Energy Savings Calculations for selected end use technologies and existing evaluation practices in the USA

A report produced for the IEA DSM Agreement, Task 21
Harmonisation of Energy Savings Calculations

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In the IEA DSM Agreement, Task 21 Harmonisation of Energy Savings Calculations, the following countries are participating:

France,
Republic of Korea
Netherlands
Norway
Spain
Switzerland
USA

Each country prepared a report on the Energy Savings Calculations for selected end use technologies and existing evaluation practices. These reports are avaible at www.ieadsm.org

The report holds information on selected case applications. These cases are selected with a view to present information on the energy savings calculations that are or could be done for the selected end use technologies. The case applications are not selected as best practice examples, but are good examples for common practise.

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1. CASE APPLICATION[1]

1.1 Introduction

The country experts discussed during the project how an overview could be created for the methods that are used for calculating or estimating (ex-post) energy savings. It was decided to use case applications in selected technology areas and energy end-users. For this project the selection of case applications is to illustrate what is or could be used for estimating energy savings from programme or project implementations. The case applications show the practise in a participating country, without suggesting that these are 'best practises'. They are a snapshot and sometimes also one of the applications that are in use in a country, but they clearly illustrate what key elements in the energy savings calculations are, how problems in data collections are handled and how default or standard values are used.

The case applications are selected for the following technologies and energy end-users:

a. Industry; Variable Speed Drive and High Efficient motor
b. Commercial Buildings; Heating system
c. Commercial Buildings; Integrated Air conditioning system
d. Households; Retrofit wall insulation
e. Households; Lighting

The following case applications are for the USA:

- Residential Insulation Programs in California
- Upstream Lighting Programs in California
- Comprehensive Commercial Building Energy Efficiency Program in New Mexico

These case applications are presented from section 1.2 onwards with additional information in Annex B.

Each of the case applications presents the information in a common format, a template. There are four groups:

1. Summary of the program
2. Formula for calculation of annual energy savings
3. Input data and calculations of energy savings
4. Greenhouse gas savings

Additional information is provided in references, one or more annex and on definitions

The template was improved during the project, based on experiences to present the information for case applications and discussions during the experts meetings. A workshop was held in April 2011 in Korea to get feed back on the final draft of the template. During the workshop three different case applications were presented to illustrate the use of the template and to discuss future application.

In Appendix A the final version of the template with instructions is enclosed.

Additional to the case application on energy savings, in Annex C one case application on the Demand Response programme "Pricing Pilot Programme in California" is included. The

[1] Input to this portion of the report was provided on behalf of US Department of Energy by Steven Schiller

information on the Demand Response programmes is used to gain knowledge on the role energy savings play in such programs.

1.2 Residential Insulation Programs in California

In the United States there are hundreds of energy efficiency weatherization programs, most of which have some form of evaluation activities. The evaluation approaches are varied but in general follow those defined in various guidelines including the IPMVP[2] and the NAPEE Impact Evaluation Guide[3] as well as state specific guidance such as the California Energy Efficiency Evaluation Protocols[4]. This example indicates a sophisticated evaluation completed for a set of very large residential insulation programs conducted by California's investor owed utilities.

All the information, in some cases text was copied exactly, in this template report is from "Residential Retrofit High Impact Measure Evaluation Report"[5]

1 Summary of the program

1.1 Short description of the program

Three insulation programs were operated during 2006-2008 by California's three major investor owed utilities (IOUs: PG&E, SCG and SDG&E).

To qualify, attic insulation had to meet these criteria:

- The pre-retrofit insulation level was R-11 or less All materials must be new
- Insulation must be installed between conditioned living areas and unconditioned areas; garages or non-living areas do not count
- Insulation must achieve a minimum of R-30 if there is 24 inches of space between the ceiling joists and the highest peak of the roof rafters. If this space is less than 24 inches, a minimum insulation level of R-19 must be installed.

To qualify, wall insulation must meet these criteria:

- Only un-insulated walls may receive rebated insulation
- All materials must be new
- Insulation must be installed in walls that separate conditioned living areas from unconditioned areas; garages or non-living areas do not count
- Insulation must achieve a minimum of R-13

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[2] International Performance Measurement and Verification Protocol (www.evo-world.org)

[3] National Action Plan for Energy Efficiency (2007). Model Energy Efficiency Program Impact Evaluation Guide. Prepared by Steven R. Schiller, Schiller Consulting, Inc. (http://www.epa.gov/cleanenergy/documents/suca/evaluation_guide.pdf). This document is being updated and a new version is anticipated for publication during October of 2012. When published, the new version can be referenced as: "State and Local Energy Efficiency Action Network. 2012. Energy-Efficiency Program Impact Evaluation Guide. Prepared by Steven R. Schiller, Schiller Consulting, Inc. www.seeaction.energy.gov"

[4] http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/EM+and+V/

[5] Work Performed Under Contract By: The Cadmus Group, Inc (Prime Contractor) Itron, Inc. Jai J. Mitchell Analytics KEMA PA Consulting Group Summit Blue Consulting, LLC Prepared For The California Public Utilities Commission Energy Division February 8, 2010

1.1.1 Purpose or goal of the programs

The PG&E Mass Markets Program - internal program code PGE2000 - targeted single-family and multi-family residential retrofit and commercial customers, who often lack information, time, and resources to engage in energy efficiency projects. The program used PG&E staff, third-party specialists, and local government partnerships to deliver a portfolio of energy efficiency, demand-response, and distributed-generation services. It included statewide and specially targeted mass marketing efforts in PG&E's service area.

The SCG Single-Family Energy Efficient Retrofit (SFEER) Program - internal program code SCG3517 **-** sought to help residential customers reduce their natural gas usage by providing rebates to off-set the initial cost of replacing less-efficient gas-fired equipment with new energy efficient equipment. In addition, the program offered incentives for retrofit insulation and other weatherization measures. The program used an array of tactics to influence key market actors, including rebates, energy education, and outreach.

The SDG&E Residential Incentive Program (RIP)- internal program code SDGE3024 - provided the residential market with incentives to purchase high-efficiency appliances and home equipment. In addition to the traditional mail-in rebates, RIP used a point-of-sale (POS) rebate for some measures. The retailer was reimbursed from the utility for the rebate, and the customer did not have to fill out a rebate application. Customers who purchase qualifying products from a non-participating retailer had the option of a mail-in or online rebate application. This program coordinated efforts with SDG&E's education and outreach programs to inform customers of energy efficient practices for the home. The program theory posited that increased education and financial incentives for the customer induces retailers to be more inclined to stock energy efficient products.

1.1.2 Type of instrument(s) used

All three of the utility programs provided an <u>incentive</u> of $0.15 per square foot for the installation of insulation

1.2 General and specific user category

The PG&E Mass Markets Program targeted residential and commercial customers.

The SCG Single-Family Energy Efficient Retrofit (SFEER) Program targeted customers, retailers, manufacturers, distributors, and contractors. A primary goal of the SCG SFEER was to reach single-family homeowners who had not previously installed energy efficient measures.

The SDG&E Residential Incentive Program (RIP) targeted residential customers

1.3 Technologie(s) involved

The PG&E Mass Markets Program was targeted to residential and commercial retrofit.

The SCG Single-Family Energy Efficient Retrofit (SFEER) Program was targeted at replacing less-efficient gas-fired equipment. In addition, the program offered incentives for retrofit insulation and other weatherization measures.

The SDG&E Residential Incentive Program (RIP) offered rebates for appliances such as pool pumps and motors, whole-house fans, storage water heaters, attic and wall insulation, and ENERGY STAR refrigerators, central natural gas furnaces, and Room ACs.

1.4 Status of the evaluation and energy savings calculations

All of the ex-ante savings claims were based on DEER[6] version 2004–2005, although each IOU used the DEER database in a slightly different way. DEER version 2004–2005 uses the 16 climate zones defined by the California Energy Commission (CEC)[7] and building type (single-family, multi-family, etc.) to determine the expected Unit Energy Savings (UES) that will result from installation of insulation. Since the insulation measures comprised two types of insulation (attic and wall) and because program participants are located in nearly each of the 16 climate zones, the utility claims included many combinations.

The ex-ante claimed energy savings for insulation for all three programs for the period 2006-2008 are included in Annex B1.

As the ex-ante savings were based on the DEER database and savings are based on the evaluation report, the status is qualified as option 3. Semi official.

1.5 Relevant as a Demand Response measure

No

2 Formula for calculation of Annual Energy Savings

2.1 Formula used for the calculation of annual energy savings

A billing analysis was performed using a basic statistical regression approach to model the differences in customers' energy usage between pre- and post-installation periods using actual customer billing data. The models were specified using billing data, tracking data, and weather data. Each model included non-participants and participants.

The billing analysis used two ANCOVA (fixed-effects) models: Conditional Savings (CSA) and Statistically Adjusted Engineering (SAE). The use of two models provided increased confidence as the results were compared to confirm that they were reasonably consistent.

[6] The Database for Energy Efficient Resources (DEER) is a California Energy Commission and California Public Utilities Commission (CPUC) sponsored database designed to provide well-documented estimates of energy and peak demand savings values, measure costs, and effective useful life (EUL) all with one data source. The users of the data are intended to be program planners, regulatory reviewers and planners, utility and regulatory forecasters, and consultants supporting utility and regulatory research and evaluation efforts. DEER has been has been designated by the CPUC as its source for deemed and impact costs for program planning. To obtain the DEER go to: http://www.deeresources.com/ User ID: DEER; password: 2008.

[7] The CEC Climate zones can be found at www.energy.ca.gov/maps/CLIMATE_ZONES.PDF

CSA Model. This model has the following specification:
$ADC_{it} = \quad i + \beta 1 AVGHDDit + \beta 2\ POSTt + \varepsilon_{it}$

SAE Model. This model has the following specification:
$ADC_{it} = \quad i + \beta 1 AVGHDDit + \beta 2\ EE\ t + \varepsilon_{it}$

The SAE model yields the realization rate directly from the coefficient of β2.

2.2 Specification of the parameters in the calculation

Parameters in the CSA Model: for each customer i and calendar month t,

- i = a unique intercept for each participant.
- ADCit = the average daily therm consumption during the pre- and post-program periods.
- AVGHDDit = the average daily heating degree days (base 65) based on home location.
- POSTt = a dummy variable that is 1 in the post-period and 0 otherwise.
- β1 = the average daily therm consumption per heating degree day.

SAE Model. This model has the following specification:for each customer i and calendar month t,

- i = a unique intercept for each participant.
- ADCit = the average daily therm consumption during the pre- and post-program periods.
- AVGHDDit = the average daily heating degree days (base 65) based on home location.
- EEt = the average daily engineering estimate of savings in the post-period, and 0 otherwise.
- β1 = the average daily therm consumption per heating degree day.
- β2 = the average daily therm or kWh net participant realization rate. For example, a coefficient of -0.9 indicates a 90% realization rate.

2.3 Specification of the unit for the calculation

The unit for the calculation is energy savings. The object of assessment, i.e. per housing unit insulated.

2.4 Baseline issues

The baseline was established as the energy consumption prior to the installation of insulation. Impact was determined through billing analysis of energy consumption before and after the insulation measures were installed (sometimes described as a pre/post analysis).

2.5 Normalisation

Bothe models use the average daily heating degree days, so normalisation has been applied for the energy savings. The natural gas therm savings were directly calculated as annual values.

2.6 Energy savings corrections

Analyses were also conducted to determine free ridership levels and the amount of spillover. The free ridership findings were used to calculate a net-to-gross value, which was then used as a correction to gross savings. The spillover findings were used as an indicator of the program's influence on participant energy-related behavior. The verification visit information was used as an indicator of how well the program requirements were being met but were not used as a direct input for savings adjustments.

3 Input data and calculations

3.1 Parameter operationalisation

For both the CSA and the SAE model, for each customer i and calendar month t,

- i = a unique intercept for each participant.
- ADCit = the average daily therm consumption during the pre- and post-program periods.
- AVGHDDit = the average daily heating degree days (base 65) based on home location.
- β1 = the average daily therm consumption per heating degree day.

<u>Specific parameters in the CSA Model:</u>

- POSTt = a dummy variable that is 1 in the post-period and 0 otherwise.

<u>Specific parameters in the SAE Model</u>. This model has the following specification:for each customer i and calendar month t,

- EEt = the average daily engineering estimate of savings in the post-period, and 0 otherwise.
- β2 = the average daily therm or kWh net participant realization rate. For example, a coefficient of -0.9 indicates a 90% realization rate.

The SAE model yields the realization rate directly from the coefficient of β2.

3.2 Calculation of the annual savings as applied

The CSA and SAE models were used for the SCG and the SDG&E programs, as planned. The CSA model was run at the measure level and at a higher level with attic and wall insulation combined. The results were generally consistent, which indicates greater confidence in the accuracy of the results. From the various results, the evaluator selected the CSA Measure model and the average of the quartile-derived results to use as the realization rates for energy-savings calculations. The closer agreement between the overall model results for attic insulation and the average quartile was the primary factor that went into this decision. UES values for two of the utilities[8] are shown in Table 1 below.

The evaluator used the Joint Simple Self-Report Net To Gross (NTG) method, administered during the telephone survey, to determine free-ridership. Results from this analysis, shown below in Table 2, indicate a very high level of free-ridership across all three programs, significantly greater than the ex ante assumptions for free-ridership of 20% for PG&E and 11% for both SCG and SDG&E.

Table 1: Insulation Per Unit Energy Savings Claimed and Evaluated

Utility Program	Measure	Climate Zone	Vintage[82] Code	Utility Claim Per Unit Therm Savings (A)	DEER 2005 Per Unit Therm Savings	Evaluated Realization Rate from CSA Model	Evaluated Per Unit Therm Savings (B)	Difference (A-B)
SCG3517	Attic Insulation	10	3, 4	0.0313	0.0313	156.40%	0.0490	0.0177
	Wall Insulation	10	3	0.0993	0.0993	36.28%	0.0360	(0.0633)
SDGE3024	Attic Insulation	7, 10	3, 4, 5	0.0227	0.0227	166.22%	0.0377	0.0150
	Wall Insulation	7, 10	3	0.0838	0.0838	42.93%	0.0360	(0.0478)

Source: Residential Retrofit Ctract roup HIM Evaluation report: Table 91, page 111

The telephone surveys included a set of spillover questions that focused on whether the respondent purchased additional energy saving measures and the extent to which the program influenced the respondent's decision. Table 3 provides the results of those questions.

[8] the analysis for the PG&E program encountered two significant issues: the measure-tracking database was incomplete and the post-installation PG&E billing data had significant gaps. The models could not be applied.

Table 2: Net to Gross Ratio Due To Freeriders

Utility Program	Participation Year	% Free-riders (FR)	NTG (1-FR)
PGE2000	2006	71.8%	0.28
	2007	68.5%	0.32
	2008	73.6%	0.26
	Total Unweighted	71.2%	0.29
	Total Weighted (kWh)	75.4%	0.25
	Total Weighted (kW)	72.3%	0.28
	Total Weighted (Therms)	74.3%	0.26
SCG3517	2006	65.0%	0.35
	2007	68.7%	0.31
	2008	64.5%	0.36
	Total Unweighted	66.8%	0.33
	Total Weighted (kWh)	70.4%	0.30
	Total Weighted (kW)	70.5%	0.30
	Total Weighted (Therms)	70.4%	0.30
SDGE3024	2006	68.6%	0.31
	2007	75.0%	0.25
	2008	75.0%	0.25
	Total Unweighted	73.2%	0.27
	Total Weighted (kWh)	74.2%	0.25
	Total Weighted (kW)	73.7%	0.26
	Total Weighted (Therms)	74.8%	0.25

Source: Residential Retrofit Ctract roup HIM Evaluation report: Table 85, page 101

Table 3: Insulation Spillover

Utility Program	Category	Respondents Reporting Spillover
PGE2000	# of respondents reporting purchase of additional energy-efficiency measures	53
	Percent of sample	11%
	Average rating for program influence (On a scale of 1-10 where 1 is no influence and 10 is complete influence)	3.9
SCG3517	# of respondents reporting purchase of additional energy-efficiency measures	85
	Percent of sample	11%
	Average rating for program influence (On a scale of 1-10 where 1 is no influence and 10 is complete influence)	4.6
SDGE3024	# of respondents reporting purchase of additional energy-efficiency measures	87
	Percent of sample	16%
	Average rating for program influence (On a scale of 1-10 where 1 is no influence and 10 is complete influence)	3.3

Source: Residential Retrofit Ctract roup HIM Evaluation report: Table 86, page 102

Overall the evaluation resulted in lower NTG ratios then the claimed ex-ante savings, as presented in Table 4.

