-The following section is an excerpt from the final report-
7. **AIR CONDITIONER CYCLING PROGRAM DESIGN**

7.1 **PROGRAM DESCRIPTION**

The objective of the Air Conditioner Cycling (“AC Cycling”) program is to reduce peak load by curtailing air conditioning during peak usage periods through the program season of June through September. This program includes both residential and commercial customers with central Air Conditioning (AC) units of five tons or less.

A Cannon Technologies LCR-5200 load control switch provided by <TECHNOLOGY VENDOR> is installed in the participant customers’ AC units on the outside of the home. This load control switch enables AC units to be turned off for limited intervals during cycling events. According to guidelines approved by the <COMMISION>, cycling events can be conducted for up to 6 hours per event, typically during the window between 12 pm and 7 pm, though not on weekends or holidays. Customers may choose to drop out of the program at any time or opt-out of an AC cycling event once per month. As of yet, there is no limit to the number of potential opt-outs, but participants who opt-out frequently could be removed from the program. The program launched in July 2011, and installations began in October 2011.

This evaluation covers the program period from July 2011 to December 2011. Evaluation activities include data collection coordination and a review of AC Cycling strategies to ensure adequate data for PY2 impact analysis.

Originally, the program offered a two-tiered incentive structure that varied according to the size of the AC unit as well as whether the customer was residential or commercial. This initial tiered incentive structure was complex. To provide more clarity and simplicity to customers, a new incentive rate of a flat $10 credit per month for the program period June through September, or $40.00 per year, was established with approval of the IURC through a 30-day filing submitted by <UTILITY>. All participating customers, even those originally enrolled under a tiered incentive structure, have been placed under the new incentive structure approved in February 2012.

7.2 **PROGRAM BUDGETS, GOALS, AND SCORECARDS**

<UTILITY> had a budget of $605,093 for the year 2011, of which they spent 98%. The table below shows the expenses for 2011.
Table 144: 2011 Program Budgets and Expenditures

<table>
<thead>
<tr>
<th>Program Category</th>
<th>Amount</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approved Budget</td>
<td>$605,093</td>
<td></td>
</tr>
<tr>
<td>Total Expenses</td>
<td>$593,637</td>
<td>98%</td>
</tr>
<tr>
<td>&lt;IMPLEMENTER&gt; Solutions</td>
<td>$138,320</td>
<td>23%</td>
</tr>
<tr>
<td>One Time Fees</td>
<td>$70,000</td>
<td>12%</td>
</tr>
<tr>
<td>Management</td>
<td>$40,000</td>
<td>7%</td>
</tr>
<tr>
<td>Customer Recruitment</td>
<td>$7,560</td>
<td>1%</td>
</tr>
<tr>
<td>Installation - First Device</td>
<td>$14,175</td>
<td>2%</td>
</tr>
<tr>
<td>Installation - Second Device</td>
<td>$585</td>
<td>0.1%</td>
</tr>
<tr>
<td>Customer Contact Center</td>
<td>$6,000</td>
<td>1%</td>
</tr>
<tr>
<td>&lt;TECHNOLOGY VENDOR&gt;/Cannon Technologies</td>
<td>$455,317</td>
<td>77%</td>
</tr>
<tr>
<td>Installation</td>
<td>$9,500</td>
<td>2%</td>
</tr>
<tr>
<td>Software License Fee</td>
<td>$3,000</td>
<td>0.5%</td>
</tr>
<tr>
<td>Hosting Software Fee</td>
<td>$2,000</td>
<td>0.3%</td>
</tr>
<tr>
<td>Project Management Fee</td>
<td>$1,500</td>
<td>0.3%</td>
</tr>
<tr>
<td>LCR 5200</td>
<td>$417,600</td>
<td>70%</td>
</tr>
<tr>
<td>LCR Minder</td>
<td>$7,500</td>
<td>1%</td>
</tr>
<tr>
<td>Portable Field Test Equipment</td>
<td>$5,750</td>
<td>1%</td>
</tr>
<tr>
<td>Shipping</td>
<td>$8,467</td>
<td>1%</td>
</tr>
</tbody>
</table>

