



SMUD's Residential Summer Solutions Study

An Investigation of the Effects of Real-Time Information, Dynamic Pricing, and Thermostat Automation on Residential Energy Conservation, Peak Load Shifting, and Demand Response

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Herter Energy
RESEARCH SOLUTIONS

Final Project Presentation to the
California Energy Commission
April 26, 2012





Research Team and Funding

■ Research Team

- Herter Energy Research Solutions
- Sacramento Municipal Utility District (SMUD)

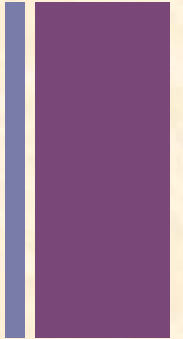
■ Funding

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





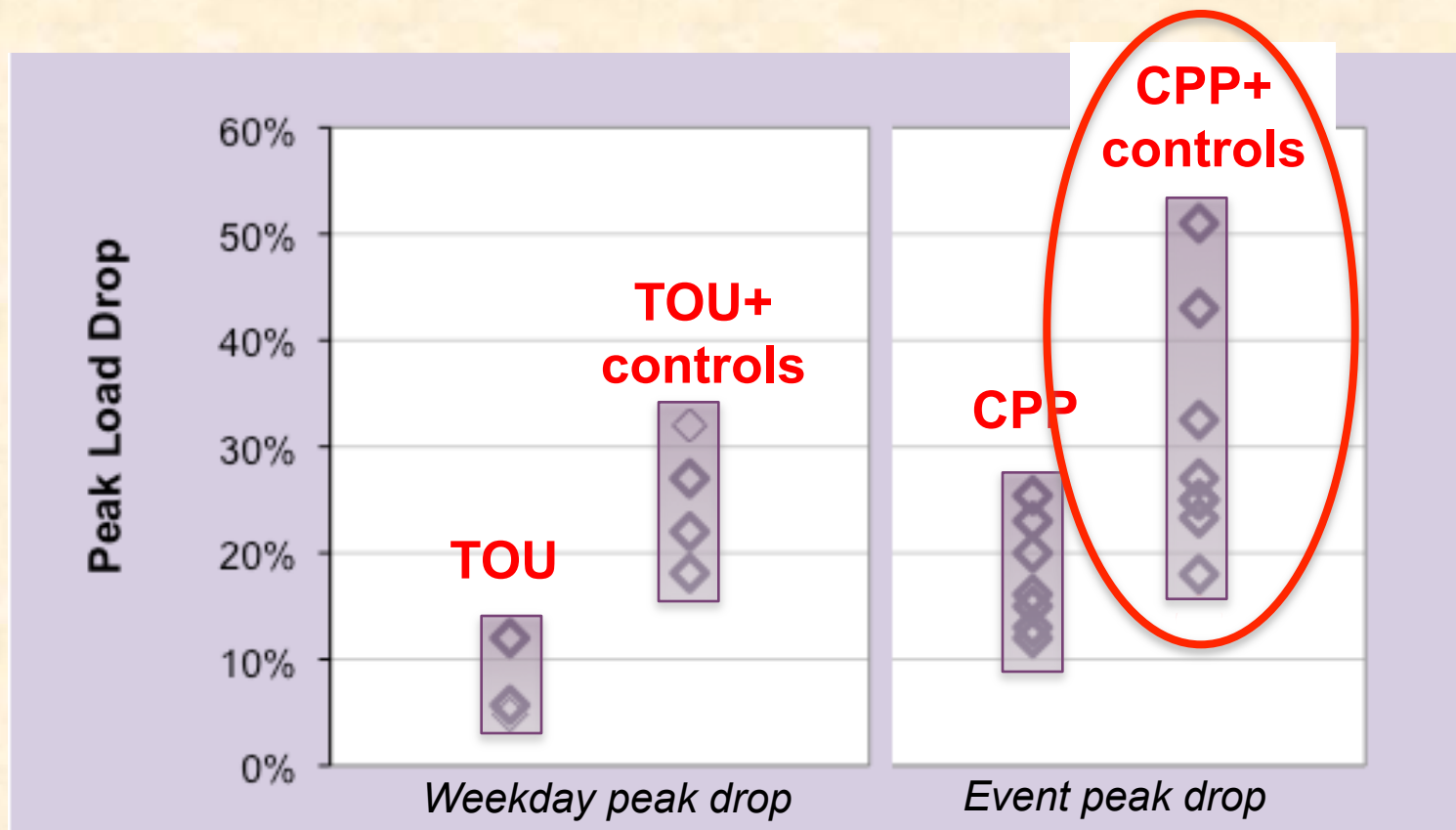
Study Goals



- Build on what we already know
 - *TOU rates* are effective for shifting load every day
 - *Dynamic rates* are effective for shedding load during events
 - *Thermostat automation* enhances both of these effects
- Answer some new questions
 - Does real-time energy data enhance energy and/or peak savings?
 - Is there added value in providing real-time appliance energy data?
- Combine rates, automation, real-time data and enhanced customer support to...
 - capture synergies between program variables
 - provide as realistic an experience as possible
 - define results that can be translated to the real world

+ What we already know

Results of residential pricing studies in Ontario, California, Puget Sound, Florida, Australia, Illinois, Missouri, New Jersey, Maryland, Connecticut, Washington DC



Q: Will real-time data provide additional value?



Hypotheses

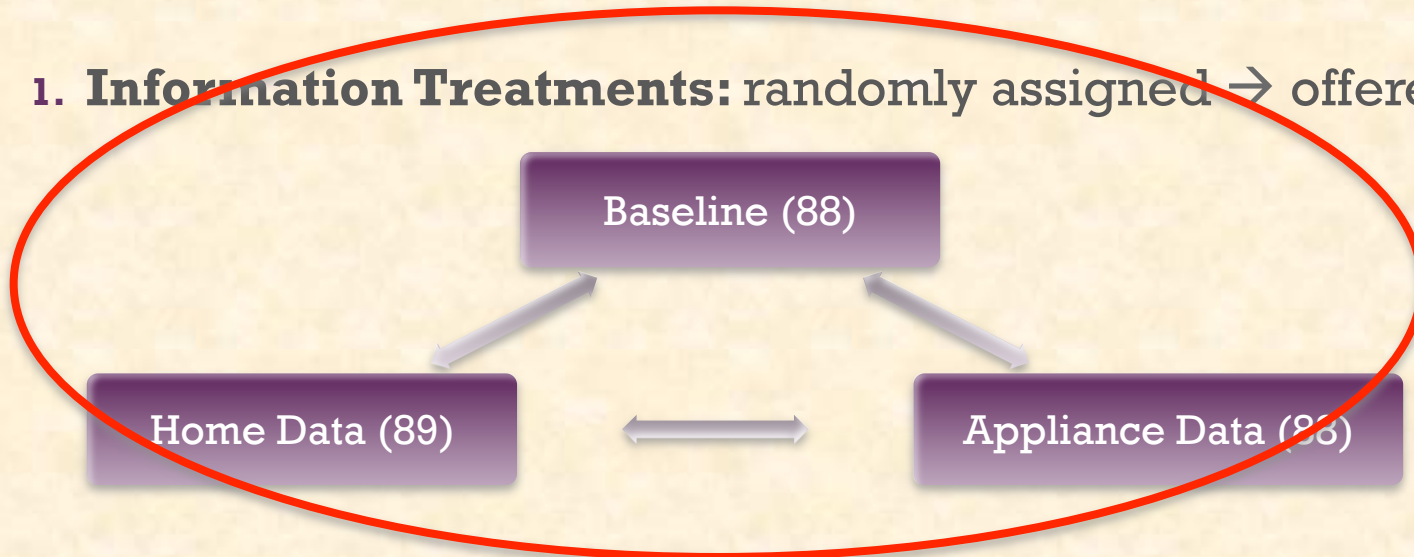
- For the overall program:
 - Energy use is lower
 - Weekday peak demand is lower
 - Peak demand on event days is lower
 - Electricity bills are lower
- Savings are better for customers:
 - with more information
 - who chose more program options
 - on the dynamic rate, compared to direct load control
 - with higher energy use
 - with certain self-reported behaviors
 - with certain dwelling characteristics
 - with certain demographic characteristics
 - with higher satisfaction levels



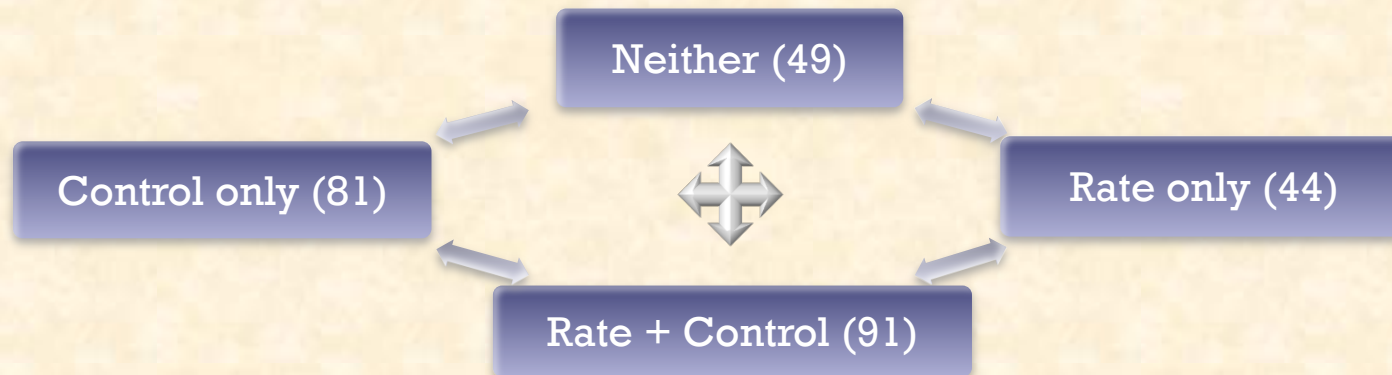
Summer Solutions Study Design

N=265 residential customers

1. **Information Treatments:** randomly assigned → offered



2. **Dynamic Rate | AC Control:** offered → customer chosen



+ Baseline Data - PCT only

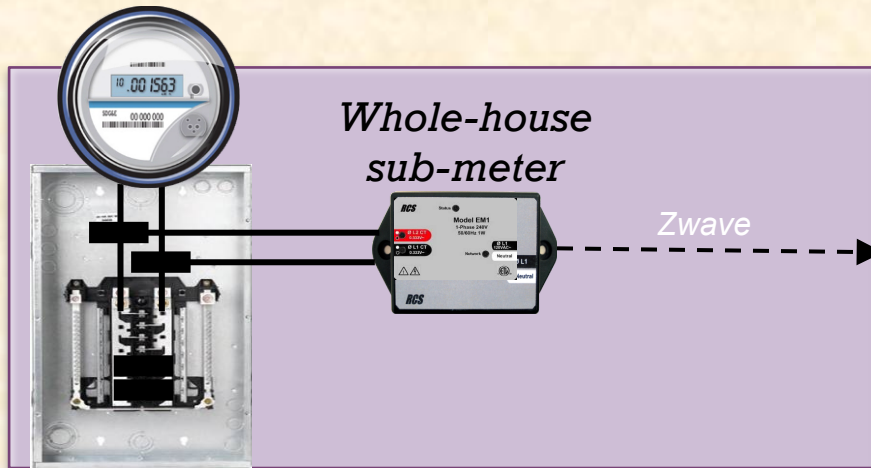
(No real-time energy information provided)



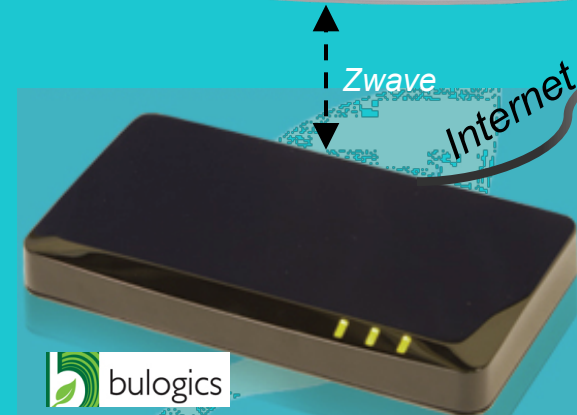
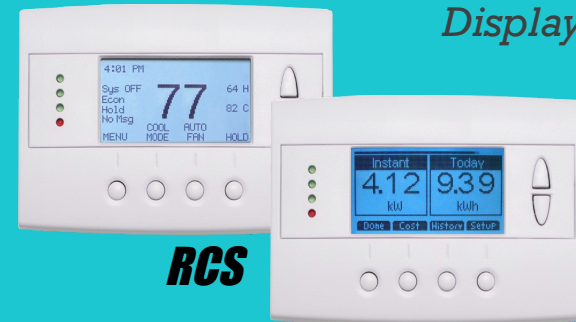


