the building. For example, a number of occupancy types, including office, laboratory and cafeteria may be found within a single building. Each space may be subject to a different baseline lighting power density allowance under Title-24. Within each space, building shell and internal load characteristics were calculated from the on-site survey data. For example, lighting power density was calculated from a fixture count, a lookup table of fixture wattage, and the space floor area. Lighting schedules were developed from the survey data and associated with the appropriate space in the building. Similarly, equipment power density was calculated from the equipment counts and connected loads in the on-site surveys. A diversity factor consistent with standard engineering practice was introduced to account for the discrepancy in nameplate versus actual running load inherent in certain types of equipment. An equipment operating schedule was developed from the survey data and associated with the appropriate space in the building.

Another important element in the generation of the input files was the accurate representation of the diversity of heating and cooling loads within the building. The subdivision of spaces also took into account the following:

- ***Unusual internal heat gain conditions***. Spaces with unusual internal heat gain conditions, such as computer rooms, kitchens, and laboratories were defined as separate spaces.
- ***HVAC system type and zoning***. HVAC systems inventoried during the on-site survey were associated with the applicable space. When the HVAC systems serving a particular space were different, the spaces were sub-divided. Reasonable HVAC system zoning practices were followed by the surveyors.

Occupancy, lighting, and equipment schedules. Each day of the week was assigned to one of three day types, as reported by the surveyor, full operation, light operation and closed. Hourly values for each day of the week were extracted from the on-site database according to the appropriate day type. These values were modified on a monthly basis, according to the monthly building occupancy history. Monitored data was especially valuable in refining these variables.

Infiltration schedule. The infiltration schedule was established from the fan system schedule. Infiltration was scheduled “off” during fan system operation, and was scheduled “on” when the fan system was off.

Shell materials. A single-layer, homogeneous material was described which contained the conductance and heat capacity properties of the exterior surfaces of the building. The thermal conductance and heat capacity of each wall and roof assembly was taken from the Title-24 documents, when available. If the Title-24 documents were not available, default values for the conductance and heat capacity were assigned from the wall and roof types specified in the on-site survey, and the observed R-values. If the R-values were not observed during the on-site survey and the Title-24 documents were not available, an “energy-neutral” approach was taken by assigning the same U-value and heat capacity for the as-built and baseline simulation runs.

Windows. Window thermal and optical properties from the building drawings or Title-24 documents (when available) were used to develop the DOE-2 inputs. If these documents were not available, default values for the glass conductance were assigned according to the glass type specified in the on-site survey. Solar radiation pyranometers were used during the on-site survey when possible to measure the as-built solar transmission of the glazing. The glass shading coefficient was calculated from the glass type and measured solar transmittance. The results of these calculations were input into the model. If the glass properties were not measurable during the on-site survey and the Title-24 documents were not available, an “energy-neutral” approach was taken by assigning the same U-value and shading coefficient for the as-built and baseline simulation runs.

Solar and shading schedules. The use of blinds by the occupants, as reported by the occupants, was simulated by the use of solar and shading schedules. The glass shading coefficient values were modified to account for the use of interior shading devices.

Lighting kW. Installed lighting power was calculated from the lighting fixture inventory reported on the survey. A standard fixture wattage was assigned to all fixture types identified by the surveyors. Lighting fixtures were identified by lamp type, number of lamps per fixture, and ballast type as appropriate.

Lighting controls. The presence of lighting controls was identified in the on-site survey. For occupancy sensor and lumen maintenance controls, the impact of these controls on lighting consumption was simulated as a reduction in connected load, according to the Title-24 lighting control credits. Daylighting controls were simulated using the “functions” utility in the Loads portion of DOE-2. Since the interior walls of the zones were not surveyed, it was not possible to use the standard DOE-2 algorithms for simulating the daylighting illuminance in the space. A daylight factor, defined as the ratio of the interior illuminance at the daylighting control point to the global horizontal illuminance was estimated for each zone subject to daylighting control. Typical values for sidelighting applications were used as default values. The daylight factor was entered into the function portion of the DOE-2 input file. Standard DOE-2 inputs for daylighting control specifications were used to simulate the impacts of daylighting controls on lighting schedules.

Equipment kW. Connected loads for equipment located in the conditioned space, including miscellaneous equipment and plug loads, kitchen equipment and refrigeration systems with integral condensers were calculated. Input data were based on the “nameplate” or total connected load. The nameplate data were adjusted using a “rated-load factor,” which is the ratio of the average operating load to the nameplate load during the definition of the equipment schedules. This adjusted value represented the hourly running load of all equipment surveyed. Equipment diversity was also accounted for in the schedule definition. Monitored data was used to refine these values to reflect actual field conditions.

For the miscellaneous equipment and plug loads, equipment counts and connected loads were taken from the on-site survey. To reduce audit time, the plug load surveys were done as a subset of the total building square footage. When the connected loads were not observed, default values based on equipment type were used.

For the kitchen equipment, equipment counts and connected loads were taken from the on-site survey. Where the connected loads were not observed, default values based on equipment type and “trade size” were used. Unlike the miscellaneous plug load schedules, the kitchen equipment schedules were defined by operating regime. An hourly value corresponding to “off”, “idle”, or “low,” “medium” or “high” production rates was assigned by the surveyor. The hourly schedule was developed from the reported hourly operating status and the ratio of the hourly average running load to the connected load for each of the operating regimes.

For the refrigeration equipment, refrigerator type, count, and size were taken from the on-site survey. Equipment observed to have an “integral” compressor/condenser, that is, equipment that rejects heat to the conditioned space, were assigned a connected load per unit size.

Source input energy. Source input energy represented all non-electric equipment in the conditioned space. In the model, the source type was set to natural gas, and a total input energy was specified in terms of Btu/hr. Sources of internal heat gains to the space that were not electrically powered include kitchen equipment, clothes dryers, and other miscellaneous process loads. The surveyors entered the input rating of the equipment. As with the electrical equipment, the ratio of the rated input energy to the actual hourly consumption was calculated by the rated load factor assigned by equipment type and operating regime.

Heat gains to space. The heat gains to space were calculated based on the actual running loads and an assessment of the proportion of the input energy that contributed to sensible and latent heat gains. This, in turn, depended on whether or not the equipment was located under a ventilation hood.

Zoned by exposure. In the instance where the "zoned by exposure" option was selected by the surveyor additional DOE-2 zones were created. The space conditions parameters developed on a zone-by-zone basis were included in the description of each space. Enclosing surfaces, as defined by the on-site surveyors, were also defined.