The program’s goal is to install 33,000 load control switches (representing approximately 7% of <UTILITY>’s approximately 450,000 customers) by the end of 2013, or 11,000 per year. However, due to the late launch of the program, the recruitment goal was revised to 2,000 units in 2011. Due to changes to the program design—especially to the incentive structure—<UTILITY> elected to postpone marketing activities until the program changes were approved by the Commission and <UTILITY> could upgrade the marketing materials accordingly. As of December 2011, <UTILITY> had enrolled approximately 756 customers.

7.3 EM&V METHODOLOGY

Table 145 highlights the activities undertaken to evaluate the AC Cycling program.

Table 145: Program Evaluation Overall Tasks

<table>
<thead>
<tr>
<th>Action</th>
<th>Details</th>
</tr>
</thead>
</table>
| Program Manager and Implementer Interviews | • Interviewed Program Manager  
  • Interviewed Implementer (<IMPLEMENTER>)  
  • Interviewed Technology Vendor (<TECHNOLOGY VENDOR>) |
| Program Database Review / Verification | • Reviewed participant-tracking database  
  • Selected a random sample of participants for PY2 data collection including 8 commercial and 70 residential customers |
| Program Material Review               | • Reviewed materials to assess marketing and outreach efforts including enrollment data, marketing materials, budgets, statements of work/implementation plans, and IURC filings  
  • Reviewed best practices and lessons learned in AC Cycling strategies for load management programs across the country to inform <UTILITY> AC Cycling Strategies |
Action | Details
--- | ---
Participant Surveys | • Participant surveys drafted to gauge awareness of event, satisfaction with and ease of enrollment process, motivations for participation, and satisfaction with the program and <UTILITY>.  
• These surveys will be fielded to participant customers during PY2 following AC Cycling events. Should AC Cycling events not be called prior to August 1, 2012, the <EVALUATION TEAM> team will field the survey during the month of August / September 2012.

Impact Analysis | • Given that program launched in the fall of 2011, no AC Cycling events were called during PY1.  
• However, given limitations in data collection, coordination with <IMPLEMENTER> to ensure that hourly data for the entire PY2 period (June 1 – September 30) for the sample population is in place.  
• Checks to ensure that sample customers’ load switches are pinged to start data collection are in place.

### 7.4 Impact Analysis

No AC Cycling events were called during 2011 since the program was launched in the fall of 2011 (i.e., after the summer season). As such, the evaluation team focused 2011 efforts on process findings and alignment of logistical aspects for estimating program impacts in 2012. In 2012, the evaluation team will collect data, should an AC Cycling event be called, to verify participant savings and provide recommendations regarding appropriate savings targets for the program. The <EVALUATION TEAM> team did, however, examine the program-tracking databases and processes to ensure that data is being collected effectively for future impact efforts. Below we present the findings from this analysis.

#### Program-Tracking Databases Verification

A review of the participant-tracking database indicates that <IMPLEMENTER> is tracking the data that will be needed to perform impact evaluations once AC Cycling events are called. Table 146 lists the critical components of data tracking.

<table>
<thead>
<tr>
<th>Customer Contact Information</th>
<th>Unit Performance Information</th>
<th>Load Needed for Impact Verification</th>
</tr>
</thead>
</table>
| • Customer Name  
• Address  
• Zip Code  
• Billing usage (ADU, or annualized kWh consumption – provided by <UTILITY>) | • Date enrolled  
• Cancelled date (if applicable)  
• AC unit tonnage  
• Compressor RLA  
• Fan FLA  
• Voltage | • Hourly run time  
• Hourly temperature data (South Bend Station, collected by <UTILITY>)  
• Household Information (dwelling type) |