Home data

Site Data



*Communicating Thermostat
with Energy Information
Display*



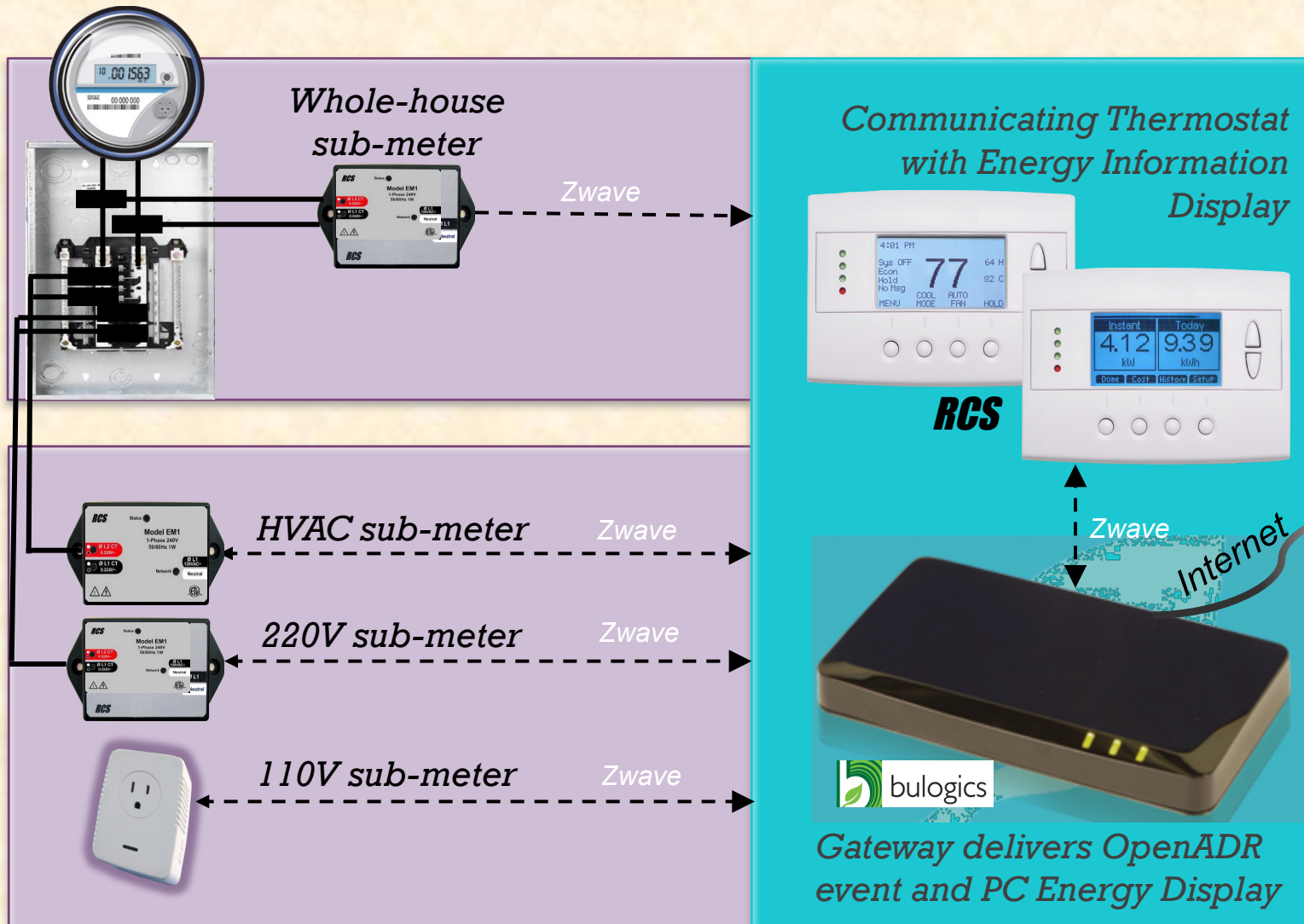
*Gateway delivers OpenADR
event and PC Energy Display*

Data Storage & Presentation

+ Appliance data

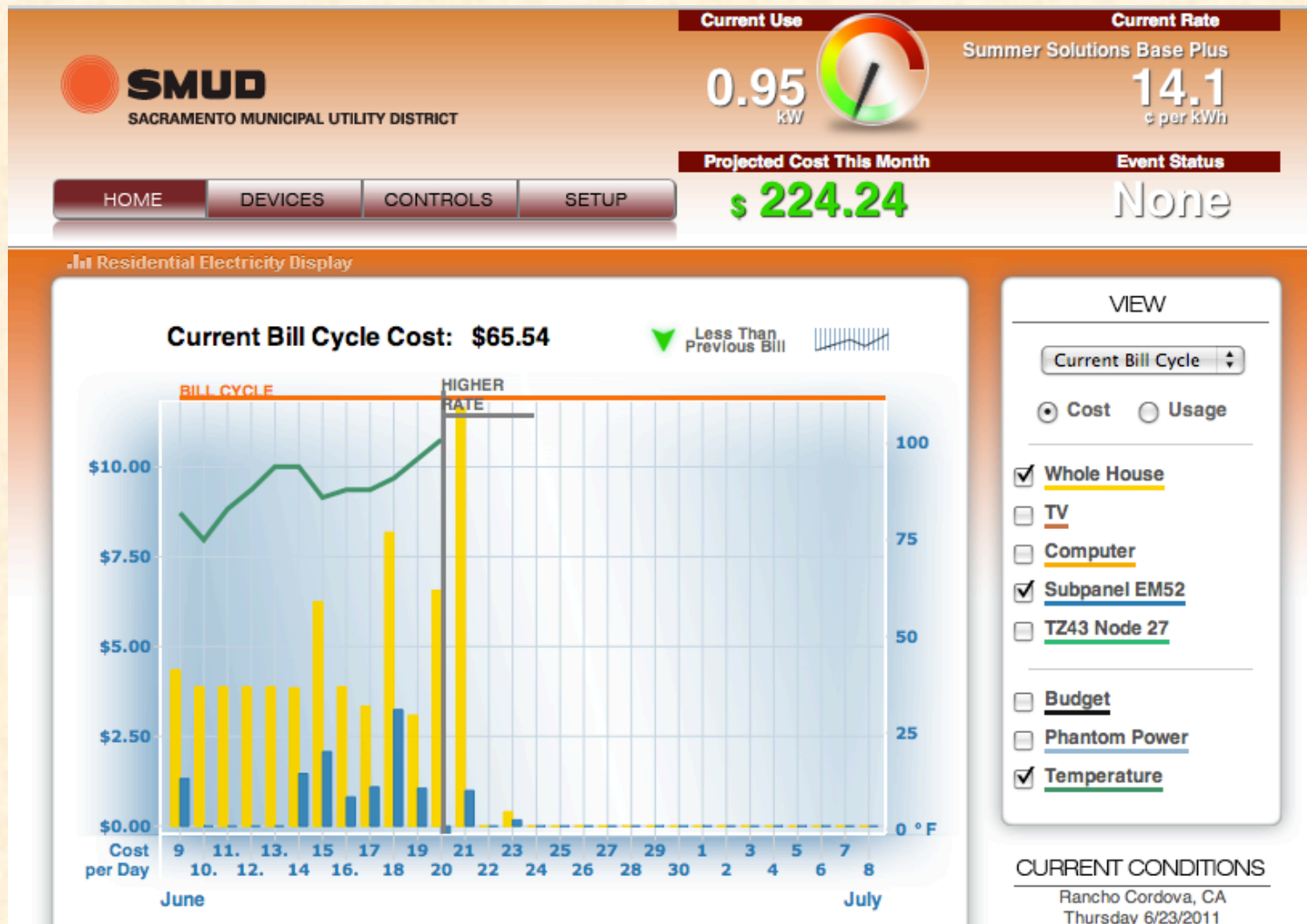
Site Data

Appliance Data



Data Storage & Presentation

+ PC Energy Display



+ PC Energy Display





Thermostat Energy Display

- Screen with instantaneous kW and daily kWh
- Scroll through appliances one at a time for Appliance group
- Can be made default screen





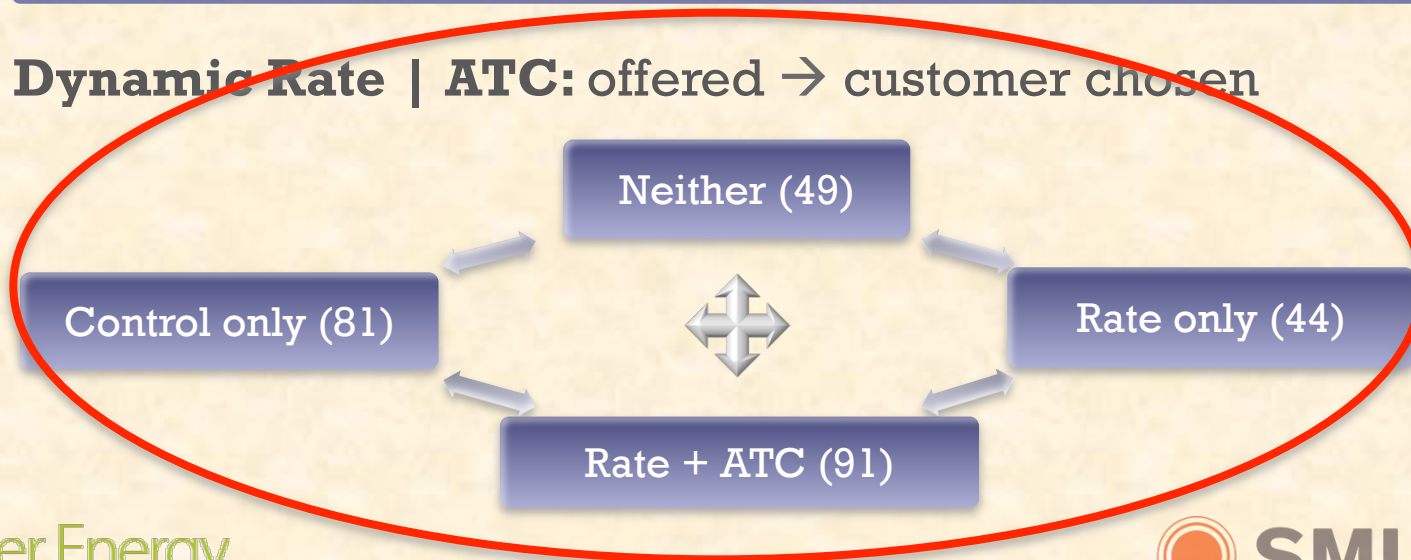
Summer Solutions Study Design

N=265 residential customers

1.

*Because rate and control options were **chosen** by participants, not randomly assigned, results will be indicative of a program in which all of these options are available to customers. (Some view this as ‘self-selection bias’ – others as ‘natural selection.’)*

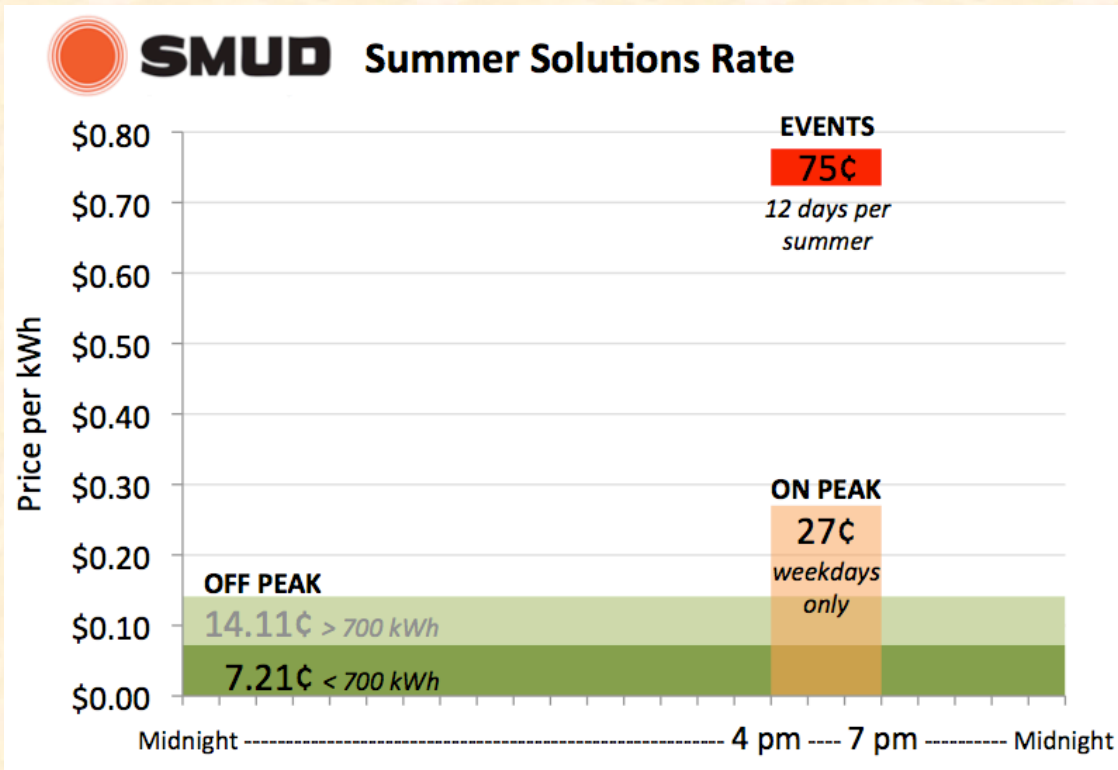
2. **Dynamic Rate | ATC:** offered → customer chosen





Optional TOU-CPP Rate

74% of respondents to initial mailings chose the experimental Summer Solutions Rate over their existing Standard tiered rate.