Table 4: NTG savings

Program	Parameter	IOU Claimed (A)	Evaluated (B)	Difference (A-B)
PGE2000	NTG Weighted (Therms)	0.80	0.26	0.54
SCG3517	NTG Weighted (Therms)	0.89	0.30	0.59
SDGE3024	NTG Weighted (Therms)	0.89	0.25	0.64

Source: Residential Retrofit Ctract roup HIM Evaluation report: Table 92, page 111

3.3 Total savings over lifetime

3.3.1 Savings lifetime of the residential insulation

For this evaluation only annual energy savings were calculated. However, for other evaluations measure life times are calculated by estimating the effective useful live of the insulation and multiplying this value times the annual savings.

3.3.2 Lifetime savings calculation of the residential insulation

N/A

4 GHG savings

4.1 Annual GHG-savings

4.1.1 Emission factor for energy source

No emission factor available, as there was no calculation of GHG savings conducted.

4.1.2 Annual GHG-savings calculation as applied

There was no calculation of GHG savings.

4.2 GHG lifetime savings

N/A

4.2.1 Emission factor

N/A

4.2.2 GHG lifetime savings as applied

References

Residential Retrofit High Impact Measure Evaluation Report; Work Performed Under Contract By: The Cadmus Group, Inc (Prime Contractor) Itron, Inc. Jai J. Mitchell Analytics KEMA PA Consulting Group Summit Blue Consulting, LLC. Prepared For The California Public Utilities Commission Energy Division, February 8, 2010 http://www.calmac.org/warn_dload.asp?e=0&id=2764

Annex

Annex B1: The ex-ante claimed energy savings for instulation for three California residential insulation programs for the period 2006-2008.

Definitions

None

1.3 Upstream Lighting Programs in California

In the United States there are hundreds of energy efficiency and demand response lighting programs, most of which have some form of evaluation activities. The evaluation approaches are varied but in general follow those defined in various guidelines including the IPMVP[9] and the NAPEE Impact Evaluation Guide[10] as well as state specific guidance such as the California Energy Efficiency Evaluation Protocols[11]. This example indicates a sophisticated evaluation completed for a set of very large upstream lighting programs conducted by California's investor owed utilities.

All the information, in some cases text was copied exactly, in this template report is from the following report: Final Evaluation Report: Upstream Lighting Program, Volume 1 CALMAC Study ID: CPU0015.01. Prepared by: KEMA, Inc. Prime Contractor: The Cadmus Group, Inc. Supported by: The Cadmus Group, Inc. Itron, Inc. PA Consulting Group Jai J. Mitchell Analytics Prepared for: California Public Utilities Commission, Energy Division, February 8, 2010

1 Summary of the program

1.1 Short description of the program

The Upstream Lighting Program was operated during 2006-2008 by California's three major investor owed utilities (IOUs) – PG&E, SCE and SDG&E. The programs – internal program codes PGE2000, PGE2080, SCE2501 and SDGE3016 - provided manufacturer and distributor buy-downs or retailer instant discounts for eligible lighting products that were then sold through participating retailers. Eligible products included screw-in CFLs, Energy Efficient Lighting Fixtures, Light-emitting diodes (LEDs).

A key difference between the IOU programs was the distribution of rebated products by retail channel, as shown in Table 1. These differences play a key role in the determination of several energy savings parameters.

The programs had both energy and demand savings goals. The evaluation was completed in 2010 with a final report published in February of 2010 and errata provided in December of 2010. Combined, the Upstream Lighting Program accounted for over half (56%) of the expected net kWh savings and 42% of the expected net kW reductions for the total statewide portfolio. Statewide annual net savings for the Upstream Lighting Program are estimated to be about 1,325 GWh and net peak demand reductions were determined to be nearly 134 MW (25% and 20% of the ex-ante estimates respectively).Screw-in CFLs account for the vast

[9] International Performance Measurement and Verification Protocol (www.evo-world.org)

[10] National Action Plan for Energy Efficiency (2007). Model Energy Efficiency Program Impact Evaluation Guide. Prepared by Steven R. Schiller, Schiller Consulting, Inc (http://www.epa.gov/cleanenergy/documents/suca/evaluation_guide.pdf) This document is being updated and a new version is anticipated for publication during October of 2012. When published, the new version can be referenced as: "State and Local Energy Efficiency Action Network. 2012. Energy-Efficiency Program Impact Evaluation Guide. Prepared by Steven R. Schiller, Schiller Consulting, Inc. www.seeaction.energy.gov"

[11] http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/EM+and+V/

majority of net savings, with 92% of net energy savings and 96% of net peak demand reductions achieved through the purchase, installation and usage of these measures.

1.1.1 Purpose or goal of the program

The goal of the program was to increase the number of energy efficient lighting.

Table 1: Distribution of Upstream Lighting Program Rebated Products by Retail Channel (2006- 2008)

Screw-in CFLs			
Retail Channel	**PG&E**	**SCE**	**SDG&E**
Discount	10%	25%	14%
Drug	13%	4%	11%
Grocery	30%	44%	32%
Hardware	6%	4%	4%
Home Improvement	8%	8%	13%
Lighting & Electronics	1%	2%	1%
Mass Merchandise	4%	5%	9%
Membership Club	28%	8%	16%
Other	0%	0%	1%
	100%	100%	100%
Energy Efficient Lighting Fixtures			
Retail Channel	**PG&E**	**SCE**	**SDG&E**
Discount	25%	45%	35%
Drug	1%	1%	0%
Grocery	4%	14%	5%
Hardware	24%	14%	37%
Home Improvement	28%	6%	6%
Lighting & Electronics	7%	5%	0%
Mass Merchandise	1%	0%	0%
Membership Club	9%	15%	17%
Other	0%	0%	0%
	100%	100%	100%
LEDs			
Retail Channel	**PG&E**	**SCE**	**SDG&E**
Discount	5%	49%	15%
Drug	3%	1%	1%
Grocery	11%	27%	56%
Hardware	7%	9%	15%
Home Improvement	0%	11%	3%
Lighting & Electronics	3%	1%	4%
Mass Merchandise	0%	3%	0%
Membership Club	70%	0%	0%
Other	1%	0%	6%
	100%	100%	100%

Source Final Evaluation Report: Upstream Lighting Program, Volume 1, Table 2, page 3

1.1.2 Type of instrument(s) used

The programs provided manufacturer and distributor buy-downs or retailer instant discounts for eligible lighting products that were then sold through participating retailers.

1.2 General and specific user category

PG&E and SCE assumed that a fraction of these products would be purchased and installed within the nonresidential sector. With the exception of a small number of LED lighting products, SDG&E assumed that 100% would be purchased and installed within the residential sector.

1.3 Technologie(s) involved

Eligible products included:

- Screw-in CFLs – All three IOUs provided rebates for basic bare spiral CFLs, as well as several types of specialty CFLs (e.g., dimmable, three-way wattage, reflector-style, A-lamp shaped, and globe-shaped).
- Energy Efficient Lighting Fixtures – All three IOUs provided rebates for hard-wired, compact fluorescent (CF) interior and exterior lighting fixtures. PG&E and SCE also offered rebates for CF torchiere lighting fixtures, and SCE provided rebates for plug-in fluorescent desk, table and non-torchiere floor lamps.
- Light-emitting diodes (LEDs) – All three IOUs also offered rebates for various types of LED lighting products:
    - LED nightlights–PG&E, SCE and SDG&E
    - LED holiday lightstrings–PG&E and SDG&E
    - LED open/close signs–SCE and SDG&E
    - LED desk/task lights–SCE and SDG&E

1.4 Status of the evaluation and energy savings calculations

Gross impacts were developed using a combination of methods, including installation rate modeling and analysis, as well as lighting logger and baseline wattage data analysis from over 1,700 sites throughout California. Net savings were developed using multiple methods and data sources ultimately relying on a preponderance of the evidence approach.

As the savings are based on the evaluation report), the status is qualified as option 3. Semi official.

1.5 Relevant as a Demand Response measure

Yes

Estimates of residential usage of lighting during peak periods were derived from the analysis of logger data collected through the Residential Lighting Metering Study. Modeling of the residential peak use was similar to that for annual hours of use (HOU), and built on the HOU analysis. Only lighting data loggers with data during the summer peak hours were used for this analysis.

2 Formula for calculation of Annual Energy Savings

2.1 Formula used for the calculation of annual energy savings

Unit energy savings (UES) estimates are the average gross energy (kWh per year) and peak demand (kW) impacts per measure. UES calculations were computed as follows for measures rebated through the Upstream Lighting Program:

- UES (kWh/year): $IR_p \times HOU_p \times \Delta W_p/1000$
- UES (peak kW): $IR_p \times CF_p \times \Delta W_p/1000$, where:

2.2 Specification of the parameters in the calculation

The parameter for the average gross energy calculationa are:

- IRp = installation rate for IOU-discounted product p
- HOU_p = annual average hours of use for IOU-discounted product p
- ΔW_p = average displaced wattage for IOU-discounted product p

The parameter for the average peak demand calculationa are:

- IR_p = installation rate for IOU-discounted product *p*
- CF_p = average percent on at peak for IOU-discounted product *p*
- ΔW_p = average displaced wattage for IOU-discounted product *p*

2.3 Specification of the unit for the calculation

The energy savings is specified per object of assessment, i.e. per lamp installed or promoted.

2.4 Baseline issues

There was no reliable method for collecting wattage data for lighting products replaced by the rebated measures. Instead, the evaluator relied on the residential lighting inventory data and the nonresidential site visits as bases for estimating delta watts. The Baseline wattage are:

- For residential CFLs, the evaluator calculated the average wattage of non-CFL equivalents by lamp shape and room type. The evaluator then averaged the room-type non-CFL wattages, weighting by the room-type distribution of CFLs of that shape.
- For nonresidential CFLs, self-report data were collected onsite to estimate the wattage of pre-existing equipment. Pre-existing wattages were estimated using regression techniques for various post-retrofit wattage categories.

Some additional details are:

- The wattage of baseline fixtures was estimated for each of the applicable fixture categories rebated through the program. The baseline for fixtures was assumed to be the same for both residential and nonresidential applications since the types of fixtures rebated implied a similar relationship between baseline and installed wattage/application.
- Baseline wattage was estimated as the average wattage in place for non-CFLs corresponding to particular lamp shapes and installed in particular room and/or fixture types. That is, for each rebated CFL product type, the average wattage of corresponding

non-CFLs was weighted by the distribution across room types for that particular CFL product type or lamp shape. For example, MSB incandescent A-line shaped lamps were weighted by the room type distribution of observed MSB twister/a-line shaped CFLs, and MSB incandescent globes were weighted by the room type distribution of observed MSB CFL globes.

- With respect to needing to adjust baseline wattages for changes in CFL saturation rates, the evaluator found no empirical evidence of decreasing replacement wattages over time for CFLs.

2.5 Normalisation

The savings were normalized to annual values for hours of operation and peak coincidence factor.

2.6 Energy savings corrections

Corrections were applied to the calculation of gross energy savings for: 1) Shipments versus sales; 2) Leakage; 3) Net versus gross savings

2.6.1 Gross-net corrections

Net to gross ratio (NTGR) estimates were developed using multiple methods that produced a range of results. The evaluator considered the validity of each method/estimate, at the channel level where available, and assessed which had the greatest validity in each case. Ultimately, the final recommended NTGR estimates represent the evaluators' best judgment based on a preponderance of evidence.

There were three primary types of methods at the core of the net savings analysis:

- Supplier and consumer self-report methods
- Econometric models (e.g., pricing/conjoint elasticity models, revealed preference purchase models, stated preference purchaser elasticity models)
- Total sales (market-based) approach

In the cases for CFL products the NTGR estimate included consideration of CFL to CFL replacements.

2.6.2 Corrections due to data collection problem

<u>Shipments Versus Sales</u>

Program tracking data included information on the quantity of lighting products rebated by the IOUs and then shipped from participating manufacturers to retailers, but it does not provide information on the actual sales of these products. Sales of the products rebated through the Upstream Lighting Program may continue to occur well after the products were shipped. Of particular interest in the 2006-2008 evaluation are IOU-discounted products that were shipped in 2006-2008, which were claimed by the IOUs as resulting in energy savings during 2006-2008, but which did not actually sell until 2009. The approach used to adjust for shipments versus sales relied on interviews with participating manufacturers, high-level retail buyers and retail store managers.

Leakage

Leakage is defined as the purchase and installation of IOU-discounted lighting products by non-IOU customers. Data from the in-store consumer intercept research was analyzed to estimate the percentage of IOU-discounted lighting products that were sold to non-IOU customers.

3 Input data and calculations

3.1 Parameter operationalisation

Three paramaters are used:

- IRp = installation rate for IOU-discounted product p
- CFp = average percent on at peak for IOU-discounted product p
- ΔWp = average displaced wattage for IOU-discounted product p

Installation Rate (IR)
For the Upstream Lighting Program, the installation rate was defined as the proportion of IOU-discounted lighting products that were installed by December 31, 2008. Installation rates were estimated for IOU-discounted products installed in both residential and nonresidential locations. Several methods were used to determine installation rates, as described below.

For energy efficient fixtures and LEDs, it was not possible to identify purchasers and assess installation rates due to the upstream nature of the program and the relatively low penetration of the IOU-discounted products in the general residential and/or nonresidential populations. Consequently, the ex-ante installation rate value of 100% was retained for fixtures and LEDs.

For determining residential installation rates, the evaluation plan proposed to estimate a set of three inter-related models from the CFL User Survey data:

1. User type diffusion model. Shows the effect of the program over time moving customers from non-users to partial users to committed users.
2. Purchase model. Relates purchases to current use and storage levels as well as program activity.
3. Installation model. Relates installations to current use and storage levels as well as program activity.

Using these models did not result in meaningful results. This is likely attributable to several reasons:

1. Customers' descriptions of their use of CFLs were not always accurate.
2. Program activity levels could not be directly mapped to purchase timing.
3. The reported changes in numbers of CFLs in use within a given survey wave were inconsistent with the changes between waves in numbers reported to be currently in use.

The approach pursued instead combined some elements of the planned modeling with some simpler estimation steps. Essentially, the evaluators constructed a trajectory from the observed CFL use and storage rates in the 2004-2005 period[12] to those observed in 2008 and 2009

[12] Based on an evaluation done of CFL programs implemented during those two years.

through this evaluation. This trajectory accounts for the flow of CFLs shipped and purchased, as well as rates of installation and replacement. The analysis relies on several sources of data and attempts to reconcile and corroborate them.

For the non-residential installation rates, initial estimates of the number of IOU-discounted, nonresidential CFL purchases were based on customer self-reports collected through telephone surveys. Site visits were used to adjust the telephone survey self- report responses, and to verify the number installed, stored, burned out, located elsewhere, etc. These site visits also collected CFL manufacturer and model numbers, which were compared to similar information contained in the program tracking data. This analysis produced installation rates for IOU-discounted CFLs purchased and installed in nonresidential locations.

Annual Hours of Operation (HOU)

Estimates of the average daily hours-of-use (HOU) for residential lighting were derived from the analysis of lighting data logger data collected through a residential lighting metering study. Nonresidential HOU values were determined using other logger data studies conducted for other evaluations.

Residential lighting HOU estimation consisted of the following steps:

1. Annualization. Because each logger collected data for only a portion of the year, a procedure was required to annualize the logger data. Annualization allows the seasonality and level of use indicated by each logger to be applied to the full year, rather than having different logger samples represent different parts of the year. Annual average HOU per day was estimated for each logger, by fitting a sinusoid curve to the daily hours of use data.
2. Weighting. Sample expansion weights were calculated for each metered home and each logger.
3. Analysis of Covariance (ANCOVA). A model was fit across the annualized loggers to calculate annual hours of use as a function of dwelling unit characteristics, room type, fixture type, lamp type, and IOU.
4. Projection to Full Inventory Sample. The estimated model was applied to each lamp observed in the full inventory of each metered home, providing an estimate of annual hours of use for each lamp in the inventory.
5. Calculation of averages. Applying the premise weights to the inventory estimates, average annual hours of use were calculated for CFLs and non-CFLs by various breakdowns, including IOU, room type, dwelling unit type, and heating/cooling type.

Table 3 illustrates the numbers of sites visited and the number of meters installed/removed in each month for each wave of metering.

Table 3: Residential Lighting Metering Study Sample Sizes by Month/Year

2008							Jul	Aug	Sep	Oct	Nov	Dec
Wave 1												
# Sites							26	191	92	118	181	15
# Meters							174	1280	622	814	1249	104
Total # Sites							**26**	**217**	**309**	**427**	**608**	**623**
Total # Meters							**174**	**1454**	**2076**	**2890**	**4139**	**4243**
2009	Jan	Febr	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wave 1												
# Sites	-26	-191	-92									
# Meters	-174	-1280	-622									
Wave 2												
# Sites					-118	-181	-15					
# Meters					-814	-1249	-104					
Wave 3												
# Sites			188	76	213	133		-24	-231		-155	-200
# Meters			1297	524	1470	918				-524	-1470	-2570
# Down-loads								291	64			
Total # Sites	**597**	**406**	**502**	**578**	**673**	**625**	**610**	**586**	**355**	**355**	**200**	**0**
Total # Meters	**4069**	**2789**	**3464**	**3988**	**4644**	**4313**	**4209**	**4500**	**4564**	**4040**	**2570**	**0**

Source Final Evaluation Report: Upstream Lighting Program, Volume 1, Table 10, page 18

Peak Coincidence Factor (CF)

Estimates of residential usage of lighting during peak periods were derived from the analysis of logger data collected through the residential lighting metering study. Nonresidential peak usage estimates were determined using other logger data studies conducted for other evaluations.

