Measuring the Load Impact of an Air Conditioner Cycling Program

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Abstract

During the summer of 2005 Southern California Edison (SCE) initiated an evaluation of its Air Conditioner Cycling Summer Discount Program. The evaluation captured and analyzed extreme (hot weather data-influenced) AC usage during California's record-breaking heat storm in the summer of 2006. System-wide baseline AC usage and cycling impacts by time of day and outdoor temperature were generated for weekday and weekend days. The results can be used by program staff and utility planners to model program impacts based on a variety of participation patterns and weather conditions.

Introduction

Southern California Edison's (SCE) Air Conditioner Cycling Summer Discount Program (ACCP) evaluation was initiated to estimate AC baseline usage and load reduction impacts in the SCE service territory. This objective was achieved through primary data collection and analysis.

Air conditioning usage data were collected from a sample of statistically representative end-use metering (EUM) points installed in the summer of 2005. Using the Duty Cycle Approach (DCA) cycling impacts were estimated as a function of time of day and outdoor air temperature. For example, during the 5-6 PM hour on a weekday, gross impact estimates are 0.81 kW for outdoor temperatures between 70-80 ºF, and 2.63 kW for outdoor temperatures over 100 ºF.

AC Cycling Summer Discount Program Description

The AC Cycling Summer Discount Program targets air conditioning systems mainly in the residential market. Only 1% of participants are commercial customers. Participants must enroll one or more air conditioners into the program and allow SCE to install a control device on each enrolled unit.[1] The control device disconnects the compressor when a signal is dispatched—typically during high electric demand in the summer season.[2] At the time they join the program, participants can choose one of two program plans:

- The Base Summer Discount Plan allows SCE to control the air conditioners a maximum of 15 cycling events (up to 6 hours per event, multiple events per day if deemed necessary) during the summer season.
- The Enhanced Summer Discount Plan allows SCE to control the air conditioners for an unlimited number of days per year (up to 6 hours per cycling event, limited to one cycling event per day) during the summer season.

[1] Not all AC units on a given account are required to enroll in the program.

[2] The summer season starts at 12:00 a.m. on the first Sunday in June and continues until 12:00 a.m. on the first Sunday in October.

- For residential customers, both plans provide a choice of three cycling options: 50% (air conditioner disconnected for 15 minutes out of every 30 minutes), 67% (air conditioner disconnected for 20 minutes out of every 30 minutes) and 100% (air conditioner disconnected continuously during the cycling event).

In exchange for allowing SCE to control their units, participants are switched to a special tariff during the summer season. Under this tariff participants receive a monthly bill credit proportional to the number of air conditioner tons enrolled in the program. Participants who choose a lower cycling percentage receive a lower credit than those who choose a higher cycling percentage. The Enhanced Plan pays double the credit of the Base Plan. Exhibit 1 shows the bill credits offered by SCE in 2006.

Exhibit 1
Air Conditioning Cycling Summer Discount Program
Bill Credits Offered in 2006

Summer Season Summer Discount Plan AC Cycling Program			
Cycling options	Time length per occurrence	Base credits per calculated ton* per day	Enhanced credits per calculated ton* per day
Residential Customers			
100%	Off continuously for entire duration of turn-off event	$0.18	$0.36
67%	Off 20 minutes out of every 30 minutes	$0.10	$0.20
50%	Off 15 minutes out of every 30 minutes	$0.05	$0.10

* The calculated tonnage may vary from the tonnage rating on the AC faceplate.

According to the tariff, the air conditioners enrolled in the AC Cycling Summer Discount Program can only be cycled in one of the following cases:

(1) Upon notification from the Independent System Operator (ISO) of the need to implement load reductions in SCE's service territory during stage 1, 2 or 3 alerts;

(2) When a declaration by SCE of a Category One, Two or Three Heat Storm alert exists that may jeopardize the integrity of SCE's distribution facilities;

(3) For testing the control devices. Testing of the control devices can only occur if SCE does not receive the desired load reduction results after a cycling event. Testing of the control devices can interrupt power to a customer's air conditioner for a maximum of 30 minutes; SCE can test during peak hours only once per summer season.