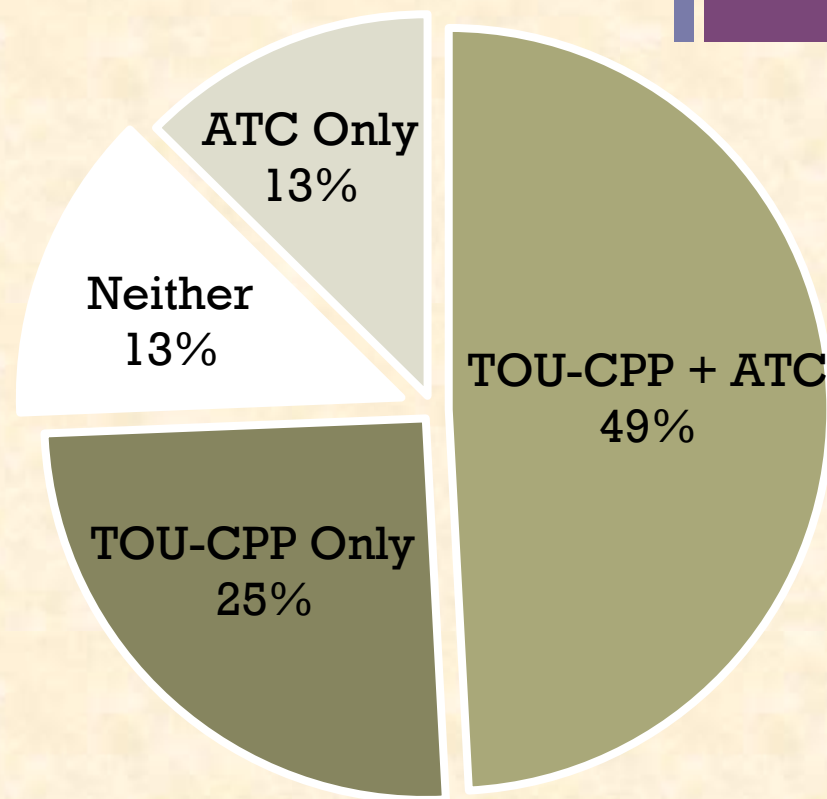


To obtain a sufficient number of participants on the Standard rate, the final mailing did not offer the Summer Solutions rate.

+ Customer Preferences

...of participants offered a Dynamic Rate and/or AC Control

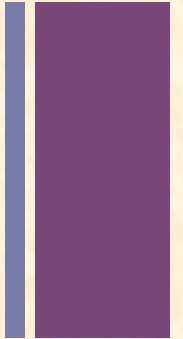
- Dynamic TOU-CPP Rate
 - “Summer Solutions rate”
 - Customer automates response to 12 high-price events
- Automatic Temperature Control (ATC)
 - 4° setpoint raise during events
 - One override in 12 events



N=238



Participant Profile



- On average, study volunteers are educated, prosperous, living in large homes – and energy efficient
 - ~5 years of college
 - Make >\$100k a year
 - Live in a 2,100 sq ft home, 26% with swimming pools
 - < 1000 kWh and \$135 per month
 - 2.7 occupants from 4-7pm in summer
- Saving money and benefiting the environment are the two most important reasons for participating

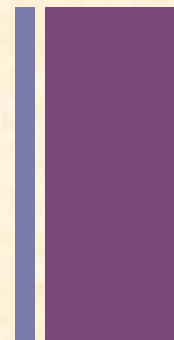


Education and Outreach



Education and Outreach

provide as realistic an experience as possible



- Installers assisted with thermostat settings
 - Encouraged all participants to automate response to critical events
- Quick Start Guide and equipment user guides
- Websites with information, tips, discussion board
- On-site energy assessments with personalized recommendations
- Summer Solutions Rate magnet
- SS rate vs. Standard bill comparison
- 24-hour advance notification of events
 - via email, thermostats, text message, phone

+ Participant Websites

- 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



The screenshot shows the SMUD Summer Solutions Study Participant Website. The header features the SMUD logo (Sacramento Municipal Utility District) with the tagline "The Power To Do More." Below the header is a navigation bar with links: Welcome, FAQs, Discussion Board, Equipment, Rates, and Links. The main content area is titled "Welcome to SMUD's Summer Solutions Study!" and includes a thank-you message. A checklist of expectations for participants is provided, covering equipment installation, post-installation tasks (reviewing the Quick Start Guide and completing the Participant Survey), getting a free energy assessment, talking to other participants, and having fun. A cartoon illustration of a house with solar panels and energy-saving appliances is shown on the right. Contact information for the study is provided at the bottom, including an email address and phone number.

SMUD
SACRAMENTO MUNICIPAL UTILITY DISTRICT
The Power To Do More.®

Welcome FAQs Discussion Board Equipment Rates Links

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



+ Energy Assessments

- Free offering to all participants
- 80+ homes visited
- Photos taken of problems/code violations
- Copy of actionable checklist provided to customer

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

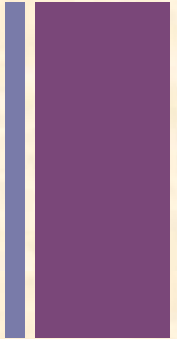
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Bill Comparison for TOU-CPP



 SMUD <i>Summer Solutions</i>		Bill Comparison
<i>Start Date</i> 7/12/2011		<i>End Date</i> 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	
Thursday, July 21, 2011	
Thursday, July 28, 2011	
	Standard Bill
	Summer Solutions Bill
	<i>Congratulations you saved 19.9% on your bill:</i>
	<i>Plus you earned from Auto Temp Control:</i>
	<i>Total savings this month:</i>

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>
<i>Total savings this month:</i>	<i>\$27.29</i>

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	788		\$77.42

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



Quick Start Guide & 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.



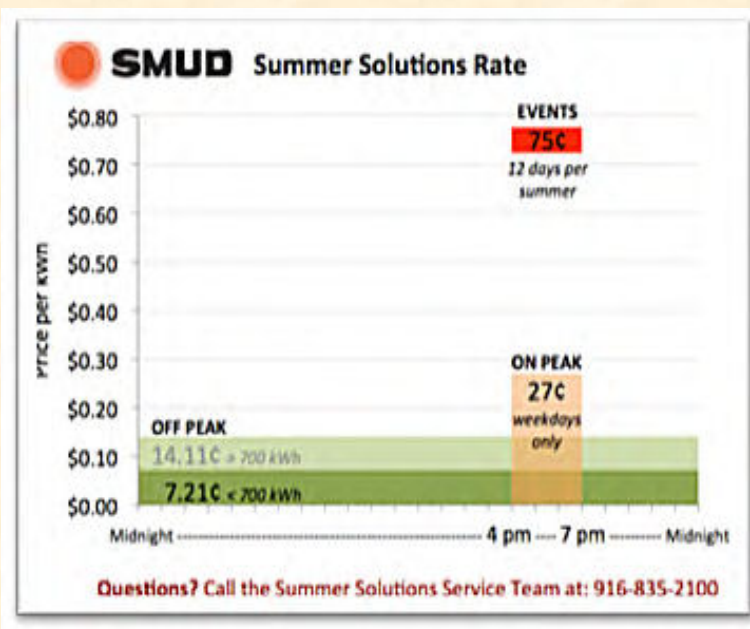
8. **Customer Service:** If you have any questions, feel free to contact the Summer Solutions Support Team. They are available Monday through Friday from 9 am to 4 pm, by email or phone:

SummerSolutions@HerterEnergy.com

(916) 835-2100

Home 4/6/11

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





Field Test & Findings

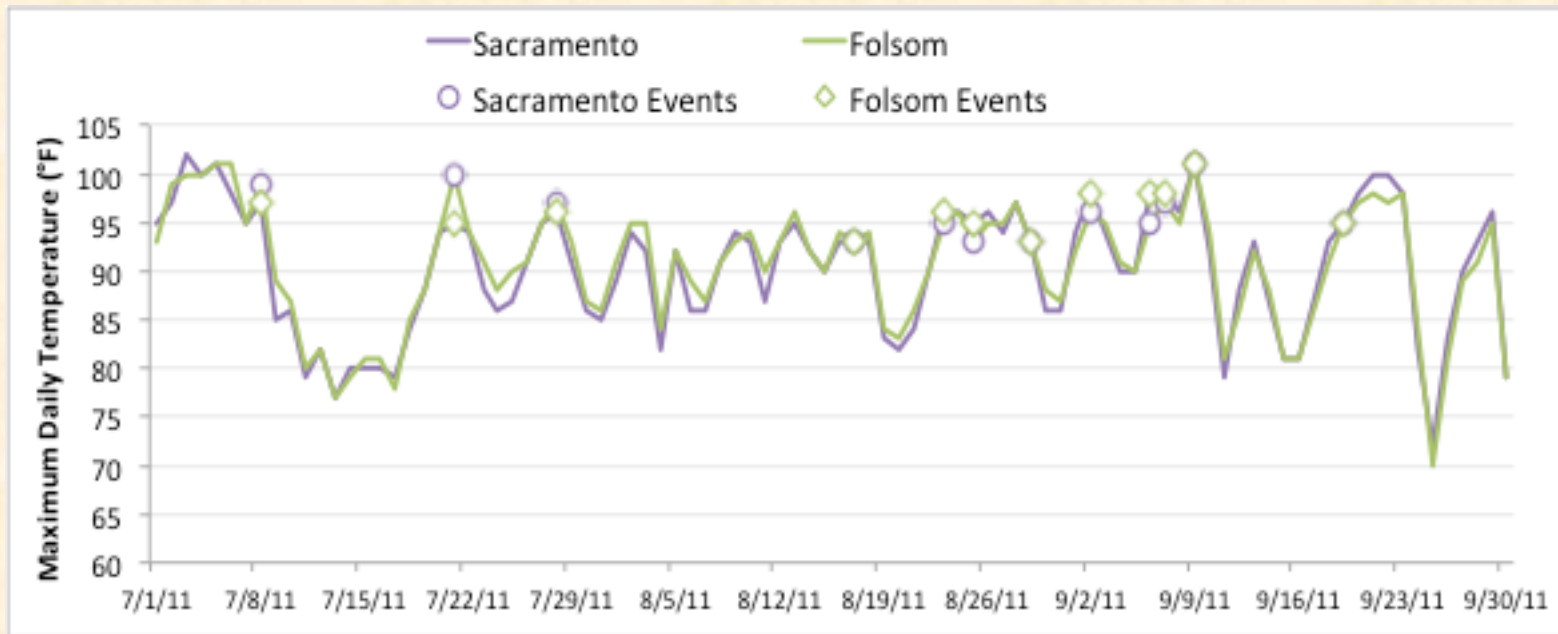
+ Events

- Twelve events from July to September
- Notify Participants
 - Email – including recommendations for participant action
 - Thermostat display – blinking light and message
 - Computer energy display – ACTIVE event status displayed
 - Special requests: Phone calls or text message
- Notify Equipment
 - OpenADR to gateway
 - ZWave from gateway to thermostat
 - Thermostat initiates Automatic Temperature Control (4°F) or customer-programmed response to events



2011 Temperatures and Events

a cool summer: normally 15 days >100°F



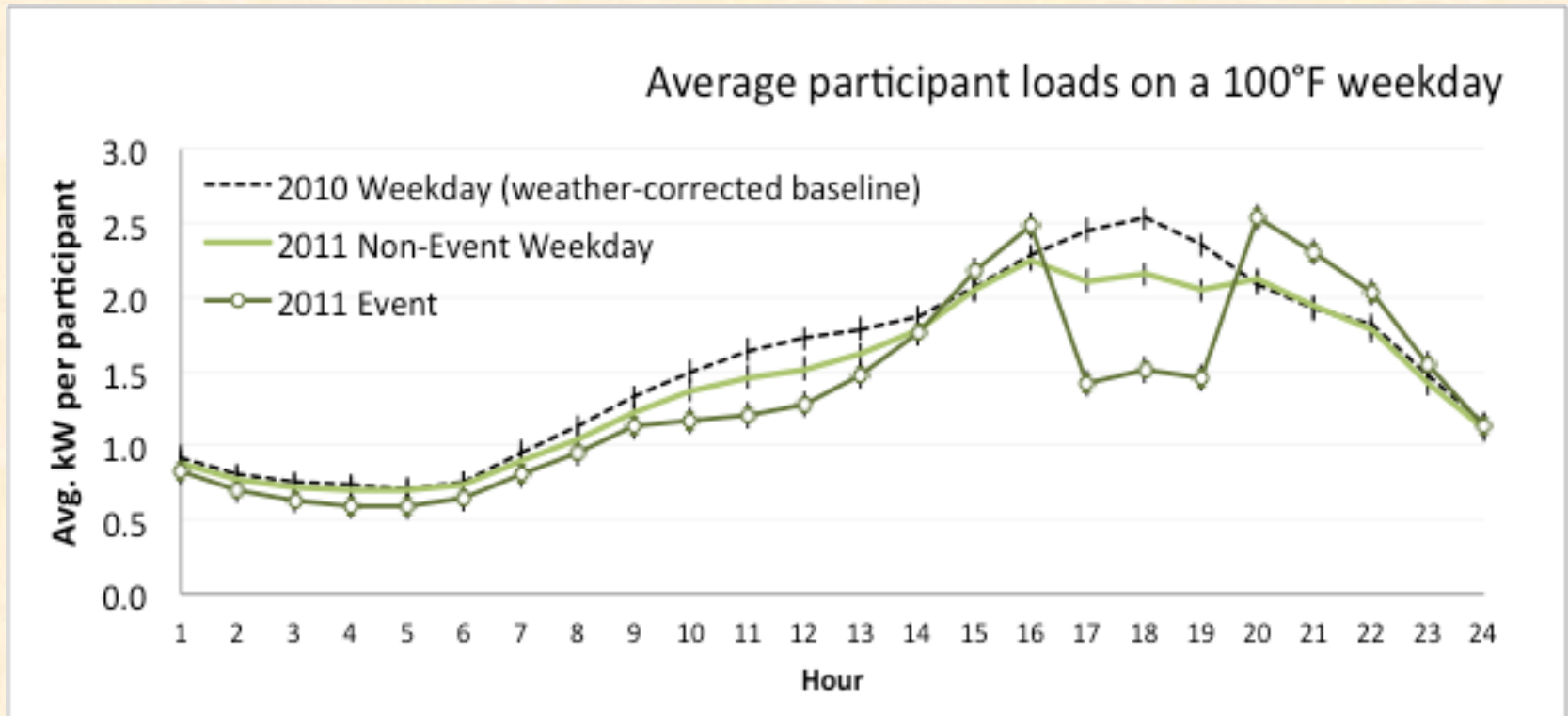
Response to events in a more typical year is likely to be higher