Modeling of residential peak use was similar to that for annual hours of use, and built on the HOU analysis. Only loggers with data during the summer peak hours were used for this analysis. Essentially, this was the third wave of loggers indicated in Table 3.

Steps in the process were:

1. CF calculation for each logger:
    a. Peak period fraction. For each logger, determine the fraction of daily use that falls during the peak hours 2:00 to 5:00 pm for peak weekdays.

b. Daily Use. For each logger, use the sinusoid model from the HOU analysis to calculate the daily use for each of the three days that define the DEER[13] 2008 peak day period (which is the California Public Utilities Commission) definition of peak for purposes of this evaluation), for each climate zone.
c. CF calculation. For each logger, calculate the coincidence factor or percent on at peak for each climate zone by multiplying the peak period fraction by the total hours of use for the three-day period, and dividing by nine hours.

2. Population Expansion. As for the HOU analysis, peak results are expanded to the full population by direct expansion, applying the adjusted expansion weights to the metering sample, as well as via ANCOVA modeling and leveraging of the full inventory sample. The leveraged expansion involves the same steps as for the HOU analysis.
   a. Analysis of Covariance (ANCOVA). A model was fit across the loggers to calculate percent on at peak as a function of dwelling unit characteristics, room type, fixture type, lamp type, and IOU, for each climate zone.
   b. ANCOVA Projection to Full Inventory Sample. For each lamp in the full inventory of each metered home, the ANCOVA peak model for that home's climate zone was applied, yielding an estimate of percent on at peak for each lamp in the inventory.
   c. Leveraged calculation of averages. Applying the premise weights to the inventory estimates, percent on at peak was calculated for each lamp in the inventory by various breakdowns, including IOU, room type, dwelling unit type, and heating/cooling type.

Delta Watts (ΔW)

Given the upstream nature of the program, there was no reliable method for collecting wattage data for lighting products replaced by the rebated measures. Instead, the evaluator relied on the residential lighting inventory data and the nonresidential site visits as bases for estimating delta watts:

Baseline wattage:

- For residential CFLs, the evaluator calculated the average wattage of non-CFL equivalents by lamp shape and room type. The evaluator then averaged the room-type non-CFL wattages, weighting by the room-type distribution of CFLs of that shape.
- For nonresidential CFLs, self-report data were collected onsite to estimate the wattage of pre-existing equipment. Pre-existing wattages were estimated using regression techniques for various post-retrofit wattage categories.

Installed wattage:

[13] The Database for Energy Efficient Resources (DEER) is a California Energy Commission and California Public Utilities Commission (CPUC) sponsored database designed to provide well-documented estimates of energy and peak demand savings values, measure costs, and effective useful life (EUL) all with one data source. The users of the data are intended to be program planners, regulatory reviewers and planners, utility and regulatory forecasters, and consultants supporting utility and regulatory research and evaluation efforts. DEER has been has been designated by the CPUC as its source for deemed and impact costs for program planning. To obtain the DEER go to: www.deeresources.com. User ID: DEER; password: 2008.

- For CFLs, the evaluator computed the population-weighted average wattage for IOU-discounted CFLs observed onsite. This approach was consistent for both residential and nonresidential CFLs.
- For fixtures, the evaluator computed the shipment-weighted average wattages since data were not collected onsite for either residential or nonresidential IOU-discounted fixtures.

3.2 Calculation of the annual savings as applied

The results for upstream screw-in CFLs are presented below. For fixtures and LEDs the information is available in the evaluation report. The results for all three are included in Table 4. Before determining the gross savings input the following corrections to the installations rates were applied: use of shipment (as a proxy for sales), leakages (for sales to non-IOU customers) and residential (from total including non-residential).

Shipments versus Sales

The approach used to adjust for the portion of rebated products that were shipped during the program but not sold by December 31, 2008 relied on interviews with participating manufacturers, high-level retail buyers and retail store managers. Manufacturers and retail buyers were asked to estimate the percentage of 2008 shipments that were not sold by the end of 2008, whereas retail store managers were asked to estimate the percentage of 2006-2008 shipments that were not sold by the end of 2008.

It should be noted that manufacturers were asked to estimate the percentage of the IOU-discounted CFLs shipped in 2008 that were sold by the end of 2008, but were not asked to differentiate this percentage by the various channels that they might deliver to. Therefore, the evaluator applied the same "2008 sell-through estimates" to all the channels they delivered to.

The results were weighted by shipment volume for each of the sources reporting the results. The overall results by source are:

- Manufacturers – 97% of 2008 shipments were sold by the end of 2008
- High-level retail buyers – 87% of 2008 shipments were sold by the end of 2008
- Retail store managers – 81% of 2006-2008 shipments were sold by the end of 2008

Results from all sources were fairly well aligned such that taking the average of all three sources is an appropriate method for estimating this adjustment. Therefore, the average of these three sets of results yields 88% for PG&E, 87% for SCE and 87% for SDG&E. These results were applied to shipments in 2008 only

Leakage

Leakage is defined as the purchase and installation of IOU-discounted lighting products by non-IOU customers. Data from the in-store consumer intercepts was analyzed to estimate the percentage of IOU- discounted lighting products that were sold to non-IOU customers. Results are shown in Table 5.

Table 4: Ex-post Net Annual Energy and Peak Demand Impacts from the 2006-2008 Upstream Lighting Program

All IOUs	Ex-post Net Annual Energy Impacts (kWh/yr)			Realization Rates		
	Nonresidential	Residential	Total	Nonresidential	Residential	Total
CFLs	233,553,499	991,965,497	1,225,518,996	13%	31%	24%
Fixtures	5,515,310	34,698,155	40,213,465	12%	40%	30%
LEDs	3,642,433	55,774,810	59,417,243	28%	63%	58%
All Measures	242,711,241	1,082,438,463	**1,325,149,704**	13%	32%	**25%**
All IOUs	**Ex-post Net Peak Demand Impacts (kW)**			**Realization Rates**		
	Nonresidential	Residential	Total	Nonresidential	Residential	Total
CFLs	36,921	92,832	129,753	10%	31%	20%
Fixtures	907	3,304	4,211	64%	94%	86%
LEDs	2	0	2	0%	0%	0%
All Measures	37,831	96,136	**133,966**	11%	32%	**20%**
PG&E	**Ex-post Net Annual Energy Impacts (kWh/yr)**			**Realization Rates**		
	Nonresidential	Residential	Total	Nonresidential	Residential	Total
CFLs	117,737,877	451,606,531	569,344,407	9%	26%	19%
Fixtures	1,959,136	11,360,311	13,319,447	14%	25%	22%
LEDs	1,604,310	23,328,540	24,932,850	12%	77%	58%
All Measures	121,301,323	486,295,382	**607,596,705**	9%	27%	**20%**
PG&E	**Ex-post Net Peak Demand Impacts (kW)**			**Realization Rates**		
	Nonresidential	Residential	Total	Nonresidential	Residential	Total
CFLs	19,072	41,677	60,748	8%	26%	16%
Fixtures	318	1,092	1,410	23%	104%	57%
LEDs	0	0	0	0%	n/a	0%
All Measures	19,390	42,769	**62,159**	8%	26%	**16%**
SCE	**Ex-post Net Annual Energy Impacts (kWh/yr)**			**Realization Rates**		
	Nonresidential	Residential	Total	Nonresidential	Residential	Total
CFLs	104,222,710	488,030,297	592,253,008	20%	39%	34%
Fixtures	3,298,080	21,511,148	24,809,228	10%	60%	36%
LEDs	1,619,159	25,172,084	26,791,242	n/a	72%	76%
All Measures	109,139,949	534,713,529	**643,853,478**	19%	41%	**34%**
SCE	**Ex-post Net Peak Demand Impacts (kW)**			**Realization Rates**		
	Nonresidential	Residential	Total	Nonresidential	Residential	Total
CFLs	15,935	45,038	60,973	12%	41%	26%
Fixtures	546	2,028	2,574	n/a	94%	119%
LEDs	2	0	2	n/a	0%	2%
All Measures	16,484	47,066	**63,550**	13%	42%	**26%**
SDG&E	**Ex-post Net Annual Energy Impacts (kWh/yr)**			**Realization Rates**		
	Nonresidential	Residential	Total	Nonresidential	Residential	Total
CFLs	11,592,911	52,328,670	63,921,581	n/a	19%	23%
Fixtures	258,094	1,826,696	2,084,790	n/a	30%	34%
LEDs	418,964	7,274,186	7,693,150	n/a	31%	33%
All Measures	12,269,969	61,429,552	**73,699,521**	n/a	20%	**24%**
SDG&E	**Ex-post Net Peak Demand Impacts (kW)**			**Realization Rates**		
	Nonresidential	Residential	Total	Nonresidential	Residential	Total
CFLs	1,915	6,117	8,031	n/a	22%	29%
Fixtures	42	184	226	n/a	62%	77%
LEDs	0.4	0.0	0.4	1%	n/a	1%
All Measures	1,957	6,301	**8,258**	n/a	23%	**30%**

Source Final Evaluation Report: Upstream Lighting Program, Volume 1, Table 35, page 223

Table 5: Leakage Adjustment Results

IOU	Vulnerability	Leakage Rate from Intercept Surveys	Total Shipments	Shipments Not Leaked	Shipment-Weighted Leakage Rate
PGE	Not Vulnerable	0.00%	26,013,863	26,013,863	0.45%
	Vulnerable 5-10 miles	0.00%	6,214,849	6,214,849	
	Vulnerable 0-5 miles	2.51%	7,100,045	6,921,652	
	Total		39,328,757	39,150,364	
SCE	Not Vulnerable	1.78%	12,275,842	12,057,928	4.10%
	Vulnerable 5-10 miles	4.33%	9,614,063	9,198,070	
	Vulnerable 0-5 miles	7.81%	7,148,539	6,590,475	
	Total		29,038,444	27,846,472	
SDGE	Not Vulnerable	0.40%	5,265,175	5,244,030	7.41%
	Vulnerable 0-10 miles [1]	31.71%	1,518,279	1,036,774	
	Total		6,783,454	6,280,804	

[1] Due to the relatively small sample size of stores visited and intercepts survey conducted in SDG&E's service territory, the categories of 0-5 and 5-10 miles were collapsed.

Residential versus Non-Residential

PG&E and SCE assumed that a portion of the lighting products rebated through the Upstream Lighting Program would be installed in nonresidential locations, whereas SDG&E assumed that 100% would be installed in residential locations. This residential v. nonresidential "split" was verified through this evaluation through several methods. Results from each method are indicated in Table 6.

Table 6: Intercept Survey and CFL User Survey Results for Residential/Nonresidential CFL Purchases

Intercept Survey			
IOU	Number of IOU-Discounted CFLs Purchased and Installed (2008-2009)		
	Residential	Nonresidential	Percent Residential
PG&E	400	28	93%
SCE	502	32	94%
SDG&E	113	0	100%
All IOUs	1,015	60	94%
CFL User Survey			
IOU	Number of CFLs Purchased and Installed (2006-2008)		
	Residential	Nonresidential	Percent Residential
PG&E	24,311,938	2,225,211	92%
SCE	23,285,935	5,350,556	81%
SDG&E	6,717,842	606,291	92%
All IOUs	54,315,715	8,182,058	87%

Gross Savings Inputs

The adjustments presented before, result in the following parameters for the residential customers: overall installation rate of 71%, an overall average daily HOU of 1.9 and an overall Delta Watts of 44.5. The overall Peak Conincidence Factor is 6.4%.

Table 7 presents the final residential gross savings inputs derived from this evaluation for the three IOUs and Table 8 presents similar inputs for the nonresidential sector.

Table 7: Final Gross Savings Inputs – Residential

Gross Savings Input	Source	PG&E	SCE	SDG&E	Overall
Installation Rate	Installation rate analysis, cumulative installation rate 2006-2008	67%	77%	67%	71%
Average Daily HOU					
Overall	Metering sample direct expansion, all bulbs	1.8	2.1	1.5	1.9
	Metering sample direct expansion, program bulbs	1.9	1.9	1.3	1.8
CFL Twister/A-Line	Metering sample direct expansion, program bulbs	2.0	1.9	1.4	1.9
CFL Globe	ANCOVA leveraged expansion estimate	1.4	1.7	1.3	1.5
CFL Reflector		1.7	2.2	1.4	1.9
Recommended for ex-post, all CFL types	**Metering sample direct expansion, program bulbs: PG&E, SCE, all bulbs: SDG&E**	**1.9**	**1.9**	**1.5**	**1.8**
Peak Coincidence Factor					
Overall	Metering sample direct expansion, all bulbs	5.7%	7.5%	5.4%	6.4%
	Metering sample direct expansion, program bulbs	5.8%	6.3%	3.0%	5.6%
CFL Twister/A-Line	Metering sample direct expansion, program bulbs	6.6%	6.4%	3.4%	6.2%
CFL Globe	ANCOVA leveraged expansion estimate	5.9%	7.4%	5.0%	6.3%
CFL Reflector		6.5%	7.6%	3.2%	6.5%
Recommended for ex- post, all CFL types	**Metering sample direct expansion, all bulbs, all IOUs**	**6.4%**	**6.4%**	**6.4%**	**6.4%**
Delta Watts					
Overall	Inventory sample avg non-CFL W minus inventory sample avg rebated CFL W	44.3	44.8	44.4	44.5
CFL Twister/A-line		47.2	47.8	48.9	47.7
CFL Globe		33.3	35.4	34.8	34.2
CFL Reflector		53.1	52.3	52.9	52.7

Table 8: Final Gross Savings Inputs – Nonresidential

Gross Savings Input	Source[1]	PG&E	SCE	SDG&E	Overall
Installation Rate	Nonresidential Customer Upstream CFL telephone surveys and site visits	73%	81%	76%	76%
Annual HOU	Metered sample	2,710	2,517	2,191	n/a
Peak CF	Metered sample	44%	39%	36%	n/a
Delta Watts	Pre-program avg non-CFL W estimates minus observed avg rebated CFL W	44.6	41.9	45.1	n/a

Net To Gross Analyses

NTGR estimates, based only on freeridership, were developed using multiple methods which produced a range of results and, in determining the final recommended NTGR estimates, we considered the validity of each method/estimate, at the channel level where available, and assessed which had the greatest validity in each case. The final recommended NTGR estimates represent the evaluator's best judgment based on a preponderance of evidence. See Table 9.

The net-to-gross adjustment included the proportion of existing CFLs that would be replaced by a CFL on burnout without the program. Note that if the evaluator reduced the delta watts by this proportion, they would be penalizing the programs twice for the same effect.

Table 9: Final Recommended NTGR Estimates by Channel, IOU and Overall

Channel	% of ULP Shipments	Final Recommended NTGR Estimate
Discount	16%	**0.90**
Drug	9%	**0.32**
Grocery - chain	15%	**0.31**
Grocery - small	21%	**0.90**
Hardware	5%	**0.35**
Home Improvement	8%	**0.36**
Ltg & Electronics	1%	**0.36**
Mass Merchandise	5%	**0.41**
Membership Club	19%	**0.33**
All IOUs		**0.54**
PG&E		**0.49**
SCE		**0.64**
SDG&E		**0.48**

Net Savings Estimates for Upstream Screw-In CFLs

Table 10 indicates the results of the evaluation. Note that as indicated for other data in this template, revisions to this table were submitted as part of the errata document posted on December 18, 2010. These tables do not include the errata.

Table 10: Net Savings and Realization Rates – Upstream Screw-in CFLs

		PG&E		SCE		SDG&E	
		Nonresidential	Residential	Nonresidential	Residential	Nonresidential	Residential
EX-ANTE NET KWH/YR							
CFL	Globe	n/a	n/a	2,891,651	4,847,171	n/a	3,024,562
	Reflector	n/a	n/a	8,978,220	23,138,575	n/a	12,038,664
	Twister/A-lamp	n/a	n/a	517,140,345	1,208,595,759	n/a	264,014,166
	All CFLs	1,250,100,941	1,715,558,531	529,010,216	1,236,581,505	n/a	279,077,392
EX-POST NET KWH/YR							
CFL	Globe	n/a	19,386,585	n/a	5,517,732	n/a	1,364,972
	Reflector	n/a	15,456,872	n/a	15,355,366	n/a	2,768,152
	Twister/A-lamp	n/a	416,763,073	n/a	467,157,199	n/a	48,195,545
	All CFLs	117,737,877	451,606,531	104,222,710	488,030,297	11,592,911	52,328,670

		PG&E		SCE		SDG&E	
		Nonresidential	Residential	Nonresidential	Residential	Nonresidential	Residential
EX-ANTE NET PEAK KW							
CFL	Globe	n/a	n/a	709	596	n/a	710
	Reflector	n/a	n/a	2,203	1,867	n/a	1,142
	Twister/A-lamp	n/a	n/a	126,641	106,129	n/a	25,610
	All CFLs	226,951	162,854	129,553	108,592	n/a	27,461
EX-POST NET PEAK KW							
CFL	Globe	n/a	1,789	n/a	509	n/a	160
	Reflector	n/a	1,426	n/a	1,417	n/a	324
	Twister/A-lamp	n/a	38,461	n/a	43,112	n/a	5,634
	All CFLs	19,072	41,677	15,935	45,038	1,915	6,117

	Realization Rates					
	PG&E		SCE		SDG&E	
	Net kWh/yr	Net Peak kW	Net kWh/yr	Net Peak kW	Net kWh/yr	Net Peak kW
All CFLs	19%	16%	34%	26%	23%	29%

3.3 Total savings over lifetime

3.3.1 Savings lifetime of the efficient lighting

For this evaluation only annual demand and energy savings were calculated. However, for other evaluations, measure life times are estimated by dividing the annual hours of operation into the measure lifetime as provided by manufacturers or from databases such as DEER.