Systems

This section describes the methodology used to develop DOE-2 input for the systems simulation. Principal data sources include the on-site survey, Title-24 documents, manufacturers' data, and other engineering references as listed in this section.

Fan schedules. Each day of the week was assigned to a particular day type, as reported by the surveyor. The fan system on and off times from the on-site survey were assigned to a schedule according to day type. These values were modified on a monthly basis, according to the monthly HVAC operating hour adjustment. The on and off times were adjusted equally until the required adjustment percentage was achieved. For example, if the original schedule was "on" at 6:00 hours and "off" at 18:00 hours, and the monthly HVAC adjustment indicated that HVAC operated at 50% of normal in June, then the operating hours were reduced by 50% by moving the "on" time up to 9:00 hours and the "off" time back to 15:00 hours. Monitored data was used when appropriate to refine these schedules.

Setback schedules. Similarly, thermostat setback schedules were created based on the responses to the on-site survey. Each day of the week was assigned to a particular day type. The thermostat set points for heating and cooling, and the setback temperatures and times were defined according to the responses. The return from setback and go to setback time was modified on a monthly basis in the same manner as the fan-operating schedule.

Exterior lighting schedule. The exterior lighting schedule was developed from the responses to the on-site survey. If the exterior lighting was controlled by a time clock, the schedule was used as entered by the surveyor. If the exterior lighting was controlled by a photocell, a schedule, which follows the annual variation in day length, was used.

System type. The HVAC system type was defined from the system description from the on-site survey. The following DOE-2 system types were employed:

- Packaged single zone (PSZ)
- Packaged VAV (PVAVS)
- Central constant volume system (RHFS)
- Central VAV system (VAVS)
- Central VAV with fan-powered terminal boxes (PIU)
- Four-pipe fan coil (FPFC)

Packaged HVAC system efficiency. Manufacturers' data were gathered for the equipment surveyed based on the make and model number observed by the surveyor. A database of equipment efficiency and capacity data was developed from an electronic version of the ARI rating catalog. Additional data were obtained directly from manufacturers' catalogs, or the on-line catalog available on the ARI website (www.ari.org). Manufacturers' data on packaged system efficiency is a net efficiency, which considers both fan and compressor energy. DOE-2 requires a specification of packaged system efficiency that considers the compressor and fan power separately. Thus, the manufacturers' data were adjusted to prevent "double-accounting" of fan energy, according to the procedures described in the 2001 Alternate Compliance Method (ACM) manual.

Pumps and fans. Input power for pumps, fans and other motor-driven equipment was calculated from motor nameplate horsepower data. Motor efficiencies as observed by the surveyors were used to calculate input power. In the absence of motor efficiency observations, standard motor efficiencies were assigned as a function of the motor horsepower. A rated load factor was used to adjust the nameplate input rating to the actual running load. For VAV system fans, custom curves were used to calculate fan power requirements as a function of flow rate in lieu of the standard curves used in DOE-2, as described in the 1998 ACM manual.

Service hot water. Service hot water consumption was calculated based on average daily values from the 2001 ACM for various occupancy types. Equipment capacity and efficiency were assigned based on survey responses.

Exterior lighting. Exterior lighting input parameters were developed similarly to those for interior lighting. The exterior lighting connected load was calculated from a fixture count, fixture identification code and the input wattage value associated with each fixture code.

Ventilation Air. Commercial HVAC systems are designed to introduce fresh air into the building to maintain a healthy indoor environment. The space type and its associated floor area were used to calculate outdoor air quantities according to Title-24 rules. Outdoor air fractions were calculated for each system from the total system airflow rate and the space outdoor air requirements.

Commercial Refrigeration. The algorithms used in the DOE-2.2 version 44E3 program were used to evaluate the performance of commercial refrigeration systems found in grocery stores, commercial kitchens, schools, and so on. Refrigerated cases, compressor plant, condensers, and control system characteristics were surveyed. The automated modeling software provided DOE-2 models of both the building and the refrigeration systems, providing an accurate representation of the refrigeration system performance, and the interactions between the refrigeration system and the building HVAC system.

Plant

This section describes the methodology used to develop DOE-2 input for the plant simulation. Principal data sources included the on-site survey, Title-24 documents, manufacturers' data, program data, and other engineering references.

Chillers. The DOE-2 input parameters required to model chiller performance included chiller type, full-load efficiency and capacity at rated conditions, and performance curves to adjust chiller performance for temperature and loading conditions different from the rated conditions. Chiller type was assigned based on the type code selected during the on-site survey. Surveyors also gathered chiller make, model number, and serial number data. These data were used to develop performance data specific to the chiller installed in the building. Program data and/or manufacturers' data were used to develop the input specifications for chiller efficiency.

Cooling towers. Cooling tower fan and pump energy was defined based on the nameplate data gathered during the on-site survey. Condenser water temperature and fan volume control specifications were derived from the on-site survey responses.

Model Review and Quality Checks

After the DOE-2 model was generated, the model was run using the CEC climate thermal zone (CTZ) long term average weather data corresponding to the climate zone where the project was located. The model either was run successfully generating a results page, or received errors and/or warnings. When warnings and/or errors were encountered, modifications to the data entry database were performed and another model for the site was created and run. This process was repeated until the model runs successfully and a results page is generated.

Sites with monitored data were calibrated using concurrent actual weather files. The calibrated models were then re-run using the CEC TMY weather files.

The on-site survey data entry program contained numerous quality control (QC) checks designed to identify invalid building characteristics data during data entry. Once the models were run successfully, the surveyor/modeler and senior engineering staff reviewed the results. A building characteristics and model results summary report was created for each site. The overall quality assurance process is outlined as follows:

A list of key physical attributes of the buildings were summarized and checked for reasonableness:

- Window to wall ratio
- Opaque wall and roof conductance
- Glazing conductance
- Glazing shading coefficient
- Lighting power density
- Equipment power density
- Floor area per ton of installed AC
- Cooling system efficiency
- Sizing ratio

The as-built characteristics were compared to Title-24 and/or common practice criteria. The energy performance of the building was also checked. Energy consumption statistics, such as the whole building EUI (kWh/sqft-yr.), and end-use shares were examined for reasonableness. The baseline model was run, and savings estimates for participants were compared to program expectations. Sites with large variances were further examined to investigate potential problems in the on-site data or modeling approach. For each site, the full set of end-use parametrics were run for each building as a component of the QC process. The measure and whole building savings by end-use were compared to program tracking system information and checked for reasonableness.