As of September 1, 2006, the AC Cycling Summer Discount Program had approximately 192,000 residential participants and 2,800 commercial participants. The program is unique in that 88% of participants choose the 100% cycling option at enrollment time, as compared to 10% who choose the 67% cycling option and 2% who choose the 50% cycling option. Other AC cycling programs across the country, such as Florida Power and Light's program, have the majority of participants enrolled in cycling options other than 100%.

Impact Analysis

This evaluation study was initiated during the summer of 2005 to quantify AC baseline usage and program impacts, and to assess participant satisfaction with the program. For the impact portion of the study a stratified sample of 150 homes was designed and recruited. AC usage data were collected during the summer of 2006 and analyzed using the Duty Cycle Approach (DCA). The DCA generated estimates of AC impacts associated with curtailment events.

Description of the Duty Cycle Approach

The DCA is based on “permanent” metering installations and data collection facilitated remotely using shared customer phone lines. By comparison, a runtime logger and spot reading method may be more cost-competitive and involve more data points; however, the logger approach is also substantially less accurate and more at risk to the weather patterns observed during the data collection period. Measurement accuracies of ± 3 percent are expected using the DCA approach, versus ± 20 percent or higher using loggers and spot kW measurement.

In addition, spot kW measurements may be significantly biased if AC usage is being measured during atypical weather conditions, or if the site engineer inadvertently allows the AC to cycle while taking the measurement. In either instance, it is likely that a spot kW measurement may underestimate the AC’s connected load, and thus underestimate program impacts. The DCA makes use of all of the data points (from homes enrolled in any program option and located in any climate zone) in a highly efficient manner, and generates a time of day and outdoor temperature model that can be used by the utility in program planning and other activities.

Finally, the DCA allows metering data collection to be achieved in a future year by simply calling-out to the recorders, while the logger approach would require completing another trip to each site. At the time when this study was initiated in summer of 2005, there was a risk that extremely hot weather would not occur to allow robust estimates for cycling impacts, and in fact 2005 was a relatively cool summer. With permanent metering equipment in place data could be collected again during the heat storms of 2006, and robust program impacts could be estimated as described below in the Baseline AC Load section.

End-use metering Data Collection

A stratified sample of end-use metering (EUM) points forms the basis for the impact analysis, providing 15-minute interval kWh data for participating AC units. The EUM sample was stratified by plan (Base or Enhanced), cycling percentage (100%, 67% or 50%), and by climate region, to capture representative program participation patterns.

Customer recruitment employed a telephone survey instrument structured to first collect demographic and other data to determine eligibility for this metering effort, and then to attempt to recruit eligible respondents. The respondents were first asked to verify that they resided at the correct address, and then if they agreed to allow their telephone lines to be used for the purposes of data collection. Information on the layout of their telephone and electrical systems was also collected, to assess the feasibility of each installation before sending metering installers to the sites. Both sets of information were used to assess a given customer’s ability to participate in the metering portion of this study.

After a home was recruited, a local subcontractor visited the site, collected site information such as manufacturer, model and location of the AC unit, and recorded spot meter readings of AC usage. The subcontractor noted the serial number of the cycling device and assessed its condition. The subcontractor then installed an S200-ECX recorder that captured 15-minute interval AC kW usage data.

Fifteen of the homes in the sample had two AC units, so 15 recorders were set up to collect data for two AC units, each on a separate channel.

One-hundred fifty residential site installations were completed in the summer of 2005. Exhibit 2 presents the disposition of the 147 residential sites from which data were collected in 2006, following opt out by some customers from the original sample.

Exhibit 2
Installed EUM Sites

Region	Cycling Percentage						Total
	50		67		100		
	Base	Enhanced	Base	Enhanced	Base	Enhanced	
South Coast	1	1	4	1	29	22	58
Inland	1	1	2	4	26	26	60
Desert	0	0	0	1	17	11	29
Mountain	0	0	0	0	0	0	0
Total	2	2	6	6	72	59	147

Communication was established to collect data from the recorders using a shared customer phone line. Once the AC usage data were collected, downstream validation consisting of a manual review of the AC load dataset and manual editing was used to prepare an analysis-ready dataset. All data underwent extensive data validation using the following steps and procedures:

The data were processed and merged to create a spreadsheet that lists AC load summaries and relevant on-site audit data for each metered AC unit. The resulting spreadsheet consisted of the following: recorder ID, business or homeowner name, recorder channel number, AC make and model, AC capacity in tons, on-site spot kW reading of the operating AC (collected at the time of recorder installation using a Watt probe), the number of available AC load data points from each recorder channel, and SAS Univariate Procedure-based AC load percentiles for the 100th, 99th, 95th and 90th highest observations. The latter were derived by sorting all AC loads for a given channel (from lowest to highest) and then picking the highest value, the 99th percentile value, and so forth. The upper percentile values for load on a given channel (100th, 99th, 95th, etc.) were used to develop estimates of the connected load for the AC unit metered on that channel.