Note that for collecting hourly run time, the load control switch does not have the capability to relay information collected on their units remotely. The switch is set up to receive one-way signals to turn units on or off. As such, impact verification of the performance of the program is necessarily limited to using statistical analysis via a representative sample to arrive at an estimated load per home.
QA/QC and Verification

The Cannon Technologies LCR-5200 load control switches used in this program have been purchased from <TECHNOLOGY VENDOR> by <IMPLEMENTER>. Using a unique ID number for each device, <IMPLEMENTER> tracks its location at all times: in the warehouse, on a <IMPLEMENTER> vehicle waiting for installation, or installed in the field.

In the event that a device is faulty, <IMPLEMENTER> will retrieve it and return it to <TECHNOLOGY VENDOR> for a replacement. Reports of faulty devices can come from several sources: a technician during installation, a subsequent call to the <IMPLEMENTER> customer service line, or a random quality test <IMPLEMENTER> performs within the warehouse. Notably, the device cannot be tested once installed unless data is collected (discussed below). In 2011, <IMPLEMENTER> made two service calls in response to customer requests, and as of May 2012, they have made seven. The evaluation team has not been provided with a list of reasons for these calls, but as of the evaluation team interview with <IMPLEMENTER> in February of 2012, <IMPLEMENTER> has not found any faulty devices.

Establishing Sample for Impact Analysis

The evaluation team reached a data collection agreement with <IMPLEMENTER> to ensure that data is collected in the participant sample homes for the PY2 summer period (June through September 2012) for impact analysis.

For PY2, the evaluation team estimated a sample based on current participants to date (n=1,591). While eventually the program will be marketed to the entire <UTILITY> service territory, for logistical expediency, initial recruiting was limited to a clustered geographic area. This clustering also implies a lack of variability in some major key factors which may impact observed load impacts during events, notably temperature and humidity levels (which may be different in distinct geographies), socio-economic factors (not often easily obtained), age of housing stock, and other related metrics. Thus, the sample selected was based on a random selection of participants to ensure a statistically valid sample with a 90%/10% confidence in observed results. As recruiting expands to include different geographies over time, or markedly different customer groups and classes, the sample may need to be increased, and/or a stratified sample selection approach may be used to ensure an adequate representation of the participant population in the service territory.

In addition, both commercial and residential customers are part of the participant population. The commercial population is likely to behave differently and yield different observed load impacts; even though based on the AC unit tonnage, they are similar to the residential population. At the time of selection, there were eight commercial customers. The evaluation team will attempt a census for commercial customers. Notably, because of the small population of commercial customers, information collected will not be extrapolated to future participants. In addition, 70 residential customers were selected for data collection to ensure a statistically representative sample.

7.5 Program Implementation and Insights

The section below provides additional details on the program, as well as insights and recommendations for future efforts.

The insights and recommendations are broken up by AC Cycling Strategies and Program Participation and Marketing.
Program insights and recommendations are based on interviews with program managers, program implementers, and technology vendors, and a review of program materials and documentation including scorecards, marketing plan/materials, and program-tracking database. In addition, recommendations are also based on a best practice review of AC Cycling strategies and evaluations from utilities across the United States and the evaluation team’s experience in conducting demand response program impact analysis. See Table 145 for a detailed overview of evaluation activities.

### 7.5.1 Program Implementation

<IMPLEMENTER>, a demand-side service provider, is the program implementer. <IMPLEMENTER> is paid a monthly fee for program and call center management, as well as a per-unit fee for each enrollment and on-site service call (i.e., switch installation, removal, service, etc.).

On the day of the appointment to install the load control switch at the customer’s premise, the technician inspects the participating customer’s AC unit to ensure it qualifies for the program (in terms of size, operational unit, and related information). Data collected at this time includes tonnage, serial number, manufacturer, the amperage of the fan (rated load amps [RLA] and full load amps [FLA]), as well as any outstanding features of the unit (i.e., a very old unit or in disrepair). If tonnage data is not available, <IMPLEMENTER> uses “a standard 3 tons for the unit” for purposes of load calculation.69

At the time of the visit, the technician installs a Cannon Technologies LCR-5200 load control switch. The devices are provided by <TECHNOLOGY VENDOR>, who also provides project management, installation, training, and support for the Yukon Software system that operates the devices.