Overall program impacts

loads on a 100°F day

- Both energy and peak load savings on non-event days
- Significant load shed during events, with some pre-cooling and rebound

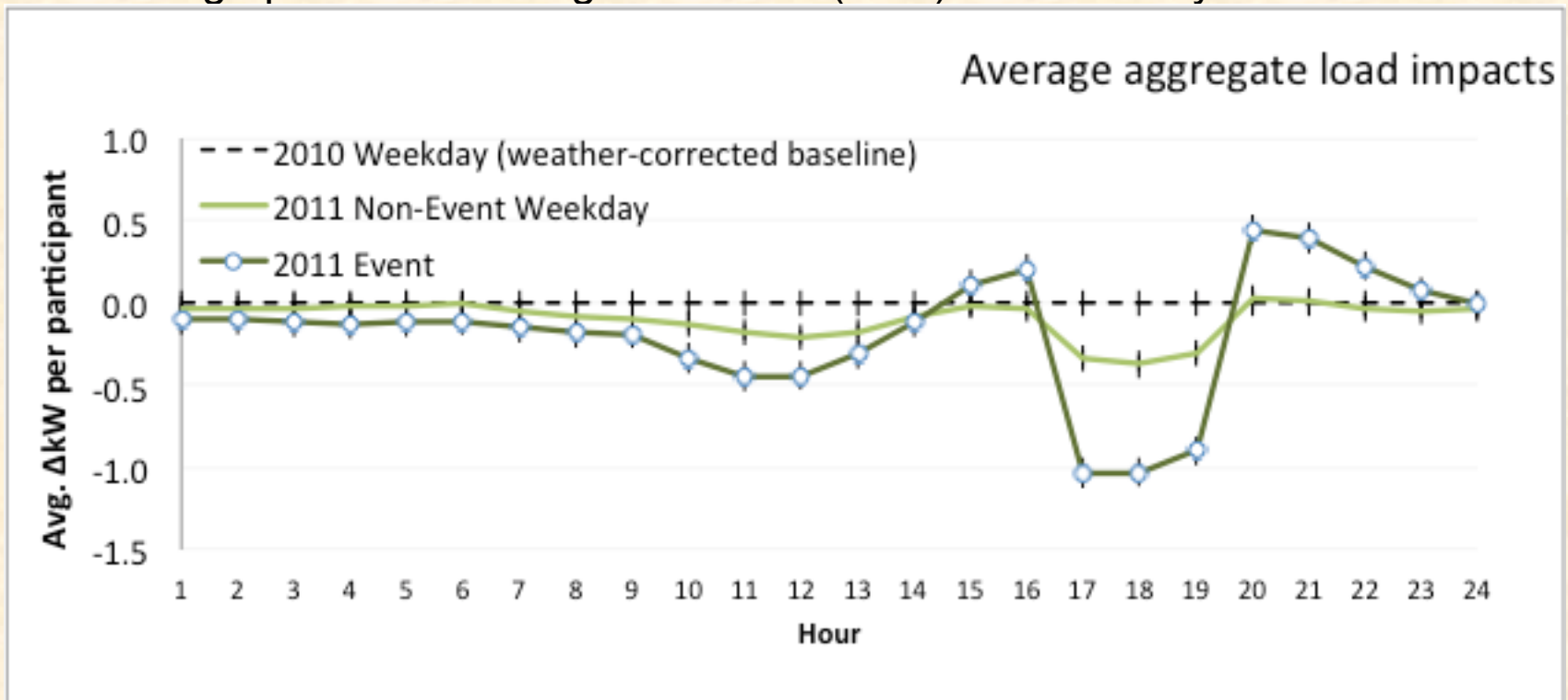




Overall program impacts

compared to a weather-corrected 2010 baseline

- Average hourly energy savings of .09 kWh (8%)
- Average peak load savings of .34 kW (14%) on non-event days
- Average peak load savings of .99 kW (40%) on event days