Next, the data in this spreadsheet were reviewed line-by-line for each channel in the sample to identify potentially invalid data. For each AC unit in the sample, the load data were visually reviewed using EnergyProfiler software. Where issues or concerns were raised in this review step, additional efforts were made to resolve those issues. During that review the following were completed: 1) check for consistency between the unit capacity, spot kW reading and AC load-based connected load observations, 2) document AC loads that are zero or near-zero for a continuous period spanning more than one week, 3) for each recorder check for potential switched channel designations (given observed load sizes across channels), 4) document AC loads that are missing, 5) identify AC load shapes that are substantially inconsistent with other channels in the sample, and 6) identify AC loads that exceed 1.5 times the nominal unit capacity.[3]

For all such issues or concerns, work orders were generated to ensure resolution of each item and correct any deficiencies. Each item was investigated by either calling the customer to ask whether or not

[3] In order for AC loads to exceed 1.5 times the nominal unit capacity in tons, the energy efficiency ratio (EER) would need to be less than 8.0. According to ARI Statistical Profiles, the average unit efficiency shipped in the United States has been greater than 8.0 EER for more than 20 years. Therefore, AC loads this high are no longer expected in the current market, since replacement rates of air conditioners, about every 15 years or less, should have long ago exhausted equipment stock of 8.0 EER or less.

they have been running their AC during the metering period, and/or conducting a site-visit assessment to complete any necessary equipment repairs.

Finally, the spreadsheet described above with AC load summaries and relevant on-site audit data was generated once more, this time using the analysis-ready dataset (i.e. in which the invalid data identified above are set equal to missing.)

Baseline AC Loads

The analysis-ready dataset was used to develop baseline AC loads by time of day and outdoor temperature. The whole set of metering data were used in the estimate of baseline AC loads, as follows:

The connected load of each unit was derived using statistics based on each individual AC usage (such as the maximum reading or the 99th percentile "operating" kW reading).[4] The spot readings and make/model data collected on-site were used to *validate* the resulting interval-based connected loads

Due to the expectation that AC units in the hot climate zones would have higher capacities, and thus higher connected loads than AC units in the cooler climate zones, the metering sample connected loads were grouped by climate zone, and climate zone-specific connected loads were estimated. The results showed no statistically significant difference among the three climate zone-specific connected loads. Since the connected load represents AC usage when a unit runs full-out, this result suggests that, for the sample of homes metered, AC unit size was relatively uniform across climate zones.

Duty cycles were calculated for each AC unit as a ratio between individual kW load data for non-control days and the connected load calculated above.[5] For each AC unit, individual duty cycles were averaged for a given half-hourly interval and outdoor temperature to estimate average AC unit-specific duty cycles (for example, the average duty cycle might be 0.7 at 4 pm for an outdoor temperature of 80 °F). Because AC usage profiles are different on weekdays and weekends, average AC unit-specific duty cycles were calculated separately for weekdays and weekend days.

The baseline AC usage for a given time of day and a given outdoor temperature was calculated for each AC unit as the product of the unit's connected load and the unit's average duty cycle. System-wide baseline AC usage by time of day and outdoor temperature were then calculated by averaging AC usage across AC units, separately for weekday and weekend days. The calculation used the number of units in each climate zone as weights.

Exhibits 3 and 4 show the estimated baseline AC usage for weekday and weekend days, respectively. These results represent average AC usage among participating ACCP units in SCE service territory, by time of day and outdoor temperature. It is important to note that these estimates include free riders, i.e. customers who do not use their units very much. Also note that baseline usage results derived using less than 30 AC independent channels are not considered robust.

Exhibit 5 presents the results from Exhibit 3 in graphic format. The reader should note that each line in the graph represents AC usage under given temperature conditions, as indicated by the labels.