The customer does not need to be present for the installation. If the customer is home, the technician will speak with them before the installation to apprise them of the situation. If not, the technician will install the device and leave a door hanger noting the event. If for some reason the AC unit is not eligible, the technician will speak with the customer, or leave a door hanger detailing the issue.

Each device is connected to the AC unit as part of a closed relay. When it receives a radio signal signifying that an event has been called, the switch opens and breaks the circuit, preventing the AC from cooling the air. This interruption does not interfere with the fan of the unit, and does not affect the unit at all until a signal has been received from the Yukon software management system, which is controlled by <UTILITY>.

The load control switch can collect data as soon as it is installed. Once set to record, the device can hold a rolling 90 days of data before it begins to overwrite the previous data with each additional day (i.e., day 91 would overwrite day 1, day 92 would overwrite day 2, etc.). The switch records a variety of data on an hourly basis including minutes of AC use in the previous hour, and minutes of AC use shed (due to a cycling event) in the previous hour, date, and time. The device receives one radio transmission per day that resets the internal clock to the correct date and time. The unit does not record actual electricity usage of the unit; this is estimated using the running time and the tonnage associated with the unit which is collected at the time of installation.

The <IMPLEMENTER> technician can collect the data in two ways. The first is a “Blue Tool” device that is held next to the relay switch and receives the data via Bluetooth. This device is then plugged

---

69 Note that this is currently being explored through other research and the average size may be closer to 2.5 tons. Research is still in progress.
into a computer via USB and the data is downloaded. The second method collects the data via Bluetooth and downloads the data directly to the computer. In the case that events are called in PY2, the evaluation team has coordinated activation of the data collection and will be using the second method to collect data.

### 7.5.2 Program Insights and Recommendations: Design of Future AC Cycling Strategies

<UTILITY> has established guidelines, listed in Table 147, for triggering AC Cycling events that have been approved by the Oversight Board.

<table>
<thead>
<tr>
<th>Type</th>
<th>Trigger events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load / Supply Triggers</td>
<td>1. MISO declares a Maximum Generation Alert</td>
</tr>
<tr>
<td></td>
<td>2. MISO’s Day Ahead Load Forecast is projected to be greater than 100 GW</td>
</tr>
<tr>
<td></td>
<td>3. &lt;UTILITY&gt;’s Forecasted Balancing Area Load is projected to be greater than</td>
</tr>
<tr>
<td></td>
<td>3400 MW</td>
</tr>
<tr>
<td></td>
<td>4. In addition, on an ongoing basis, &lt;UTILITY&gt; will identify possible problem</td>
</tr>
<tr>
<td></td>
<td>circuits that could be grouped within the Yukon software system to reduce</td>
</tr>
<tr>
<td></td>
<td>load. The AC Cycling program could be used to reduce load on those circuits if</td>
</tr>
<tr>
<td></td>
<td>necessary</td>
</tr>
<tr>
<td>Economic Triggers</td>
<td>1. The Day Ahead locational marginal prices (“LMP”) for &lt;UTILITY&gt;</td>
</tr>
<tr>
<td></td>
<td>2. Real Time LMP for &lt;UTILITY&gt;</td>
</tr>
<tr>
<td>Program Guidelines</td>
<td>1. Customer satisfaction is the key to a positive experience with the AC Cycling Program</td>
</tr>
<tr>
<td></td>
<td>2. Cycling normally will occur between mid-morning and early evening (12 pm–7 pm)</td>
</tr>
<tr>
<td></td>
<td>3. Cycling event may last up to 6 hours</td>
</tr>
<tr>
<td></td>
<td>4. In a typical AC Cycling season, four to ten cycling events may occur</td>
</tr>
<tr>
<td></td>
<td>5. Cycling will occur no more than 20 times per season</td>
</tr>
<tr>
<td></td>
<td>6. 50% cycle strategy will be used for the initial launch of the program (AC unit will be cycled for approximately 15 minutes each half hour)</td>
</tr>
<tr>
<td></td>
<td>7. Customer may opt out of one event per month; ongoing opt-outs in excess of</td>
</tr>
<tr>
<td></td>
<td>the one event per month may mean a customer is disenrolled from the program</td>
</tr>
</tbody>
</table>

