

SMUD's Single-Family Summer Solutions Study

Vikki Wood
OpenADR Alliance Meeting

June 19, 2014

Powering forward. Together.

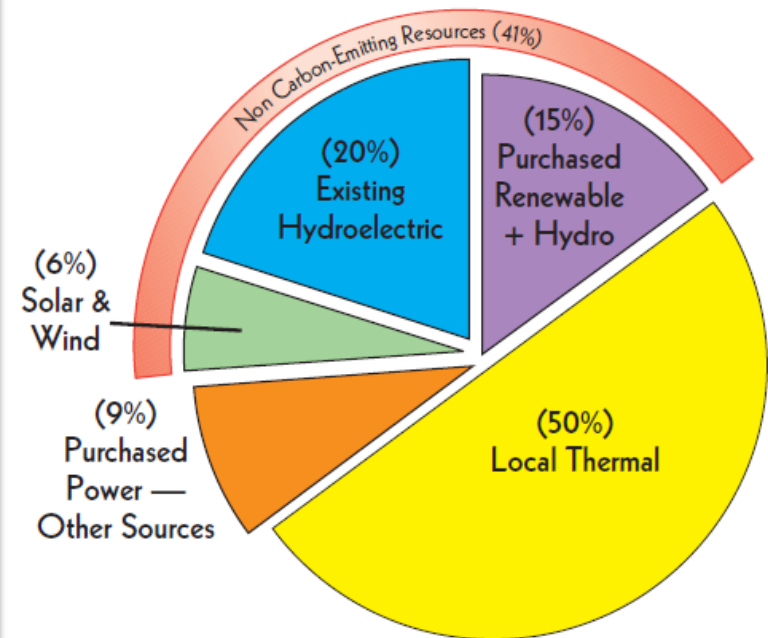


Agenda

- About SMUD
- Summer Solutions Design
- HAN Equipment
- Recruitment
- Education and Outreach
- Impact Findings
- Behaviors, Preferences, Satisfaction Findings
- Correlations with Impacts
- Conclusions

About SMUD

- SMUD is a public electric utility serving ~ Sacramento County, CA
- Governed by a seven-member elected Board of Directors (not regulated by CPUC)
- ~600k customer-owners, 530k residential, 70k commercial, 1.4M population, 900 mi²
- System peak ~3,000 MW, sales 10.5 GWh , \$1.26 billion
- Very proactive in promoting energy efficiency and renewable resources



SMUD DR Studies and Pilots

Single-Family Summer Solutions: 303 standard vs. TOU-CPP rate, 3 levels of energy information on web display and PCT, utility direct AC control with PCT vs. customer AC automation with PCT

Thermostat Usability: 163 residential, lab test of 12 thermostats for ease of use, feel and sound and appearance

PowerStat Precooling : 175 residential single family, utility direct AC control with PCT , 3 automated pre-cooling strategies

Smart Pricing Options: ~12k + ~47k controls, ~41k non-participants, residential single- and multifamily, dynamic rates (TOU, CPP, TOU-CPP), opt-in vs. opt-out , IHD vs. none

PowerStat: 866 residential single family and small commercial (<21 kW), TOU-CPP rate vs. incentive, utility direct AC control with PCT vs. customer AC automation with PCT

In-Home Display Checkout: ~900 and counting, residential and small commercial, 2-month loan of IHD

Multifamily Summer Solutions: 313 TOU-CPP rate, customer AC automation with PCT vs. none, IHD vs. none

Smart Thermostats: 810 residential single family, compare two PCTs that optimize for energy savings and comfort, TOU-CPP vs. standard

Low-Income Weatherization: 628 residential single-family, energy audit, optimizing PCT vs. IHD vs. online education

Auto-DR: 3.5 MW, 9 customers, 126 sites medium to large commercial, 4 incentive/rate options, technical assistance and incentives

EV Smart Charging: 180 residential EV owners, 2 TOU-CPP pricing plans (1 with demand charge on event days), self-managed vs. SMUD-managed charging

Research Team and Funding

- Research Team
 - Herter Energy Research Solutions
 - Sacramento Municipal Utility District (SMUD)
- Funding
 - Sacramento Municipal Utility District (SMUD)
 - California Energy Commission Public Interest Energy Research via the Demand Response Research Center at Lawrence Berkeley Lab

Project Objectives

- Compare energy, demand, and bill impacts under:
 - 3 randomly applied information treatments
 - baseline information (no real-time data)
 - real-time home-level data
 - real-time appliance-level energy data
 - 2 participant-selected rate options
 - SMUD's standard residential 2-tier rate
 - an experimental dynamic TOU-CPP rate
 - 2 participant-selected automation options for events
 - utility-controlled PCTs
 - customer-controlled PCTs
- Determine participation rates of the various options
- Correlate impacts with customer demographics, dwelling characteristics, energy using behaviors

Study Design

Study Component	Description
Information Treatments	<ul style="list-style-type: none"> Baseline = PCT only Home = PCT + real-time energy use data for the home Appliance = PCT + real-time energy data for the home, AC, and 2 appliances
Rate Options	<ul style="list-style-type: none"> Tiered rate = SMUD's standard residential flat 2-tier rate TOU-CPP rate = a time-of use rate with 12 critical price events per summer
Automation Options	<ul style="list-style-type: none"> Customer PCT = $\chi^{\circ}\text{F}$ default event offset that could be changed at any time Utility PCT = a 4°F mandatory event offset with 1 override per summer

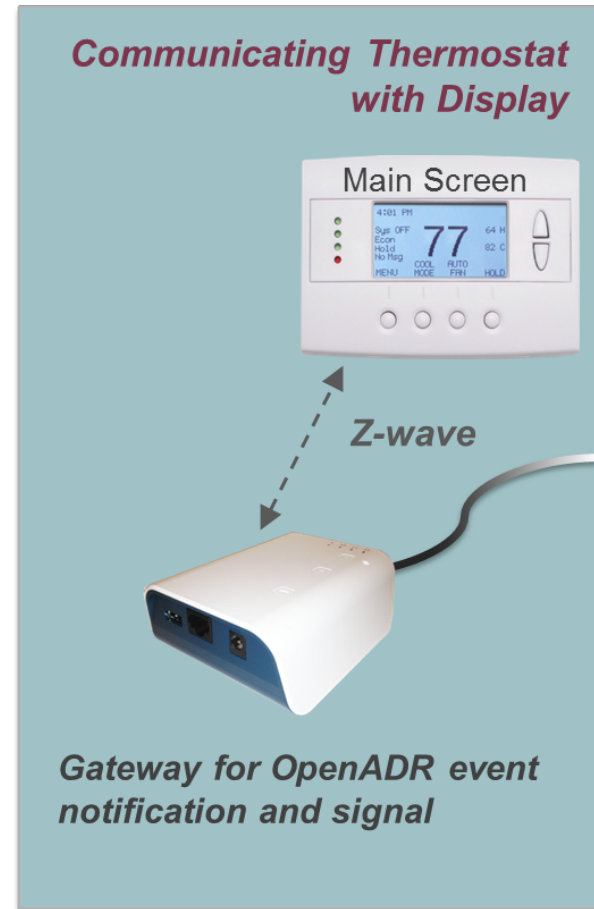
Program	Tiered Rate + Customer PCT	Tiered Rate + Utility PCT	TOU-CPP Rate + Customer PCT	TOU-CPP Rate + Utility PCT	Total Sample
Treatment					
Baseline	11	30	33	26	100
Home	24	27	21	29	101
Appliance	21	21	29	41	112
Total Sample	56	78	83	96	313

Analysis Methodology

- **Load and Energy Impacts:** Estimated overall energy impacts, non-event impacts and event peak impacts using three-level mixed-effects models regressing 2011-12 hourly summer electricity use on year, hour, temperature, event day and treatment group relative to modeled baselines using 2010 pretreatment data and corrected for exogenous effects using a matched control group
- **Bill Impacts:** Estimated energy impacts for individual customers using fixed-effects models incorporating the same variables above, and calculated the average monthly dollar savings based on elected rates
- **Demographics and Dwelling Characteristics:** Surveyed participants at the time of equipment installation
- **Energy Use Behaviors, Comfort, Satisfaction:** Surveyed participants at the end of 2011 and 2012 summers