An example of some of the QC criteria that were utilized is shown below in Table 69. Data falling outside of the QC range were validated during the QC process.

Building Parameter	Range	Definition
Cooling Ratio	95 - 200%	capacity from annual run / capacity from sizing run
Cooling EER	8 - 14	capacity weighted cooling efficiency
Wall U-Value	0.5 - 0.033	area weighted average, includes air film
Roof U-Value	0.5 - 0.033	area weighted average, includes air film
Win U-Value	0.3 - 0.88	area weighted average, includes air film
Win-Shading Coefficient	0.35 - 0.88	area weighted average
Window to Wall Ratio	0 - 70%	Percentage of gross wall area associated w/windows, expressed as a true percentage 0 –100
Skylight U-Value	0.3 - 0.9	area weighted average of glazing contained in roof
Skylight-Shading Coefficient	0.35 - 0.88	area weighted SC for all horizontal glazing
Skylight Area To Roof Area Ratio	0 - 10%	Percentage of gross roof area associated with sky light, expressed as a true percentage 0 –100
Lighting Occupancy Controlled	0 - 50%	Percentage of lighting watts controlled by occupancy sensors, expressed as a true percentage 0 –100
Lighting Daylighting Controlled	0 - 50%	Percentage of lighting watts controlled by daylighting sensors, expressed as a true percentage 0 –100
Measures only savings relative to program expectations	50% - 150%	measures-only savings / program expectations
Total Savings relative to Baseline (Gross)	0% - 50%	Savings expressed as a percentage of baseline energy consumption

Table 69: Model Quality Control Criteria

Building type specific performance data from the California NRNC Baseline study were used to develop additional QC criteria. Any site below the 25th percentile or greater than the 75th percentile for whole building EUI, end-use EUI, lighting power density, or equipment power density was flagged for closer study. The building type specific QC criteria are listed in Table 70.

Building Type	Whole Building EUI (kWh/SF)		Cooling EUI (kWh/SF)		Fan EUI (kWh/SF)		Lighting EUI (kWh/SF)		Refrigeration EUI (kWh/SF)		Other EUI (kWh/SF)		Lighting Power Density (W/SF)		Equip Power Density (W/SF)	
	25th pct	75th pct	25th pct	75th pct	25th pct	75th pct	25th pct	75th pct	25th pct	75th pct	25th pct	75th pct	25th pct	75th pct	25th pct	75th pct
C&I Storage	1.50	8.68	0.04	0.51	0.07	1.29	1.07	3.92	0.00	0.00	0.27	2.33	0.50	0.93	0.10	0.56
Grocery Store	40.30	53.62	0.38	1.19	1.77	3.61	7.38	11.77	22.88	34.65	2.60	7.12	1.25	1.70	0.04	0.19
General C&I Work	7.88	28.88	0.07	2.56	0.13	2.21	2.55	5.49	0.00	0.00	2.29	14.55	0.70	1.37	0.08	0.85
Medical/Clinical	13.26	28.65	2.13	5.82	1.71	9.18	2.97	6.59	0.00	0.00	1.74	7.88	0.94	1.45	0.63	1.79
Office	9.27	17.92	1.38	3.48	1.07	3.43	2.91	4.57	0.00	0.00	1.58	5.98	0.97	1.38	0.98	2.45
Other	6.55	29.87	0.00	4.33	0.50	4.32	2.37	5.34	0.00	0.00	1.74	18.00	0.85	1.44	0.06	1.09
Religious Worship, Auditorium, Convention	5.01	14.35	0.53	3.84	0.57	3.85	1.56	3.83	0.00	0.00	0.98	3.12	1.00	1.49	0.00	0.28
Restaurant	36.25	73.94	3.07	9.10	5.22	10.07	5.54	9.74	0.00	3.98	14.29	44.14	1.24	2.01	0.08	0.59
Retail and Wholesale Store	14.30	26.37	1.45	3.67	1.89	4.47	5.92	10.50	0.00	0.00	1.31	4.78	1.35	1.96	0.06	0.42
School	6.33	10.75	0.58	1.96	0.95	2.37	2.34	3.73	0.00	0.00	0.73	2.84	1.07	1.56	0.23	1.01
Theater	12.30	19.29	2.62	5.39	2.03	5.39	2.49	4.53	0.00	0.00	1.92	5.36	0.79	1.34	0.04	0.14
Fire/Police/Jails	9.32	18.62	0.98	2.44	1.40	3.28	3.27	5.00	0.00	0.00	2.28	5.46	0.69	1.00	0.44	1.20
Community Center	7.26	19.94	1.35	2.85	1.27	4.18	2.55	5.48	0.00	0.00	1.28	6.02	0.95	1.28	0.18	1.19
Gymnasium	7.80	13.96	0.03	2.28	0.76	5.98	2.76	4.07	0.00	0.00	1.48	2.67	1.04	1.54	0.03	0.28
Libraries	10.96	13.40	1.35	2.72	1.34	3.05	3.74	4.92	0.00	0.00	1.48	2.80	1.12	1.35	0.42	1.02

Table 70: Survey It^{tm} Quality Control EUI Reference Table

Parametric Runs

Once the models were quality checked, an automated process was used to create a series of parametric simulation runs. These runs were used to simulate gross savings for participants on a whole building and measure-class basis by subtracting the as-built energy consumption and demand from the baseline energy consumption and demand. The parametric runs used in this study are listed below:

As-Built Parametric Run

Once the models were completed and QC checked, the as-built parametric run was done. The energy performance of the as-built building was simulated using long-term average weather data from the National Weather Service.

Baseline Parametric Run

Key building performance parameters were reset to a baseline condition to calculate gross energy savings for participants. The 2001 California Building Energy Efficiency Standard (Title-24) was the primary reference for establishing baseline performance parameters. Title-24 specifies minimum specifications for building attributes such as:

- Opaque shell conductance
- Window conductance
- Window shading coefficient
- HVAC equipment efficiency
- Lighting power density

Title-24 applies to most of the building types covered in the programs covered under this project, with the exception of:

- Hospitals
- Prisons/Correctional Institutions
- Industrial projects
- Unconditioned space (including warehouses)

Incentives are also offered by the program for building attributes not addressed by Title-24. In situations where Title-24 does not address building types or equipment covered under the program, baseline parameters equivalent to those used for the program baseline efficiencies were used for participants.