Below are program insights and recommendations based on interviews with program managers, program implementers, and technology vendors; review of program materials; review of impact studies from demand response programs from utilities across the country; and the evaluation team’s experience in designing and evaluating demand response programs.

1. **Current impact estimates will likely be revised depending on the duty cycle, participant customer profile, and timing of events**

No AC Cycling events were called during 2011 since the program was launched after the summer season in the fall of 2011. Given that no events were called in 2011, current impact estimates are about 1 kW per premise as per vendor claims on typical load per program at other utilities where a similar switch was installed. Actual verified load per home will depend on a number of factors that will be verified on the impact evaluations for 2012 AC Cycling events.

As the program continues, <UTILITY> will be in a position to test different AC Cycling strategies. While the 50% cycling strategy is an effective “rule-of-thumb” based on AC Cycling programs implemented by other utilities, it is possible that by varying the duty cycle percentage, the time of day, the duration
of the event, and the event trigger criteria, <UTILITY> may find that an alternate strategy could be more effective in offering increased savings without negatively impacting customer satisfaction. These efforts can be implemented in conjunction with the 2012 satisfaction surveys, in order to better understand their effects.

Testing events will provide <UTILITY> with information regarding how much load the program can deliver during an AC Cycling event. This load is likely to vary by a variety of factors:

- Outside temperature and humidity
- Residential vs. small commercial load
- Geography (zip codes differential, which are linked to temperature)
- Physical characteristics of HVAC units (# of units per home, size of units being cycled, primary vs. secondary HVAC unit)
- Physical characteristics of participant premises (housing stock and size, multifamily vs. single-family vs. commercial)
- Duration of event
- Timing of events (including peak coincidence)
- Duty cycle (currently set at 50%, but can vary from this target based on <UTILITY> needs and customer feedback)

Because no events have been called to date, it is important to conduct tests to inform program participant load/capacity, recruiting of future participants, and economic values that can be attributed to program. The value of testing outcomes under different scenarios through calling AC Cycling events (even in the absence of emergency situations) is as follows:

- Maximize load reduction through refinement of cycling strategies
- Test program robustness under different conditions (temperature, seasons, time of day, duration of event)
- Identify potential economic benefits, in addition to peak load reduction outcomes
- Assure program cost-effectiveness through targeting customers that yield highest load reductions
- Inform recruitment strategies to maximize cost-effectiveness and capacity

In addition, understanding the program outcomes will assist with overall system-wide planning by allowing <UTILITY> to do the following:

- Reduce and manage volatility, especially in light of large swings in industrial load
- Increase overall system reliability
- Smooth peak loads
- Understand potential program economic benefits associated with influencing locational marginal prices (LMPs) and deferring capital investment in transmission and distribution upgrades/expansions

Recommendation: <UTILITY> should call events that enable observations of impacts of variables on impact estimates (i.e., times, duration, outdoor temperature/humidity duty cycles) to inform future program planning (i.e., impact estimates). Further, because different types of customers may provide different impacts, <UTILITY> should track customer variables (i.e., usage, geography, multiple units, and dwelling type) that can be incorporated into impact evaluations. Results may help the program identify future customer targeting / eligibility to maximize savings per enrollee.
2. **Cycling strategies should consider the relationship between humidity, temperature, and loads**

There is typically a high correlation between temperature and humidity and overall load consumption. It is also well understood in general that AC Cycling events are typically deployed during hot afternoons where a system peak is expected. The figure below demonstrates the relationship between load and temperature. What that means in practical terms is that an AC Cycling event will likely yield different observed load impacts depending on the temperature and time when the event is called. Thus, when claims are made that an event will yield an average load per home, it is important to understand the characteristics of the days when the event was called.