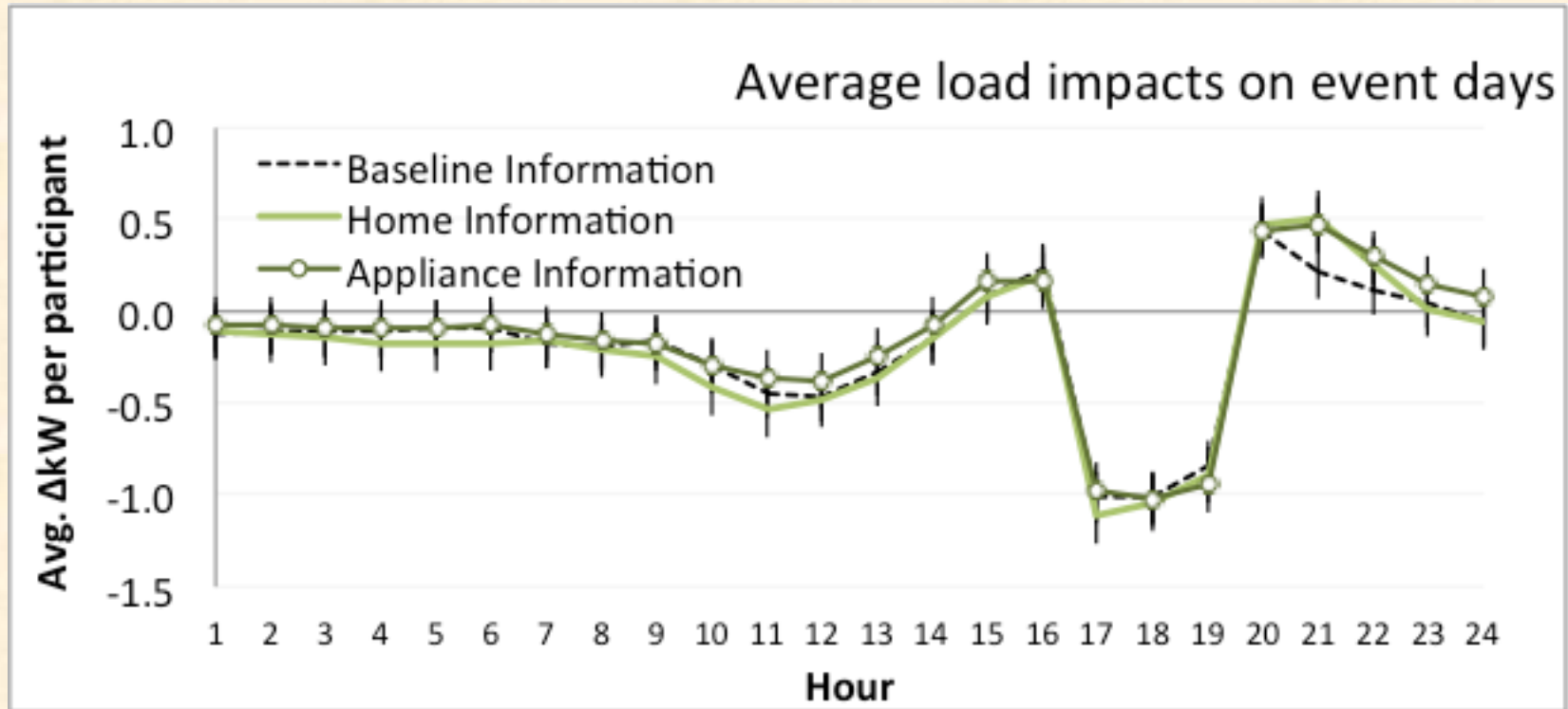




Real-time Information Effects

event impacts

- All three treatment groups had statistically similar responses to events

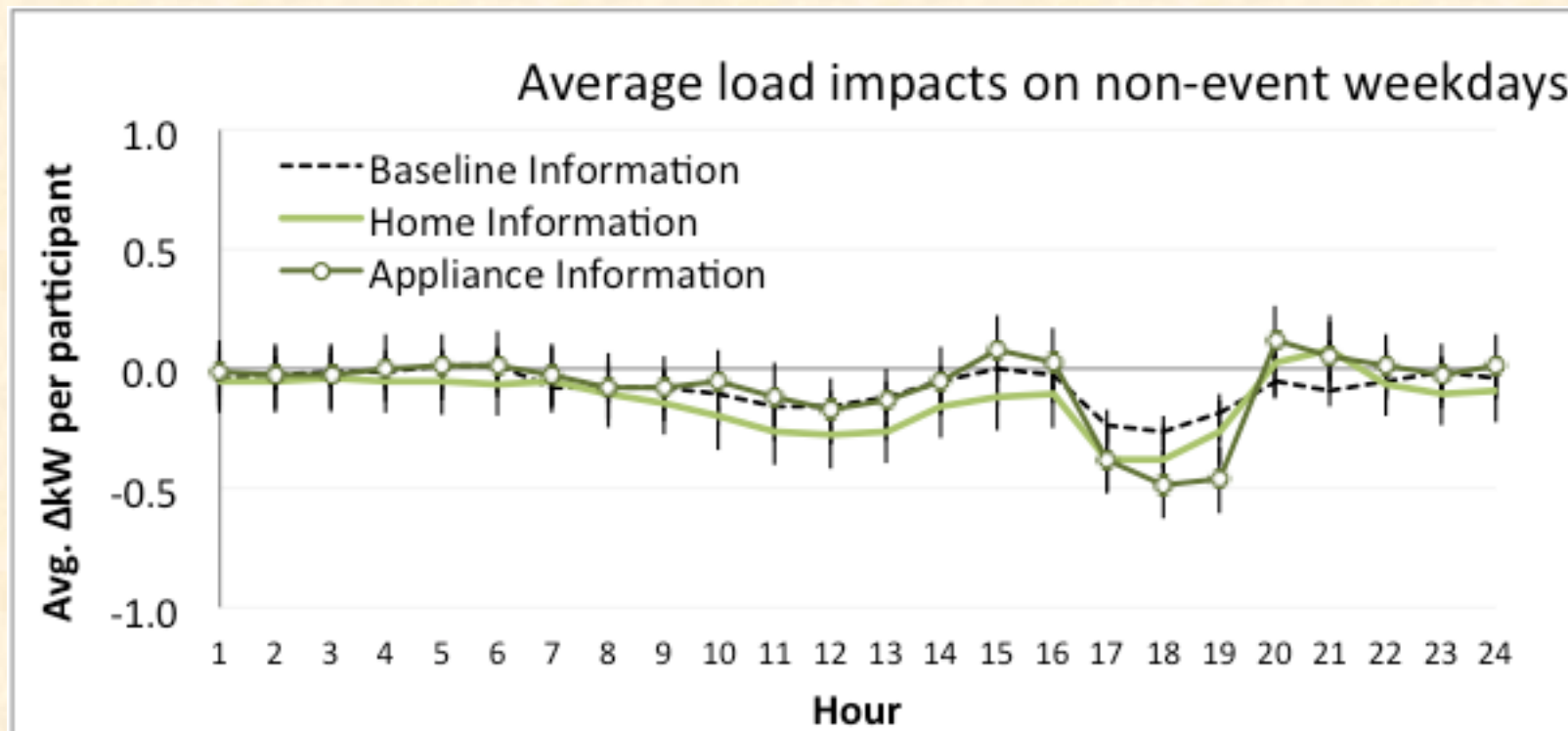




Real-time Information Effects

non-event weekdays

- All three treatment groups had statistically different impacts on weekdays

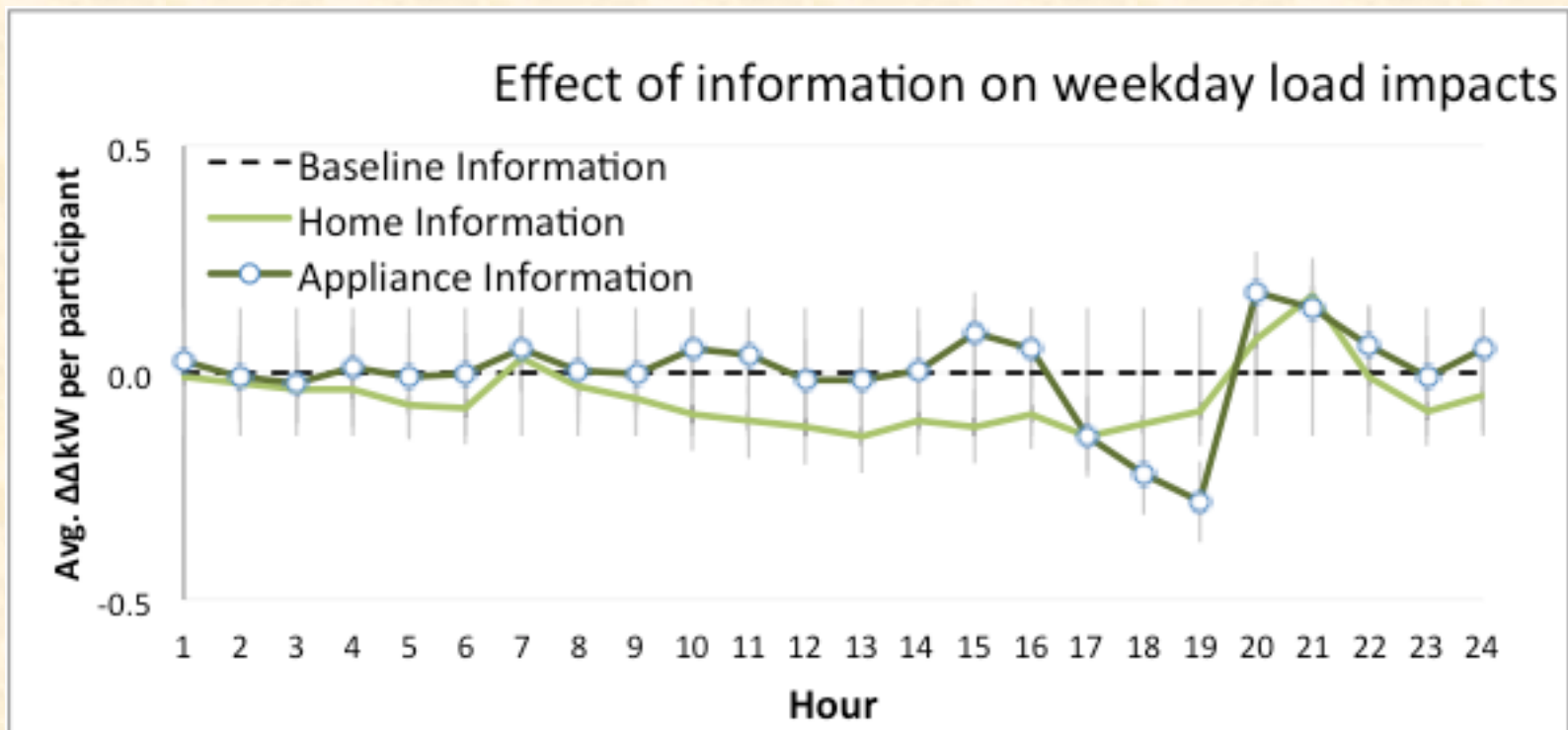




Real-time Information Effects

non-event weekdays

- All three treatment groups had statistically different impacts on weekdays
 - Home data improved energy savings
 - Appliance data improved peak savings



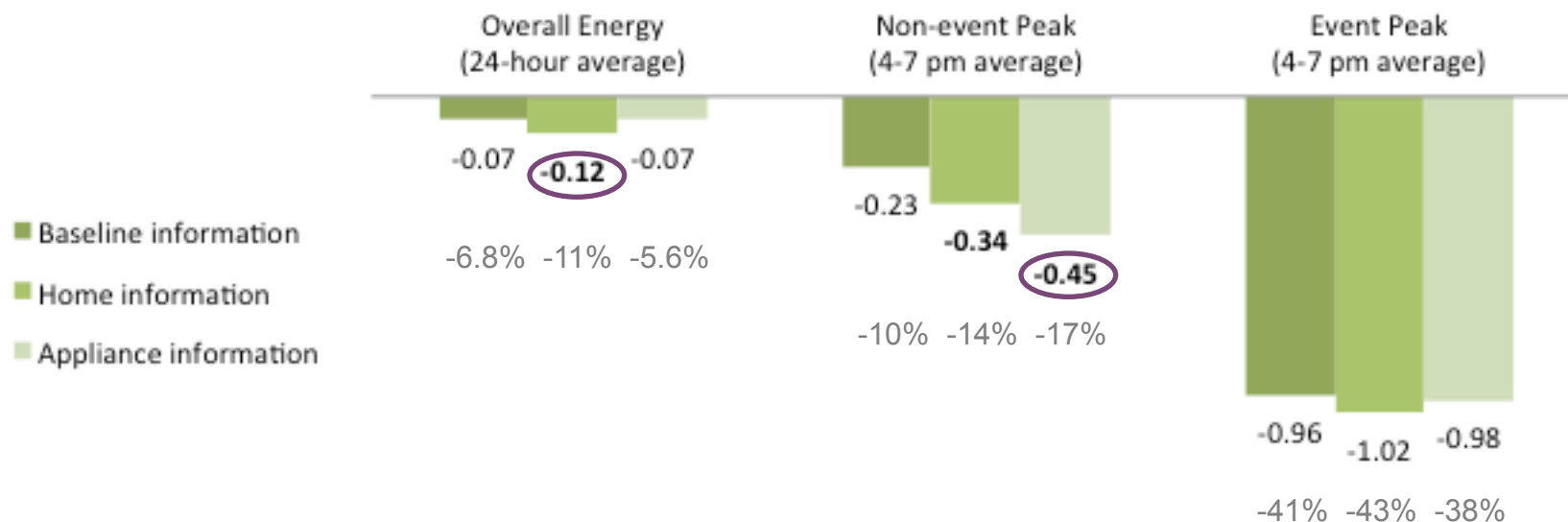


Real-time Information Effects

summary

- Home data improved energy savings
- Appliance data improved peak savings
- No effect on event savings

Load Impacts by Information Treatment

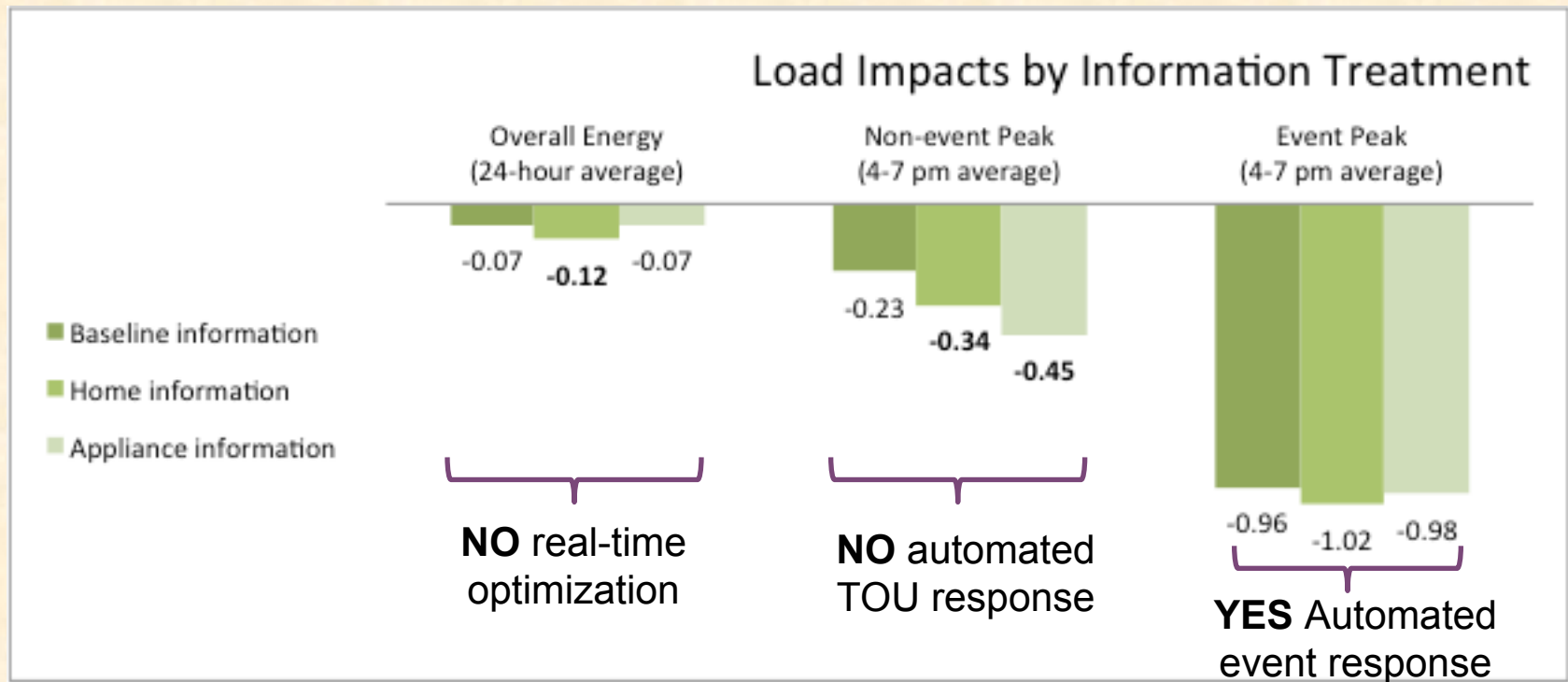


Values in bold indicate a statistically significant difference from “Baseline information”



Real-time Information Effects

no effect where automation was present?



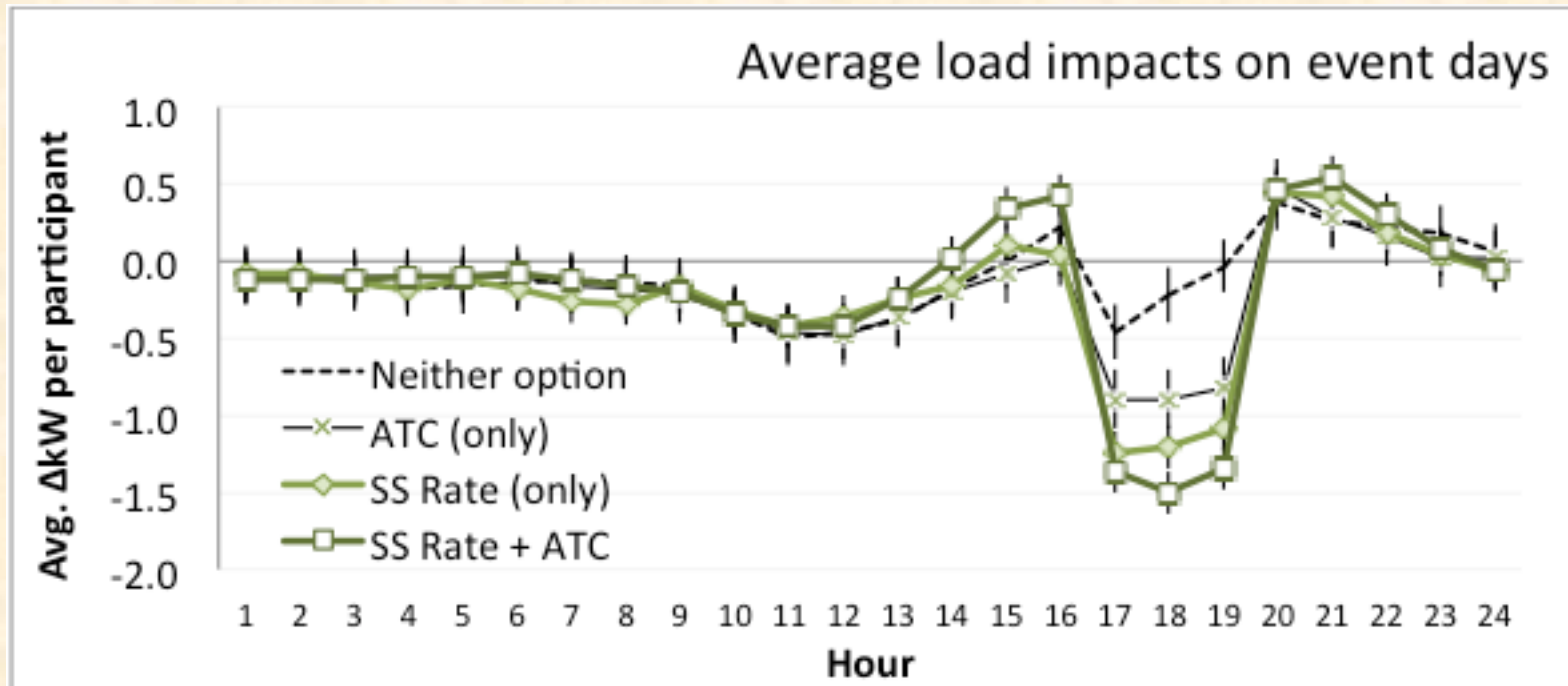
Future thermostats will provide user options for all three types of automation.