Envelope

Opaque shell U-values were assigned based on Title-24 requirements as a function of climate zone and heat capacity of the observed construction. For windows, Title-24 specifications for maximum relative solar heat gain were used to establish baseline glazing shading coefficients. Fixed overhangs were removed from the baseline building. Glass conductance values as a function of climate zone were applied. For skylights, shading coefficients and overall conductance were assigned according to climate zone.

Mechanical

Baseline specifications for HVAC equipment efficiency were derived from the Title-24 requirements as a function of equipment type and capacity. Maximum power specifications for fans were established based on Title-24 requirements, which address fan systems larger than 25 hp. Specific fan power was held energy neutral (as built W/CFM = baseline W/CFM) for fan systems under 25 hp. Additionally, all systems larger than 2500 CFM or 75,000 Btu/hr of cooling capacity (except for hospitals) were simulated with economizers in the baseline run. All variable-volume pumps were simulated with throttling valve control.

HVAC System Sizing

HVAC system sizing for the as-built case was determined by direct observation of the nameplate capacities of the HVAC equipment. The installed HVAC system capacity was compared to the design loads imposed on the system to determine a sizing ratio for the as-built building. Once established, the sizing ratio was held constant for each subsequent DOE-2 run. A separate sizing run was done prior to each baseline and parametric run, using the equipment sizing algorithms in DOE-2. The system capacity was reset using the calculated peak cooling capacity, and the as-built sizing ratio.

Lighting

The Title-24 area category method was used to set the baseline lighting power for each space as a function of the observed occupancy, except in spaces using the Tailored lighting approach, where the allowed lighting power from the Title-24 documents was used. All lighting controls were turned off for the baseline simulation.

Grocery Store Refrigeration Systems

- Since there are no energy standards for grocery store refrigeration systems, the Savings By Design program baseline equipment specifications served as the baseline or reference point for the gross impact calculations.

Additional Parametric Runs

Once the as-built and baseline building models were defined, an additional set of parametric runs were done to estimate the program impact on the lighting, HVAC, shell / daylighting, and refrigeration measure groups. The baseline model was returned to the as-built design in a series of steps outlined as follows:

1. *Shell, measures only*. Baseline envelope properties (glazing U-value and shading coefficient; and opaque surface insulation) for incented measures only were returned to their as-built condition.
2. *All Shell.* All baseline envelope properties were returned to their as-built condition.
3. *Lighting Power Density, measures only.* Run 2 above, plus baseline lighting power densities for spaces in the building that received incentives were returned to their as-built condition.

4. *All Lighting Power Density.* Run 2 above, plus all baseline lighting power densities were returned to their as-built condition.
5. *Daylighting Controls, measures only.* Run 4 above, plus daylighting controls that received incentives were returned to their as-built condition.
6. *All Daylighting Controls.* Run 4 above, plus all daylighting controls were returned to their as-built condition.
7. *Other Lighting Controls, measures only.* Run 6 above, plus all other lighting controls that received incentives were returned to their as-built condition.
8. *All Other Lighting Controls.* Run 6 above, plus all other lighting controls were returned to their as-built condition.
9. *Motors and Air Distribution, measures only.* Run 8 above, plus baseline motor efficiency, fan power indices (W/CFM), and motor controls for incented measures only were returned to their as-built condition.
10. *All Motors and Air Distribution.* Run 8 above, plus all baseline motor efficiency fan power indices (W/CFM), and motor controls were returned to their as-built condition.
11. *HVAC, measures only.* Run 10 above, plus HVAC parameters for incented measures only were returned to their as-built condition.
12. *All HVAC.* Run 10 above, plus all HVAC parameters were returned to their as-built condition.
13. *Refrigeration, measures only.* Run 12 above, plus refrigeration parameters for incented measures in buildings eligible for the grocery store refrigeration program only were returned to their as-built condition.
14. *All Refrigeration.* Run 12 above, plus all refrigeration parameters in buildings eligible for the grocery store refrigeration programs were returned to their as-built condition. Note: refrigeration parameters in buildings not eligible for the grocery store refrigeration programs remained at the as-built level for all parametric runs.
15. *DHW, measures only.* Run 14 above, plus hot water parameters for incented measures only were returned to their as-built condition.
16. *All DHW.* Run 14 above, plus all hot water parameters were returned to their as-built condition. *This run is equivalent to the full as-built run.*

When applicable, savings from projects participating under the “Other Systems” option were added to the applicable parametric categories defined above. For example, savings from refrigerated warehouse improvements were added to the refrigeration parametric.

Data Collection

There were three on-going components to the data collection in this study. They were:

- Structured telephone surveys with program participants decision-makers
- On-site surveys with SBD program participant's operating new non-residential buildings and industrial projects completed in 2004 and 2005. Data collected on-site is used to generate site specific DOE-2 models.
- The industrial on-site surveys are comprised of verification of incented equipment and at some sites, when feasible, installation of data loggers to obtain run-time and energy consumption information to inform the engineering calculations.

These two components worked with the secondary sources of information – the program files, and Title-24 documentation to develop a complete picture of the Statewide SBD non-residential new construction program. The on-site surveys provided inputs for DOE-2 engineering models used to estimate the energy and demand use of each building. The structured qualitative/quantitative surveys with decision-makers provided data for the net savings and spillover analysis. Additionally, these surveys collected research information from the building owners to address the following general areas:

- Building classification
- Design and construction practices
- Energy attitudes
- Energy performance
- SBD program participation

The key feature in the process is that the building models are constructed and reviewed by the surveyor within days of the on-site visit. This course of action noticeably improves the team's ability to produce models that accurately reflect the building as it is actually operated. It also allows for timely feedback from the modeling to the site data collection effort, allowing for quick resolution of any data collection problems. The overall process is:

1. The site is recruited and the recruiter asks basic decision-maker questions of the building owner and designers as appropriate.
2. The surveyor reviews program project file prior to the site visit.
3. The surveyor responsible for the model collects the on-site data.