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[4] Operating loads are defined as interval loads in excess of a minimum threshold, normally 200 Watts. By isolating loads that are substantially greater than zero, the 99th percentile is likely to approach each unit's connected load.

[5] The duty cycle may be interpreted as the percentage of time the AC unit is observed to operate during a given time interval.

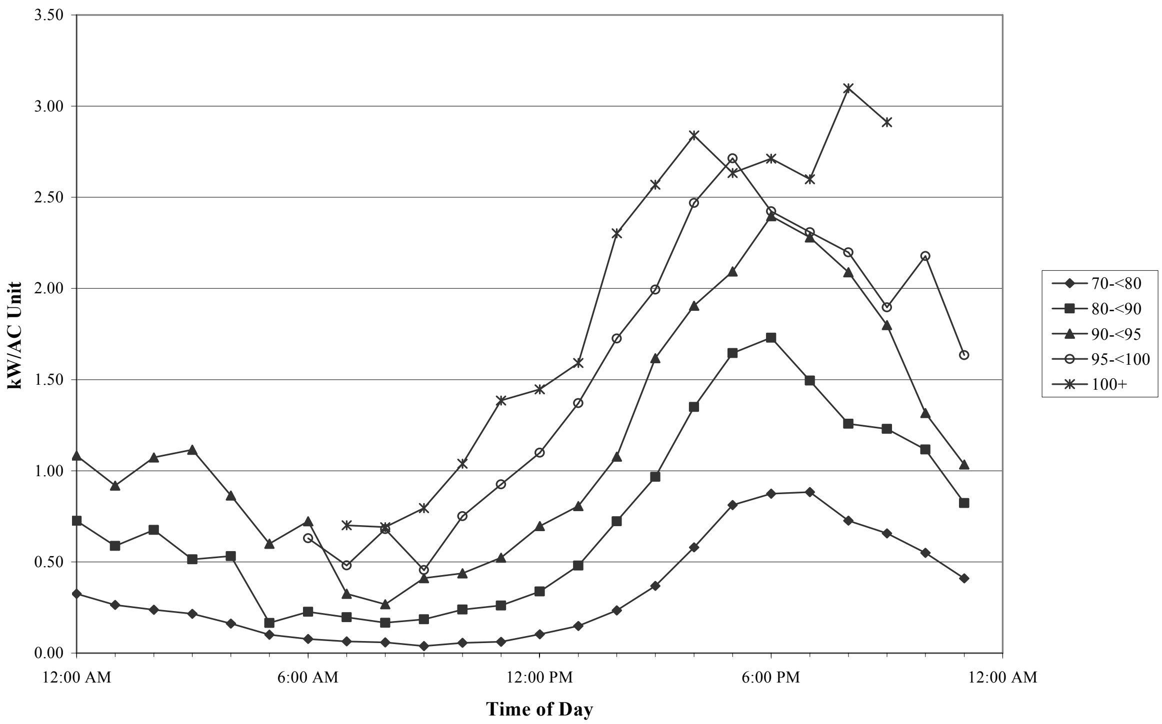
Exhibit 3
Baseline AC Usage by Time of Day and Outdoor Temperature
Weekdays