Dynamic Rate & AC Control (ATC)

event days

- Automation and incentives resulted in greater event day savings
- Dynamic rate participants shed more peak load than ATC participants



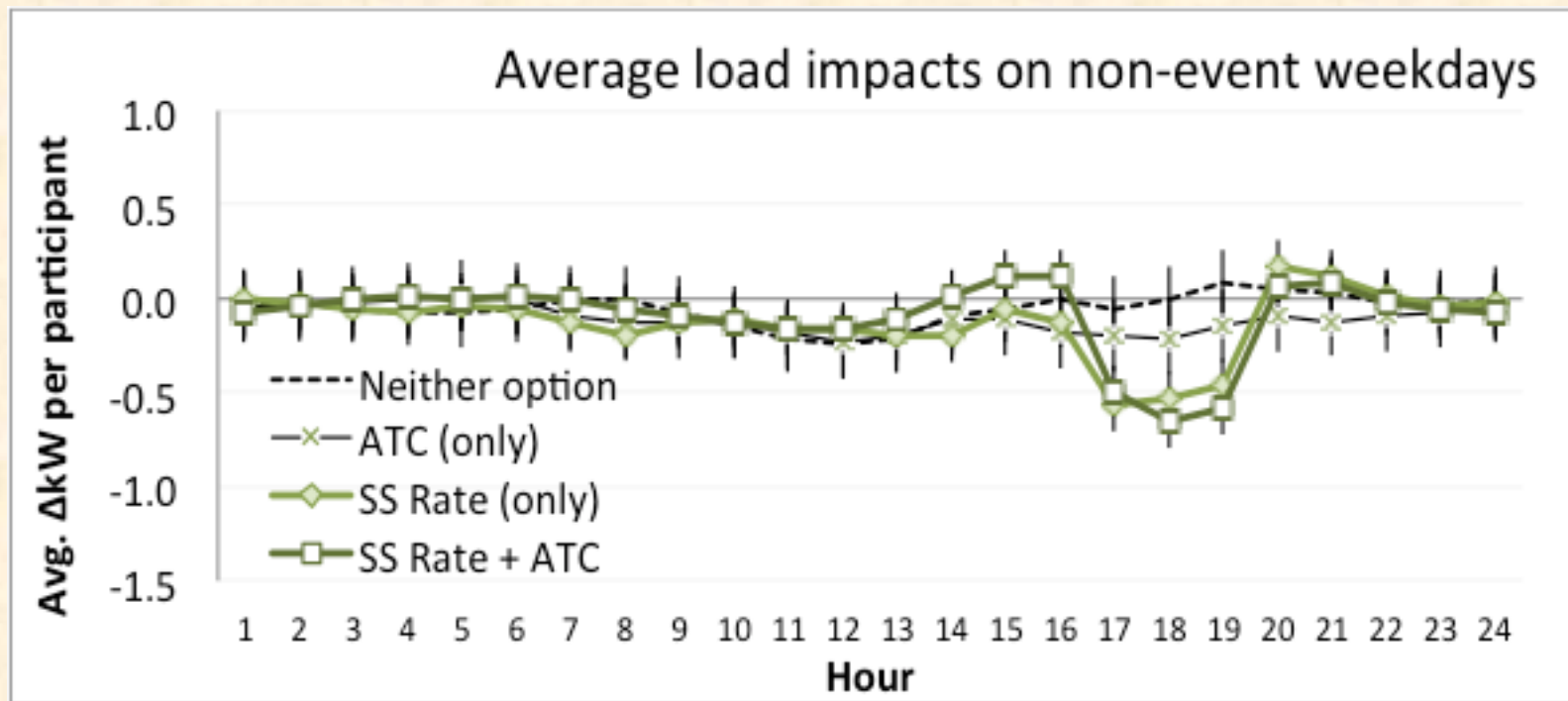
Remember: options were chosen by participants, not randomly assigned.



Dynamic Rate & AC Control (ATC)

non-event weekdays (normal days)

- No automation available to shed peak load every day
- Dynamic rate participants had the greatest daily peak load reductions



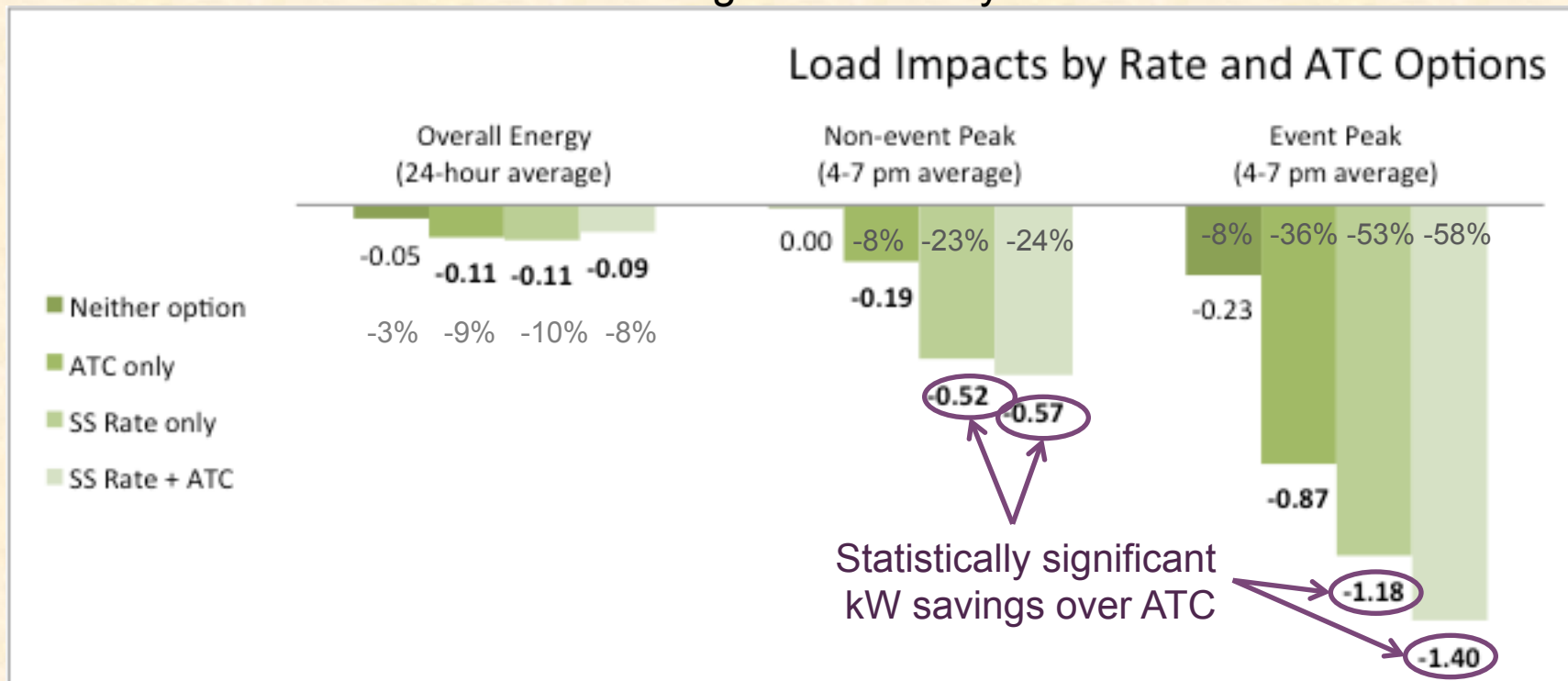
Remember: options were chosen by participants, not randomly assigned.



Dynamic Rate & AC Control (ATC)

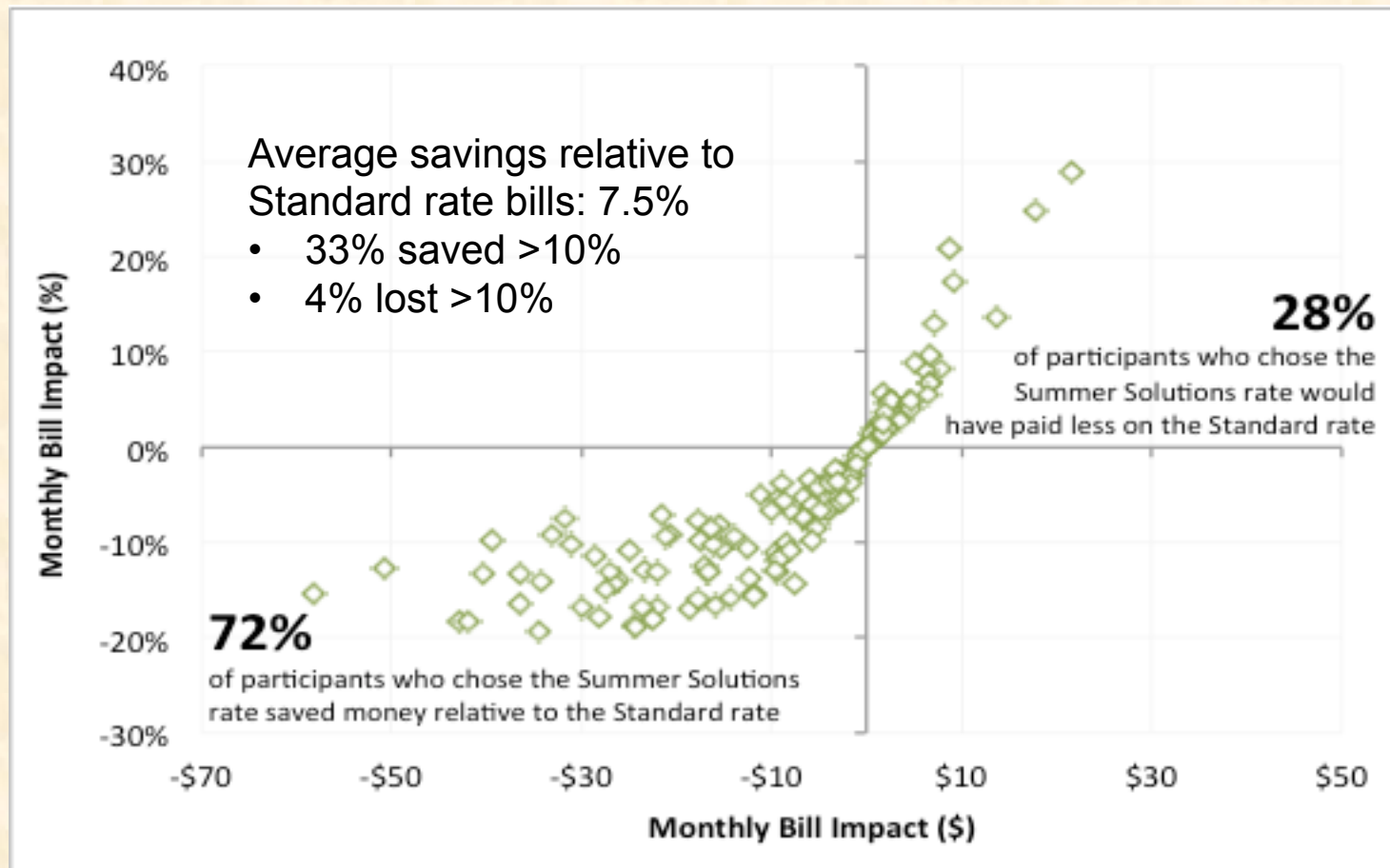
those choosing the dynamic rate performed best

- Similar energy savings across all program options
- Peak and event load reductions greatest for Dynamic Rate



Values in bold indicate a statistically significant difference from “Neither option”

+ Findings: Bill Impacts

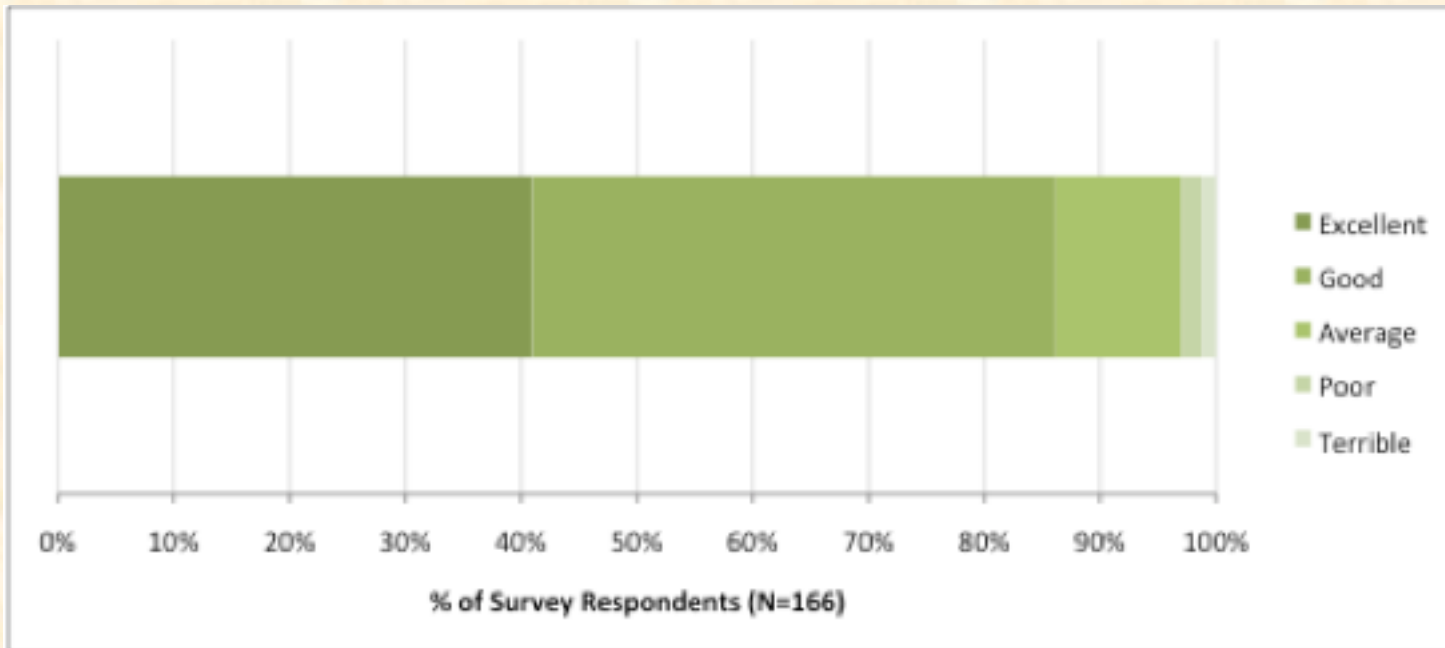


These bill savings are in addition to those associated with energy savings: those on the SS rate saved about twice as much (\$20/mo) as those on the Standard rate (\$10/mo).