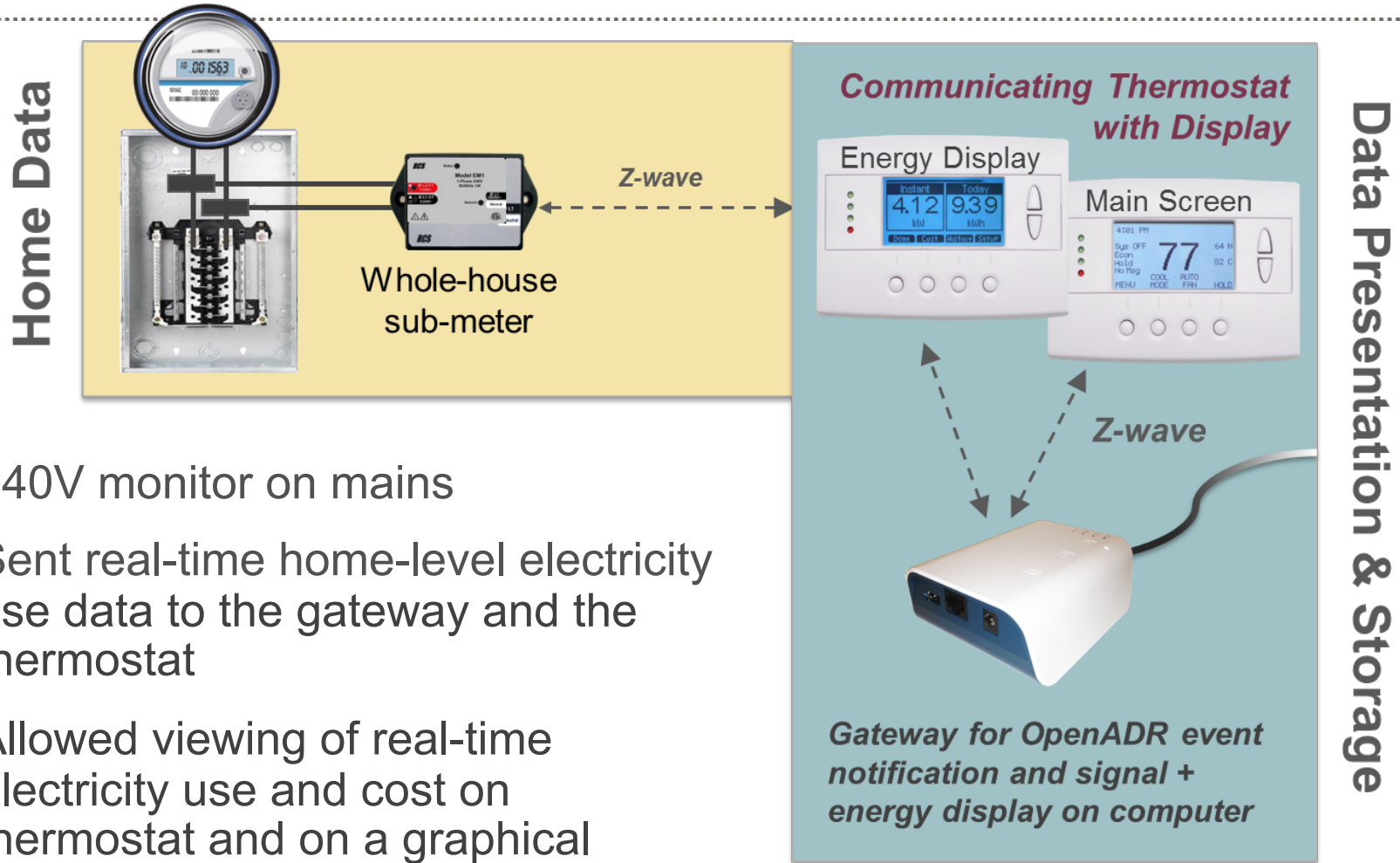
Information System: Baseline

- Communicating thermostat + gateway
- System enabled event notification and automatic air conditioning response
- No real-time energy information
- Installer assisted everyone in setting the thermostat
- 91% set their thermostat to respond to events—regardless of rate option



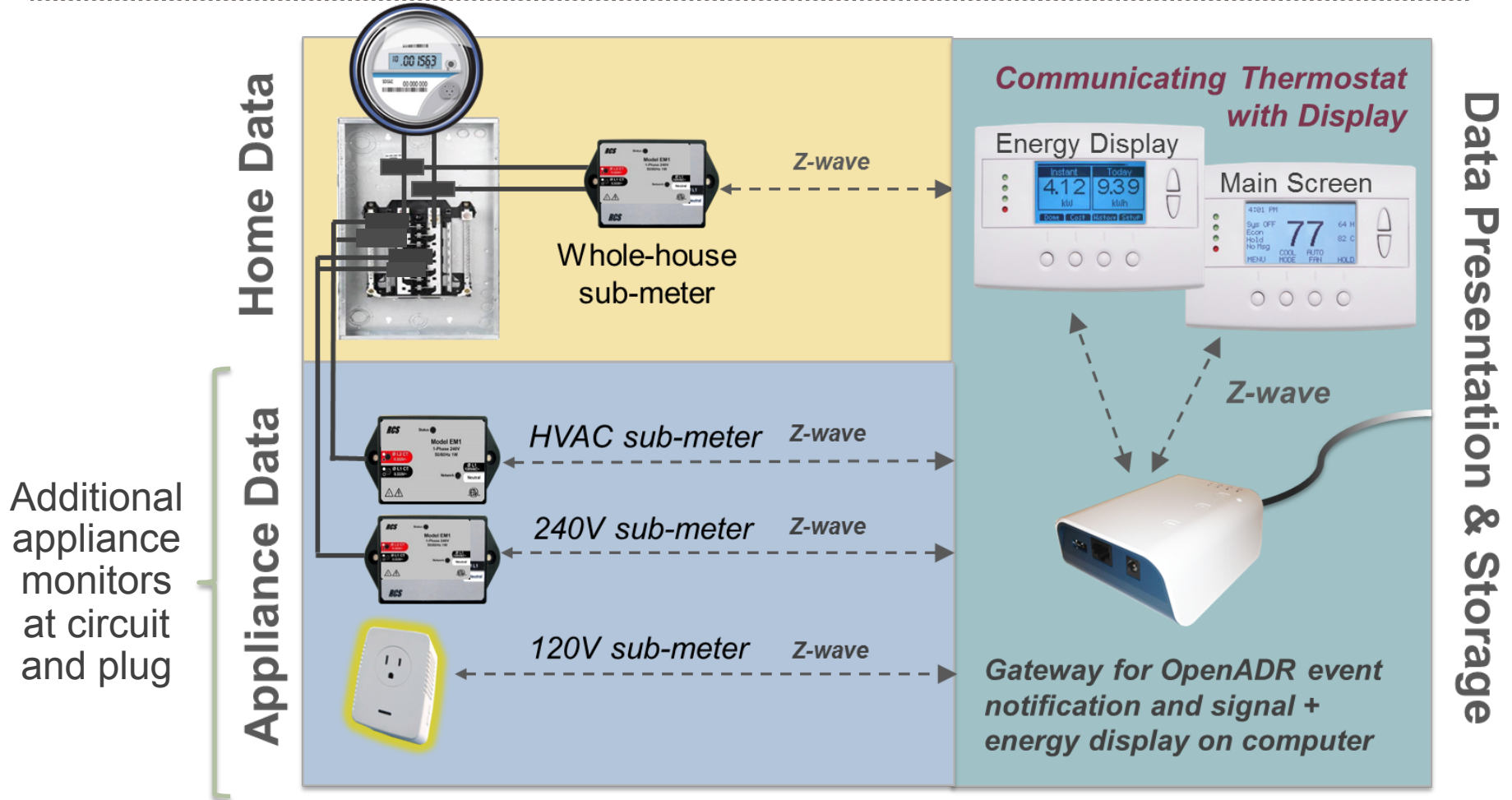
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Information System: Home Data



- 240V monitor on mains
- Sent real-time home-level electricity use data to the gateway and the thermostat
- Allowed viewing of real-time electricity use and cost on thermostat and on a graphical computer display

Information System: Appliance Data

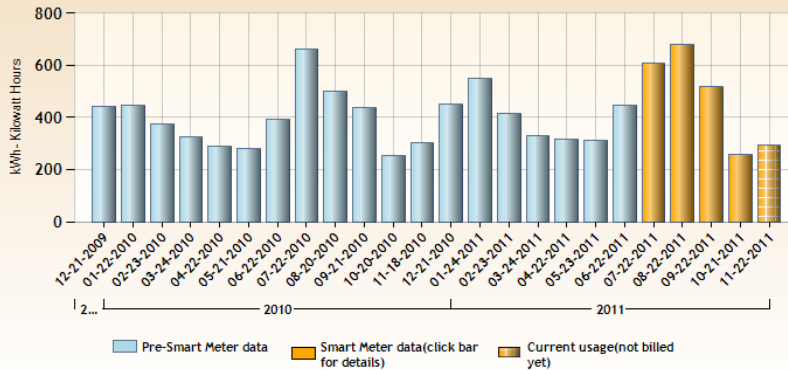


Baseline: Standard Billing Data

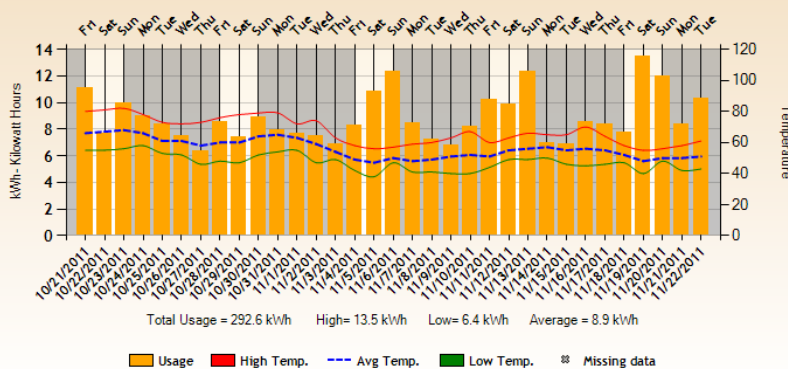
My Electricity Use online

- 24-hour old hourly data by day and aggregated by billing period and year
- Use data only—no cost data
- Requires setting up an account

