The Behaviors Behind the Impacts

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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

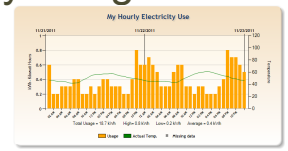
Study Goals

- Build on what we already know
  - *TOU rates* are effective for shifting and reducing load every day
  - *Dynamic rates* and *direct load control* 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 rates, automation and information
  - provide as realistic an experience as possible
  - obtain results that can be translated to the real world

Summer Solutions Study Design

N=265 residential customers

Random Information Treatments:
randomly assigned → offered

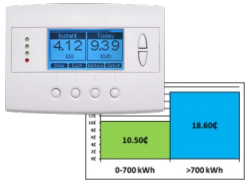


My Energy Usage Online

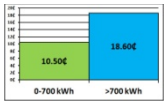
Real-Time Whole-House Info **vs.** Real-Time Appliance Info

Dynamic Rate & AC Control Options:
offered → customer chosen

AC Control + Standard



Standard Rate



vs.

TOU-CPP Rate

AC Control + TOU-CPP

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Hypotheses:

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

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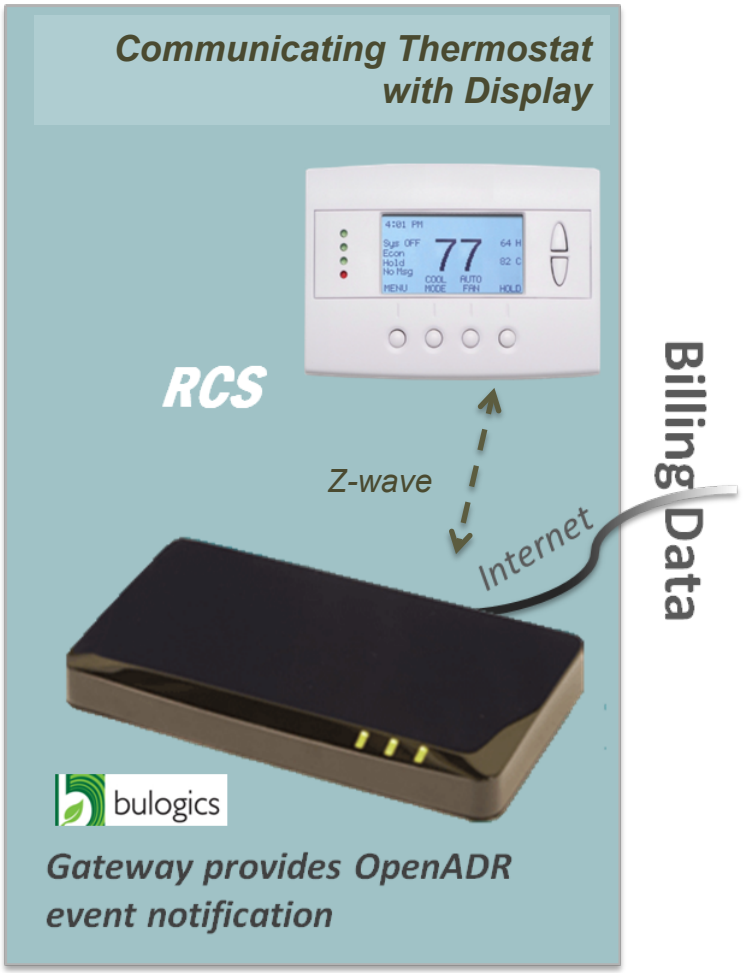
Information System A