4. Decision-maker information available from the building owner or facility manager is collected during the on-site survey or later on the phone. This process minimizes customer “burn-out” due to multiple contacts.
5. The on-site surveyor enters the field data directly into the building database. All data problems and data inconsistencies are corrected within a few days of the on-site visit.
6. As soon as the data are keyed into the program, the automated model building software automatically creates the DOE-2 model and calculates the gross savings. The models are comprehensively checked for reasonableness, first by the modeler, and last by senior engineering staff. There is constant communication between the surveyor and senior engineering staff. Sites with large variances in the savings estimates relative to program expectations are investigated and resolved in a timely manner. Sites that fall out of the standard quality control range are re-evaluated and rechecked for reasonableness.
7. An audit savings report is produced for each site, summarizing savings and noting any discrepancies between the audit model and program estimates. The surveyor and senior engineering staff review these reports within a few days of the audit, resulting in rapid feedback and data validation.
8. One final simulation of the modified as-built is model is required to produce net savings estimates. These simulations are based on the decision-maker data, and are completed at the end-use level.

Recruiting & Decision-Maker Surveys

Experienced energy program recruiters contacted building owners and attempted to secure their participation in the study. The recruiters were briefed on the required data collection activities and on the audit process in order to facilitate “selling” the prospective owner/manager on allowing the audit. Before any recruiting began, RLW provided each participating utility the list of customers they planned to contact in order to identify potentially sensitive sites.

The utilities received a list of the primary and backup sample sites from RLW before data collection. The list allowed the utility account representatives the chance to alert RLW of any potentially sensitive customers.

Our trained, experienced staff asked the owner several questions that accomplished the following objectives:

- Validated the site for inclusion in the study,
- Confirmed the location,
- Collected SBD process information to inform program managers, and
- Collected decision-maker survey data for the net savings and spillover analysis.

Once a site was recruited, the recruiter administered the decision-maker survey. If a respondent could not answer specific questions in the survey, the recruiter obtained contact information for other individuals who were able to provide the requested information. This frequently resulted in contacting the mechanical designer in addition to the owner. This methodology was proven to be effective in the prior NRNC studies conducted by RLW Analytics in collecting complete data from the correct decision-makers.

The recruiters used owner contact information provided in the tracking database and the project file to identify a decision-maker. These contacts were used as the initial contact. The recruiters followed up with additional contacts identified by the initial contact, as necessary. As in past studies, we found that it was necessary to interview more than one respondent for some of the projects. To expedite the on-site survey process, the recruiter asked the customers to have building plans available for the surveyors when they arrived at the site at the scheduled date and time.

Building characteristics

Building characteristics refer to the size, type (e.g. grocery, restaurant, etc.), location, stand alone vs. multi-tenant, own/build vs. speculative, and other similar characteristics. Building characteristics does not mean equipment stock and schedule. This data is captured in the savings estimate and therefore does not have a role as an econometric predictor.

Interaction with utility

In the 1996 study, the 1994 binary variables were replaced with scaled variables to more accurately capture interaction with utility staff. This methodology was retained for the 1998 evaluations. However, since this study required an end use or measure specific estimate of net savings and spillover, the survey instrument required a higher level of detail on utility interaction responses.

To support this requirement, questions were asked to determine the utilities' past and present role in the customer's energy related design decisions and overall awareness of the SBD program. We also explicitly asked about previous participation in utility programs in an attempt to include transformative affects from those interactions. The decision-maker was questioned on design plans prior to utility interaction and whether plans changed after utility interaction. This level of detail was required at the end-use level when it appeared that free-ridership and spillover had occurred.

Decision-maker (DM) Attitudes/Behaviors

Participant decision-makers were surveyed to gather an understanding of what influences or market forces contribute to and guide the building design process. Decision-makers were asked to answer questions on their attitudes regarding the SBD program, its components and its delivery. Respondents were asked about design practices, in relation to energy efficiency, they commonly use when building new buildings. Measure specific and end-use specific questions aimed to identify common practices and behaviors regarding equipment choices and levels of efficiency installed were also included.

Energy Efficient Design Practices

We used the decision-maker interviews to obtain data to assist the IOUs in understanding the SBD impacts on energy efficient design requirements submitted with new construction RFPs and RFQs. A set of questions were included that aimed to assess the level of importance energy efficient design during project planning, and design stages.

Scoring the Surveys

The decision-maker (DM) surveys were scored at the measure and end-use level based upon completed survey data. A senior level analyst was responsible for reviewing each survey response and making a final determination for each score using a predetermined scoring method. These scores were then applied to the parametric run simulation results to determine total free-ridership and spillover in the SBD program area. The detailed scoring methodology for free-ridership can be found in the "Net Savings" section of this report.

Recruiting and Decision-maker Survey Data Entry

An MS Access database was designed to house all data collected over the phone during the recruiting and DM survey process. Recruiting dispositions and DM survey data were entered daily into a set of 'forms' designed specifically for this study. Random data entry checks served as a quality control mechanism for maintaining consistent error free data entry. Moreover, where applicable, data entry forms were designed such that only valid parameters could be entered into the database vastly reducing data entry error.

On-Site Surveys

Experienced surveyors/DOE-2 modelers from RLW, AEC, and EBA conducted the on-site surveys. The on-site visits required anywhere from three hours to a full day, by one or more surveyors, depending on the size and complexity of the building.

The on-site surveys began with a brief interview with the site contact to gather basic information about the building – operating schedules, number of occupants, control strategies, etc. The surveyor then walked through the building to examine the energy-using systems (e.g. lighting, HVAC, energy management systems, etc.) System types and sizes were cataloged, along with information about the condition of the equipment. The presence of incented measures were verified. If plans were available, the surveyor used the plans to gather information on building shell and inaccessible equipment.

The surveyors were instructed not to do anything to disrupt the normal operations of the building or any of the systems. The surveyors did not open equipment to collect nameplate data on inaccessible parts.

Training of On-Site Survey Staff

The process of gathering accurate, timely field data was the foundation upon which the project's analysis ultimately rested. Training surveyors to collect the proper field information was the first step in the building this foundation. Lead surveyors/engineers from RLW Analytics and AEC conducted the training for the audit phase of the project. The training built upon the lessons learned during the evaluation of the 1994, 96, and 98 commercial new construction programs, the 1998 CBEE NRNC baseline study, the 1999-2001 and 2002 SBD studies, and upon the considerable building survey experience of the surveyors.

This training team conducted a one-day training session that covered relevant theory and new construction practice as well as the mechanics of completing the on-site forms. Items that received special emphasis based on the results of past evaluations were:

- Details of reading SBD program project documentation,
- Identification of project and non project areas within a single building,

- Importance of communication between the surveyors and senior technical staff, and
- Keys to gathering valid decision-maker data.
- Identification of lighting and HVAC technologies

Special attention was paid to the unique requirements of auditing commercial refrigeration systems, such as those found in grocery stores.