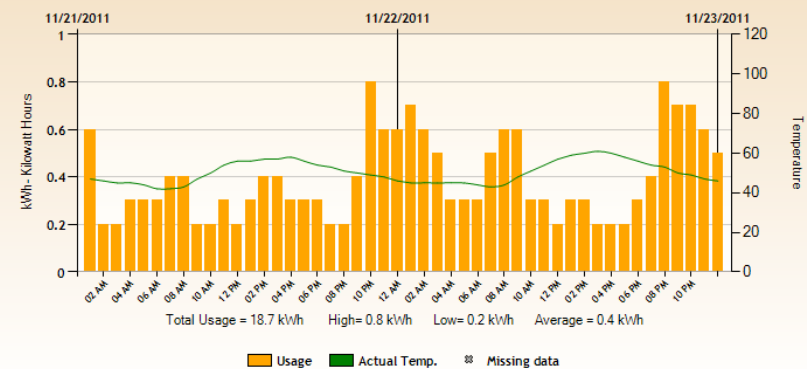
My Electricity Use by Billing Period



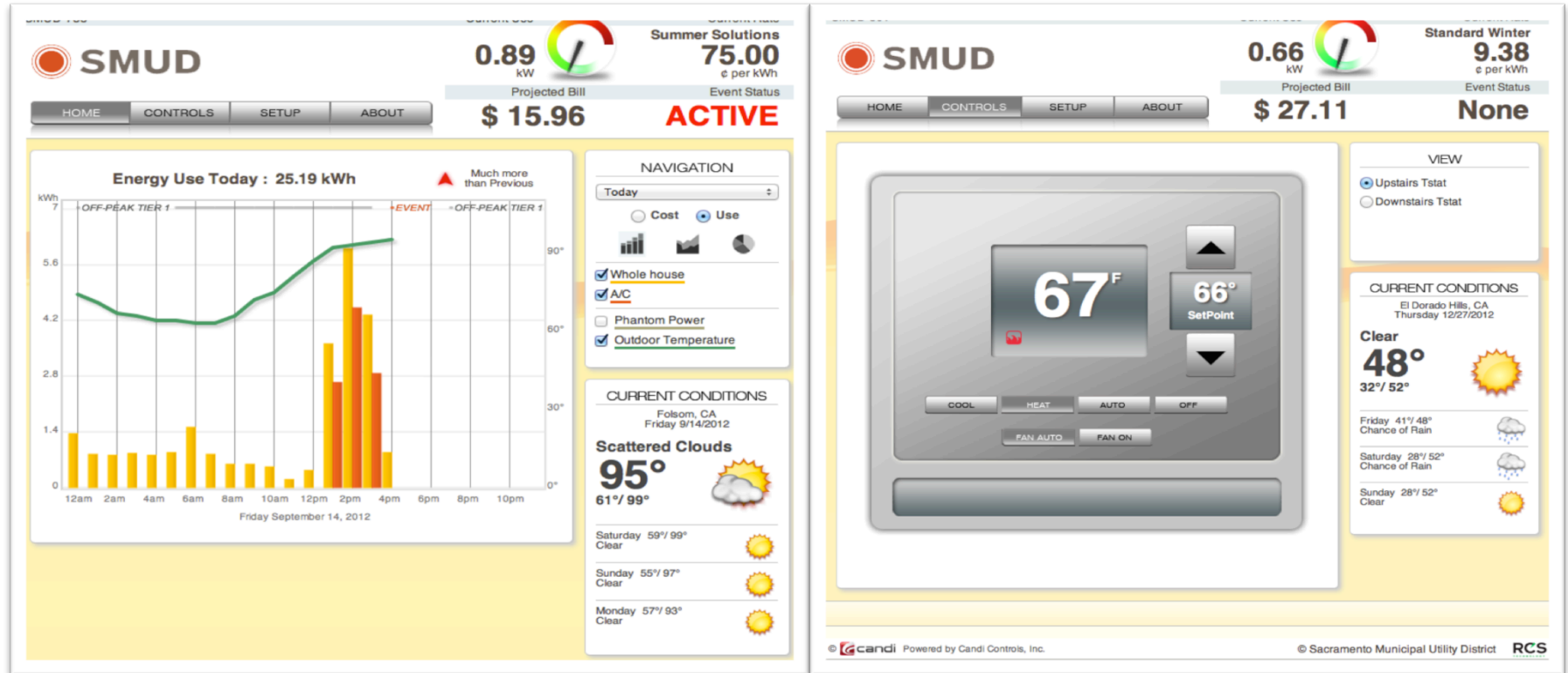
My Daily Electricity Use



My Hourly Electricity Use



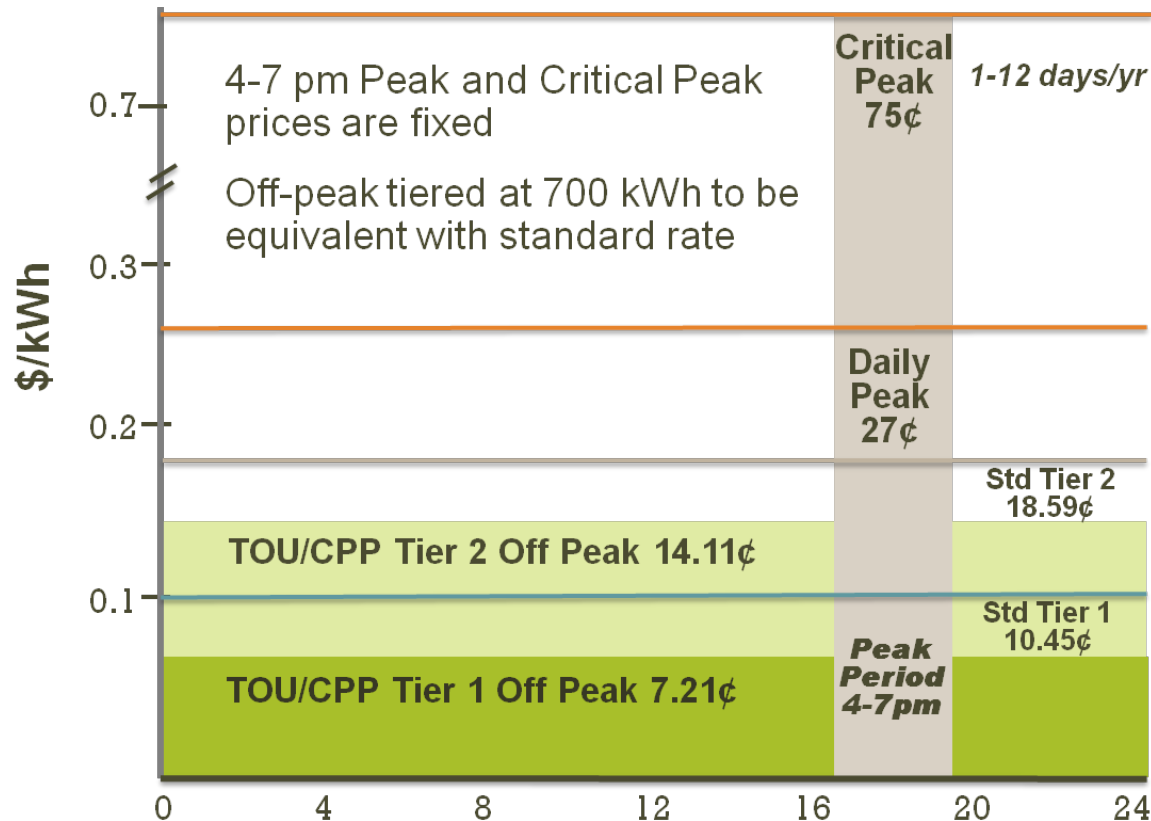
Home and Appliance Data *user interface on the computer*



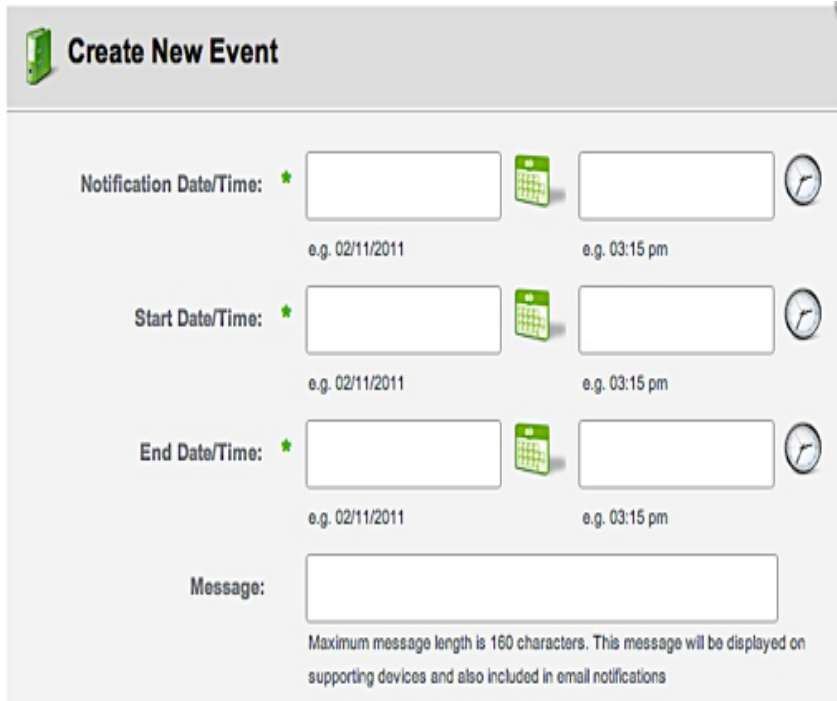
- Real-time use and cost data by day and aggregated by week and billing period
- Same display for home level and appliance level data

TOU-CPP vs. Standard Rate

with consumption tiers




Event Scheduling and Notification




The screenshot shows a web interface titled "Create New Event". It contains three rows of date and time selection fields, each with a green calendar icon and a clock icon. Below these is a message input field with a character limit note.