Time	Baseline AC usage (kW/AC unit)					Sample Size (EUM points)				
	Outdoor Temperature Group (°F)					Outdoor Temperature Group (°F)				
	70-<80	80-<90	90-<95	95-<100	100+	70 - <80	80-<90	90-<95	95-<100	100+
12:00 AM	0.33	0.73	1.08	.	.	159	94	10	0	0
1:00	0.26	0.59	0.92	.	.	147	94	10	0	0
2:00	0.24	0.68	1.07	.	.	146	46	10	0	0
3:00	0.22	0.51	1.12	.	.	146	28	10	0	0
4:00	0.16	0.53	0.86	.	.	146	28	10	0	0
5:00	0.10	0.17	0.60	.	.	158	107	10	0	0
6:00	0.08	0.23	0.72	0.63	.	159	109	17	10	0
7:00	0.06	0.20	0.33	0.48	0.70	158	159	103	10	10
8:00	0.06	0.17	0.27	0.68	0.69	158	159	120	17	10
9:00	0.04	0.19	0.41	0.46	0.80	149	159	109	119	10
10:00	0.06	0.24	0.44	0.75	1.04	149	158	158	109	46
11:00	0.06	0.26	0.52	0.93	1.39	149	158	147	109	93
12:00 PM	0.10	0.34	0.70	1.10	1.45	149	158	147	110	95
13:00	0.15	0.48	0.81	1.37	1.59	149	158	159	112	95
14:00	0.23	0.72	1.08	1.73	2.30	149	158	159	112	94
15:00	0.37	0.97	1.62	1.99	2.57	149	158	158	110	94
16:00	0.58	1.35	1.91	2.47	2.84	149	158	123	95	86
17:00	0.81	1.65	2.09	2.71	2.63	158	159	96	93	28
18:00	0.87	1.73	2.40	2.42	2.71	158	147	93	39	10
19:00	0.88	1.49	2.28	2.31	2.60	158	112	46	10	10
20:00	0.73	1.26	2.09	2.20	3.10	159	111	39	10	10
21:00	0.66	1.23	1.80	1.90	2.91	159	111	10	10	10
22:00	0.55	1.12	1.32	2.18	.	159	97	10	10	0
23:00	0.41	0.82	1.03	1.63	.	148	97	10	10	0

Exhibit 4
Baseline AC Usage by Time of Day and Outdoor Temperature
Weekend Days

Time	Baseline AC usage (kW/AC unit)					Sample Size (EUM points)				
	Outdoor Temperature Group (°F)					Outdoor Temperature Group (°F)				
	70-<80	80-<90	90-<95	95-<100	100+	70 - <80	80-<90	90-<95	95-<100	100+
12:00 AM	0.37	1.02	0.99	1.05	.	157	107	10	10	0
1:00	0.34	0.79	1.04	0.70	.	157	93	10	10	0
2:00	0.32	0.68	1.04	.	.	156	81	10	0	0
3:00	0.22	0.64	1.13	.	.	156	82	10	0	0
4:00	0.17	0.35	0.94	.	.	156	81	10	0	0
5:00	0.12	0.33	0.13	.	.	157	95	57	0	0
6:00	0.08	0.30	0.26	0.51	0.55	158	120	75	10	10
7:00	0.07	0.18	0.58	0.88	0.78	157	156	86	28	10
8:00	0.05	0.19	0.34	0.89	0.81	149	158	92	93	10
9:00	0.05	0.19	0.50	0.60	0.96	149	158	109	91	28
10:00	0.09	0.22	0.52	0.89	1.25	149	158	120	108	28
11:00	0.12	0.29	0.76	1.02	1.35	148	158	153	109	83
12:00 PM	0.13	0.38	0.80	1.21	1.71	147	158	144	109	95
13:00	0.20	0.51	1.09	1.48	1.99	147	158	154	110	95
14:00	0.25	0.77	1.07	1.80	2.22	147	158	108	121	95
15:00	0.40	1.00	1.76	2.06	2.47	148	158	109	119	39
16:00	0.55	1.21	2.03	2.30	2.60	149	158	110	95	28
17:00	0.75	1.60	2.17	2.47	2.53	149	156	95	46	10
18:00	0.81	1.78	1.81	2.76	2.66	158	110	83	35	10
19:00	0.71	1.48	2.11	2.02	2.48	158	145	45	10	10
20:00	0.60	1.29	2.03	2.05	2.41	158	110	42	10	10
21:00	0.60	1.17	1.88	1.80	1.24	157	96	33	10	8
22:00	0.51	1.00	1.20	1.49	0.61	158	96	10	10	8
23:00	0.37	0.74	0.94	1.19	.	155	95	10	10	0

Exhibit 5
Graphic Representation of Baseline AC Usage by Time of Day and Outdoor Temperature
Weekdays



Impacts Associated with Curtailment Events

The Duty Cycle Approach (DCA) to estimating cycling impacts focuses on the frequency distribution of duty cycles across a population of appliances. The DCA recognizes that cycling impacts are not identical across program participants. AC units with low demand during the control period will essentially be unaffected by the cycling event. In contrast, AC units that normally maintain a high level of demand during these periods will contribute a substantial demand reduction for the system. Implementation of the DCA in the calculation of load impacts is described in what follows.