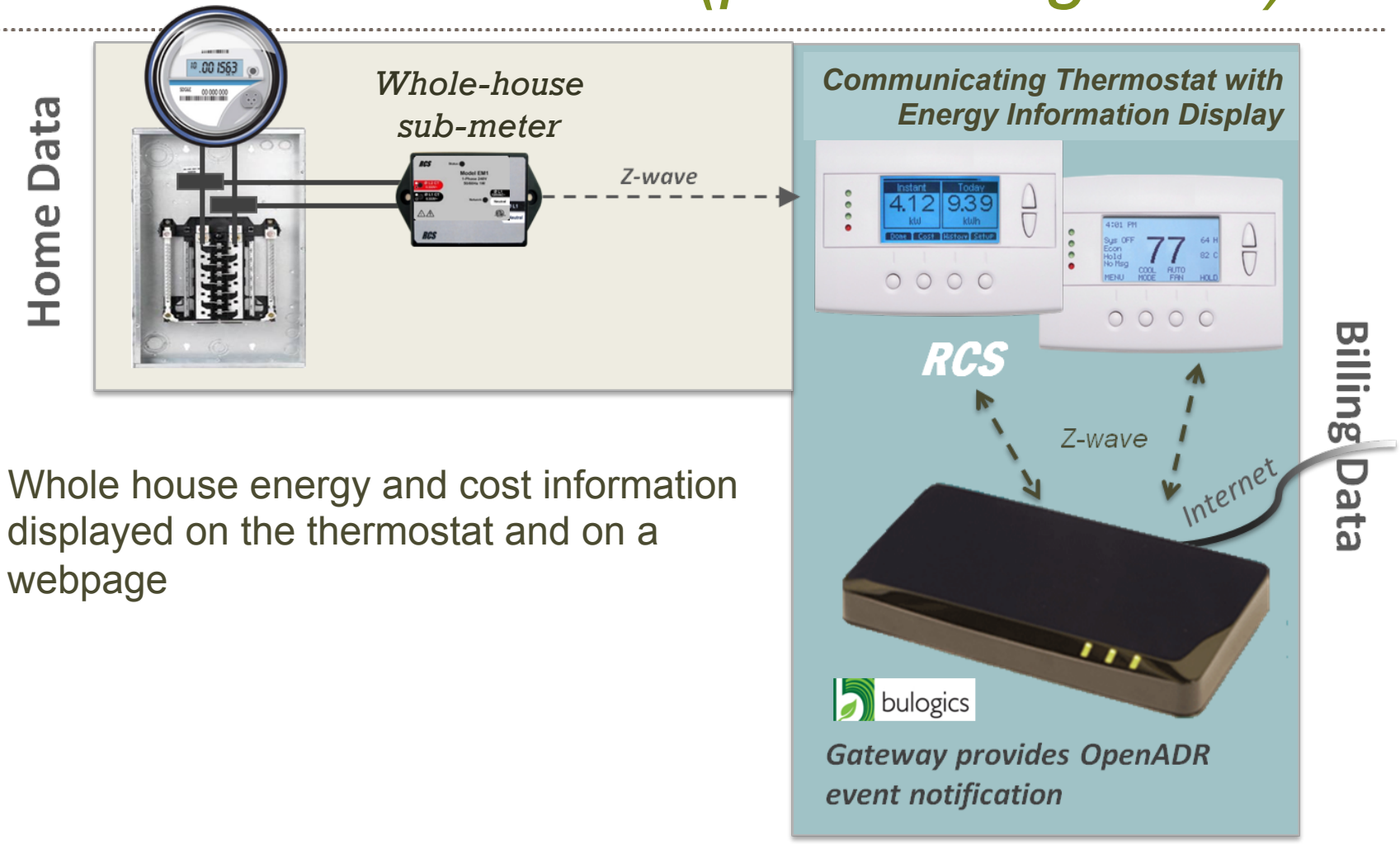
baseline = PCT and standard billing data

- Gateway used only to communicate an event signal to the thermostat—does not transmit any use or cost data