Create New Event

Notification Date/Time: *  
e.g. 02/11/2011 e.g. 03:15 pm

Start Date/Time: *  
e.g. 02/11/2011 e.g. 03:15 pm

End Date/Time: *  
e.g. 02/11/2011 e.g. 03:15 pm

Message:
Maximum message length is 160 characters. This message will be displayed on supporting devices and also included in email notifications

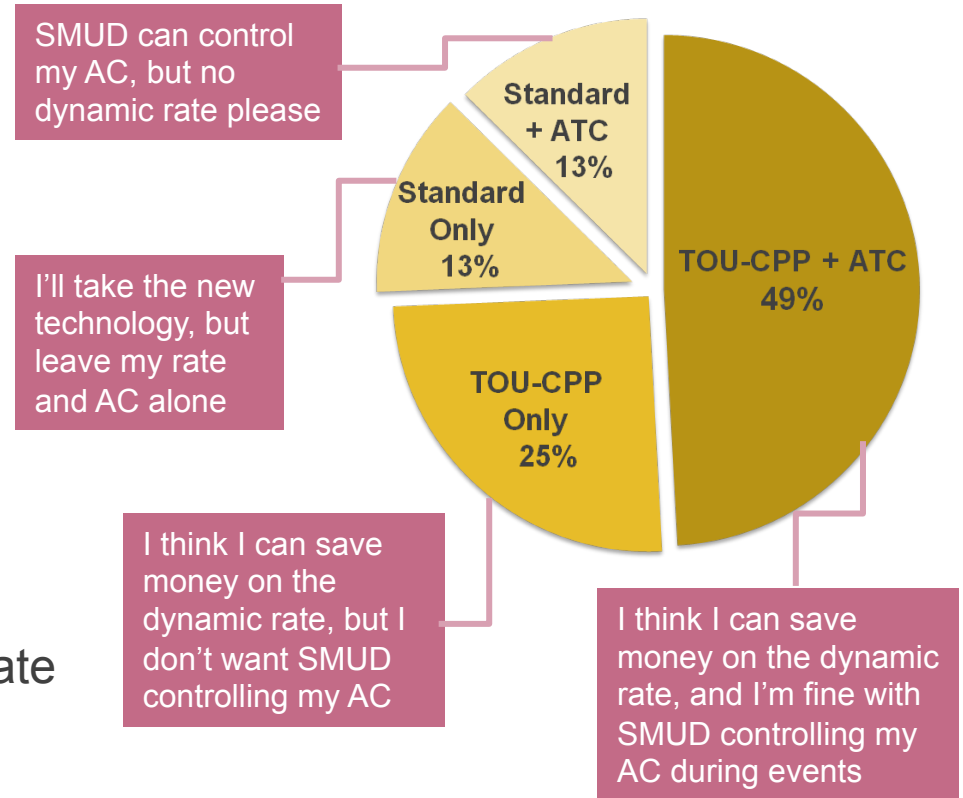
- OpenADR-enabled gateway
- Logged on to DRAS through secure website
- Set parameters for event
- Participants notified 24-hours in advance by energy display, thermostat, email, phone or text
- Called 12 events in each of 2011 and 2012 summers



Recruitment: Program Choices 2011

dynamic rate and/or SMUD AC control

- Summer Solutions Rate – **74%**
 - Customer determines response to high-price events
 - 12 events
- Utility AC Control – **62%**
 - 4° set point raise during events
 - One override allowed
 - Same 12 events as TOU-CPP rate



Data from first mailing only. To obtain a sufficient number of participants on the Standard rate, the final mailing did not offer the Summer Solutions rate.

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Education and Outreach

- Websites for each treatment
- Free energy assessment with actionable checklist of energy-saving measures
- Quick Start Guide describing study
- Refrigerator rate magnet
- Bill Comparison Report

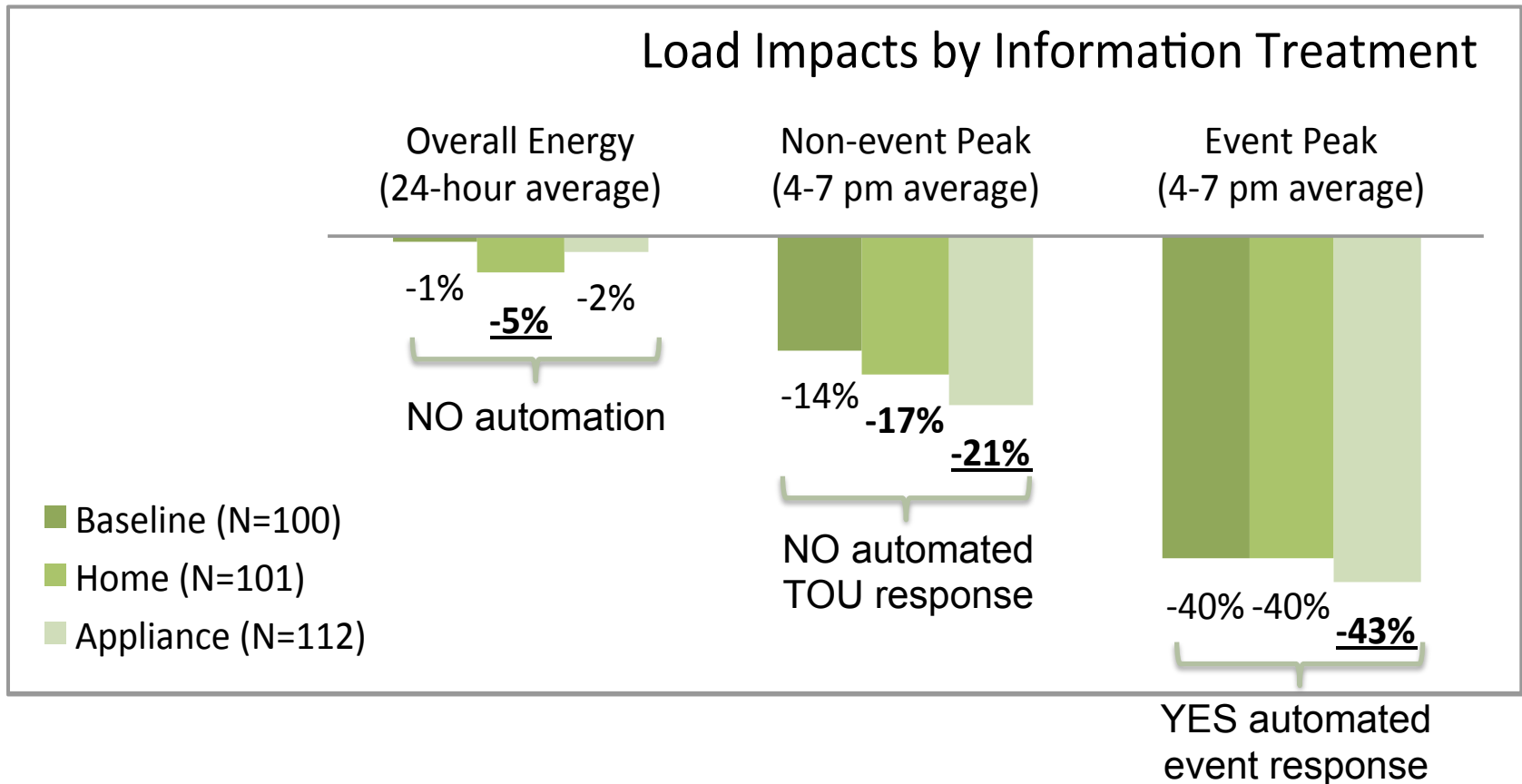




Results

Real-time Information Effects *by treatment group*

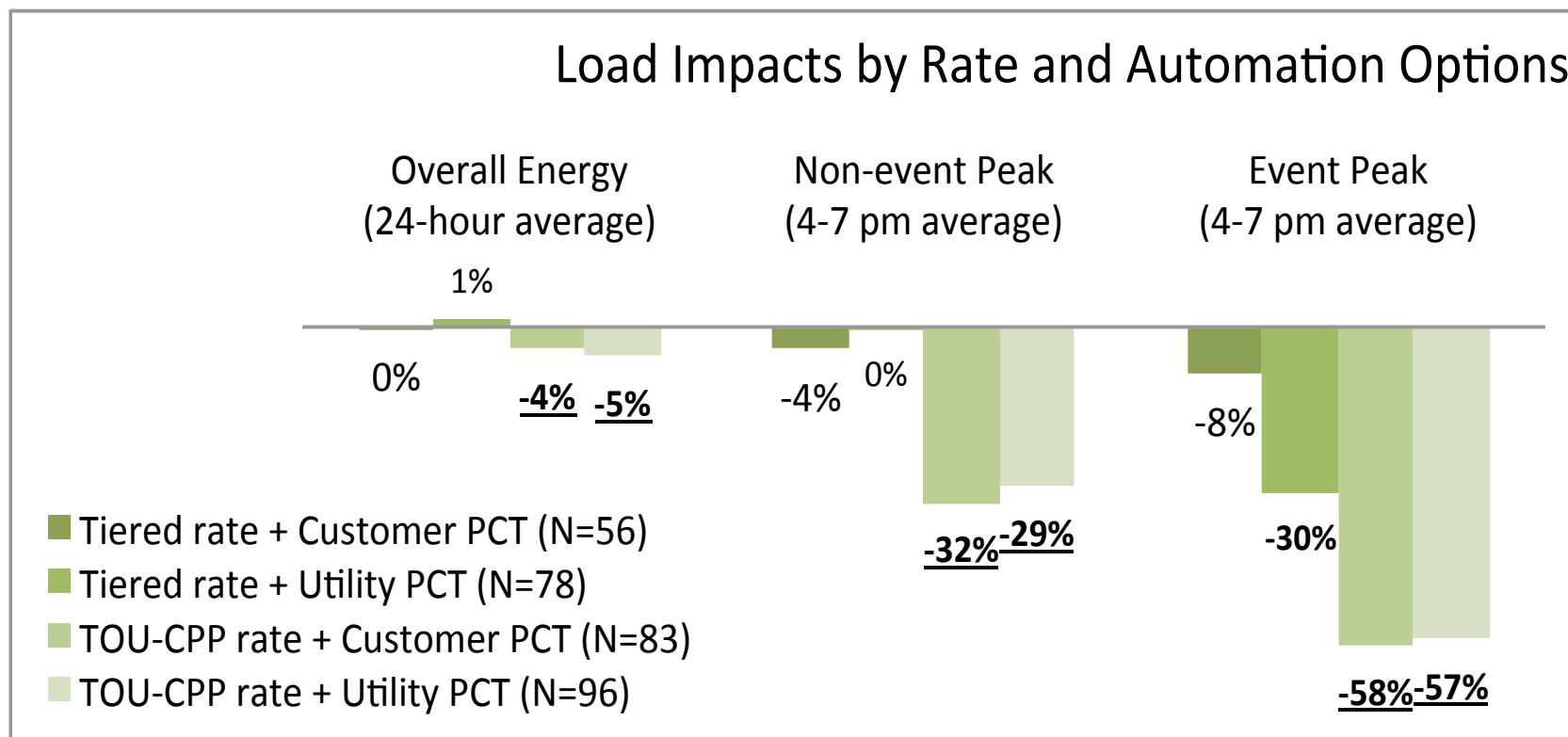
- Home data slightly improved energy savings
- Appliance data slightly improved peak savings