Given a minimum of fifteen-minute air conditioner cycling, as employed by SCE for the 50% cycling option, impacts are calculated on the assumption that the duty cycle during the control period can be reduced by no more than 50 percent. This is expressed in kW by multiplying the difference between the duty cycle and 0.5 by each AC connected load.

AC 30-minute interval $\text{impact}_{50\%}$ = max (0, duty cycle - 0.5) * connected load

Similarly, for the 67% cycling option:

AC 30-minute interval $\text{impact}_{67\%}$ = max (0, duty cycle - 0.33) * connected load

And for the 100% cycling option:

AC 30-minute interval $\text{impact}_{100\%}$ = duty cycle * connected load

By segmenting the load data by time and temperature bin, as illustrated in Exhibits 3 and 4, the resulting impact tables provide SCE with a predictive model of gross impacts over an array of weather conditions and time of day.

Estimated gross impacts were calculated as follows:

For each AC unit, the DCA used 30-minute interval duty cycles and the connected load of each unit, derived as described above in the EUM Data Collection section.

For each AC unit, “normalized impacts” (impacts divided by connected load) were calculated for each 30-minute interval and each cycling strategy using the following formulas:

30-minute normalized $\text{impact}_{50\%}$ = max (0, duty cycle - 0.5)

30-minute normalized $\text{impact}_{67\%}$ = max (0, duty cycle - 0.33)

30-minute interval $\text{impact}_{100\%}$ = duty cycle

Individual 30-minute “normalized impacts” for each AC unit were averaged for each half-hourly interval and outdoor temperature.[6] The gross cycling impact for a given AC unit, a given time of day, a given outdoor temperature, and a given cycling strategy was calculated as the product of the average “normalized impact” for the AC unit and its connected load.

System-wide cycling impacts by time of day and outdoor temperature were then calculated by averaging across AC units, using the number of units in each climate zone as weights. These system-wide cycling impacts represent the demand by which the AC units load in the SCE service territory *is reduced* during a control event that occurs at a given time of day and under given outdoor temperature conditions. Similar to the baseline calculation, the gross cycling impacts include free ridership. Net program impacts can be calculated by multiplying the gross impacts by one minus the cycling device failure rate.

As expected, impacts for the 100% cycling strategy are equal to AC usage levels (see Exhibits 3, 4 and 5). Exhibits 6 and 7 present system-wide gross cycling impacts for the 50% cycling strategy, for weekdays and weekend days respectively. Similar to Exhibit 5, Exhibit 8 presents the data from Exhibit 6 in graphic format. For brevity, impacts for 67% cycling strategies are omitted from this paper.

Exhibit 6
Gross Cycling Impact Estimates by Time of Day and Outdoor Temperature
50% Cycling Strategy, Weekdays