Information System B

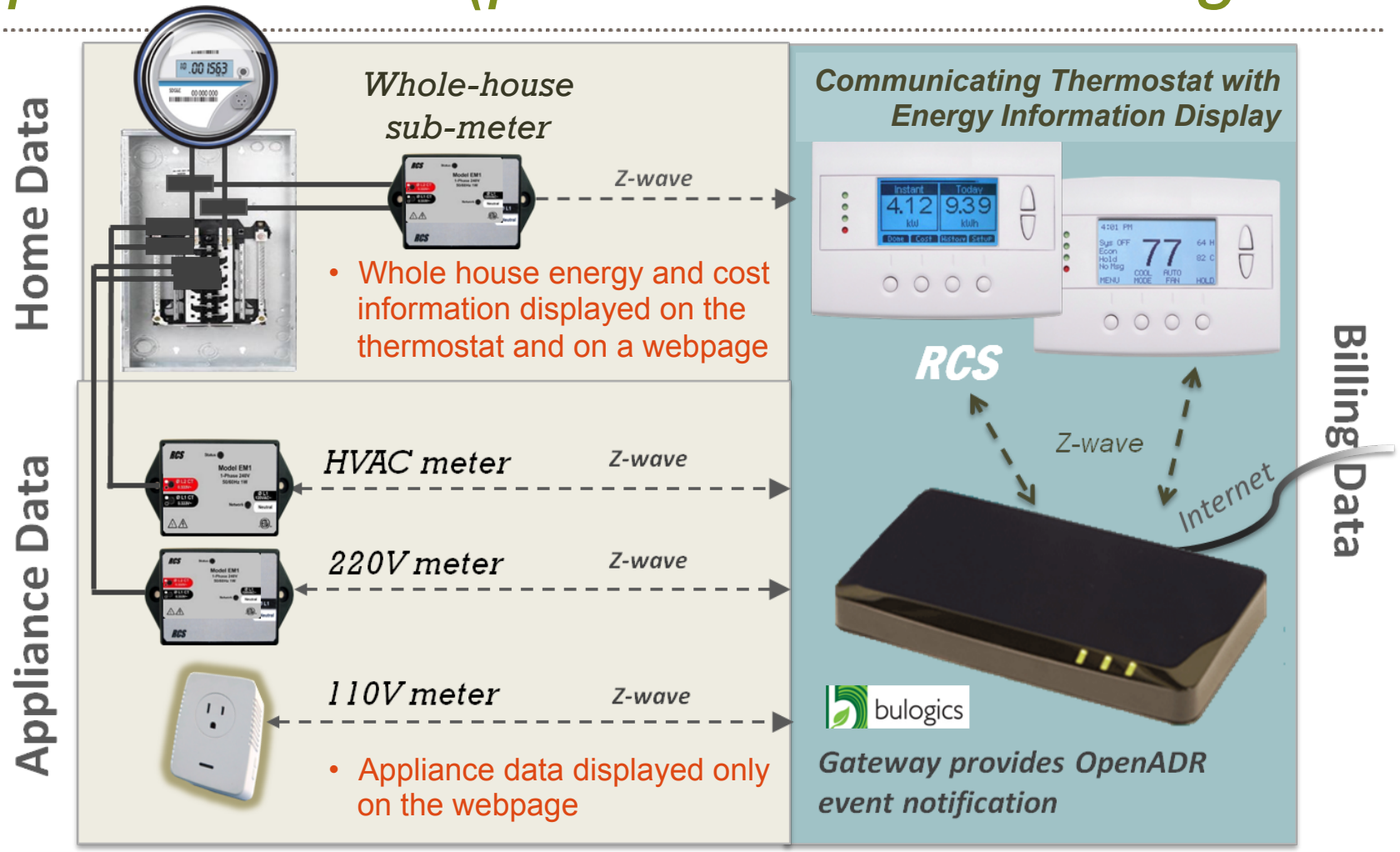
real-time home data (plus billing data)



- Whole house energy and cost information displayed on the thermostat and on a webpage

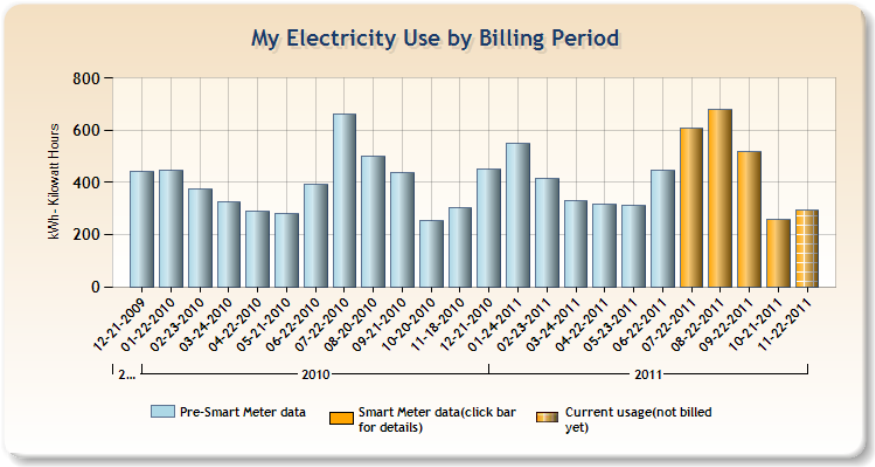
Information System C

appliance data (plus home and billing data)