Dynamic Rate vs. AC Control

by rate and automation options

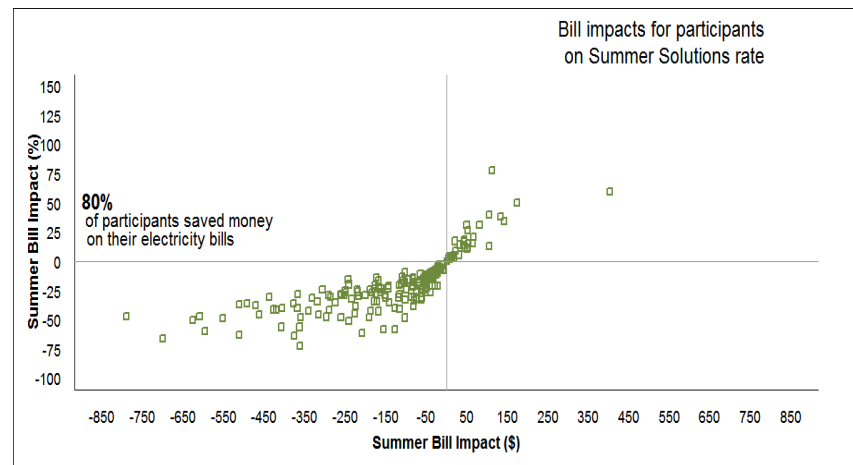
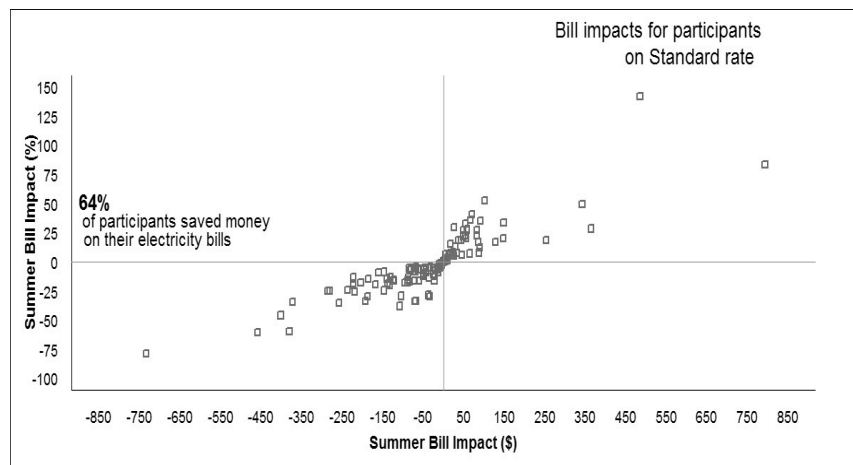
- Customers on the TOU-CPP rate with customer-controlled PCT event automation outperformed standard rate with information-only and utility load control programs



Bill Impacts

on standard vs. TOU-CPP rate

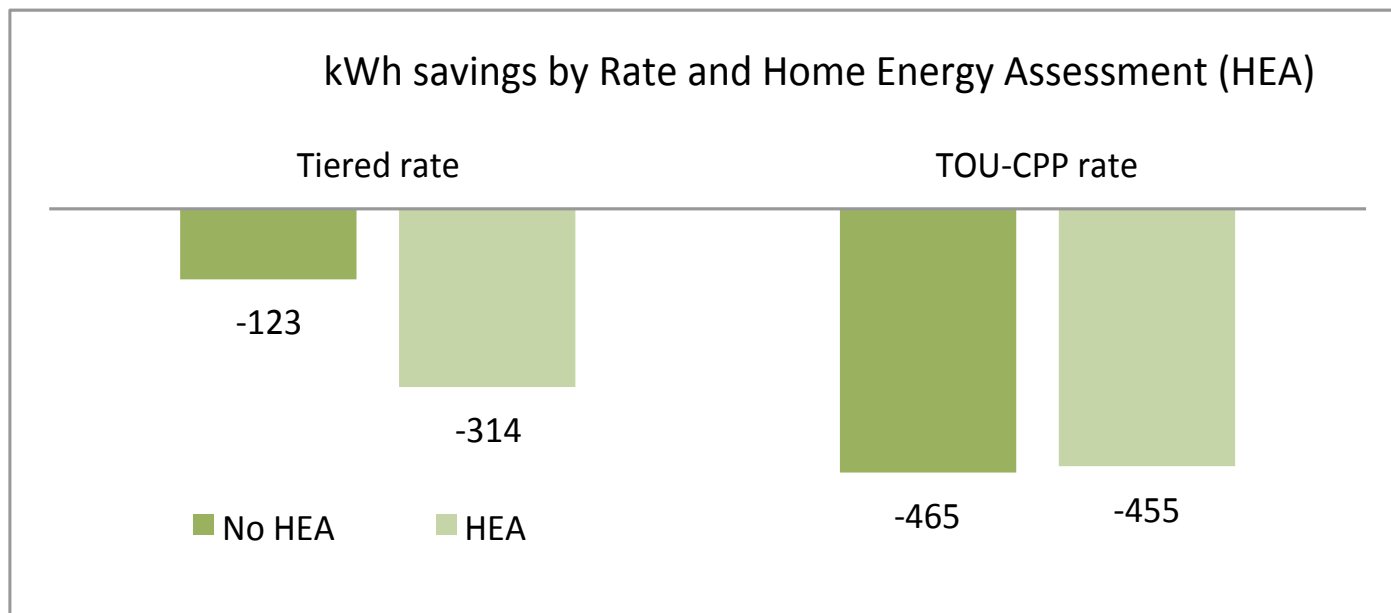
- 64% of standard rate customers saved money on their summer bills
- Average bill savings across the summer months was \$40
- 80% of TOU-CPP rate customers saved money on their summer bills
- Average bill savings across the summer months was \$145



Savings - Energy Efficiency

before/after Home Energy Assessment

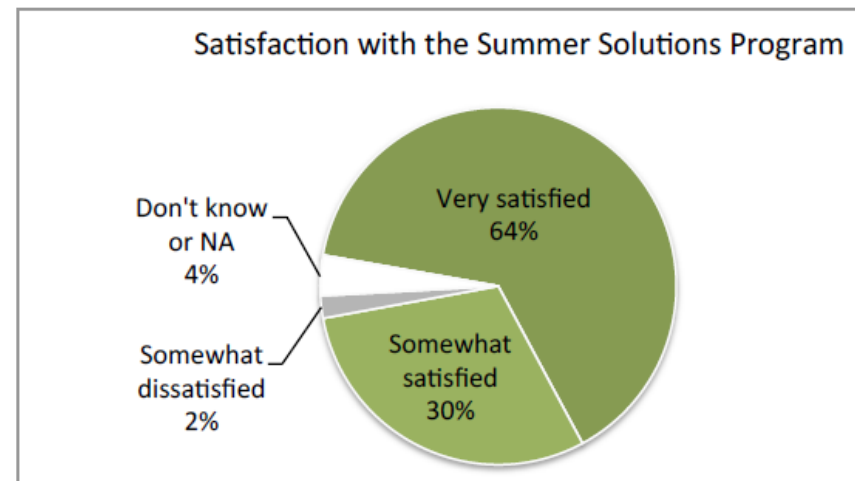
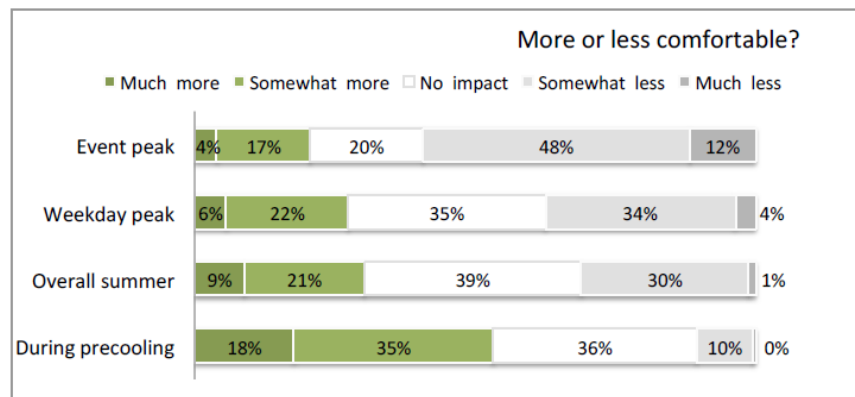
- Higher average savings are associated with Home Energy Assessments
 - Those who had an HEA saved 405 kWh and \$115 over the summer
 - Those who did not have an HEA saved 299 kWh and \$86 over the summer
- However, these savings only accrued to customers on the standard tiered rate