3.3.2 Lifetime savings calculation of the efficient lighting

N/A

4 GHG savings

4.1 Annual GHG-savings

4.1.1 Emission factor for energy source

As there was no calculation of GHG savings part of the evaluation, no information on an emission factor is available.

4.1.2 Annual GHG-savings calculation as applied

There was no calculation of GHG savings

4.2 GHG lifetime savings

4.2.1 Emission factor

N/A

4.2.2 GHG lifetime savings as applied

N/A

References

Final Evaluation Report: Upstream Lighting Program, Volume 1, CALMAC Study ID: CPU0015.01 Prepared by: KEMA, Inc. Prime Contractor: The Cadmus Group, Inc. Supported by: The Cadmus Group, Inc. Itron, Inc. PA Consulting Group Jai J. Mitchell Analytics Prepared for: California Public Utilities Commission, Energy Division, February 8, 2010 http://www.calmac.org/publications/FinalUpstreamLightingEvaluationReport_Vol1_CALMAC_3.pdf

Advanced Lighting Baseline Study Phases 1 and 2, Pacific Gas & Electric, Southern California Edison, San Diego Gas & Electric, Prepared by KEMA, Inc. Supported by ITRON, Inc. Study ID: SCE0309 CALMAC ID: SCE0311.01, August 1, 2011 http://www.calmac.org/publications/110801_Advanced_Lighting_Baseline_Study_-_FINAL.pdf

Annex

ANNEX B2: The ex-ante energy and demand impacts for the upstream lighting programs for the period 2006-2008

Definitions

None

1.4 Comprehensive Commercial Building Energy Efficiency Program in New Mexico

In the United States there are hundreds of energy efficiency and demand response comprehensive commercial energy efficiency programs that include lighting, cooling, heating, motors, controls and other measures; most of these programs have some form of evaluation activities. The evaluation approaches are varied but in general follow those defined in various guidelines including the IPMVP[14] and the NAPEE Impact Evaluation Guide[15] as well as state specific guidance such as the California Energy Efficiency Evaluation Protocols[16]. This example indicates a basic, relatively low cost, evaluation completed for a commercial retrofit program conducted for a New Mexico investor owed utility. The program had 81 projects at 73 sites during 2009.

All the information, in some cases text was copied exactly, in this template report is from the following report: EM&V OF ENERGY EFFICIENCY PROGRAMS, Commercial Comprehensive Program Prepared for: Public Service Company of New Mexico. Prepared by: ADM Associates, Inc. 3239 Ramos Circle Sacramento, CA 95827 916-363-8383, May 2010

1 Summary of the program

1.1 Short description of the program

Public Service Company of New Mexico (PNM) implements the Commercial Comprehensive Program (CCP). The CCP offers financial incentives for electric energy-efficiency measures to qualifying commercial applicants. Funding for Commercial Comprehensive Program is provided by PNM as approved by the New Mexico Public Regulation Commission (NMPRC).

Under this program, prescriptive incentives are available for electric energy efficiency equipment upgrades and improvements including lighting, cooling, motors, refrigeration and miscellaneous measures. Incentives are provided for qualified equipment commonly installed in a retrofit or equipment replacement. The program also offers incentives for custom measures.

Data provided by PNM showed that during 2009, there were projects at 73 sites for the program, which were expected to provide savings of 10,492,981 kWh.

While not a demand response program, the CCP did have reported demand savings.

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[14] International Performance Measurement and Verification Protocol (www.evo-world.org)

[15] National Action Plan for Energy Efficiency (2007). Model Energy Efficiency Program Impact Evaluation Guide. Prepared by Steven R. Schiller, Schiller Consulting, Inc (http://www.epa.gov/cleanenergy/documents/suca/evaluation_guide.pdf) This document is being updated and a new version is anticipated for publication during October of 2012. When published, the new version can be referenced as: “State and Local Energy Efficiency Action Network. 2012. Energy-Efficiency Program Impact Evaluation Guide. Prepared by Steven R. Schiller, Schiller Consulting, Inc. www.seeaction.energy.gov"

[16] http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/EM+and+V/

1.1.1 Purpose or goal of the program

The goal of the program is to increase the number of electric energy efficiency equipment upgrades and improvements.

1.1.2 Type of instrument(s) used

Incentives.

1.2 General and specific user category

Commercial customers.

1.3 Technologie(s) involved

The program provides incentives for electric energy efficiency equipment upgrades and improvements including lighting, cooling, motors, refrigeration and miscellaneous measures. Incentives are provided for qualified equipment commonly installed in a retrofit or equipment replacement. The program also offers incentives for custom measures as e.g., LED lighting in non-exit lighting applications and energy management systems designed to link control of lighting and HVAC systems.

1.4 Status of the evaluation and energy savings calculations

The impact evaluation report was completed by ADM Associates, Inc. (ADM) and accepted by PNM and its regulator the Public Service Commission of New Mexico. So the status is qualified as option 2. official.

1.5 Relevant as a Demand Response measure

While not a demand response program, demand savings are reported.

2 Formula for calculation of Annual Energy Savings

2.1 Formula used for the calculation of annual energy savings

A wide range of formula were used for the impact evaluation. The approach for the impact evaluation had the following main features:

- Available documentation (e.g., audit reports, savings calculation work papers, etc.) was reviewed for a sample of sites, with particular attention given to the calculation procedures and documentation for savings estimates.
- On-site data collection was conducted at a sample of sites to provide the information needed for estimating savings and demand reductions.
- Gross savings were estimated using proven techniques:

- Analysis of lighting savings was accomplished using a custom-designed *Lighting Evaluation Model* with system parameters (fixture wattage, etc.) based on information on operating parameters collected on-site and, if appropriate, industry standards.
- For HVAC and Whole-Building New Construction measures, the original analyses used to calculate the expected savings were reviewed and the operating and structural parameters of the analysis were verified.
- For custom measures or relatively more complex measures, simulations with the computer simulation energy analysis model program, DOE-2, were used to develop estimates of energy use and savings from the installed measures.

2.2 Specification of the parameters in the calculation

The procedures used to estimate savings resulting from CCP projects depended on the type of measure being analyzed. The different types of measures included the following lighting measures, and HVAC measures.

The lighting measures that were examined in this evaluation study included retrofits of existing fixtures, lamps and/or ballasts with energy efficient fixtures, lamps and/or ballasts. These types of measures reduce demand, but operating hours for fixtures are the same pre- and post-retrofit.

For sites with HVAC measures, the model used in the calculations of savings was evaluated. The emphasis of the savings verification was on the Equivalent Full Load Hours (EFLH) of the affected equipment with regards to its geographical location and type of operations.

2.3 Specification of the unit for the calculation

The energy savings is specified per object of assessment, per project.

2.4 Baseline issues

For early replacement lighting retrofit measures, the baseline lamp wattage and operating hours were determined as the existing conditions. For normal replacement lighting retrofits or lighting measures in new construction applications, baselines were determined via minimum code as defined in IECC 2006 (which derives values from ASHRAE 2004).

For HVAC measures, IECC 2006 was applied across all retrofits as there were no instances of early replacement, and as with lighting, this code was used for new construction measures.

2.5 Normalisation

The annual savings determined were expanded to life-cycle values by using project measure life estimates. ADM obtained effective useful life (EUL) values from the California DEER 2008 database[17].

2.6 Energy savings corrections

[17] http://www.energy.ca.gov/deer/

Corrections using a net to gross savings factor were applied to the calculation of gross energy savings. Analysis of net savings focused on four main aspects of free-ridership:

1. Financial ability;
2. Prior planning;
3. Importance of the rebate in the decision making process; and
4. Likelihood of equipment installation without rebate.

These four aspects were addressed in the telephone surveys, with questions asked about each of the four elements. Based upon the answers to the questions, the respondents are placed in Free-Ridership Terciles, with scores of 0%, 33%, 67%, and 100% Free-Ridership. The scoring is based upon all possible interactions between the four questions. Part 1 of free-ridership, Financial Ability, essentially serves as a gateway; if it does not equal "Yes" then other aspects of free-ridership are irrelevant.

Table 3: Free-Ridership Scoring

Financial Ability	***Prior Planning***	***Rebate Was Important***	***Likely to Install w/o Rebate***	***Aggregated Category***	***Free-Ridership Score***
Y	N	N	Y	YNNY	.67
Y	N	N	N	YNNN	.33
Y	N	Y	Y	YNYY	.33
Y	N	Y	N	YNYN	0
Y	Y	N	Y	YYNY	1
Y	Y	N	N	YYNN	.67
Y	Y	Y	Y	YYYY	.67
Y	Y	Y	N	YYYN	.33
N	N	N	Y	NNNY	0
N	N	N	N	NNNN	0
N	N	Y	Y	NNYY	0
N	N	Y	N	NNYN	0
N	Y	N	Y	NYNY	0
N	Y	N	N	NYNN	0
N	Y	Y	Y	NYYY	0
N	Y	Y	N	NYYN	0

3 Input data and calculations

3.1 Parameter operationalisation

The procedures used to estimate savings resulting from CCP projects depended on the type of measure being analyzed.

<u>Lighting Measures Calculations</u>

The lighting measures that were examined in this evaluation study included retrofits of existing fixtures, lamps and/or ballasts with energy efficient fixtures, lamps and/or ballasts. These types of measures reduce demand, but operating hours for fixtures are the same pre- and post-retrofit.

Analyzing the savings from such lighting measures required data for retrofitted fixtures on three parameters: (1) wattages before and after retrofit, (2) hours of operation before and after the retrofit and (3) number of fixtures affected by the measure. The PNM documentation file was reviewed for these parameters.

The fixture wattages as claimed in the documentation were verified against existing databases and industry sources based on the rated power of the original lamps. These claimed wattages were used for the purpose of calculations unless they deviated significantly from published databases or manufacturers' claims. The hours of operations were also evaluated for the type of facility and functionality of the areas where the measures were installed.

For the sites chosen for site visits, the three parameters listed above were verified during the onsite visit. An interview was conducted with the facility personnel to verify the operating hours and determine the areas where the measures were applied. In general, the operating hours provided by facility personnel correlated very well with the hours originally provided during incentive application. The field engineer then collected the lamp information and count of fixtures, including the quantity of fixtures affected by lighting control systems such as motion sensors and daylighting control.

During the visit, the field staff also installed time-of-use loggers to obtain some important items of data needed for the analysis of energy savings. These loggers monitored the hours of operation as the basis for calculating lighting efficiency allowed the calculation of kWh usage according to peak/off-peak periods. The loggers sense when a fixture is on by detecting the light emitted from a fixture when it is operating.

HVAC Measures Calculations

For sites with HVAC measures, the model used in the calculations of savings was evaluated. The emphasis of the savings verification was on the Equivalent Full Load Hours (EFLH) of the affected equipment with regards to its geographical location and type of operations.
For the projects whereby the energy savings calculations were modeled using DOE-2 or other simulation models, the input values and assumptions made for the model were analyzed and verified. In the event that no modeling information was available, ADM contacted the engineering firms to obtain more information for the site in question and then ADM performed simulation using building simulation software. Simulation models were calibrated using current-year weather data for Albuquerque or Santa Fe NM (where appropriate). When extrapolating annual kWh savings, Typical Meteorological Year (TMY) data for the appropriate region was applied, as this provides a better estimate of what annual savings would be on average over the life of the measure.

The facility inspection and verification was focused primarily on the proper installation of equipment and operating hours from interview with the site contact. The characteristics for the equipment installed were also verified. For example, where a VFD was installed on supply fans, data on the operating parameters of the motor were obtained, and it was verified that the VFD was fully functional at the time of inspection. For projects where additional control components were added, the programming inputs were checked and verified to make sure that they were consistent with those provided in the original calculations.

For sites where HVAC or custom VFD measures had been installed, monitoring was conducted to obtain more accurate information on the hours of operation for the equipment. The HVAC and Custom VFD monitoring data have been used to verify that the VFD is functioning as designed (exhibiting fluctuations based on changing input conditions). In most cases, the data have not been used to perform the savings calculations because the two-week data may not reflect the operation of the HVAC system year round. Instead, saving calculations rely more on energy simulation based on the operating parameters collected year round (such as building schedule, construction and occupancy). It should be noted that in general, a large majority of the Custom VFD projects involve HVAC applications. All monitored Custom VFD projects involved HVAC applications.

3.2 Calculation of the annual savings as applied

A wide range of formula were used for the impact evaluation. In the impact evaluation a documentation review and a on site visit were conducted.

After the sample of sites was selected, PNM and its implementation contractor provided documentation on the energy efficiency projects undertaken at these sites. The first step in the evaluation effort was to review this documentation and other program materials that were relevant to the evaluation effort. For each site, the available documentation (e.g., audit reports, savings calculation work papers, etc.) for each rebated measure was reviewed, with particular attention given to the calculation procedures and documentation for savings estimates. Documentation that was reviewed for all sites selected for the sample included program forms, data bases, reports, billing system data, weather data, and any other potentially useful data. Each application was reviewed to see whether the following types of information had been provided:

- Documentation for the equipment changed, including (1) descriptions, (2) schematics, (3) performance data, and (4) other supporting information
- Documentation for the new equipment installed, including (1) descriptions, (2) schematics, (3) performance data, and (4) other supporting information
- Information about the savings calculation methodology, including (1) what methodology was used, (2) specifications of assumptions and sources for these specifications, and (3) correctness of calculations

On-site visits were used to collect data that were used in calculating savings impacts. The on-site visits to the sampled sites were used to collect primary data on the facilities participating in the program.

During an on-site visit, the evaluation field staff accomplished three major things. First, they verified the implementation status of all measures for which customers received incentives. They verified that the energy efficiency measures were indeed installed, that they were installed correctly and that they still functioned properly. Second, they collected the physical data needed to analyze the energy savings that have been realized from the installed improvements and measures. Data were collected using a form that was prepared specifically for the project in question after an in-house review of the project file. Third, they interviewed the contact personnel at a facility to obtain additional information on the installed system to complement the data collected from other sources.

At some sites, monitoring was conducted to gather more information on the operating hours of the installed measures. Monitoring was conducted at sites where it was judged that the monitored data would be useful for further refinement and higher accuracy of savings calculations. Monitoring was not considered necessary for sites where project documentation allowed for sufficiently detailed calculations.

Gross savings were estimated using proven techniques. Analysis of lighting savings was accomplished using a custom-designed Lighting Evaluation Model with system parameters (fixture wattage, etc.) based on information on operating parameters collected on-site and, if appropriate, industry standards. For HVAC and Whole-Building New Construction measures, the original analyses used to calculate the expected savings were reviewed and the operating and structural parameters of the analysis were verified. For custom measures or relatively more complex measures, simulations with the computer simulation energy analysis model program, DOE-2, were used to develop estimates of energy use and savings from the installed measures.

The sample design for the evaluation of the program was developed based upon tracking data provided by PNM after completion of the 2009 program year. The design variable used in developing the sampling plan was ex-ante gross kWh savings. Sample strata were defined by applying the Dalenius-Hodges stratification procedure to the data on ex ante kWh savings. The efficacy of different allocations of sample points across strata was examined by considering the precision with which total kWh savings could be estimated at the 90% confidence level, with 10% precision being the target.

The distribution of kWh savings for projects in the program was highly skewed, with the projects with the largest savings, at over 210,000 kWh per year each, accounting for a relatively small percentage of the total number of projects but for much higher percentages of the total program-level savings. All of these project sites were included in the sample. In total, the sample sites account for approximately 77% of the total program expected energy savings.

Table 2 provides the estimate project energy savings and peak demand savings as well as the realization rates (comparison of reported versus evaluated savings). NTGR was 75.3% and applied equally to all projects, which may over and/or underestimate some technologies

Table 2: Program Gross and Net Annual Savings

Savings	***Peak Demand Savings, kW***		***Annual Energy Savings, kWh***	
	Ex Ante	***Ex Post***	***Ex Ante***	***Ex Post***
Gross Savings	1,890	1,966	10,492,981	8,914,348
Net Savings	1,388	1,055	8,422,135	6,707,095

3.3 Total savings over lifetime

3.3.1 Savings lifetime of the measures

The measure lifetimes were derived from California DEER 2008 values.