**Figure 19: Load Consumption in Residences Non-Event Weekdays, Utility in the Pacific Northwest**

A review of the 2011 summer period in Indiana based on data from the South Bend station shows significant temperature variability during the summer period, even in what was considered a “cool” summer.
Thus, the <EVALUATION TEAM> team recommends that events be called in <UTILITY> territory to test the observed load impact based on temperature bins. In addition, it is important to note that the curvilinear patterns of temperature levels, that is, temperature spikes, may occur anytime during the summer, but on average, temperatures are cooler around May/mid-June and in late September, and consistently higher in July and August. Thus, for <UTILITY>’s purpose, a particular temperature early or late in the summer season may trigger different load levels than at the peak of the summer months.

**Recommendations:**

- **i. Call events at different temperature / humidity levels:** test sensitivity of load shed based on outside temperature / humidity levels
  - a. Call at least 2 events each:
  - b. At temperatures > 100°F
  - c. At temperatures between 90°F and 100°F
  - d. At temperatures between 80°F and 90°F

- **ii. Call events at different periods:** test sensitivity of load shed based on different months to test whether load shed earlier in the summer is equivalent to load shed later in the summer, even at same temperatures
  - a. Call events at least once in June, July, August, September
  - b. Ideally, events should follow high temperature thresholds where possible

3. **Cycling strategies should consider the relationship between average energy consumption and expected load drops**

Previous load management studies (CA ADRS, BPA) have indicated that high users provide a disproportionate amount of the observed load shed during event days. Load shed is usually dependent on the energy usage level of participants with higher consumption typically leading to more potential for load shed. Premises with large loads generally tend to yield more load during peak
events. This is particularly important if the program also has a focus on cost-effectiveness and optimization of load shed.

**Figure 21: Stratified Load Consumption**

The load curves for commercial customers may also be different and more sustained than those of residential customers, although based on initial review of the participant population, the AC unit system tends to be similar in size. Still, it is important to understand the load profile and load shed capability of commercial as well as residential participants. Understanding this information will enable targeting recruiting that maximizes program cost-effectiveness and load shed capabilities.

Barring issues of customer equity, this aids in making the program cost-effective, and in maximizing expected capacity of installed participant population

**Recommendations:** Understand participant population profiles and load shed capabilities during PY2 impact analysis and use this data to enhance <UTILITY> targeted recruitment strategy based on population characteristics:

- Physical characteristics (AC unit size, average energy consumption, zip code, home size (rooms and/or square footage, etc.)
- Behavioral characteristics (AC usage [from surveys or review of billing data], home occupancy during peak periods, etc.)

4. **Current cycling strategies should consider the relationship between time of events and load achieved, degradation, and snapback**

Timing and duration of load is important—it must be matched against peak periods and take into account snapback and event degradation. <UTILITY> current AC Cycling guidelines state that cycling events can be called for up to 6 hours, within a 7-hour window (12:00 pm to 7:00 pm). While <UTILITY> should maintain this flexibility, it is important to understand that there is usually a degradation in observed load over the event period. Typically, maximum load is achieved at onset of the program, but as temperatures rise, so does the work effort that the AC unit engages in once it is switched back on. It is also common to observe a snapback effect, where some of the load shed during the event period tends to be shifted towards the end of the cycling event often due to AC units working harder than they otherwise would in the absence of event to cool premises following an AC cycling event. Thus, should <UTILITY>’s objective be to flatten and/or shift load, it is important to