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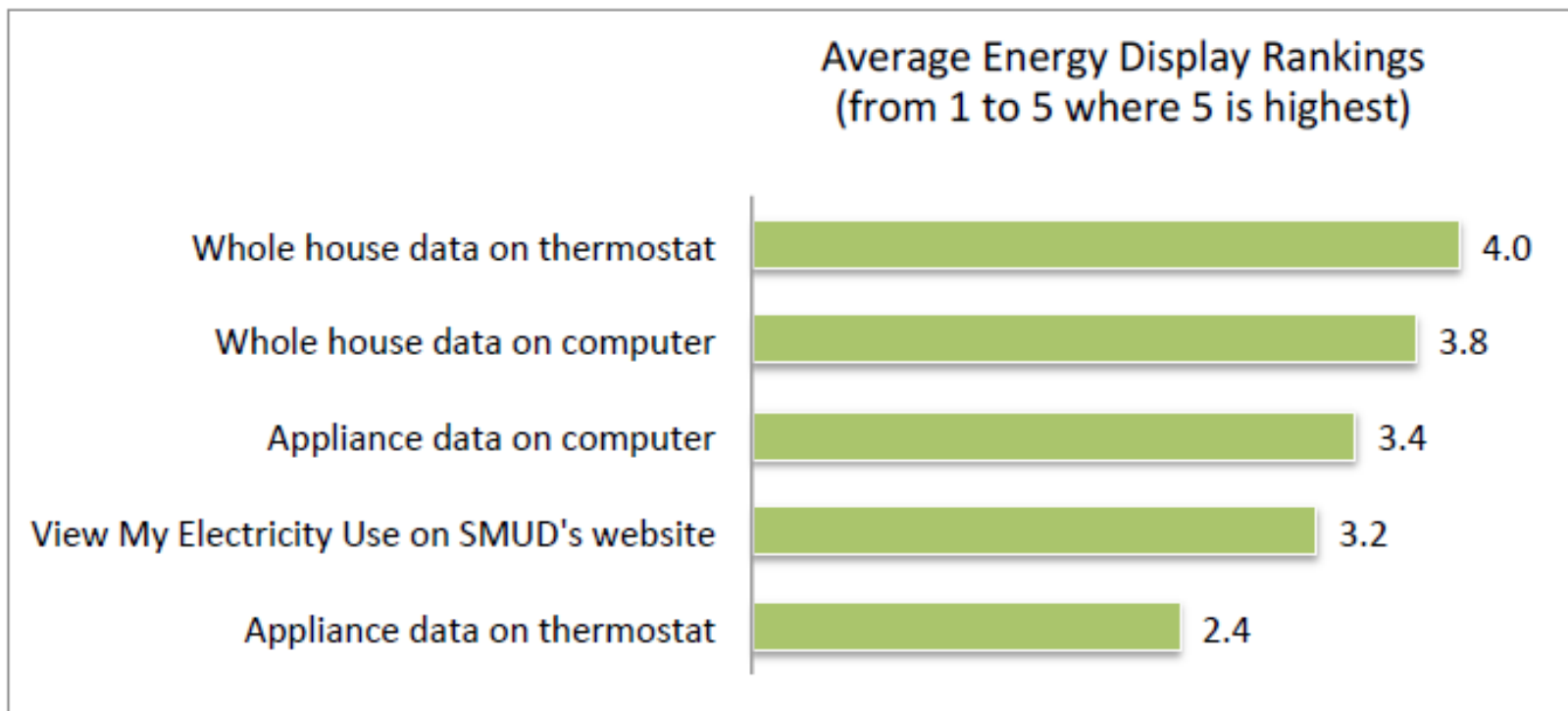
Comfort and Satisfaction

- 84% of customers were satisfied with their comfort level during summer 2012
- Conservation events were the least comfortable, precooling periods were the most comfortable
- TOU-CPP rate customers were least comfortable during events
- Nearly all participants were satisfied with the program
- No difference in satisfaction among study groups



Most Preferred Information

- Whole house data preferred to appliance data
- The thermostat is preferred over the computer to view whole house data



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Conclusions

- The addition of real-time data provided between 3%-7% improvement in energy and daily peak savings
- The TOU-CPP rate outperformed the standard rate with and without utility load control on all measures
 - Customers preferred the TOU-CPP rate to the standard rate 3:1; this preference increased with experience
 - 4%-5% energy savings vs. 0%
 - 30% daily peak vs. 2%
 - 58% event peak vs. 30% with utility load control and 8% without
 - Average summer bill savings for the TOU-CPP rate was 3.6 times the standard rate
- Much of the peak savings may be due to automation

Lessons Learned

- The equipment is not market ready—all of the service calls and technical support site visits were related to equipment problems
- Providing real-time and aggregate pricing data is difficult, and there is no open source platform for use with multiple vendors
- Helping customers to set their thermostats to automatically respond to price events is crucial
 - Less than 1% of customers in all groups set their thermostats to run on a program prior to the study
 - With the help of installers, 91% on average set their thermostats to automatically increase temperature during peak during the study
- The AutoDR event notification platform was easily implemented and successfully initiated all 12 events

Recommendations

- **Rates:** Offer at least one residential time-of-use or dynamic rate—*SMUD will be putting all residential customers on a default, opt-out TOU rate in 2018*
- **Automation.** Offer PCTs that work with dynamic rates
 - Enable customers to automate offsets for both daily TOU periods and CPP events
 - Only offer thermostats that have been tested for usability and score high
- **Information.** Provide customers with information to make decisions regarding energy use, rates and DR programs
 - Graphical representations of the rates
 - A website bill comparison
 - Notification of prices and events (phone app, thermostat)
 - Hourly whole-house electricity use and cost data
- **Customer Service.** Provide customers with technical support for setting and using PCTs
- **Next Steps.** Directly test the value of automation in single-family dwellings

Questions?



Contact:

http://www.herterenergy.com/pdfs/Publications/2013_Herter-SMUD_ResSummerSolutions2011-2012.pdf

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Education and Outreach

websites (3 versions)

- Links to participant materials and customer survey
- Frequently Asked Questions
- Discussion Board
- Equipment info
- Rates info
- Links to rebates and info
- Customer Service contact info



Welcome to SMUD's Summer Solutions Study!

Thank you for your participation this summer! Our goal is to find out what technologies and communications work best for our customers. Your experiences and opinions are essential to the development of customer-friendly solutions for our energy system moving forward.

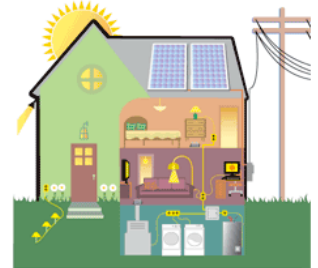
Here's checklist of things you can expect this summer:

- ✓ **Equipment installation** will take place soon after you sign up. Please review the [Installation Preparation Sheet](#) so you are prepared when the installer calls to schedule an appointment.
- ✓ **After installation**, take a few minutes to:
 - review the [Quick Start Guide](#) the installer left with you.
 - complete the [Participant Survey](#).
- ✓ **Get a free energy assessment** for your home. Call us at 835-2100 to schedule an appointment.
- ✓ **Talk to other participants** by joining us on the discussion board located on the tab above.
- ✓ **Do your best** to reduce electricity use during system events.
- ✓ **Have fun** and watch your energy bill drop!

If you have any questions or concerns, contact us!
SummerSolutions@HerterEnergy.com

Weekdays 9:00 am - 4:00 pm
(916) 835-2100

SMUD's Summer Solutions Study
Participant Website



Education and Outreach

energy assessments

Summer Solutions

HOME ENERGY ASSESSMENT CHECKLIST

Unless otherwise indicated, the homeowner or a skilled professional can complete the following efficiency upgrades. Find rebates and more at: www.smud.org

✓ ENVELOPE + DUCTS	Ventilation	Insulation	Penetration	Notes
Ducts		<input type="checkbox"/> Insulate ¹	<input type="checkbox"/> Metal tape/mastic ¹	
Attic	<input type="checkbox"/> Vent/turbine/attic fan ¹	<input type="checkbox"/> Insulate to R38 (12") ¹		
Attic hatch		<input type="checkbox"/> Insulate to R38 (12")	<input type="checkbox"/> Weather strip	
Ceiling	<input type="checkbox"/> Whole house fan ¹		<input type="checkbox"/> Foam or tape/mud	
Walls		<input type="checkbox"/> Insulate to R13 (4") ²	<input type="checkbox"/> Foam or tape/mud	
- electrical outlets			<input type="checkbox"/> Foam cover plates	
Windows		<input type="checkbox"/> Replace ² <input type="checkbox"/> Cover	<input type="checkbox"/> Caulk	
Doors		<input type="checkbox"/> Replace ¹	<input type="checkbox"/> Weather strip	
Fireplace	<input type="checkbox"/> Close flue when unused	<input type="checkbox"/> Insulate ²	<input type="checkbox"/> Seal ²	
Floor			<input type="checkbox"/> Foam	
Crawl space	<input type="checkbox"/> Vent ¹	<input type="checkbox"/> Insulate to R19 (6") ¹		

1 = services of a skilled professional or contractor are recommended; 2 = services of a licensed contractor are recommended or required

✓ APPLIANCES	Schedule	Efficiency	Temperature	Notes
HVAC + thermostat	<input type="checkbox"/> Avoid 4-7 pm	<input type="checkbox"/> Replace ² <input type="checkbox"/> Clean coils <input type="checkbox"/> Clean/change filter	<input type="checkbox"/> Summer 78°F or higher <input type="checkbox"/> Winter 68°F or lower <input type="checkbox"/> Night/away offset ±10°F	
Water heater	<input type="checkbox"/> Avoid 4-7 pm ⁽²⁾	<input type="checkbox"/> Replace ² <input type="checkbox"/> Blanket	<input type="checkbox"/> 120°F or lower	
- water pipes		<input type="checkbox"/> Insulate first 2-5 feet		
Refrigerator		<input type="checkbox"/> Replace <input type="checkbox"/> Clean coils	<input type="checkbox"/> As recommended	
- refrigerator in garage		<input type="checkbox"/> Remove <input type="checkbox"/> Unplug	<input type="checkbox"/> As needed	
Pool pump	<input type="checkbox"/> Avoid 4-7 pm	<input type="checkbox"/> Replace ²		
Pool heat	<input type="checkbox"/> Avoid 4-7 pm	<input type="checkbox"/> Replace ² <input type="checkbox"/> Cover	<input type="checkbox"/> 78°F or lower	
Spa pump	<input type="checkbox"/> Avoid 4-7 pm	<input type="checkbox"/> Replace ¹		
Spa heat	<input type="checkbox"/> Avoid 4-7 pm	<input type="checkbox"/> Replace ¹ <input type="checkbox"/> Cover	<input type="checkbox"/> 101°F or lower	

1 = services of a skilled professional or contractor are recommended; 2 = services of a licensed contractor are recommended or required

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06/11



- Free offering to all participants as one of the benefits of the study
- 40% of customers took advantage of home energy assessments
- Photos taken of problems and code violations
- An actionable checklist of energy-saving measures provided to customers

Education and Outreach

Quick Start Guide and Rate Magnet



Summer Solutions Quick Start Guide

Welcome to SMUD's Summer Solutions Study!

Please take a few moments to review this guide. In it are the essentials to get the most out of your participation this summer.

1. **Study Basics:** The Summer Solutions study will run from June 1 through September 30, 2011. As part of the study, you'll be provided with advice and equipment to help manage your energy use.