3.3.2 Lifetime savings calculation of the measure or technique

Measure lives were estimated to prepare the follow lifetime savings estimates, with measure lives derived from California DEER 2008 values.

Table 3: Program Gross and Net Lifetime Savings

Savings	***Lifetime Energy Savings, kWh***	
	Ex Ante	***Ex Post***
Gross Savings	104,478,913	93,651,054
Net Savings	87,469,297	70,454,329

4 GHG savings

4.1 Annual GHG-savings

4.1.1 Emission factor for energy source

No emission factor available, as there was no calculation of GHG savings conducted.

4.1.2 Annual GHG-savings calculation as applied

There was no calculation of GHG savings.

4.2 GHG lifetime savings

4.2.1 Emission factor

N/A

4.2.2 GHG lifetime savings as applied

N/A

References

EM&V OF ENERGY EFFICIENCY PROGRAMS, Commercial Comprehensive Program, Prepared for: Public Service Company of New Mexico. Prepared by: ADM Associates, Inc., 3239 Ramos Circle, Sacramento, CA 95827, 916-363-8383. May 2010. Not available at the internet

Best Practices for Evaluation of Efficiency Programs for New Mexico, The National Association of Regulatory Utility Commissioners, January 2011 http://www.naruc.org/Publications/SERCAT_New_Mexico_2010.pdf

Annex

None

Definitions

None

2. EVALUATION PRACTISE

2.1 Introduction

2.2 National Evaluation guidelines, guides and selected reports on evaluations and energy savings calculations

While the case applications, as presented in chapter 1, are strongly influenced by the rules imposed by the individual state regulatory commissions, in the United States the evaluation approaches in general follow those defined in various guidelines including the IPMVP and the NAPEE Impact Evaluation Guide as well as state specific guidance such as the California Energy Efficiency Evaluation Protocols. Also there are actions in the Northeast of the USA (from Maine to New Jersey) on common state-wide guidelines. Most information is accessible on the internet. For example. the Consortium for Energy Efficiency (CEE) has on their site http://www.cee1.org/eval/eval-res.php3 an overview document "Energy Efficiency Program Evaluation: A guide to the Guides" that is among others used as input for this chapter. Other resource lists are at:

- www.emvwebinar.org
- http://neep.org/emv-forum
- http://www.calmac.org/search.asp
- www.iepec.org

2.2.1 List of guidelines

We restrict us on two important national-level documents about energy efficiency program impact evaluation with a national scope, both released in 2007:

- DOE/EERE's Impact Evaluation Framework for Technology Deployment Programs and
- National Action Plan for Energy Efficiency's Model Energy Efficiency Program Impact Evaluation Guide.

Both documents are complementary in their approaches and scope, and together provide a fairly comprehensive overview of impact evaluation for all types of program approaches.

The *Impact Evaluation Framework for Technology Deployment Programs*[18] is based on the premise that "identifying the linkages between outputs and outcomes"—that is, how what the program does (its activities or "outputs") are translated by partners and target audiences into actions that produce a variety of impacts or "outcomes," including but not limited to energy and demand impacts—"is one of the most critical and most difficult problems in program evaluation." To help managers and evaluators address this problem, it provides specific tools to use in identifying the linkages between program activities or outputs and the resulting impacts or outcomes. Identifying these linkages helps to clarify and prioritize what should be

[18] The term "technology deployment programs" is used instead of "energy efficiency programs." because the document is meant to provide guidance on evaluating clean energy programs and renewables programs as well as efficiency programs. For efficiency program evaluation purposes, however, this language can simply be interpreted as energy efficiency programs.

measured in the evaluation, thus enabling evaluators to apply with greater effectiveness the more technically oriented measurement and analysis tools presented in guides.
The identification of outputs, outcomes, and the linkages among them also helps to separate program-induced impacts from the same effects that may be generated by other factors. The ability to separate program-induced impacts from other factors will become increasingly important as more players enter the field in which ratepayer funded energy efficiency programs used to play alone, offering messages, programs, or services designed to reduce energy use for a variety of different reasons.

The *Model Energy Efficiency Program Impact Evaluation Guide* provides technical guidance for calculating energy and demand savings and avoided emissions from energy efficiency programs via a set of practical processes and methodologies. It focuses on evaluation specifically for program approaches relying primarily on direct energy savings. It lays out clearly the steps involved in selecting the appropriate measurement and analysis approach for the program and evaluation goals. This includes, but may not be limited to, the use of billing analysis, deemed savings, and project- or facility-level data collection, monitoring and analysis (M&V). It also provides important context and background for implementing the International Performance Measurement and Verification Protocol (IPMVP) as part of evaluation. It provides some basic approaches to including limited market effects measurement in impact evaluation for the calculation of net savings.

This document is being updated and a new version is anticipated for publication during October of 2012. When published, the new version can be referenced as: "State and Local Energy Efficiency Action Network. 2012. Energy-Efficiency Program Impact Evaluation Guide. Prepared by Steven R. Schiller, Schiller Consulting, Inc. http://www.seeaction.energy.gov" http://www1.eere.energy.gov/seeaction/

Another source of more detailed impact information is the U.S. DOE's Uniform Methods Project (UMP), which provides model evaluation plans for specific energy-efficiency measures and project categories. These UMP documents provide additional information and specific examples that apply the concepts presented in this guide and include examples of the three impact evaluation approaches presented in the following sections. Information on UMP is available at http://www1.eere.energy.gov/office_eere/de_ump.html

2.2.2 Lists of guides

California has a long history on investor-owned utilities' (IOUs) energy efficiency programs and evaluations of such programs. We restrict us to the following to guidance provided in two documents (more reports are included in section 2.2.3):

- California Energy Efficiency Evaluation Protocols (2006) and
- The California Evaluation Framework (2004).

The *California Energy Efficiency Evaluation Protocols: Technical, Methodological and Reporting Requirements for Evaluation Professionals* are designed to meet California's evaluation objectives and has to be used to guide the efforts associated with conducting evaluations of California's energy efficiency programs and program portfolios launched since 2006. The Protocols are the primary guidance tools policy makers will use to plan and structure evaluation efforts and that staff of the California Public Utilities Commission's Energy Division (CPUC-ED) and the California Energy Commission (CEC) and are also the primary guidance documents for evaluation contractors.

It includes a separate Protocol for each of the following categories:

- Impact Evaluation - Direct and Indirect Effects
- Measurement and Verification
- Process Evaluation
- Market Effects Evaluation
- Codes and Standards Program Evaluation
- Emerging Technology Program Evaluation
- Sampling and Uncertainty Protocol (for use in determining evaluation sampling approaches)
- Reporting Protocol (to guide evaluation data collection and reporting)
- Effective Useful Life Protocol (used to establish the period over which energy savings can be relied upon)

The *California Evaluation Framework* provides a comprehensive set of guidelines for conducting evaluations of California's energy efficiency programs. The framework provides recommendations for conducting impact evaluations and describes evaluation methodologies. It presents guidelines for evaluation sample design and statistical analysis. Most of the information was used for the Evaluation Protocols as mentioned ahead.

Since the mid 2000s the Northeast Energy Efficiency Partnerships (NEEP) is active developing common protocols for energy efficiency savings in the Northeast of the USA[19]. This resulted among others in 2010 in two interesting guidelines:

- Common statewide energy efficiency reporting guidelines and
- Regional EM&V methods and savings assumptions guidelines.

The intent of *Common statewide energy efficiency reporting guidelines* is to provide for consistent definitions and the reporting of electric and natural gas energy-efficiency program energy and demand savings and associated costs, and their emission and job impacts across the region. It includes recommended state-level reporting templates and several process recommendations.

The intent of *Regional EM&V methods and savings assumptions guidelines* is to provide clarity, transparency, and a common understanding of methods to consider in determining gross energy and demand savings, and savings assumptions for a priority set of energy efficiency program/project types or measures. They are presented in the format of cross-cutting recommendations that are applicable to fourteen measures/programs (covering topics such as rigor, site inspections and measure life determination), and in the form of measure specific recommendations. The Guidelines recommend basic EM&V methods, and alternative or additional approaches for conducting EM&V.

As a follow up of this report in 2011 the Mid-Atlantic Technical Reference Manual (TRM) Version was published. It documents in detail common savings assumptions for approximately fifty prescriptive residential and commercial/industrial electric and gas energy efficiency measures for use in program planning and calculation of program savings. It is one of the few TRMs in the country to serve a multi-jurisdictional audience.

[19] New England, New York, New Jersey, Maryland, Delaware, and the District of Columbia.

FEMP M&V Guidelines. The purpose of this document is to provide guidelines and methods for measuring and verifying the savings associated with federal agency performance contracts. It contains procedures and guidelines for quantifying the savings resulting from energy-efficiency equipment, water conservation, improved operation and maintenance, renewable energy, and cogeneration projects. Along with the FEMP M&V Guidelines are several useful companion documents. Reference: U.S. Department of Energy (2000). M&V Guidelines: Measurement and Verification for Federal Energy Projects. Version 3.0 http://mnv.lbl.gov/keyMnVDocs

ASHRAE Guideline 14 Measurement of Energy and Demand Savings. ASHRAE is the professional engineering society that has been the most involved in writing guidelines and standards associated with energy efficiency. Compared to the FEMP M&V Guidelines and the IPMVP, Guideline 14 is a more detailed technical document that addresses the analyses, statistics, and physical measurement of energy use for determining energy savings. Reference: American Society of Heating, Refrigerating, and Air-Conditioning Engineers (2002). A new version is expected to be available in 2013. www.ashrae.org.

ASHRAE Performance Measurement Protocols (PMP) for Commercial Buildings. These provide a standardized, consistent set of protocols for facilitating the comparison of measured energy, water and indoor quality performance of commercial buildings. www.ashrae.org

2.2.3 Selected reports and websites

Selected reports

2007 NAPEE Model Energy Efficiency Program Impact Evaluation Guide.
www.epa.gov/cleanrgy/documents/evaluation_guide.pdf

2007 Federal Energy Management Program M&V Guide.
http://ateam.lbl.gov/mv/

2006 California Energy Efficiency Evaluation Protocols:
http://www.calmac.org/publications/EvaluatorsProtocols_Final_AdoptedviaRuling_06-19-2006ES.pdf

2004 The California Evaluation Framework.
http://www.calmac.org/publications/California_Evaluation_Framework_June_2004.pdf

2007 US DOE Impact Evaluation Framework for Technology Deployment Programs.
http://www.eere.energy.gov/ba/pba/km_portal/docs/pdf/2007/impact_framework_tech_deploy_2007_main.pdf

2006 US DOE Guide for Managing General Program Evaluation Studies.
http://www1.eere.energy.gov/ba/pba/pdfs/evl_mg_app.pdf

2007 Model Energy Efficiency Program Impact Evaluation Guide:
http://www.epa.gov/cleanenergy/documents/suca/evaluation_guide.pdf

2011 MID-ATLANTIC TECHNICAL REFERENCE MANUAL, VERSION 2.0
http://neep.org/uploads/EMV%20Forum/EMV%20Products/A5_Mid_Atlantic_TRM_V2_FINAL.pdf

Selected websites

Information on programs within the framework of the National Action Plan for Energy Efficiency and the State and Local Energy Efficiency Action Network (SEE Action): http://www.epa.gov/cleanenergy/energy-programs/suca/resources.html and http://www1.eere.energy.gov/seeaction/

CALifornia Measurement Advisory Council (CALMAC): www.calmac.org

The Consortium for Energy Efficiency's Market Assessment and Program Evaluation (MAPE) Clearinghouse: www.cee1.org/eval/clearinghouse.php3

Northeast Energy Efficiency Partnerships (NEEP): http://neep.org/emv-forum/emv-library

Northwest Energy Efficiency Alliance: http://www.nwalliance.org/research/evaluationreports.aspx

California DEER Database: http://eega.cpuc.ca.gov/deer

2.3 Use of international guidelines and guidance

2.3.1 List of guidelines

There are no international guidelines in use for energy savings calculations.

2.3.2 List of guides

The IPMVP, a product of the Efficiency Valuation Organization, is a set of framework documents used to develop strategies and plans for quantifying energy and water savings at the project level—that is, in individual facilities or groups of facilities—for retrofits and new construction. This document is referred to Model Energy-Efficiency Program Impact Evaluation Guide described above.

The IPMVP describes appropriate approaches to selecting facilities for measurement and verification (M&V); measuring and verifying equipment installation and usage; monitoring indoor environmental quality under different circumstances; and addressing how to quantify avoided emissions from facilities and projects.

The International Standards Organization entered the world of energy management with the release of ISO 50001 - Energy Management Systems. This protocol includes the following:

- ISO 50001:2011 specifies requirements for establishing, implementing, maintaining, and improving an energy management system, whose purpose is to enable an organization to follow a systematic approach in achieving continual improvement of energy performance, including energy efficiency, energy use, and consumption.
- ISO 50001:2011 specifies requirements applicable to energy use and consumption, including measurement, documentation and reporting, design, and procurement

practices for equipment, systems, processes, and personnel that contribute to energy performance.

- ISO 50001:2011 applies to all variables affecting energy performance that can be monitored and influenced by the organization. ISO 50001:2011 does not prescribe specific performance criteria with respect to energy.
- Subsequent to the release of 50001, ISO created a technical committee (TC242) to support the deployment of ISO 50001. In January 2011, the ISO Technical Management Board announced the creation of another committee to create standards on measuring and verifying savings—TC 257 Energy Savings. Any standards originating from TC 242, TC 257, or the joint working group are expected to provide broad guidance on M&V principles in 2012 or 2013.

2.3.3 Selected reports

2007 International Performance Measurement and Verification Protocol (IPMVP).
www.evoworld.org

3. STANDARDS RELATED TO ENERGY SAVINGS CALCULATIONS

3.1 Introduction

There are no national standards on energy savings calculations. But there is ASHRAE's guideline 14-2002 for measurements of energy and demand savings. There are also Building or Energy Codes for minimum standards for buildings in USA states and state and federal appliance standards that can be used for setting baselines.

3.2 National EM&V standards

The ASHRAE's guideline 14-2002 for measurements of energy and demand savings is intended to be a guideline that provides a minimum acceptable level of performance in the measurement of energy and demand savings from energy management projects applied to residential, commercial or industrial building. It is intended to be applied to an individual building, or a few buildings, but large scale energy conservation programs are not addressed.

ASHRAE Guideline 14 is being updated and a new version is expectedin 2013.

3.3 Developments on building and appliance standards

3.3.1 Ongoing and expected developments

More and more states are switching from the state-developed Energy Code to the nationally-developed International Energy Conservation Code (IECC). The IECC is a building code created by the International Code Council in 2000 and now holds the 2009 and 2012 version for use in States. It is a model code adopted by many state and municipal governments in the United States for the establishment of minimum design and construction requirements for energy efficiency. In this process States and regions get much stronger interest in the development of the IECC than they had previously. In the period 2013-2015 the 2015 code development process will take place.

A large number of States hold Energy Codes for minimum standards for buildings or Building Energy Efficiency Standards. The purpose of these codes is to provide minimum standards for new or altered buildings and structures or portions thereof to achieve efficient use and conservation of energy.

The California Energy Commission istarting a process to adopt changes to the Building Energy Efficiency Standards contained in the California Code of Regulations (CCR), also known as the California Energy Code. The proposed amended standards will be adopted in 2014. Other states are also invovled in code development and updates – see http://aceee.org/topics/building-codes and https://www1.eere.energy.gov/buildings/appliance_standards/.

3.3.2 Comments on (draft) international standards

The USA is involved in the ISO/TC 257. In 2011 the International Organisation for Standardisation (ISO) started follow-up work on energy savings and installed a Task

Committee, **ISO/TC 257** dealing with "General technical rules for determination of energy savings in renovation projects, industrial enterprises and regions". Workgroups are preparing draft documents to be discussed in meetings in the coming years.

3.4 Relevant organisations

The USA DOE is involved in the work for international standardisation (ISO), while States organizations are responsible for regional codes, like the Energy Codes.

Annex A: Template Energy Savings Calculation, with instructions, for case examples in IEA-DSM Task XXI

Frontpage:
Case application: [Name, including technology and user category]
Country: [Name]
Author(s): [Name]
Date and version: [day month year] [only full numbers of version]

Page 1

1 Summary of the program

1.1 Short description of the program

1.1.1 Purpose or goal of the program

[Also include the period the program was running or when it started.]

1.1.2 Type of instrument(s) used

[Please indicate the type of instrument used. E.g. financial support, subsidize, label and standard, agreements, tax reduction]

1.2 General and specific user category

[Please by a specific as possible. Make a clear distinction between households, industry, services (commercial and non-commercial. If more users are targeted, please give some specification, especially if formulas would be different for different user categories.]