A second training session was held for the surveyors and technicians involved with the short-term metering component. The training was held at an at a large SBD participant building where facility staff had granted permission for the training

The second training focused on development of a monitoring plan, instruction on instantaneous measurement instrumentation, special instruction for the data loggers that were used in the study, as well as safety and site etiquette issues.

Engineering File Reviews

In advance of each audit, the on-site surveyor conducted a complete file review on the building/facility to be visited. If the customer was a participant, the surveyor reviewed the program file to determine the following:

- Installed measures,
- Location of measures, and
- Any special circumstances.

Instruments

The two data collection instruments used for the on-site data collection portion of this study were,

- On-site Survey Form,
- Refrigerated Warehouse On-site Survey Form.

The on-site survey form is similar to the one used in the 1998 PG&E NRNC evaluation, the 1998 CBEE baseline study, and the 1999-2001, 2002 and 2003 SBD studies. Some minor changes were made to reflect lessons learned in the 1994 and 1996 evaluations. An electronic version of the form was used to facilitate data entry and QA. This is a Microsoft Access database application that accepts data from the surveyor, performs basic QA on the data, and formats the data for input into the model generator.

The refrigerated warehouse survey form is the same as the one used in the 1999-2001, 2002 and 2003 SBD studies.

Regulatory Summary

Net Program Lifecycle Savings

The following 5 tables are what have been reported to the CPUC for net program lifecycle savings of the Savings By Design program. The first table lists the "statewide" savings, which is the aggregate of all four utilities; the subsequent four tables are the utility specific net program lifecycle savings. The lifecycle savings were estimated by projecting the net savings for the program for the length of the effective useful life (EUL) estimates as filed in the program cost-effectiveness workbooks. . SDG&E and SoCalGas used a EUL 15 years for all measures. PG&E and SCE input EULs varying from 15 to 20 years for different measure categories. To create those net savings tables, program impacts were parsed into the measure categories and projected into the future using the corresponding EUL. Since EUL values for measure categories varied across utilities, identical measures are credited differently in year 16 through 20. Although RLW recognizes that this is not ideal, EUL analyses were not in the scope of this evaluation, therefore utility supplied EULs were not subject to revision, even for the purpose of consistency.

Program IDs*:	1161-04 1183-04 1506-04 1127-04 1323-04 1346-04 1249-04							
Program Name:	Savings By Design							
	Year	Calendar Year	Ex-ante Gross Program-Projected Program MWh Savings (1)	Ex-Post Net Evaluation Confirmed Program MWh Savings (2)	Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)	Ex-Post Net Evaluation Projected Peak MW Savings (2**)	Ex-Ante Gross Program-Projected Program Therm Savings (1)	Ex-Post Net Evaluation Confirmed Program Therm Savings (2)
	1	2004	344,748	259,530	68.74	42.27	8,662,541	7,916,725
	2	2005	344,748	259,530	68.74	42.27	8,662,541	7,916,725
	3	2006	344,748	259,530	68.74	42.27	8,662,541	7,916,725
	4	2007	344,748	259,530	68.74	42.27	8,662,541	7,916,725
	5	2008	344,748	259,530	68.74	42.27	8,662,541	7,916,725
	6	2009	344,748	259,530	68.74	42.27	8,662,541	7,916,725
	7	2010	344,748	259,530	68.74	42.27	8,662,541	7,916,725
	8	2011	344,748	259,530	68.74	42.27	8,662,541	7,916,725
	9	2012	344,748	259,530	68.74	42.27	8,662,541	7,916,725
	10	2013	344,748	259,530	68.74	42.27	8,662,541	7,916,725
	11	2014	344,748	259,530	68.74	42.27	8,662,541	7,916,725
	12	2015	344,748	259,530	68.74	42.27	8,662,541	7,916,725
	13	2016	344,748	259,530	68.74	42.27	8,662,541	7,916,725
	14	2017	344,748	259,530	68.74	42.27	8,662,541	7,916,725
	15	2018	326,693	259,530	64.91	42.27	7,644,619	7,916,725
	16	2019	204,517	178,367	39.73	28.34	5,040,455	1,408,227
	17	2020	37,386	53,381	7.12	7.37	672,450	1,114,771
	18	2021	37,386	53,381	7.12	7.37	672,450	1,114,771
	19	2022	37,386	53,381	7.12	7.37	672,450	1,114,771
	20	2023	37,386	53,381	7.12	7.37	672,450	1,114,771
	TOTAL	2004-2023	5,469,833	4,231,455			135,977,998	123,503,414

Table 71: Statewide 2004-2005 Net Program Lifecycle Savings

Program ID*:	1506-04(proc) 1127-04							
Program Name:	Savings By Design							
	Year	Calendar Year	Ex-ante Gross Program-Projected Program MWh Savings (1)	Ex-Post Net Evaluation Confirmed Program MWh Savings (2)	Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)	Ex-Post Net Evaluation Projected Peak MW Savings (2**)	Ex-Ante Gross Program-Projected Program Therm Savings (1)	Ex-Post Net Evaluation Confirmed Program Therm Savings (2)
	1	2004	108,856	74,989	23.11	13.84	6,137,245	1,421,523
	2	2005	108,856	74,989	23.11	13.84	6,137,245	1,421,523
	3	2006	108,856	74,989	23.11	13.84	6,137,245	1,421,523
	4	2007	108,856	74,989	23.11	13.84	6,137,245	1,421,523
	5	2008	108,856	74,989	23.11	13.84	6,137,245	1,421,523
	6	2009	108,856	74,989	23.11	13.84	6,137,245	1,421,523
	7	2010	108,856	74,989	23.11	13.84	6,137,245	1,421,523
	8	2011	108,856	74,989	23.11	13.84	6,137,245	1,421,523
	9	2012	108,856	74,989	23.11	13.84	6,137,245	1,421,523
	10	2013	108,856	74,989	23.11	13.84	6,137,245	1,421,523
	11	2014	108,856	74,989	23.11	13.84	6,137,245	1,421,523
	12	2015	108,856	74,989	23.11	13.84	6,137,245	1,421,523
	13	2016	108,856	74,989	23.11	13.84	6,137,245	1,421,523
	14	2017	108,856	74,989	23.11	13.84	6,137,245	1,421,523
	15	2018	90,801	74,989	19.28	13.84	5,119,323	1,421,523
	16	2019	84,811	75,171	18.00	13.22	4,781,623	1,424,005
	17	2020	10,912	23,753	2.32	4.87	615,207	1,114,771
	18	2021	10,912	23,753	2.32	4.87	615,207	1,114,771
	19	2022	10,912	23,753	2.32	4.87	615,207	1,114,771
	20	2023	10,912	23,753	2.32	4.87	615,207	1,114,771
	TOTAL	2004-2023	1,732,334	1,271,269			97,667,996	26,091,158

Table 72: PG&E 2004-2005 Net Program Lifecycle Savings.