2. **Participant Website:** This site will provide educational resources, rate information, equipment user guides, a discussion board, and answers to frequently asked questions:

<http://www.smud.org/en/SS/Participant>

3. **Discussion Board:** Here's where you can ask questions and share your experiences with other participants and the Summer Solutions service team.

4. **Rate Magnet:** If you signed up for the Summer Solutions rate, the welcome packet includes a rate magnet. Place your magnet somewhere in the home at eye level (we suggest the refrigerator) and refer to it during the summer.

5. **System Events:** There will be 12 System Events this summer on weekdays between 4 pm and 7 pm. During these hours, we are asking customers to reduce system costs by lowering their home energy use. If you signed up for the Summer Solutions rate, these savings are passed on to you with a 30% discount on Off Peak rates.

6. **Thermostat:** The Summer Solutions thermostat is a tool you can use to program in your energy savings during Events and every day. A User Guide is available on the participant website.



7. **Energy Display:** The Summer Solutions installer provided you with a link to a computer application that allows you to view your home's real-time energy use and costs from a web browser. A User Guide is available on the participant website.

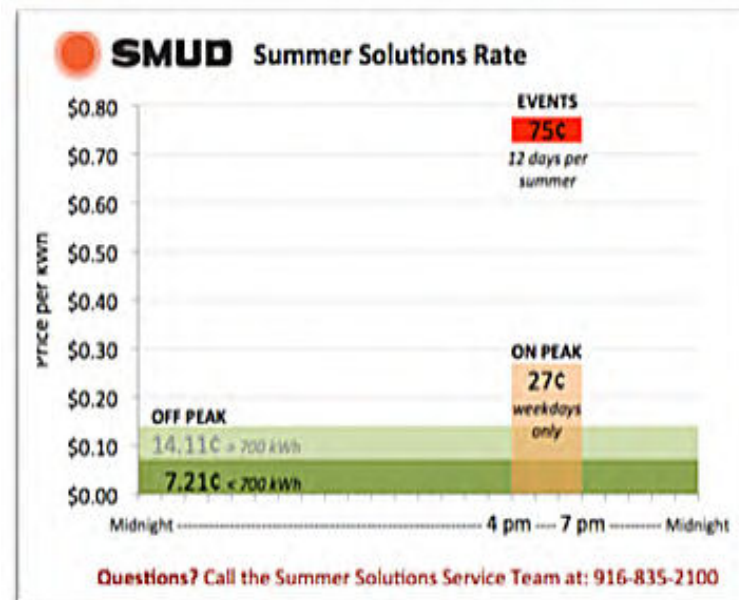


8. **Customer Service:** If you have any questions, feel free to contact the Summer Solutions Support Team. They are available Monday through Friday from 9 am to 4 pm, by email or phone:

SummerSolutions@HerterEnergy.com

(916) 835-2100


Home 4/4/11



- A refrigerator magnet was provided to participants who elected the Summer Solutions rate

Education and Outreach 2011

Bill Comparison Report for TOU-CPP rate

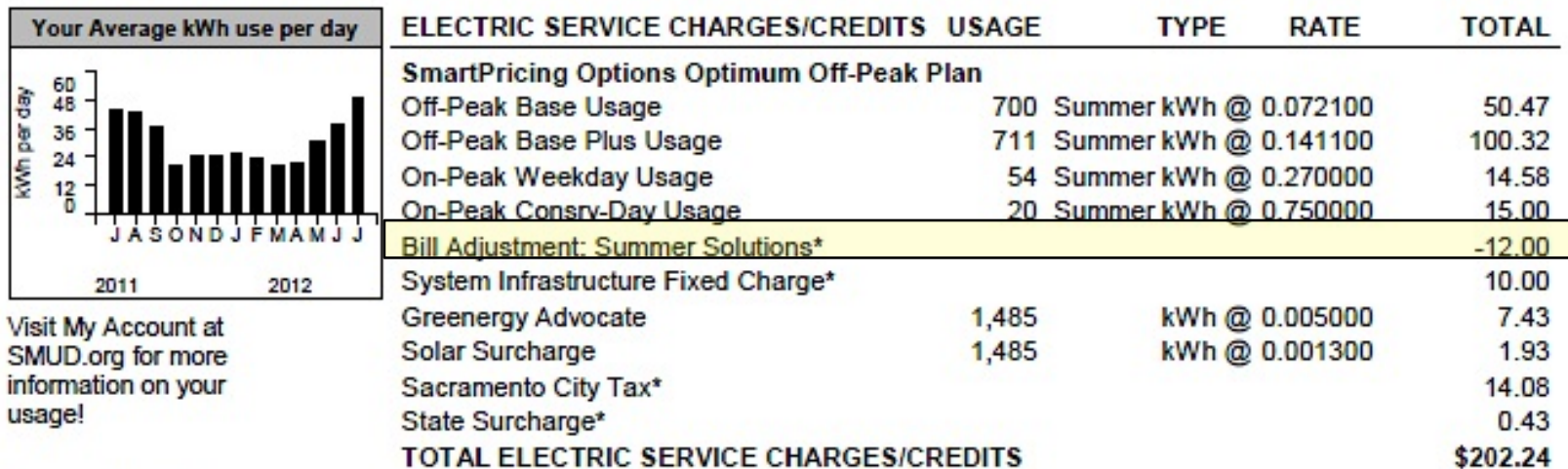
 SMUD <i>Summer Solutions</i>		Bill Comparison	
Start Date 7/12/2011		End Date 8/10/2011	
Standard Rate: RSG		Sherlock Holmes	
Billing Month: August		221B Baker Street	
Account Number: 1234567		Folsom, CA 95630	
Summary Bill Comparison			
Critical Peak Days This Month		<div>Standard Bill</div> <div>Summer Solutions Bill</div> <div>Congratulations you saved 19.9% on your bill:</div> <div>Plus you earned from Auto Temp Control:</div> <div>Total savings this month:</div>	
Thursday, July 21, 2011			
Thursday, July 28, 2011			
Your Bill on Standard Rate			
Bill Component	Monthly KWh	Price per kWh	Charges
Base Usage	700	\$0.1045	\$73.15
Base-Plus Usage	88	\$0.1859	\$16.36
Electricity Use Subtotals	788	\$0.1136	\$89.51
System Infrastructure Fixed Charge			\$7.20
Standard Rate Charges			\$96.71
Your Bill on Summer Solutions Rate			
Bill Component	Monthly KWh	Price per kWh	Charges
Off-Peak Base Usage	700	\$0.0721	\$50.47
Off-Peak Base-Plus Usage	46	\$0.1411	\$6.49
On Peak Usage	38	\$0.27	\$10.26
Critical Peak Usage	4	\$0.75	\$3.00
Electricity Use Subtotals	788	\$0.0891	\$70.22
Summer Solutions Rate Charges			\$77.42

Standard Bill	\$96.71
Summer Solutions Bill	\$77.42
<i>saved 19.9% on your bill:</i>	<i>\$19.29</i>
<i>from Auto Temp Control:</i>	<i>\$8.00</i>
Total savings this month:	\$27.29

- Summer Solutions rate participants received a Bill Comparison Report in 2011, showing bill savings or losses compared to what they would have paid on the Standard rate

Education and Outreach 2012

standard bill for TOU-CPP rate



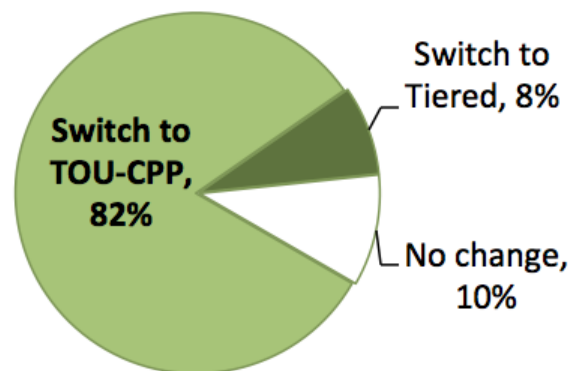
- In 2012, Summer Solutions rate participants received the standard bill showing on- and off-peak use and cost
- The Automatic Temperature Control option payment of \$4 per event was reflected as Bill Adjustment: Summer Solutions

Recruitment: Program Choices 2012

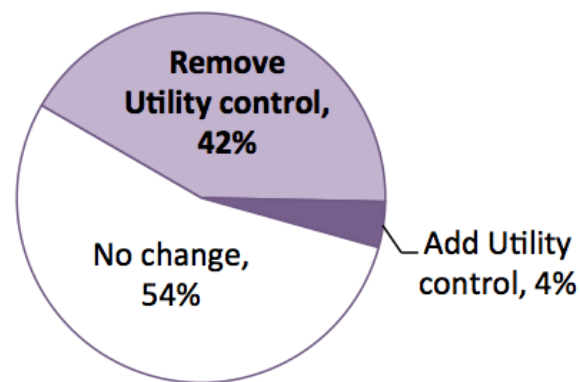
elected program changes for 2nd year

- In 2012, 222 customers who participated in both 2011 and 2012 were given the option to change their original choices
 - 23% (50) chose different rate or automation options
 - 82% (of the 50) chose to switch to the Summer Solutions rate, 8% chose to return to the standard rate
 - 42% chose to change to customer control from utility control, 4% chose to add utility control