1.3 Technologie(s) involved

[Present the technology or technologies; please clarify in case a not well-known technology is used]

1.4 Status of the evaluation and energy savings calculations

[Provide information whether the energy savings calculations are used in an evaluation report. Include references and source in the Annex]

[Provide information whether the energy savings calculations itself have been evaluated. Include references and source in the Annex]

[Use one of the following options to qualifiy the status: 1. Legal; 2. Official stamped; 3. Semi official; 4. Use in practice; 5. Under development; 6. Under research)

1.5 Relevant as a Demand Response measure

[Indicate when the case is relevant for DR; if so refer to the separate DR case application description]

2 Formula for calculation of Annual Energy Savings

2.1 Formula used for the calculation of annual energy savings

[Short introduction and provide information on the origin of the formula; please use one of the three options:

- an existing formula (give reference; also in reference list in Annex the traceable source), or
- an adapted version of an existing formula; please describe adaptations in short and give reference for the original formula (also in reference list in Annex the traceable source), or
- self developed (short description; present additional documentation in Annex)]

[Present the formula]

2.2 Specification of the parameters in the calculation

[Provide information on the parameters and the reasoning of selecting those paramaters]

2.3 Specification of the unit for the calculation

[The most common units are: an object of assessment; an action or an energy end-user]

2.4 Baseline issues

[Brief description which type of baseline is used in the energy savings calculations. The most commonly used types are:

a. before situation; evaluate the measure against the technique used before
b. stock average; evaluate the measure against the average stock technique
c. market average; evaluate the measure against the average technique on the market
d. common practice; evaluate the measure against the most commonly used technique]

[Describe whether a static or a dynamic baseline is used.
The before situation is always a static baseline. The other methods can be either static (using the values of a base-year or base period) or dynamic (changing over time, for example reflecting the change in most commonly used techniques)]
[Specify if a combination of approaches is used]

[Describe the important assumptions and the reasoning of the choice]

2.5 Normalization

[Normalization is a way to adjust the data in line with a normal situation; most common this is normalization for degree heating or cooling days.]
[Please describe briefly and give sources / references for the normal situation].

2.6 Energy savings corrections

2.6.1 Gross-net corrections

[Specify which (gross to net) corrections have been applied and how these are calculated. Please be clear in the corrections taken into consideration and used to correct.
[The most common categories are: a) double counting; b) free riders; c) technical interactions; d) spillover effects and e) rebound effect]

2.6.2 Corrections due to data collection problem

[Specify which corrections have been applied to handle imperfect data collections e.g. using sales data as a proxy for installation data, using a secondary data source for a bigger region than the region a programme is implemented]

3 Input data and calculations

3.1 Parameter operationalisation

[Describe how the calculation parameters are obtained; both for actual and reference situation.]

[Please also clearly indicate what type of values is used:
a) deemed (rough approximations, expert opinions, etc.)
b) calculated (for example using survey data)
c) measured (for example real measurements taken, billing information, etc.)
d) combination]

3.2 Calculation of the annual savings as applied

[Present the calculation with the values used. Please provide the data is several steps as this improves transparency and understanding]

3.3 Total savings over lifetime
3.3.1 Savings lifetime of the measure or technique selected

[Present information on the lifetime used. Also indicated whether this is an economical lifetime or not.]
[Present the number of years and the source for this value; include the reference in the Annex]

3.3.2 Lifetime savings calculation of the measure or technique

[Present the formula and the conducted calculation. In most cases this will be the outcome of 3.3.1 multiplied with the lifetime years. Please clarify if the energy savings calculated are not the same in all years. Explain if this is the case.]

4 GHG savings

4.1 Annual GHG-savings
4.1.1 Emission factor for energy source

[Present the emission factor used and give reference; included the source in the appendix.]
[Please specify what GHG emissions are included in the calculation: CO_2; CH_4 or N_2O]

4.1.2 Annual GHG-savings calculation as applied

[Present the formula as well as the calculation]

4.2 GHG lifetime savings

4.2.1 Emission factor

[Present the emission factors used when not the same factor is used for the lifetime, and give reference; included the source in the appendix. Otherwise include: The same GHG emission factor(s) are used for the lifetime.]

4.2.2 GHG lifetime savings as applied

[Present the formula as well as the calculation]
[The lifetime should be the same as for the energy savings; if not please clarify]

References

[Please use: Report title, Author, year and if applicable the website]

Annex

[Present in the Annex additional information on methods, data sources etc. to elaborate the data, formulas etc]
[If no or no clear energy savings calculations is used in the case application, but a method could be used, please describe this in an Annex]

Definitions

Annex B1: The ex-ante claimed energy savings for insulation for three California residential insulation programs for the period 2006-2008.

Utility Program	Program Year	Measure	Measures Installed (Sq. Feet)	Assumed NTG	Claimed Per Unit Therm Savings (Therms/Square Foot)	Total Claimed Net Therm Savings	Total Claimed Net kWh Savings	Total Claimed Net kW Savings	Percent of Claimed Gas Savings
PGE2000	2006	Attic Insulation	4,891,551	0.80	0.02	85,052	176,584	515	0.13%
		Wall Insulation	1,395,342	0.80	0.146	162,645	238,484	340	0.25%
	2007	Attic Insulation	6,403,844	0.80	0.023	118,205	253,298	708	0.18%
		Wall Insulation	1,727,563	0.80	0.148	204,866	301,910	444	0.31%
	2008	Attic Insulation	7,045,058	0.80	0.030	168,451	383,511	1,030	0.25%
		Wall Insulation	2,084,799	0.80	0.149	249,147	364,998	548	0.38%
	Total	Attic Insulation	18,340,453	0.80	0.025	371,708	813,393	2,252	0.56%
		Wall Insulation	5,207,704	0.80	0.148	616,658	905,392	1,332	0.93%
	Total PGE2000		**23,548,157**	**0.80**	**0.052**	**988,366**	**1,718,785**	**3,585**	**1.49%**
SCG3517	2006	Attic Insulation	2,909,184	0.89	0.031	81,124	422,167	258	0.12%
		Wall Insulation	1,179,252	0.89	0.099	104,193	434,399	194	0.16%
	2007	Attic Insulation	4,991,812	0.89	0.031	139,200	724,388	443	0.21%
		Wall Insulation	2,062,323	0.89	0.099	182,217	759,694	340	0.27%
	2008	Attic Insulation	5,022,757	0.89	0.031	140,063	728,879	446	0.21%
		Wall Insulation	2,040,074	0.89	0.099	180,251	751,499	336	0.27%
	Total	Attic Insulation	12,923,753	0.89	0.031	360,387	1,875,434	1,148	0.54%
		Wall Insulation	5,281,649	0.89	0.099	466,662	1,945,592	871	0.70%
	Total SCG3517		**18,205,402**	**0.89**	**0.051**	**827,048**	**3,821,027**	**2,019**	**1.24%**
SDGE3024	2006	Attic Insulation	684,692	0.89	0.023	13,813	48,292	59	0.17%
		Wall Insulation	238,848	0.89	0.084	17,814	41,368	33	0.22%
	2007	Attic Insulation	1,193,577	0.89	0.023	24,079	84,184	102	0.30%
		Wall Insulation	441,275	0.89	0.084	32,912	76,428	62	0.41%
	2008	Attic Insulation	1,342,155	0.89	0.023	27,076	94,664	115	0.34%
		Wall Insulation	361,202	0.89	0.084	26,940	62,560	51	0.34%
	Total	Attic Insulation	3,220,424	0.89	0.023	64,968	227,140	276	0.82%
		Wall Insulation	1,041,325	0.89	0.084	77,667	180,357	146	0.98%
	Total SDGE3024		**4,261,749**	**0.89**	**0.038**	**142,635**	**407,497**	**422**	**1.79%**

Source: Residential Retrofit Ctract roup HIM Evaluation report: Table 81, page 94

ANNEX B2: THE EX-ANTE ENERGY AND DEMAND IMPACTS FOR THE UPSTEEAM LIGHTING PROGRAMS FOR THE PERIOD 2006-2008

Ex-Ante Net Energy and Demand Impacts from the Upstream Lighting Program by IOU, Product Type and Sector (2006-2008)

Ex-ante Net Annual kWh						
Program ID	**Sector**	**CFLs**	**Fixtures**	**LEDs**	**All Products**	**Total Portfolio**
PGE2000/ 2080	Nonresidential	1,250,100,941	14,126,385	12,879,616	1,277,106,941	
	Residential	1,715,558,531	45,349,481	30,608,896	1,791,516,908	
	Total	2,965,659,471	59,475,866	43,488,512	3,068,623,850	5,254,423,907
	Percent of Total Portfolio	**56%**	**1%**	**1%**	**58%**	
SCE2501	Nonresidential	529,182,704	32,656,476	0	561,839,180	
	Residential	1,236,987,908	35,688,372	35,022,908	1,307,699,188	
	Total	1,766,170,612	68,344,848	35,022,908	1,869,538,368	3,263,648,649
	Percent of Total Portfolio	**54%**	**2%**	**1%**	**57%**	
SDGE3016	Nonresidential	0	0	45,289	45,289	
	Residential	279,077,392	6,155,341	23,467,063	308,699,796	
	Total	279,077,392	6,155,341	23,512,352	308,745,085	849,277,220
	Percent of Total Portfolio	**33%**	**1%**	**3%**	**36%**	
All IOUs	Nonresidential	1,779,283,644	46,782,861	12,924,905	1,838,991,411	
	Residential	3,231,623,831	87,193,194	89,098,867	3,407,915,892	
	Total	5,010,907,475	133,976,056	102,023,772	5,246,907,303	9,367,349,776
	Percent of Total Portfolio	**53%**	**1%**	**1%**	**56%**	
Ex-ante Net Peak kW						
Program ID	**Sector**	**CFLs**	**Fixtures**	**LEDs**	**All Products**	**Total Portfolio**
PGE2000/ 2080	Nonresidential	226,951	1,409	941	229,301	
	Residential	162,854	1,055	0	163,909	
	Total	389,805	2,464	941	393,209	845,662
	Percent of Total Portfolio	**46%**	**0%**	**0%**	**46%**	
SCE2501	Nonresidential	129,595	0	0	129,595	
	Residential	108,628	2,163	96	110,888	
	Total	238,223	2,163	96	240,483	592,508
	Percent of Total Portfolio	**40%**	**0%**	**0%**	**41%**	
SDGE3016	Nonresidential	0	0	41	41	
	Residential	27,461	295	0	27,756	
	Total	27,461	295	41	27,797	147,360
	Percent of Total Portfolio	**19%**	**0%**	**0%**	**19%**	
All IOUs	Nonresidential	356,546	1,409	982	358,937	
	Residential	298,943	3,513	96	302,552	
	Total	655,489	4,922	1,079	661,489	1,585,530
	Percent of Total Portfolio	**41%**	**0%**	**0%**	**42%**	

Source Final Evaluation Report: Upstream Lighting Program, Volume 1, Table 4, page 5

Ex-Ante Savings Parameters for the Upstream Lighting Program by IOU, Product Type and Sector (2006-2008)

	PGE2000/2080	SCE250	SDGE3016
	CFLs		
Parameter			
Rebated Units	52,938,751	35,284,687	7,611,804
Percent Residential	90%	90%	100%
Residential			
Installation rate	76%	90%	90%
UES (kWh/yr)	59.15	57.62	50.92
UES (kW)	0.0056	0.0051	0.0050
NTGR	0.80	0.75-0.78	0.80
Nonresidential			
Installation rate	92%	92%	n/a
UES (kWh/yr)	327.34	222.55	n/a
UES (kW)	0.0594	0.0545	n/a
NTGR	0.96	0.75-0.78	n/a
	Fixtures		
Parameter			
Rebated Units	452,563	756,954	105,977
Percent Residential	91%	68%	100%
Residential			
Installation rate	100%	100%	100%
UES (kWh/yr)	138.22	91.61	72.60
UES (kW)	0.0032	0.0056	0.0035
NTGR			
Nonresidential			
Installation rate	100%	100%	n/a
UES (kWh/yr)	346.74	175.62	n/a
UES (kW)	0.0346	0.0000	n/a
NTGR	0.96	0.76	n/a
	LEDs		
Parameter			
Rebated Units	10,089,539	1,812,352	3,640,010
Percent Residential	90%	100%	100%
Residential			
Installation rate	100%	100%	100%
UES (kWh/yr)	4.18	24.16	8.06
UES (kW)	0.0000	0.0001	0.0000
NTGR	80%	80%	80%
Nonresidential			
Installation rate	100%	n/a	100%
UES (kWh/yr)	14.34	n/a	54.75
UES (kW)	0.0012	n/a	0.0500
NTGR	0.80-0.96	n/a	80%

Source Final Evaluation Report: Upstream Lighting Program, Volume 1, Table 5, page 6

ANNEX C: CASE APPLICATION OF DEMAND RESPONSE: STATE-WIDE PRICING PILOT PROGRAMME IN CALIFORNIA

Introduction

Demand response (DR) refers to the reduction of customer energy usage at times of peak usage in order to help address system reliability, reflect market conditions and pricing, and support infrastructure optimization or deferral. Demand response programs may include dynamic pricing/tariffs, price-responsive demand bidding, contractually obligated and voluntary curtailment, and direct load control/cycling.

The information on Demand Response products is collected to relating impacts of DR projects to those for energy savings. For this reason the information is organised as following. We start with general information on the DR project and relations with other DR initiatives (section 1 and 2). Then we present information to be related to energy savings calculations: input data, baseline definition and key parameters considered, and savings calculations (section 3-5). Next is information on changes in the load shape and benefits in sections 6-8. We end with sources and documentation.

1. Description of the DR initiative

The State-wide Pricing Pilot Programme (SPP) carried out 2003-2004 by The California Public Utilities Commission and the California Energy Commission under about 1,450 customers and a control group of 750 (see figure 1). This programme has been implemented by Southern California Edison (SCE), San Diego Gas and Electric (SDG&E) and PacificGas and Electric (PG&E).
This program holds 3 rate forms, additional to the existing rate:

1) An experimental rate (Time of USE; TOU), applicable state wide, holding a seasonal, different rate for fixed on-peak and off-peak time periods;
2) An experimental rate (Critical Peak Fixed; CPP-F), applicable state wide, holding a time-of-use rate with an additional ‘critical peak’ price that can be dispatched during the peak-period for up to 15 times each year, with day ahead notice;
3) An experimental rate (Critical Peak Variable; CPP-V), applicable to the target population only, holding a Critical Peak Fixed rate with a critical peak price that can be dispatched during the peak-period for 2-5 hours, with 4 hour advance notice.

All three rate treatments were examined for residential customers. The CPP-F and TOU rates were implemented among a state wide sample of customers. The CPP-V rate was implemented only in the SDG&E service territory and the Information Only treatment in the PG&E service territory. CPP-V and TOU tariffs were also tested among commercial and industrial customers with demands below 200 kW in Southern California Edison’s service territory. The sample was segmented into two size strata, customers with demands below 20 kW (referred to here as the LT20 segment) and customers with demands between 20 and 200 kW (referred to as the GT20 segment).