Satisfaction

- 86% = Excellent or Good
 - All groups were equally satisfied
- 90% signed up again for Summer Solutions 2012
 - 5% dropped out, 5% unreachable





Hypotheses

- For the overall program:
 - Energy use is lower: **YES**
 - Weekday peak demand is lower: **YES**
 - Peak demand on event days is lower: **YES**
 - Electricity bills are lower: **YES**
- Savings are better for customers:
 - with more information: **MIXED** (evidence that appliance-level info is too much?)
 - who chose more program options: **YES**
 - on the dynamic rate, compared to direct load control: **YES**
 - with higher energy use: **YES**
 - with certain self-reported behaviors: **YES** (e.g. precooling, peak offset)
 - with certain dwelling characteristics: **YES** (e.g. swimming pools)
 - with certain demographic characteristics: **NO** (age, education, income)
 - with higher satisfaction levels: **MIXED** (no savings for dropouts)

Contacts



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www.HerterEnergy.com
916.397.0101

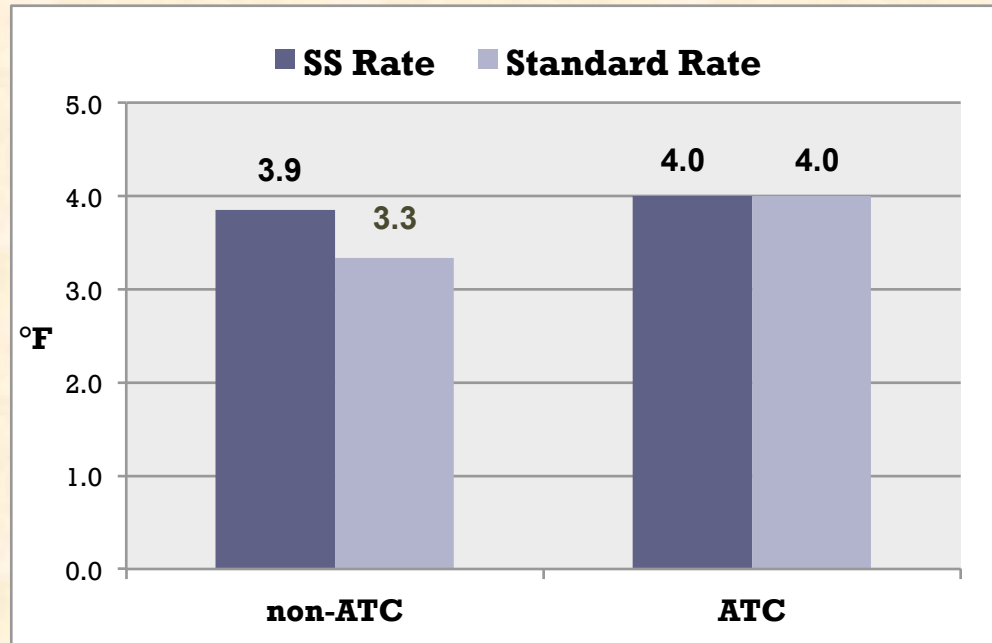
Vikki Wood
Sacramento Municipal Utility District
www.SMUD.org
916.732.6278

February 2012 Report at:
<http://www.HerterEnergy.com>



Behaviors - Event Settings

by program option

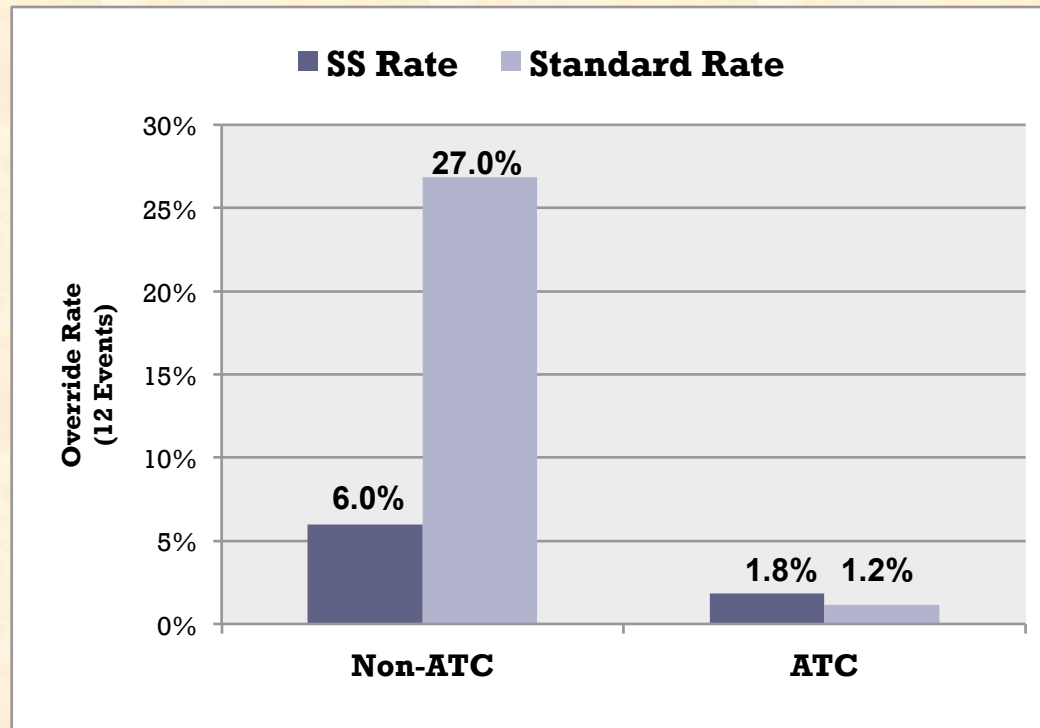
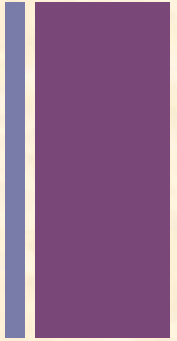


- Participants were assisted in setting thermostats for critical event days
 - ATC participants could not change the 4-degree setting
 - SS rate and Standard rate participants could change settings at any time



Behaviors - Event Overrides

by program option



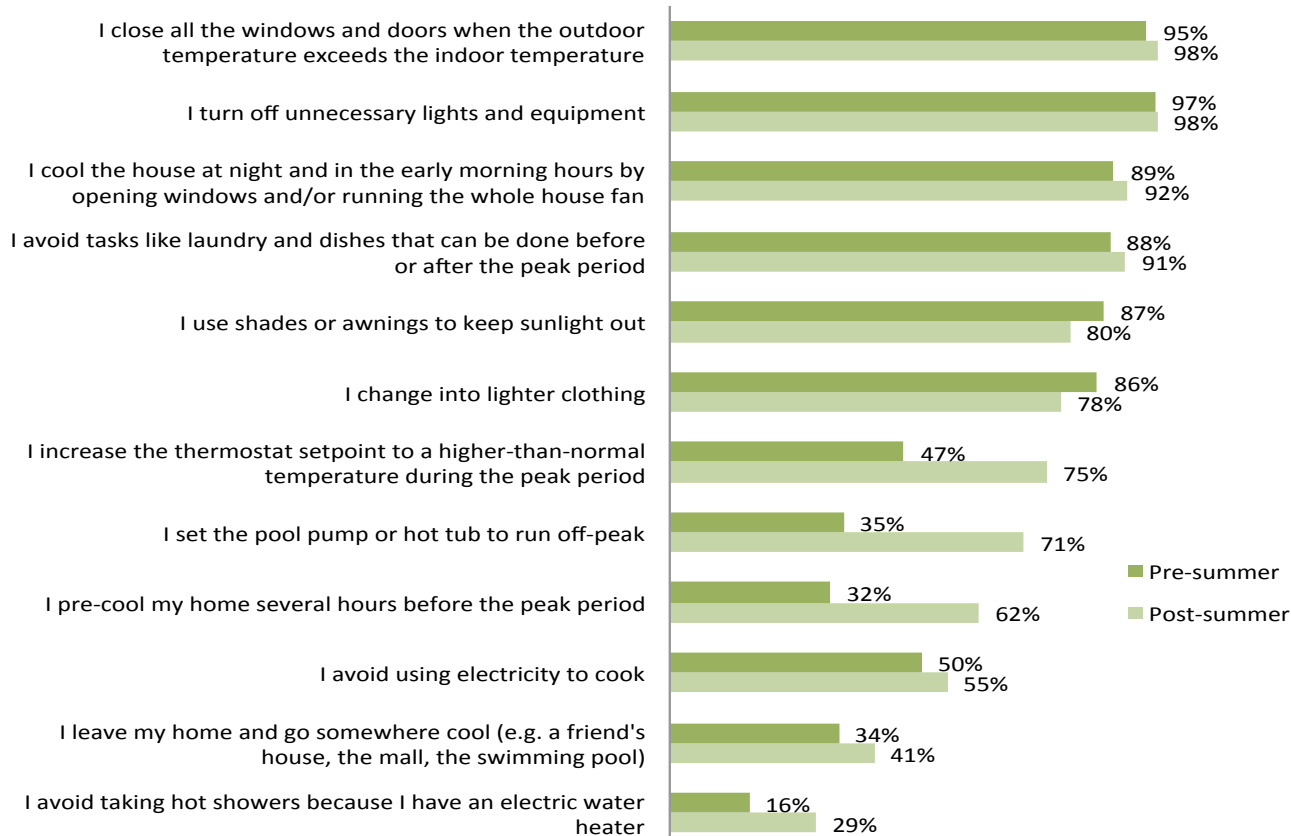
- ATC participants were limited to one override, resulting in only a 1%-2% override rate
- SS rate and Standard rate participants could override any or all events



Behaviors - Peak and Event

before/after Summer Solutions

Peak and Event Strategies

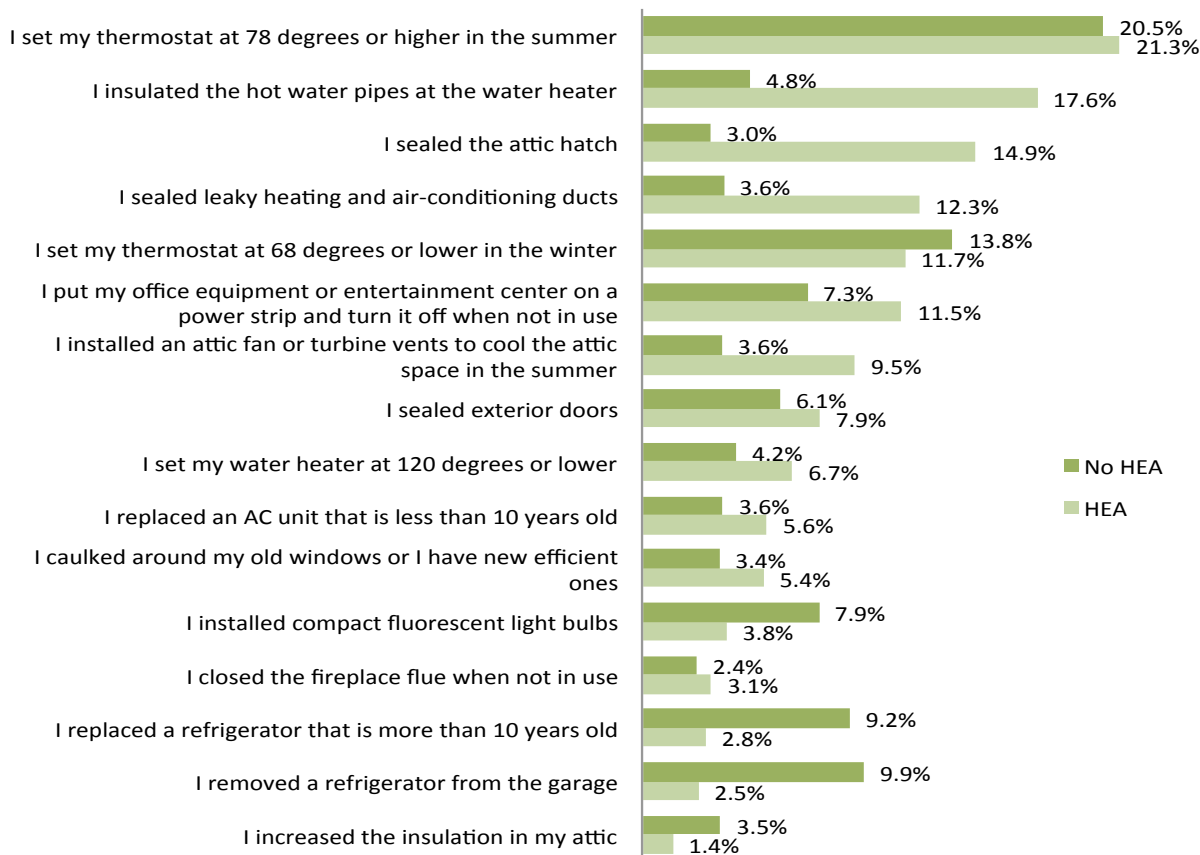




Behaviors - Energy Efficiency

without/with Home Energy Assessment

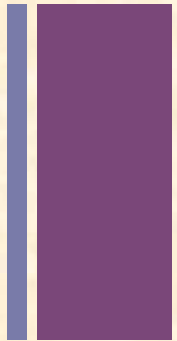
Efficiency measures resulting from Summer Solutions