Program ID*:	1183-04(procurement) and 1161-04							
Program Name:	Savings By Design							
	Year	Calendar Year	Ex-ante Gross Program-Projected Program MWh Savings (1)	Ex-Post Net Evaluation Confirmed Program MWh Savings (2)	Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)	Ex-Post Net Evaluation Projected Peak MW Savings (2**)	Ex-Ante Gross Program-Projected Program Therm Savings (1)	Ex-Post Net Evaluation Confirmed Program Therm Savings (2)
	1	2004	153,610	126,964	27.87	18.76	332,143	4,129,443
	2	2005	153,610	126,964	27.87	18.76	332,143	4,129,443
	3	2006	153,610	126,964	27.87	18.76	332,143	4,129,443
	4	2007	153,610	126,964	27.87	18.76	332,143	4,129,443
	5	2008	153,610	126,964	27.87	18.76	332,143	4,129,443
	6	2009	153,610	126,964	27.87	18.76	332,143	4,129,443
	7	2010	153,610	126,964	27.87	18.76	332,143	4,129,443
	8	2011	153,610	126,964	27.87	18.76	332,143	4,129,443
	9	2012	153,610	126,964	27.87	18.76	332,143	4,129,443
	10	2013	153,610	126,964	27.87	18.76	332,143	4,129,443
	11	2014	153,610	126,964	27.87	18.76	332,143	4,129,443
	12	2015	153,610	126,964	27.87	18.76	332,143	4,129,443
	13	2016	153,610	126,964	27.87	18.76	332,143	4,129,443
	14	2017	153,610	126,964	27.87	18.76	332,143	4,129,443
	15	2018	153,610	126,964	27.87	18.76	332,143	4,129,443
	16	2019	119,705	103,196	22	15.12	258,832	(15,778)
	17	2020	26,474	29,628	5	2.50	57,243	-
	18	2021	26,474	29,628	5	2.50	57,243	-
	19	2022	26,474	29,628	5	2.50	57,243	-
	20	2023	26,474	29,628	5	2.50	57,243	-
	TOTAL	2004-2023	2,503,278	2,096,540			5,412,706	61,925,861

Table 73: SCE Net Program Lifecycle Savings

Program ID*:	1323-04 (proc) 1346-04							
Program Name:	Savings By Design							
Year	Calendar Year	Ex-ante Gross Program-Projected Program MWh Savings (1)	Ex-Post Net Evaluation Confirmed Program MWh Savings (2)	Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)	Ex-Post Net Evaluation Projected Peak MW Savings (2**)	Ex-Ante Gross Program-Projected Program Therm Savings (1)	Ex-Post Net Evaluation Confirmed Program Therm Savings (2)
1	2004	63,959	42,240	14.26	7.31	2,121,796	2,362,047
2	2005	63,959	42,240	14.26	7.31	2,121,796	2,362,047
3	2006	63,959	42,240	14.26	7.31	2,121,796	2,362,047
4	2007	63,959	42,240	14.26	7.31	2,121,796	2,362,047
5	2008	63,959	42,240	14.26	7.31	2,121,796	2,362,047
6	2009	63,959	42,240	14.26	7.31	2,121,796	2,362,047
7	2010	63,959	42,240	14.26	7.31	2,121,796	2,362,047
8	2011	63,959	42,240	14.26	7.31	2,121,796	2,362,047
9	2012	63,959	42,240	14.26	7.31	2,121,796	2,362,047
10	2013	63,959	42,240	14.26	7.31	2,121,796	2,362,047
11	2014	63,959	42,240	14.26	7.31	2,121,796	2,362,047
12	2015	63,959	42,240	14.26	7.31	2,121,796	2,362,047
13	2016	63,959	42,240	14.26	7.31	2,121,796	2,362,047
14	2017	63,959	42,240	14.26	7.31	2,121,796	2,362,047
15	2018	63,959	42,240	14.26	7.31	2,121,796	2,362,047
16	2019						
17	2020						
18	2021						
19	2022						
20	2023						
TOTAL	2004-2023	959,385	633,597			31,826,940	35,430,705

Table 74: SDG&E Net Program Lifecycle Savings

Program ID*:	1249-04						
Program Name:	Savings By Design						
Year	Calendar Year	Ex-ante Gross Program-Projected Program MWh Savings (1)	Ex-Post Net Evaluation Confirmed Program MWh Savings (2)	Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)	Ex-Post Net Evaluation Projected Peak MW Savings (2**)	Ex-Ante Gross Program-Projected Program Therm Savings (1)	Ex-Post Net Evaluation Confirmed Program Therm Savings (2)
1	2004	18,322	15,337	3.50	2.35	71,357	3,713
2	2005	18,322	15,337	3.50	2.35	71,357	3,713
3	2006	18,322	15,337	3.50	2.35	71,357	3,713
4	2007	18,322	15,337	3.50	2.35	71,357	3,713
5	2008	18,322	15,337	3.50	2.35	71,357	3,713
6	2009	18,322	15,337	3.50	2.35	71,357	3,713
7	2010	18,322	15,337	3.50	2.35	71,357	3,713
8	2011	18,322	15,337	3.50	2.35	71,357	3,713
9	2012	18,322	15,337	3.50	2.35	71,357	3,713
10	2013	18,322	15,337	3.50	2.35	71,357	3,713
11	2014	18,322	15,337	3.50	2.35	71,357	3,713
12	2015	18,322	15,337	3.50	2.35	71,357	3,713
13	2016	18,322	15,337	3.50	2.35	71,357	3,713
14	2017	18,322	15,337	3.50	2.35	71,357	3,713
15	2018	18,322	15,337	3.50	2.35	71,357	3,713
16	2019						
17	2020						
18	2021						
19	2022						
20	2023						
TOTAL	2004-2023	274,836	230,048			1,070,355	55,690

Table 75: SoCalGas Net Program Lifecycle Savings

Total Resource Cost Results

The Total Resource Cost (TRC) is a ratio of net benefits to the net costs, including both the participants' and the utility and benefits, of a demand-side management program. A TRC value greater than one means that the sum of benefits are greater than the sum of costs, and the program is considered "cost effective".