Figure 1: Sample size of customers in the programme

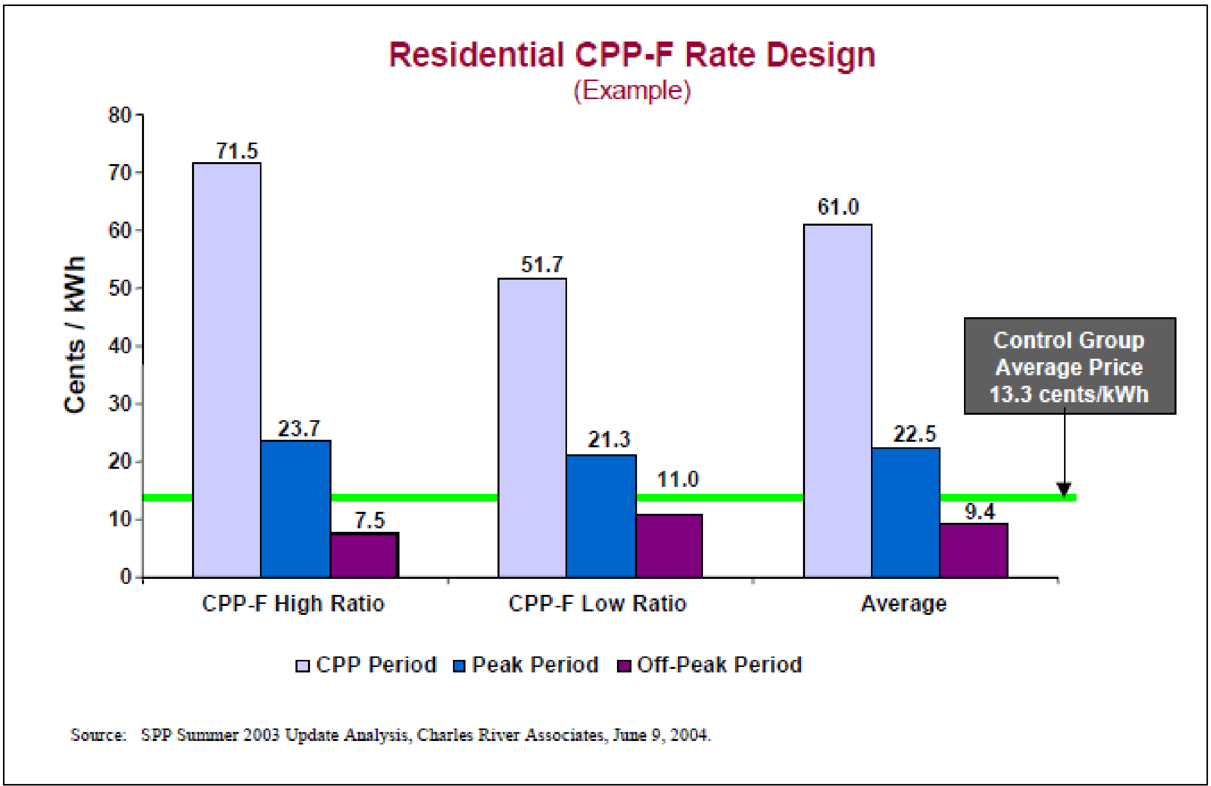
	Control	CPP-F	CPP-F Info Only	CPP-V SDGE	Info Only	TOU	Total Participants
Track A – Random Sampling with Opt Out Design							
Residential	470	542	0	125	126	200	1463
Commercial < 20kW	88	0	0	58	0	50	196
Commercial > 20kW < 200kW	88	0	0	80	0	50	218
Track B – San Francisco Cooperative							
Residential (PGE)	0	64	126	0	63	0	253
Track C – AB 970 Sub-Sample							
Residential	20	0	0	125	0	0	145
Commercial < 20kW	42	0	0	56	0	0	98
Commercial >20kW < 200kW	42	0	0	76	0	0	118
TOTAL PARTICIPANTS	750	606	126	520	189	300	2,491

Source: Statewide Pricing Pilot, Summer 2003 Impact Analysis, Charles River Associates, August 9, 2004.

With the CPP rate, on most weekdays, a peak-period price was in effect between noon and 6 pm. On critical peak days, a significantly higher peak-period price was in effect for up to five hours, all of which fell within the noon to 6 pm time period. While the tariff allowed the critical peak period to be any length up to 5 hours, during the experiment, the critical peak period was either 2 or 5 hours long. Prices changed over the two summers during which the treatment was tested (2004 and 2005).

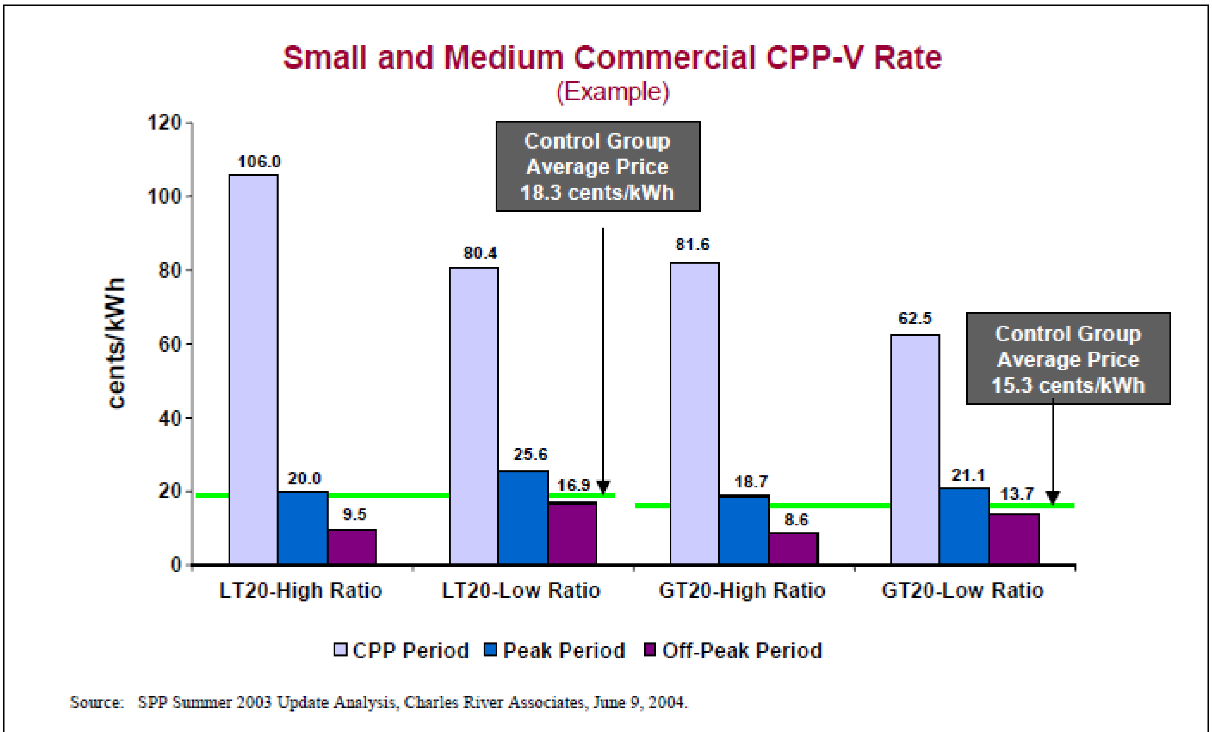
Each pilot rate was designed to be revenue-neutral. The TOU rate had an off-peak price lower than the average price for the standard rate, offsetting the price increase for on-peak periods. The underlying TOU peak price was 2 to 3 times the off-peak rate, depending on the utility. TOU peak prices were approximately 70 percent higher than the standard flat rate.
CPP-F and CPP-V prices on average across all utilities were about 10 cents/kWh in off-peak hours, 20 cents/kWh in peak periods, and 60 cents/kWh during critical peak hours. The critical-peak price for CPP customers was between 5 and 10 times the off-peak price for the CPP rates, depending on the utility. Figure 2 holds an example of these prices for residential customers.

Figure 2: Example of residential critical peak price fixed (CPP-F)



The average standard price for LT20 customers across the two summers was roughly $0.17/kWh and the average critical peak price was almost $1.00/kWh. For GT20 customers, the standard average price was $0.16/kWh and the critical peak price was roughly $0.60/kWh. Figure 32 holds an example of these prices for commercial customers.

Figure 3: Example or commercial critical peak price variable (CPPV)



Under the pilot the utility could call a critical peak event for up to 15 critical days of the year. The ordinary peak period for all residential tariffs ran from 2 pm to 7 pm on weekdays. The TOU peak periods were from 2 p.m. to 7 p.m. The critical peak periods for participants on the CPP-F rate were also from 2 p.m. to 7 p.m., on critical event days. Thus, for CPP-F customers, the critical peak period during any given critical peak day was fixed at the 5 hours between 2 and 7 p.m. By contrast, the utility could define the critical peak period for the CPP-V customers between 2 hours and 5 hours, during the 2 p.m. to 7 p.m. period on critical peak event days.
The utilities notified CPP-F customers the day ahead of a critical peak event. They could notify CPP-V no later than the day of the critical peak event. The utility also signalled the PCTs of those customers with such devices at the beginning of the critical peak period. The utility could call up to 15 critical-peak events during the year (12 during the summer, and 3 during the winter).80 Between July 1, 2003 and September 30, 2004, program managers called 27 critical peak periods.

2. Related DR initiatives

Since this programme, the number of US States and utilities with dynamic pricing programs continue to grow. By the end of 2009 sixteen States and more then twenty utilities offered programs including critical peak pricing (CPP), real time pricing (RTP), and peak time rebate (PTR)/critical peak rebate (CPR) rate structures. Appendix 1 holds the overview, published by the Edison Foundation.

3. Input data

In the pricing pilot, the consumption data from customers is gathered through a software solution. With this software, the utility receives real-time energy consumption data. All customers targeted received a free advance digital electric meter designed to facilitate energy information and management. Website portals were established for enrolled customers through their utility websites to check their usage online, using a password-protected login.
Residential and commercial customers were given a free Honeywell programmable thermostat. Adjustments to thermostats were encouraged by providing tips on pre-cooling and presettings.

The impacts of the programs were analysed using two demand equations in a CES demand system. The demand models estimate the demand response impacts for each SPP tariff, as opposed to alternative methods, in part because they allow for estimation of the impact of prices other than those used in the pilot. In order to estimate the models four types of data were needed:
• Customer-specific load data
The primary load data for each customer consisted of 96 values for each day representing integrated demand at 15-minute intervals. For model estimation, the interval data were aggregated by rate period.
• Weather
Hourly temperature data were used to calculate cooling and heating degree hours by time period.
• Customer characteristics
• Electricity prices

4. Baseline definition and key parameters considered

Based on customer-provided survey information and hourly meter data, customers receive a monthly bill "Scorecard" with a personalized examination of the costs of air conditioning, lighting and other appliances during critical peak periods, and what can be saved by managing how those appliances are used. The current consumption can be considered as the baseline energy use.

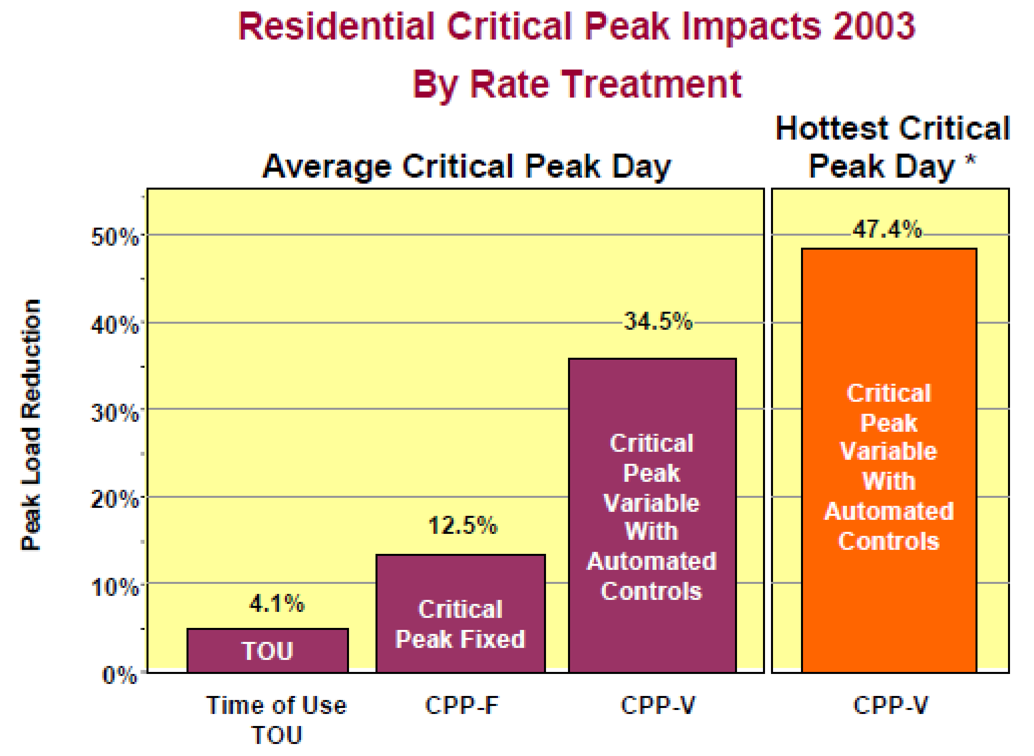
5. Savings calculation

No overall reduction in energy consumption occurred on an annual basis within the CPP-F trial group.

6. Load shape impact

The load shape impact was estimated by the aggregation of all participant customers, but some difference could be observed between segments.

Figure 4: Residential Critical Peak Impacts in 2003



Source: Statewide Pricing Pilot Summer 2003 Impact Analysis, Charles River Associates, Table 1-3, 1-4, August 9, 2004.

The average peak load reductions ranged from 12% to 40% of baseline peak usage for different customer types. Figure 4 illustrates the rage by rate treatment. The degree of reduction depended on the tariff rate, weather, customer appliance holdings, and availability and use of demand response controls:

- Average Residential peak period impacts held constant during multiple day peak pricing events usually associated with heat storms
- Small commercial customers (<20kW) reduced peak period demand on CPP days between 6% to 9%
- Medium commercial customers (>20kW but < 200kW) reduce peak period demand on CPP days between 8% to 10%
- Observed peak load impacts persist across multiple consecutive CPP days and across two years of the experiment

Figure 5 shows the residential CPP response in 2003, using some of the consumers' characteristics. Especially the high energy users and pool owners show over 15% peak reductions.

Figure 5: Residential peak reduction, 2003

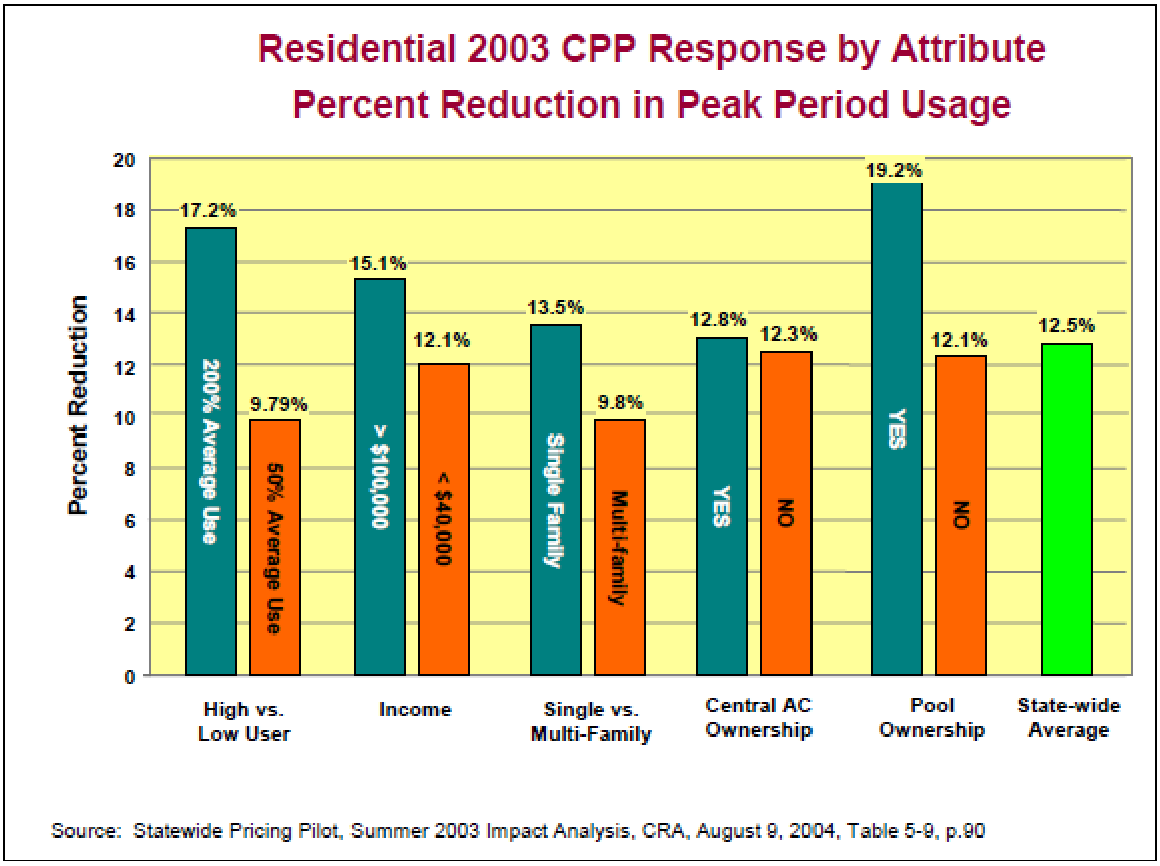
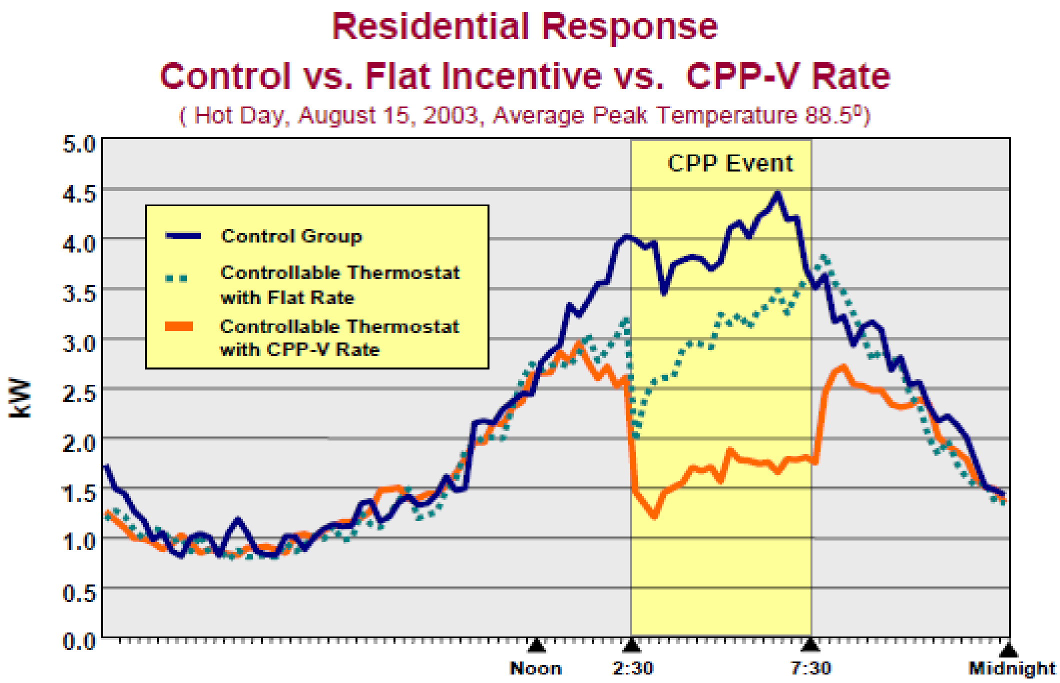


Figure 6 presents how the load impact is extrapolated to the global energy load shape for two different residential groups.