Rate changes



PCT automation changes

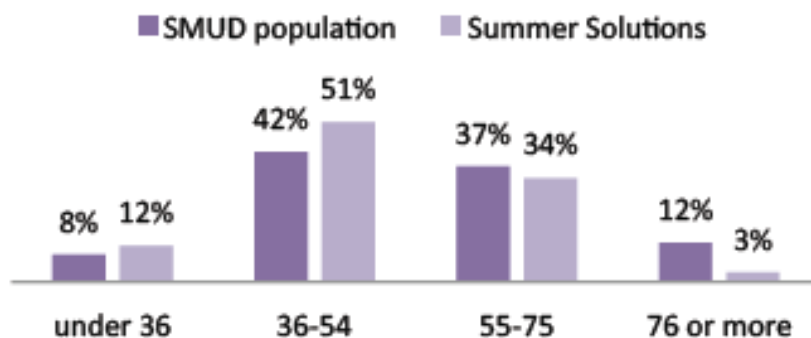


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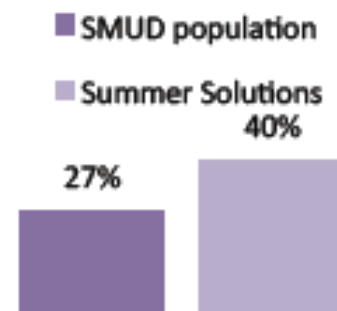
Participant Profile

from pre- and post-surveys

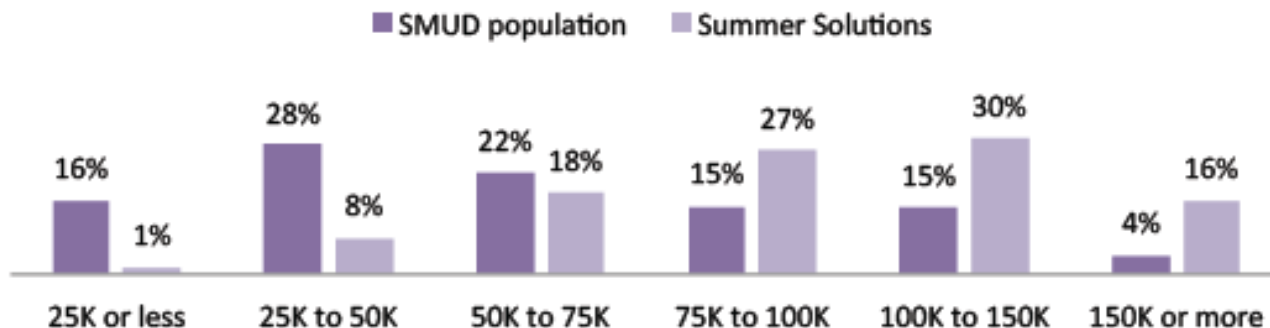
Summer Solutions participants are younger ...



... more likely to be ACLM participants ...

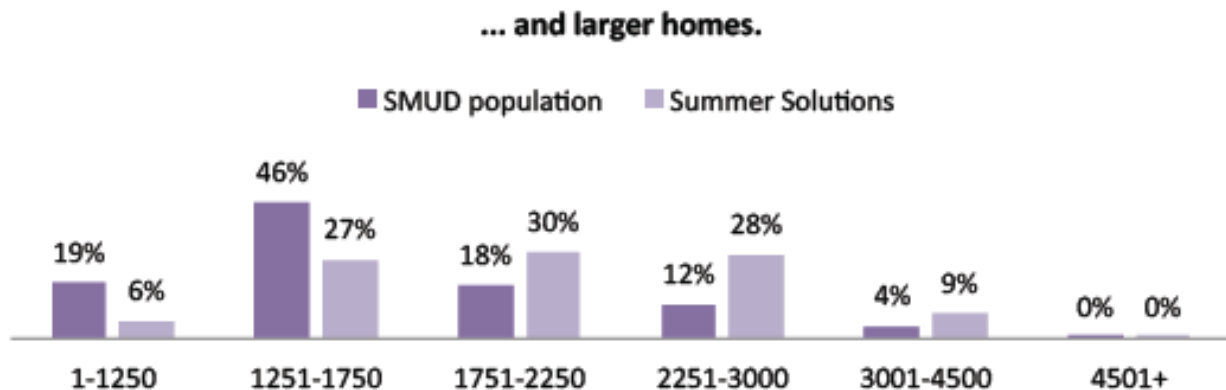
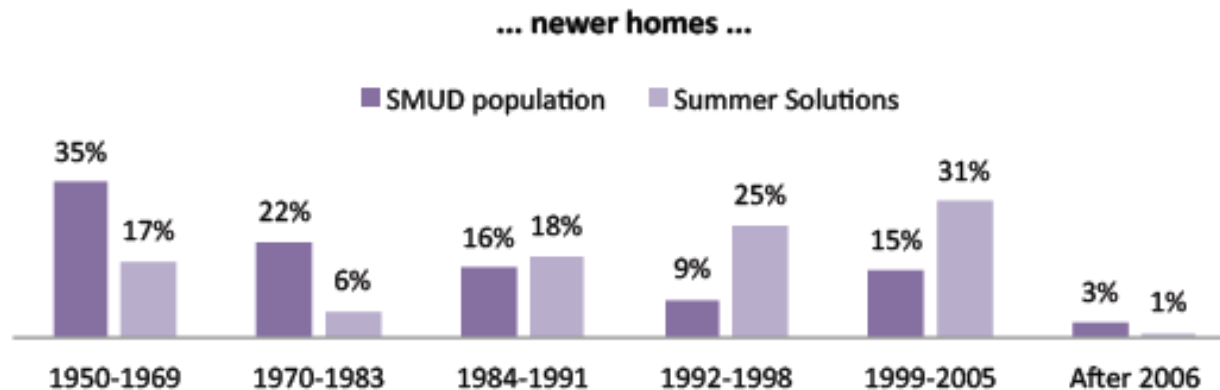


... have higher incomes ...



Participant Profile

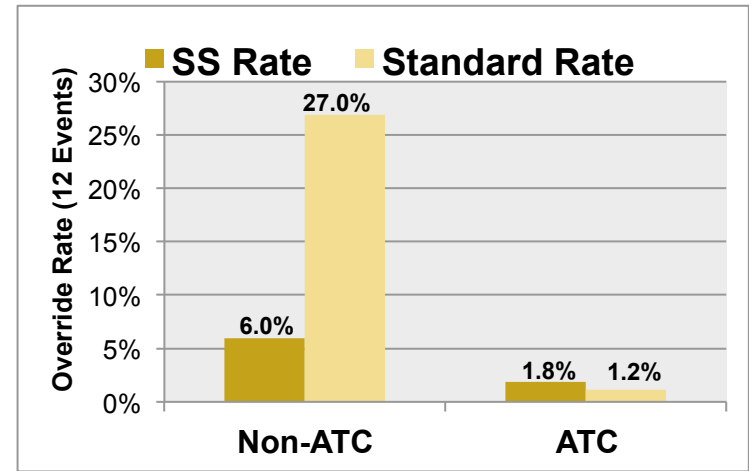
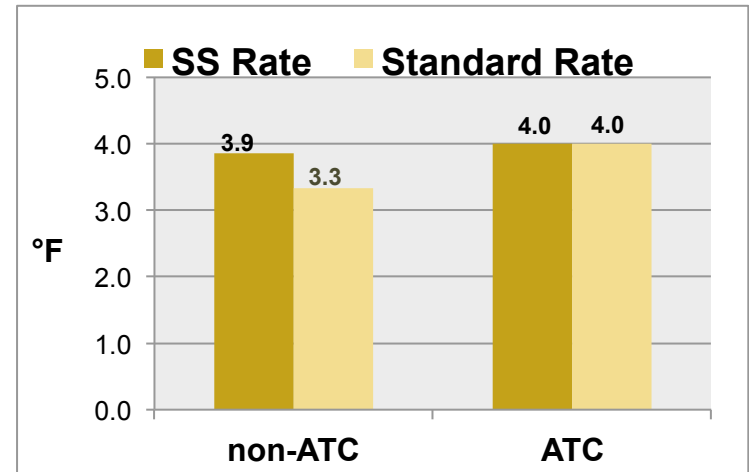
from pre- and post-surveys



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Behaviors - Event Settings and Overrides *by program option*

- Participants were assisted in setting thermostats for critical event days
 - Customer PCT (ATC) participants could not change this setting
 - TOU-CPP rate (SS rate) participants as a whole did not change settings
 - Standard tiered rate participants lowered one degree on average
- Utility PCT (ATC) participants were limited to one override, resulting in only a 1%-2% override rate
- Customer PCT (non-ATC) participants on the TOU-CPP rate overrode 6%
- Standard tiered rate + customer PCT (non-ATC) participants overrode 27%



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Correlations of Savings x Energy Use

- Participants with higher pre-treatment energy use had greater savings
- Those who reduced peak more likely to save overall—didn't just shift
- Those who reduced daily peak more likely to reduce event peak, and vice-versa
- All forms of savings reduced bills—overall energy savings the most, then daily peak savings, then event savings

Impact	Pre-treatment kWh	Overall Energy Impact	Non-Event Peak Impact	Event Peak Impact
Overall energy impact	-0.27	1.00		
Non-event peak impact	-0.27	0.66	1.00	
Event peak impact	-0.21	0.48	0.77	1.00
Bill impact	-0.52	0.87	0.73	0.58

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Correlations of Savings x Dwelling Characteristics

- Participants with electric ovens and swimming pools saved more

Characteristic	Pre-treatment kWh	Overall Energy Impact	Non-Event Peak Impact	Event Peak Impact
Electric ovens	0.3	-0.12	-0.11	-0.1
Swimming pool pump	0.56	-0.22	-0.24	-0.19
Passive solar pool heater	0.32	-0.12	-0.15	-0.06

Values in bold are statistically significant at $p < 0.05$

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Correlations of Savings x Behaviors

- Setting thermostats up during peaks, shifting use of appliances off peak and pre-cooling all affect savings

Behavior	Pre-treatment kWh	Overall Energy Impact	Non-Event Peak Impact	Event Peak Impact
I increased the thermostat setpoint to a higher-than-normal temperature during the peak period	-0.03	-0.06	-0.22	-0.23
I avoided washing or drying clothes during the peak	0.02	-0.08	-0.15	-0.23
I closed all the windows and doors when the outdoor temperature exceeded the indoor temperature	-0.12	0.02	-0.03	-0.17
I avoided using the dishwasher during the peak	0	-0.03	-0.09	-0.15
I pre-cooled my home several hours before the peak period	0.06	0.12	-0.05	-0.14

Values in bold are statistically significant at $p < 0.05$