Ex ante TRCs were for each utility were calculated with the CPUC cost effectiveness calculator or program workbook. RLW used each utilities workbook and updated the savings values and the net to gross ratio for each measure category with those found in this study. Table 13 shows that all of the utilities have a total resource cost (TRC) value greater than one. SCE has the greatest TRC ratio at 3.29, but a large factor (0.7) was a result of 4,000,000 therms savings from HVAC measures which had an error bound as large as the estimated value, showing a very low relative precision. The TRC values listed below were calculated using the utility workbooks described earlier in this section. This means that there was variation in measure categories for EUL's and incremental measure costs across utilities.

The electric utilities had two workbooks filed for their SBD program, a portion of the program funded by public goods charges and a procurement funded portion. TRC ratios are the aggregate of benefits of both workbooks divided by aggregate costs of both workbooks. Note that SCE procurement portion program workbook did not have recorded activities and consequently no and the associated ex-ante TRC ratios only considered cost from that portion.

Utility	Utility Projected TRC Ratio	Utility Ex-Ante TRC Ratio	Ex-Post TRC Ratio
PGE	* 2.10	* 2.60	2.06
SCE	* 2.56	* 2.45	3.29
SDGE	* 1.91	* 3.37	2.34
SoCalGas	2.59	2.89	2.64
Overall	2.27	2.60	2.65

Table 76: Total Resource Cost (TRC) by Utility[18]

[18] *Combined TRC of utility's SBD public goods and procurement funded projects

Program Observations and Recommendations

This chapter presents observations made about SBD through the course of conducting this project. Recommendations to improve SBD are also presented. Furthermore, some of the recommendations in this section are similar, if not the same as those reported in the 2003 SBD EM&V report. RLW has chosen to include previous recommendations either because they continued to arise in the 2004-2005 evaluation, or because the issue is important and on-going, and should be a consideration for future program planning.

Judging Continuing Need for the Savings By Design Program

Judging continuing need for the Savings By Design program cannot easily be summed up given the lack of information regarding program cost effectiveness. Many of the metrics used to measure the cost effectiveness and the continuing need for the SBD program are not easily obtainable given the timing of the evaluation and the duration of NRNC cycles. In this section we discuss these issues and possible ways to modify and enhance future evaluations to answer cost effectiveness questions. In lieu of such information, this section also touches on other findings from this evaluation that do address continuing need for Savings By Design.

Due to the nature of the market (NRNC) served by the program it would be very difficult to calculate cost effectiveness of the Savings By Design program. This evaluation considers only projects that were paid incentives within the evaluation years (2004 and 2005), which means we are evaluating projects that initially signed onto the program several years ago or as late as 2005. Due to the long NRNC construction cycles that characterize this program, it becomes extremely difficult to account for the costs that would be associated with only the projects that were paid in 2004 and 2005.

The utilities and the CPUC should consider this when writing the RFP for future SBD evaluations, acknowledging the fact that it may be years after the program year before it would be possible to complete the cost effectiveness testing of the Savings By Design Program without significant revisions to the design of the evaluation.

Testing the true cost effectiveness of the program would require significant revision to the evaluation design. As reported in previous evaluations, there is a reasonable approach to overcoming the problem of testing cost effectiveness as part of the evaluation activities. The utilities could allocate the total program costs for a particular program year to each of the projects committed in that particular program year. This information would be tracked in the program tracking system, which would be provided to the evaluation consultant. The evaluation consultant would then have the ability to sum all program costs for the participants that are included in the evaluation (i.e., projects paid incentives in any given year), resulting in a quasi paid year SBD program budget. Therefore, a relatively easy program cost accounting by project would produce the basic cost information needed for testing cost effectiveness as part of the evaluation activities.

Other inputs that go into the cost effectiveness test (such as Gross IMC, NTG, EUL), would certainly introduce another level of complexity to the evaluation. Therefore, if cost effectiveness testing were to be undertaken in future evaluations these inputs would also require thorough review. For this particular program, a significant investment would likely be necessary if the evaluations were to undertake review and evaluation of all cost-effectiveness inputs, most notably Gross IMC.

Cost effectiveness aside, it is clear through these evaluation activities that the Savings By Design program is delivering energy efficiency and long-term energy savings to the nonresidential new construction commercial sector market. For the time being, however, we must rely on indicators other than cost effectiveness to verify whether there is a continuing need for the program. Many findings from this evaluation substantiate a continuing need for the Savings By Design program. The great majority of the measures promoted by the program are long-life measures that should deliver energy savings for a long time to come. At the same time many of the program's measures are innovative and push the energy efficiency envelope, effectively preparing the NRNC market for future code changes. Net-to-gross ratios are in an acceptable range for most measures, and for the program as a whole. The dominant role of the incentives in motivating the implementation of measures is less certain. An emerging finding is that market actors participating in the program are reporting near equal satisfaction with other aspects of the SBD program that are designed to increase energy savings at the project level and lead to market transformation, such as the design analysis offerings.

Participating building designers and owners are gaining valuable building science expertise through the program's design assistance and design analysis components, which may lead to future generations of energy efficiency infrastructure even without a NRNC program. Incentives offered by the program go further to encourage whole building design practice over 'systems' projects, aptly putting emphasis on the whole building integrated systems design philosophy.

Evaluation of Complex Building Models

The SBD sample frequently captured state-of-the-art buildings which had been designed based on complex building energy modeling. The resources which were invested in this modeling far exceed the level of investment available for the evaluation model. Study resources would be more effectively utilized by accepting the design team model rather than creating a competing energy model.

Industrial Projects

Although the aggregate net-to-gross ratio of industrial projects has improved greatly since 2002, freeridership is still prevalent in many industrial projects. Similar to previous years' evaluations, decision maker interviews uncovered industrial projects that would have been installed exactly the same absent program interaction including incentives. This was especially true of projects conceived "in-house" by the participants and were well developed before any interaction with Savings By Design representatives and consultants, rather than being a result of interaction with Savings By Design. In most cases we found these particular participants to be highly aware of the trade-offs between energy efficient and baseline equipment, including the cost differences and payback between the two