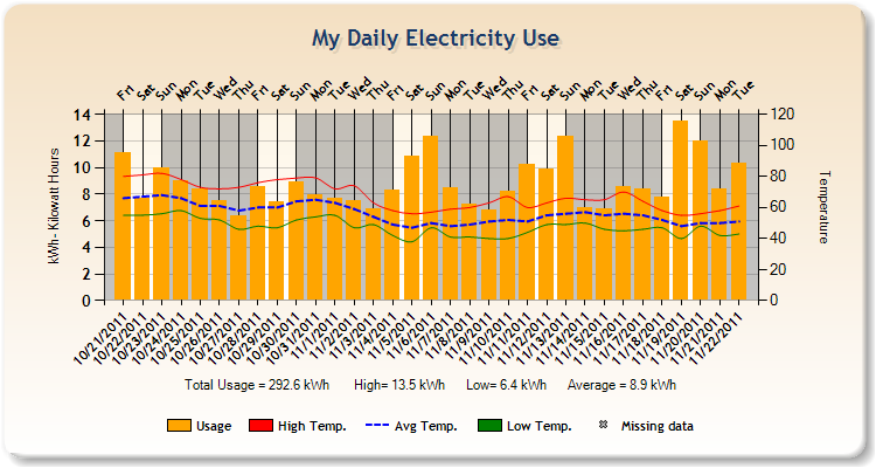


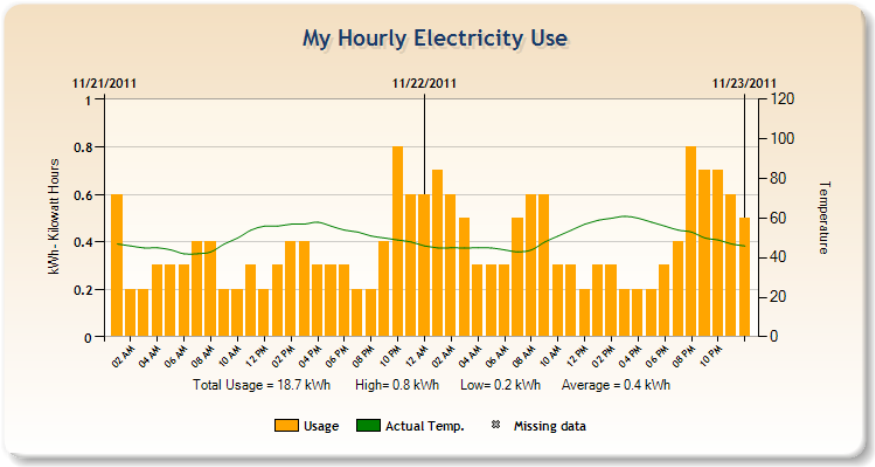
Baseline: Standard Billing Data

My Energy Online on SMUD website



- Usage data only—no cost data
- Requires setting up an account