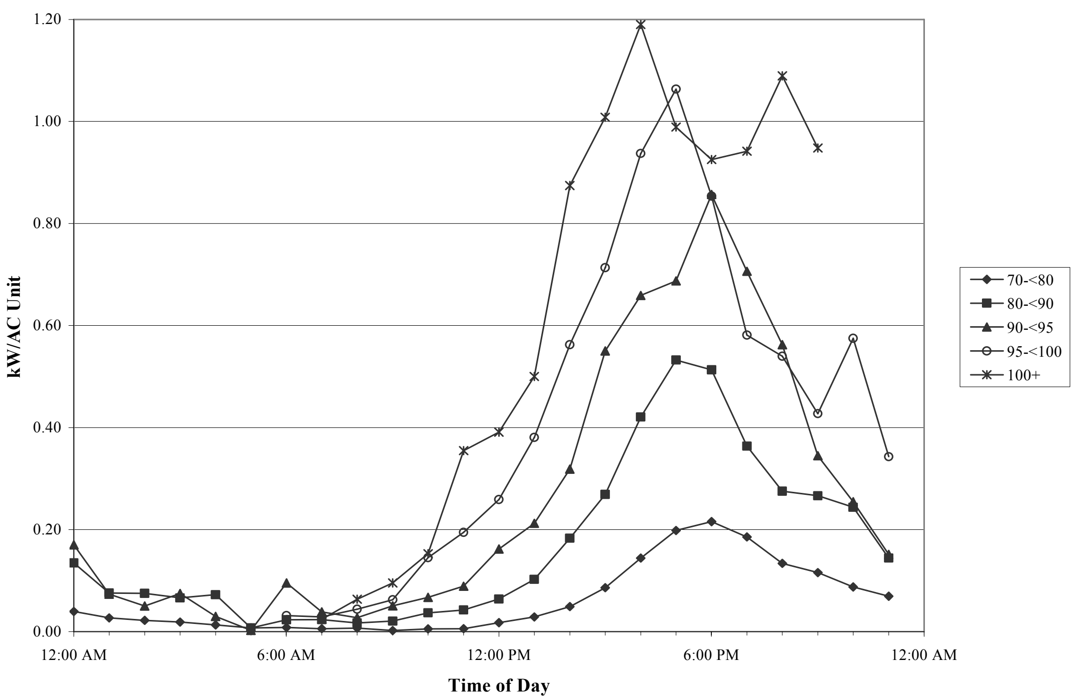
Time	Gross Impacts (kW/Appliance)					Sample Size (EUM points)				
	Outdoor Temperature Group (°F)					Outdoor Temperature Group (°F)				
	70-<80	80-<90	90-<95	95-<100	100+	70 - <80	80-<90	90-<95	95-<100	100+
12:00 AM	0.04	0.13	0.17	.	.	159	94	10	0	0
1:00	0.03	0.08	0.07	.	.	147	94	10	0	0
2:00	0.02	0.07	0.05	.	.	146	46	10	0	0
3:00	0.02	0.07	0.07	.	.	146	28	10	0	0
4:00	0.01	0.07	0.03	.	.	146	28	10	0	0
5:00	0.01	0.01	0.00	.	.	158	107	10	0	0
6:00	0.01	0.02	0.10	0.03	.	159	109	17	10	0
7:00	0.01	0.02	0.04	0.03	0.02	158	159	103	10	10
8:00	0.01	0.02	0.03	0.04	0.06	158	159	120	17	10
9:00	0.00	0.02	0.05	0.06	0.10	149	159	109	119	10
10:00	0.01	0.04	0.07	0.15	0.15	149	158	158	109	46
11:00	0.01	0.04	0.09	0.19	0.35	149	158	147	109	93
12:00 PM	0.02	0.06	0.16	0.26	0.39	149	158	147	110	95
13:00	0.03	0.10	0.21	0.38	0.50	149	158	159	112	95
14:00	0.05	0.18	0.32	0.56	0.87	149	158	159	112	94
15:00	0.09	0.27	0.55	0.71	1.01	149	158	158	110	94
16:00	0.14	0.42	0.66	0.94	1.19	149	158	123	95	86
17:00	0.20	0.53	0.69	1.06	0.99	158	159	96	93	28
18:00	0.22	0.51	0.86	0.85	0.93	158	147	93	39	10
19:00	0.19	0.36	0.71	0.58	0.94	158	112	46	10	10
20:00	0.13	0.28	0.56	0.54	1.09	159	111	39	10	10
21:00	0.12	0.27	0.34	0.43	0.95	159	111	10	10	10
22:00	0.09	0.24	0.25	0.58	.	159	97	10	10	0
23:00	0.07	0.14	0.15	0.34	.	148	97	10	10	0

[6] Even though the EUM sample included only a few AC units that were enrolled in the 50% and 67% cycling strategies, the DCA method uses data from the entire sample to estimate gross impacts for each cycling scenario.

Exhibit 7
Gross Cycling Impact Estimates by Time of Day and Outdoor Temperature
50% Cycling Strategy, Weekend Days