Figure 6: Residential response and the load curve



Source: Response of Residential Customers to Critical Peak Pricing and Time-of-Use Rates during the Summer of 2003, September 13, 2004, CEC Report.

7. Benefits to participants

Sending dynamic prices to residential customers led to average peak savings of 14% and bill savings of $60 per year. But about ¼ of the residential and commercial customers had a bill increase (see figure 7). The commercial customers, having a higher energy use than residential customers, on average had higher bill savings, up to over $ 2,000 per year (see figure 8)

George and Faruqui concluded follows. The numerous surveys and other studies that have been done in conjunction with the SPP, and especially the ongoing real world data concerning customer decisions to stay or leave the rates, provide a strong body of evidence that customers like time-varying rates once they experience them.

- “If asked ahead of time if they would choose a time varying rate, most customers say no;”
- “If placed on such a rate and asked to leave, most customers say no.”

Figure 7: Bill impacts, 2004

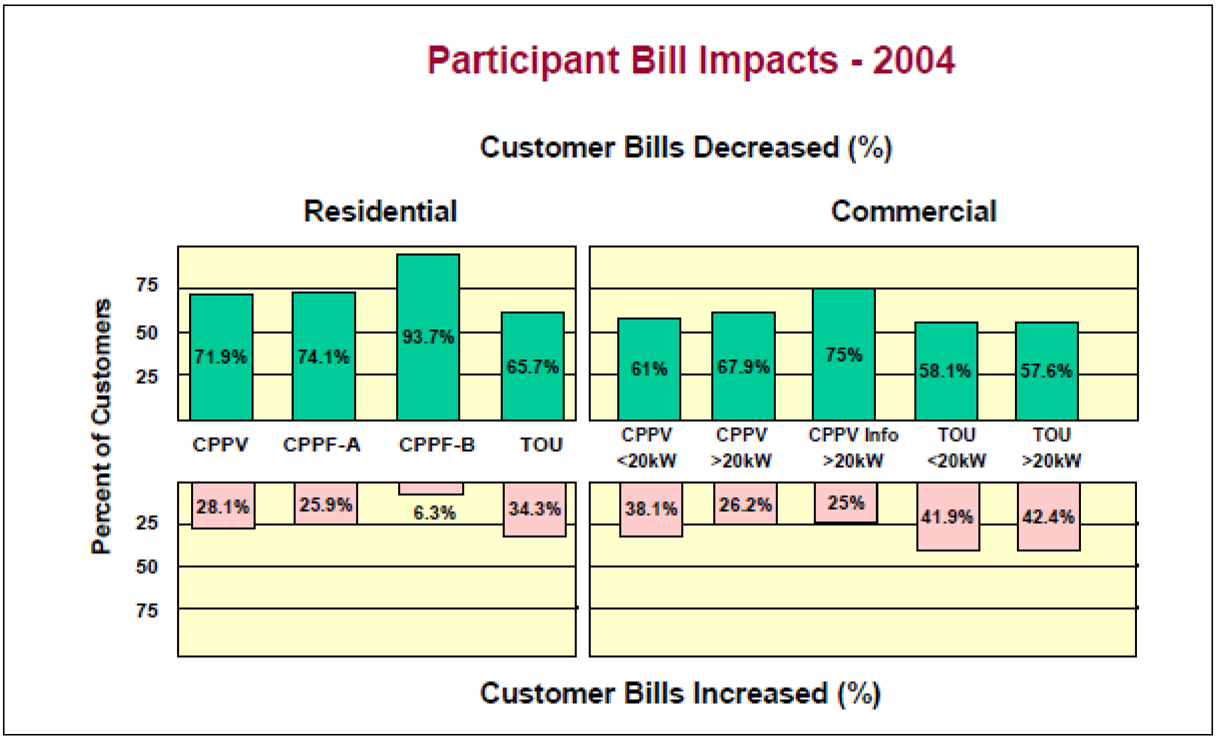


Figure 8: Bill impact commercial participants in $

Commercial Participant Bill Impacts

		2003		2004				
		CPPV	TOU	CPPV <20kW	CPPV >20kW	CPPV Info >20 kW	TOU <20 kW	TOU >20kW
Customers With Bill Savings	Participants (%)	80.3%	58.2%	61.0%	67.9%	75.0%	58.1%	57.6%
	Average Monthly Savings (%)	12.2%	9.6%	12.1%	11.4%	15.5%	12.1%	8.7%
	Average Monthly Savings ($)	$155.17	$90.65	$46.83	$184.59	$32.75	$26.45	$176.39
Customers With Bill Increases	Participants (%)	19.7%	41.8%	38.1%	26.2%	25.0%	41.9%	42.4%
	Average Monthly Increase (%)	5.0%	10.0%	7.1%	6.5%	3.3%	8.5%	5.6%
	Average Monthly Increase ($)	$22.89	$62.52	$18.24	$75.12	$23.48	$24.02	$92.99

Source: Statewide Pricing Pilot, Shadow Bill Results, WG3 report, June 9, 2004 and Joint Utility Bill Analysis, January 12, 2004.

8. Other benefits

The Pricing Impact Simulation Model (PRISM) Suite developed by the Edison Foundation
http://www.edisonfoundation.net/iee/ourwork/Pages/databases.aspx

This database can be use to quantifying the benefits of dynamic pricing in the mass market. Its extends models are based on the 2003-2005 California State wide Pricing Pilot to estimate the change in consumption per customer resulting from dynamic pricing programs. The PRISM Suite allows the user to input a dynamic rate structure, load shapes, weather data, and CAC saturations, then estimates customer bill savings and as well as utility benefits such as capacity cost savings, energy cost savings, and transmission and distribution cost savings. The PRISM Suite is a powerful tool for evaluating the benefits of dynamic pricing programs to both the customer and the utility.

9. Sources and documentation

California State wide Pricing Pilot (SPP), Overview and Results 2003-2004

http://sites.energetics.com/MADRI/toolbox/pdfs/pricing/pricing_pilot.pdf

Charles River Associates, *Impact evaluation of the California state wide pricing pilot,* March 2005
http://www.calmac.org/publications/2005-03-24_SPP_FINAL_REP.pdf
Stephen S. George and Ahmad Faruqui, *California's State wide Pricing Pilot: Commercial & Industrial Analysis Update,* June 2006
http://www.fypower.org/pdf/SPP_FINAL_REPORT_UPDATE.pdf

Edison Foundation, *Summary of IOU-Administered Residential Customer Dynamic Pricing Pilots & Programs by State, December 2009*
http://www.edisonfoundation.net/IEE/Documents/IEE_DP_Map_Residential_1209.pdf

Edison Foundation, *The Pricing Impact Simulation Model (PRISM) Suite* Foundation
http://www.edisonfoundation.net/iee/ourwork/Pages/databases.aspx

Faruqui, Ahmad and Sergici, Sanem, *Household response to dynamic pricing of electricity. A survey of the experimental evidence*, January 2009
http://www.science.smith.edu/~jcardell/Readings/uGrid/House%20DemandResp%20Experience.pdf

Brockway, Nancy, Presentation *Can residential customers' response to dynamic pricing?* Kansa corporation commission workshop on energy efficiency, March 25, 2008
http://www.kcc.state.ks.us/energy_efficiency/brockway.ppt#1

Stephen S. George and Ahmad Faruqui, *California's State wide Pricing Pilot Overview of Key Findings,* MADRI Advanced Metering Infrastructure Workshop May 4, 2005 http://sites.energetics.com/MADRI/pdfs/california_050405.pdf

Appendix: Summary of IOU-Administered Residential Customer Dynamic Pricing Pilots & Programs by State December 2009

State	**Utility Program**	**Details**
Alabama	Alabama Power Co.*	APCO instituted CPP as part of their SmartPOWER pilot in the Birmingham area for approximately 300 customers. They receive off-peak (3 cents), intermediate (6.2 cents), on-peak (13 cents), and critical peak (30.5 cents) rates during the summer period (June- September), and lower off-peak and intermediate rates the rest of the year. Off-peak rates apply on weekends and holidays
California	San Diego Gas & Electric	SDG&E currently offers a PTR rate that credits $0.75/kWh during critical peak periods for customers without enabling technologies and $1.25/kWh for those customers with enabling technologies. This rate is available for all residential and small business customers in their service area.
	Southern California Edison	As of September 2009, TOU and CPP rates are available to residential customers whether or not they have a “SmartConnect” meter. SCE also plans to offer a PTR rate to those customers that have a SmartConnect meter installed starting in 2010.
	Pacific Gas & Electric	PG&E is currently operating a “SmartRate” program, which includes a CPP program (60 cents for peak times on “SmartDays,” applicable only May-October). The program is open to customers with installed smart meters and offers bill protection through a participant’s first summer. A recent CPUC decision requires PG&E to make dynamic rates available to all customers. As an initial step, PG&E is required to offer optional TOU and CPP rates in 2010 and optional RTP rates in 2011 to its small and medium customers including residential customers.
	Statewide Pilot	The state’s three IOUs conducted a state wide pricing pilot (SPP) with the cooperation of the CPUC and the California Energy Commission from July 2003 to December 2004. The three IOUs tested several dynamic rate options among 2,500 customers.
Connecticut	Connecticut Power & Light	CP&L recently completed a pilot under their “Plan-it Wise” program that included CPP and PTR rates for 1,500 customers. The results have been promising: residential customers under the CPP rate structure reduced their peak-time energy use by 23% when using controlling technology and 17% under the PTR rate structure when using the technology.

District of Columbia	Pepco	Pepco was recently awarded $44M in SGIG funds to expand their smart meter pilot in Washington, DC, including dynamic pricing (details pending). Under the ongoing PowerCentsDC pilot which runs through Feb. 2010, 1,400 smart meters have been installed. Participants may choose between CPP or CPR rate options.
Florida	Gulf Power	Gulf Power has had a CPP program (Residential Service Variable Pricing) in effect since 2000, consisting of four pricing periods dependant on the time of day and the season (Low - 9 cents, Medium - 10.2 cents, High - 14.8 cents, and Critical - 35.7 cents). The critical periods are called one day prior for winter periods and by noon of the same day in summer. Critical periods may not exceed one percent of the total annual hours. There are approximately 9,000 customers enrolled in the program.
	Tampa Electric	Tampa Electric's Energy Planner is a CPP program that offers four pricing rates for electricity (Low - 8.9 cents, Medium - 9.5 cents, High - 17.8 cents and Critical - 51.9 cents). The Critical rate can become active at any time and cannot exceed 1.5 percent of the total hours in a year. The program pilot began with 250 customers and is being extended throughout the utility's service territory. Participants are offered a programmable communicating thermostat (PCT) with the ability to control up to eight appliances.
Idaho	Idaho Power	"Energy Watch" is a CPP pilot program for customers in the Emmett Valley area. Critical days may be called between June 15 and August 15. Participants pay an off-peak rate of 6.3 cents/kWh and a critical peak rate of 20 cents/kWh.
Illinois	Commonwealth Edison	Commonwealth Edison's recently approved AMI Assessment & Customer Applications Plan will include several rates and enabling technologies for residential customers including: a CPP rate (1,600 customers), a PTR rate (1,400 customers), a day-ahead RTP rate, an increasing block rate (IBR), and a TOU rate. In 2007, ComEd transitioned the Community Energy Cooperative (CEC) pilot (2003-06) into a territory-wide RTP program. Participants are notified via phone or email one day prior to days when rates are expected to exceed 14 cents/kWh. Customers can track prices and find other information on www.thewattspot.com.
	Ameren	Ameren has set a goal of enrolling 20,000 customers in their Power Smart Pricing program throughout

		their three Illinois service territories by 2010 and the rates are open to all residential Ameren customers. Approximately 6,000 have signed up, to date. Prices are listed on Ameren's web site, on www.powersmartpricing.org, or available through a toll-free number. Peak rates can range from 12 cents/kWh to 30 cents/kWh depending on the season.
Kentucky	Louisville Gas & Electric	LG&E initiated a dynamic pricing pilot in 2007 in parallel with their smart meter deployment. The Responsive Pricing program includes CPP and TOU rates and 150 LG&E customers had signed up to the program as of September 2009. There are four tiers of rates: low, medium, high and critical, with the critical rates ranging between $.29-$.31/kWh in 2008.
Maryland	Baltimore Gas & Electric	BGE was awarded SGIG funds to deploy 1.1 million smart meters and a residential "Smart Meter Pricing" program that will include a peak time rebate (PTR) for residential customers. In 2008-2009, BGE conducted a dynamic rate pilot with 1,000 residential customers over two consecutive summers that included dynamic peak pricing (i.e., a CPP rate) and two different peak time rebates. The Maryland PSC is holding hearings in November. If approved, all residential customers with a smart meter may participate in the PTR rate.
Michigan	Detroit Edison Co	DTE plans to deploy dynamic pricing pilots in the summer of 2010 as a complement to their AMI rollout. Approval is pending; the utility was recently awarded SGIG funding for their SmartCurrents program, which includes a proposal to deploy dynamic pricing to 5,000 customers.
Mississippi	Mississippi Power Company	Mississippi Power plans to initiate a CPP pilot for 100 customers that will receive a two-way, programmable thermostat which will inform them of critical-peak events. The exact rate structure has not yet been released
New Jersey	Public Service Electric & Gas	PSEG piloted "myPower Sense" and "myPower Connection," two TOU/CPP pilot programs in 2006-07, to 379 participants and 319 participants, respectively, to examine customer response to price signals and technology. Customers in the "myPower Connection" program received a programmable communicating thermostat to automate their response to price signals.
Oregon	Portland General Electric	PGE has been approved for a CPP pilot from November 2010 to October 2012 which allows for ten critical peak days in each six month season. PGE is making this rate structure available to all

		customers with a smart meter and will notify participants on the day prior to each event. Rates vary from 5.6 cents (off-peak) to 7.1 cents (on-peak) and 33.5 cents for critical peak periods. Off-peak rates apply on Sundays and holidays.
Oklahoma	Oklahoma Gas & Electric	OG&E will include variable peak pricing (VPP - a variant of CPP) for 42,000 participants in its "SmartPower" pilot in Norman, OK. This optional rate plan has four rate tiers: Low (4.5 cents), Standard (11.1 cents), High (23 cents) and Critical (46 cents - events are announced the day prior). The rate includes a "best bill" provision under which the customer will be credited any amount charged through the VPP that exceeds what the customer would have paid under the traditional rate after one year.
Pennsylvania	Allegheny Power	Allegheny Power's recently approved energy efficiency and conservation plan includes TOU and CPP rate structures for residential customers beginning in 2011. Certain customers will receive a programmable, communicating thermostat capable of receiving price signals from the utility. The customer can reduce energy use voluntarily or choose an automated setting where the thermostat reduces the energy use of the HVAC system.
Wisconsin	Wisconsin Electric Power Company	Wisconsin Electric Power has both CPP and PTR pilots for residential customers. Both pilots will be run through May 2012. The CPP program is available to residential customers that have a meter with automated reading capability and the critical peak rate is 88 cents per kWh (applicable only from 2-6 PM on weekdays). Customers on the PTR pilot will receive a rebate for shifting load of 47 cents per kWh during peak events. Participants in both pilots will receive notifications of peak events the day prior.
	Wisconsin Public Service Corp.	WPSC's "Response Rewards" program is a CPP program that offers three pricing levels: an on-peak rate of 19.5 cents/kWh, an off-peak rate of 7.1 cents/kWh, and a critical-peak rate that varies. Critical-peak times are limited to a maximum of 150 hours per year. Customers are notified of critical peak hours at least 30 minutes prior.

Source: http://www.edisonfoundation.net/IEE/Pages/IEEHome.aspx