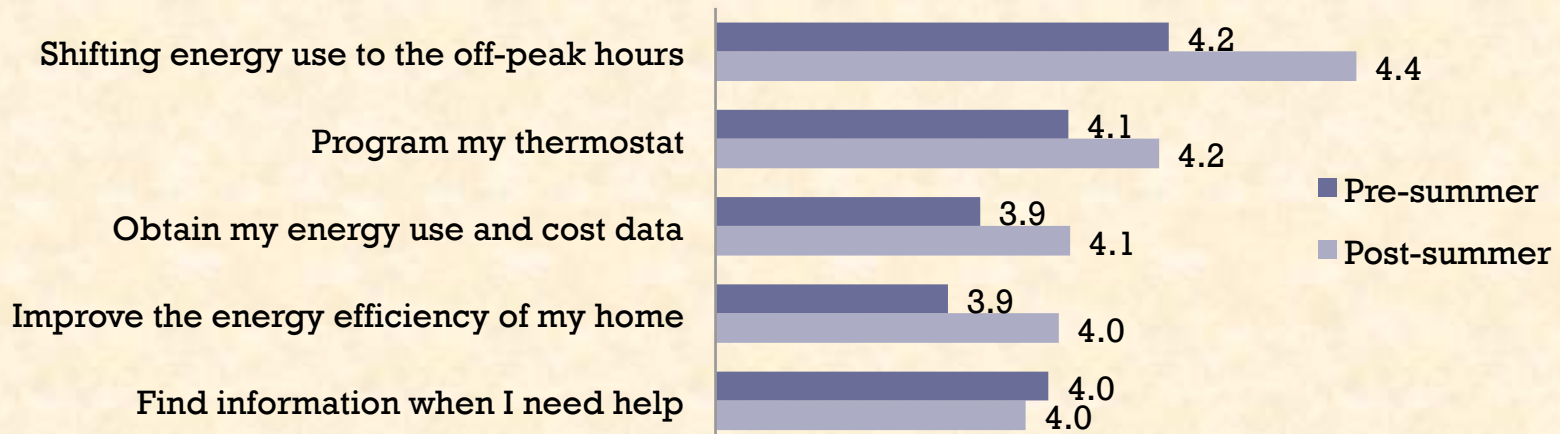


Confidence in Completing Tasks *pre-and post-summer*

- On a scale of 1 to 5, where 1 = “I can’t do this at all” and 5 = “I feel very confident”
- Scores indicate increased confidence from beginning to end of summer



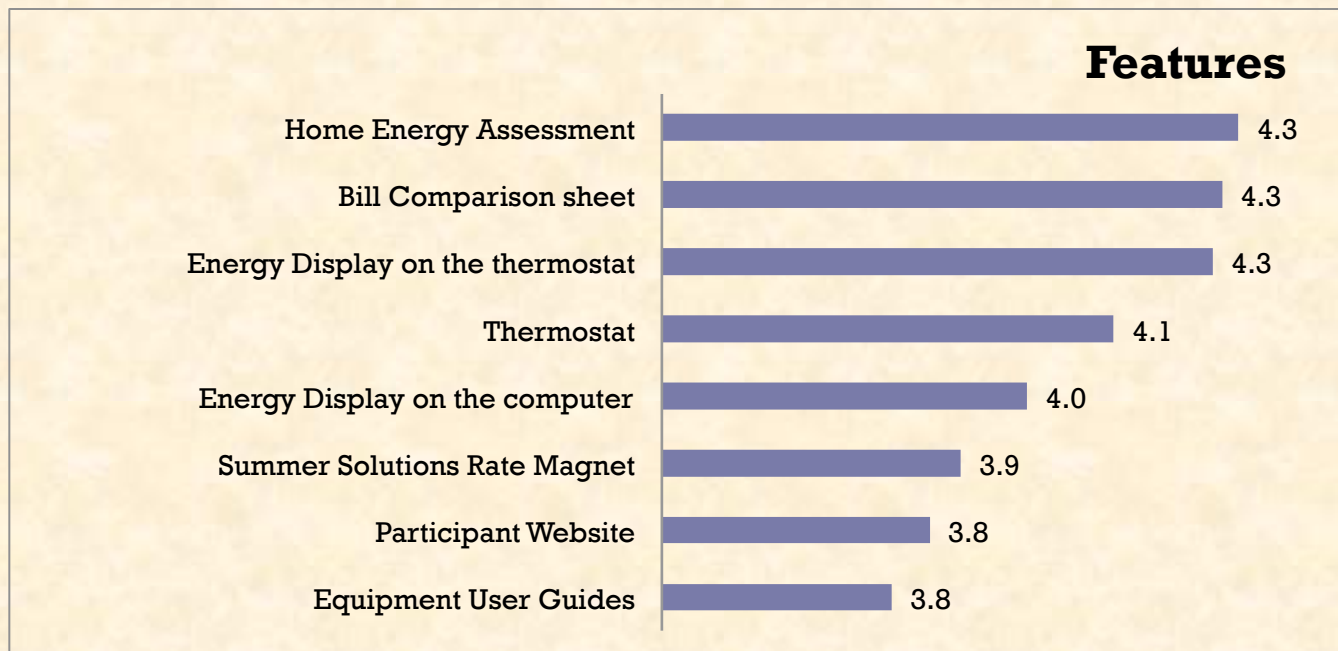
Confidence in completing tasks





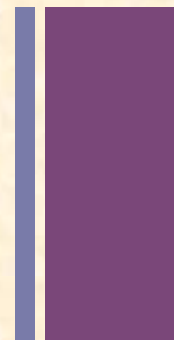
Usefulness of Pilot Features

- On a scale of 1 to 5, where 1 = “This is actually a negative for me,” 3 = “Neutral” and 5 = “Most important”
- Home Energy Assessment, Bill Comparison, thermostat energy display and real-time data are the most highly valued pilot features

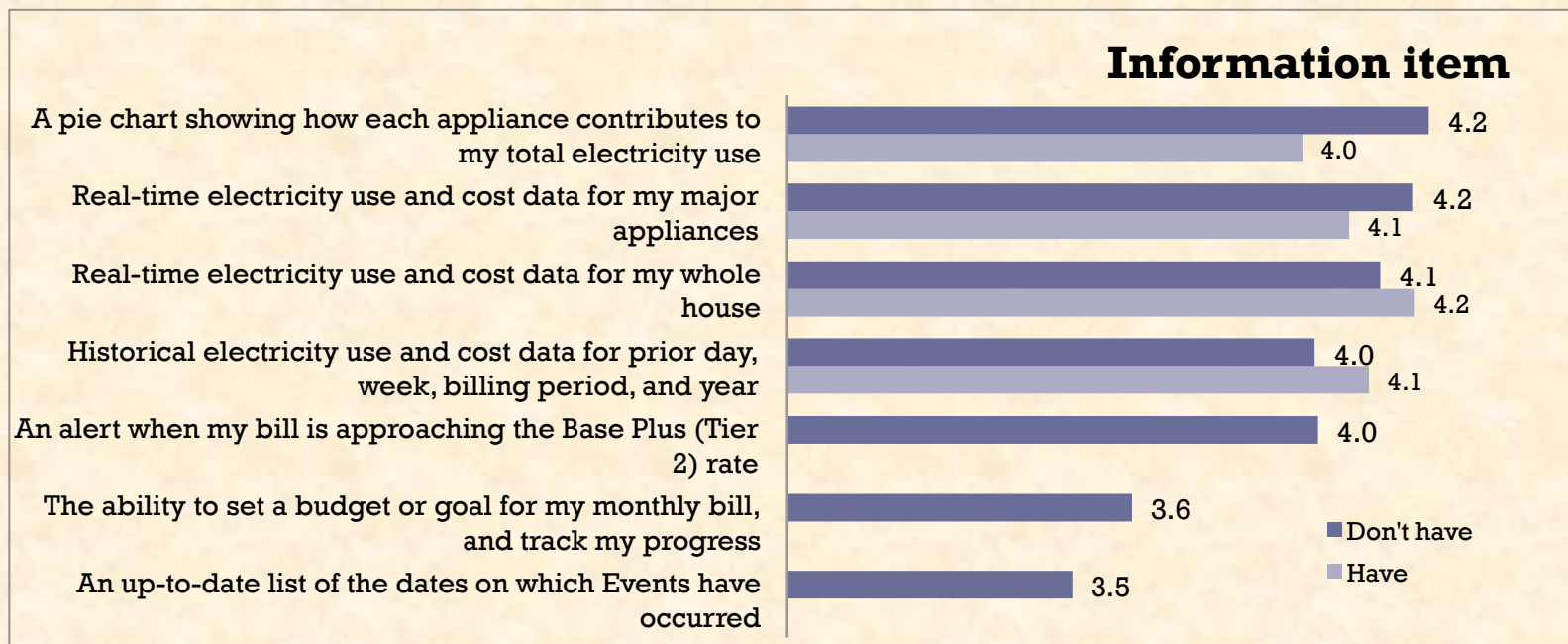




Usefulness of Information Items *by whether available or not*

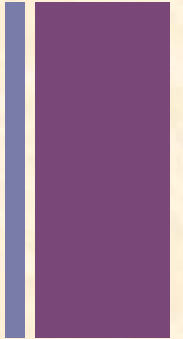


- On a scale of 1 to 5, where 1 = “This is actually a negative for me,” 3 = “Neutral” and 5 = “Most important”
 - Those who have appliance data value it less
 - Those who have whole house data value it more

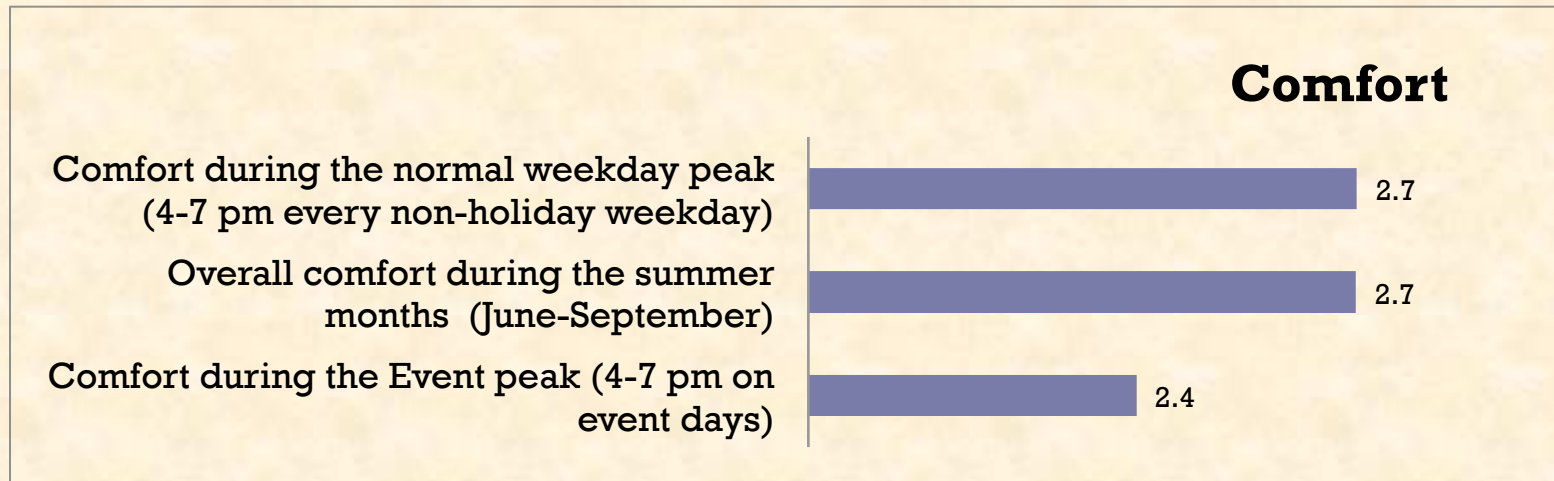




Comfort

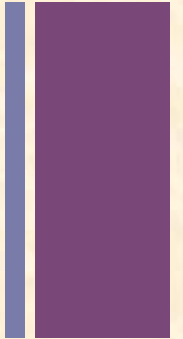


- On a scale of 1 to 5, where 1 = “I was very uncomfortable” and 5 = “I was much more comfortable”
 - Scores indicate minimal discomfort, even during peak events
 - No significant differences among program options





Satisfaction *by program element*



- On a scale of 1 to 5 from “terrible” to “excellent”
 - All elements averaged “good” or better