Time	Gross Impacts (kW/Appliance)					Sample Size (EUM points)				
	Outdoor Temperature Group (°F)					Outdoor Temperature Group (°F)				
	70-<80	80-<90	90-<95	95-<100	100+	70 - <80	80-<90	90-<95	95-<100	100+
12:00 AM	0.06	0.24	0.17	0.03	.	157	107	10	10	0
1:00	0.05	0.14	0.20	0.00	.	157	93	10	10	0
2:00	0.04	0.09	0.13	.	.	156	81	10	0	0
3:00	0.01	0.07	0.11	.	.	156	82	10	0	0
4:00	0.01	0.03	0.04	.	.	156	81	10	0	0
5:00	0.01	0.01	0.01	.	.	157	95	57	0	0
6:00	0.01	0.04	0.02	0.04	0.01	158	120	75	10	10
7:00	0.01	0.02	0.07	0.12	0.09	157	156	86	28	10
8:00	0.00	0.02	0.03	0.15	0.11	149	158	92	93	10
9:00	0.00	0.03	0.07	0.09	0.15	149	158	109	91	28
10:00	0.01	0.03	0.09	0.18	0.20	149	158	120	108	28
11:00	0.02	0.05	0.15	0.23	0.33	148	158	153	109	83
12:00 PM	0.02	0.08	0.20	0.32	0.51	147	158	144	109	95
13:00	0.03	0.11	0.30	0.44	0.66	147	158	154	110	95
14:00	0.04	0.20	0.32	0.59	0.76	147	158	108	121	95
15:00	0.08	0.29	0.60	0.72	0.89	148	158	109	119	39
16:00	0.13	0.37	0.71	0.84	0.90	149	158	110	95	28
17:00	0.18	0.52	0.75	0.86	0.83	149	156	95	46	10
18:00	0.20	0.52	0.56	0.96	0.85	158	110	83	35	10
19:00	0.15	0.35	0.60	0.44	0.71	158	145	45	10	10
20:00	0.09	0.28	0.50	0.48	0.60	158	110	42	10	10
21:00	0.10	0.23	0.39	0.37	0.06	157	96	33	10	8
22:00	0.09	0.19	0.17	0.21	0.03	158	96	10	10	8
23:00	0.06	0.11	0.12	0.10	.	155	95	10	10	0

Exhibit 8
Graphic Representation of Gross Cycling Impact Estimates
by Time of Day and Outdoor Temperature
50% Cycling Strategy, Weekdays



The reader should note that the gross impact estimates produced by the DCA are **not** actual impacts measured during control events that occurred in 2006. Rather, they are "potential" impacts, derived on the basis of average AC usage observed in the EUM sample on non-control days.

A comparison of Exhibits 3 and 6 for weekdays shows that cycling impacts are higher for the 100% cycling strategy than for the 50% cycling strategy. Within a given temperature bin, cycling impacts are relatively low in the morning, increase in the afternoon, peak around 5 - 6 PM, and then decrease again. Since AC demand increases with increasing outdoor temperature, cycling impacts increase with outdoor temperature as well.

The main benefit of reporting gross AC impacts in the format shown in Exhibits 3, 4, 7 and 8 is that it allows program staff and utility planners to determine the magnitude of the AC impact at given times of day and under specific outdoor temperature conditions.

For example, if the outdoor temperature is 90-95 ºF on a weekday, an AC unit enrolled in the 100% cycling option is expected to yield 0.44 kW in gross impacts at 10-11 AM, and 1.91 kW at 4-5 PM. Obviously, AC units will experience lower temperatures in the morning and evening, and higher temperatures in the middle of the day; the impact tables provide estimates of gross AC impacts given different temperature conditions at different times of day. Furthermore, at a given time of day AC units across the SCE territory will operate under different temperatures if they are located on the coast, as compared to units located in the desert; the impact tables provide gross impact estimates for the different temperature conditions associated with different districts.

Being able to gauge the magnitude of impacts that can be obtained at certain locations under certain weather conditions allows utility planners to decide, for example, which areas of the SCE territory should be cycled to provide the optimum response to an ISO-called event. By comparison, an "impact shape" derived using the runtime logger and spot reading method provides only the average impact that can be expected from an AC unit at different times of the day, under average summer conditions. Initiating cycling events based on knowledge of the average impact only may lead to the curtailment of too few or too many program participants.

Using the gross impact results estimated by the DCA, a model was built that takes into account the distribution of program participants in the SCE territory, and the different outdoor temperature conditions that are likely to occur at different hours of the day. The model rolls up expected gross impacts by weather station and for the entire service territory at any desired time of day, and provides estimates of impacts that can be achieved by issuing cycling events to different areas within the service territory.

The gross impact results can also be used to assess the cost effectiveness of the program and to inform the demand response forecasting model.

Conclusion

The Duty Cycle Approach used in the evaluation of SCE's AC Cycling Summer Discount Program provides program staff and utility planners with gross impact results for different outdoor temperature conditions at different times of day. This allows accurate response to ISO-called events without necessarily calling for cycling events that affect all AC Cycling Summer Discount Program participants.