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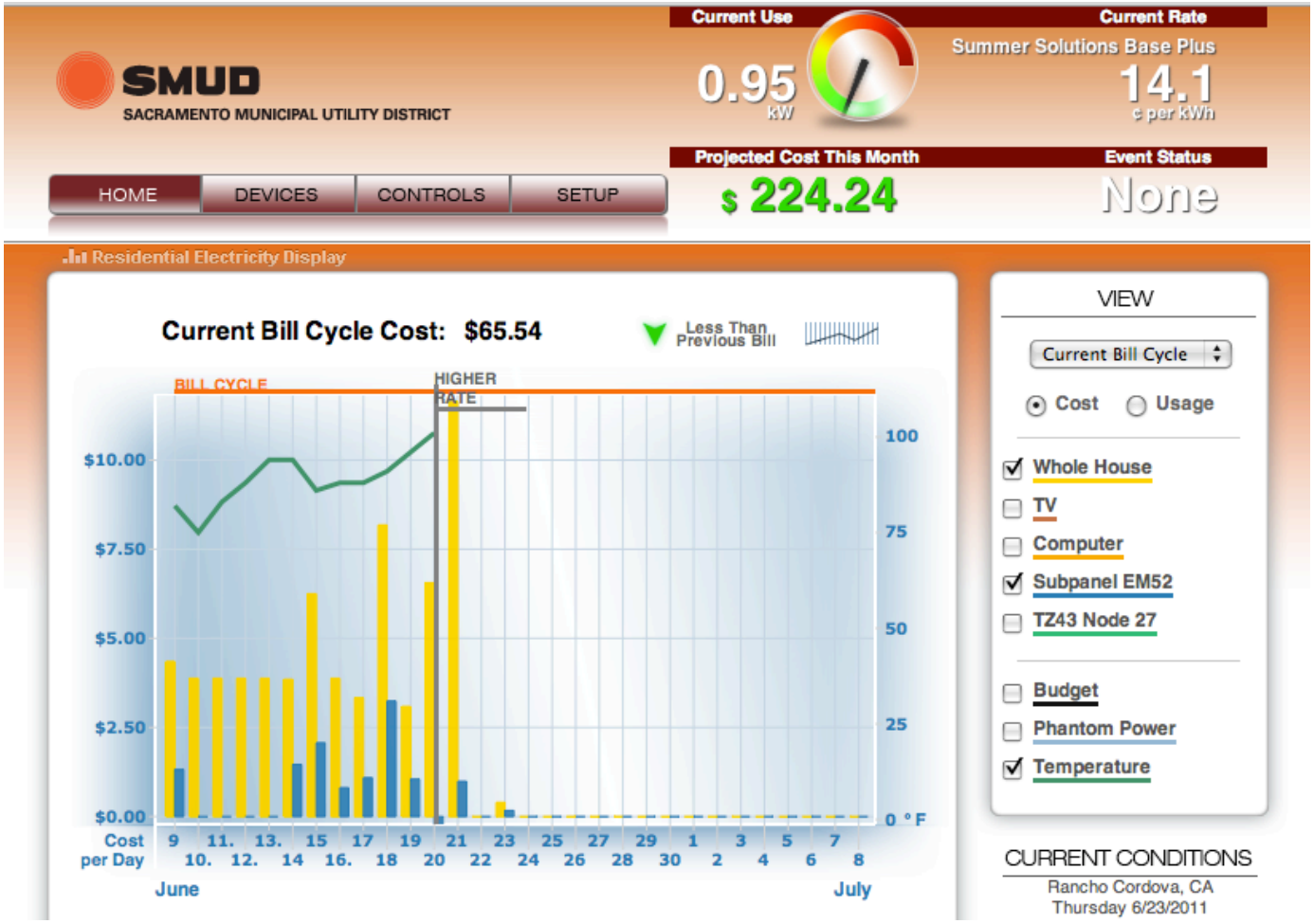
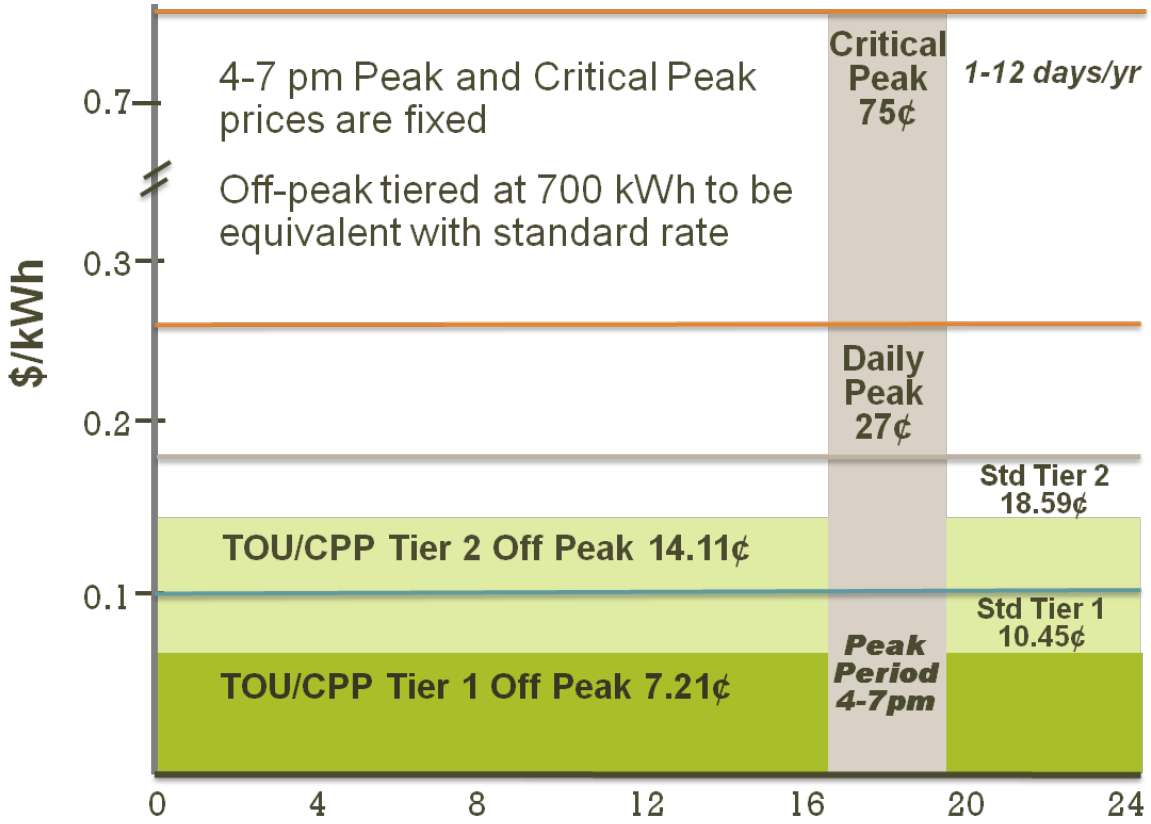
Local User Interface

home or home/appliance data



Local User Interface
appliance data

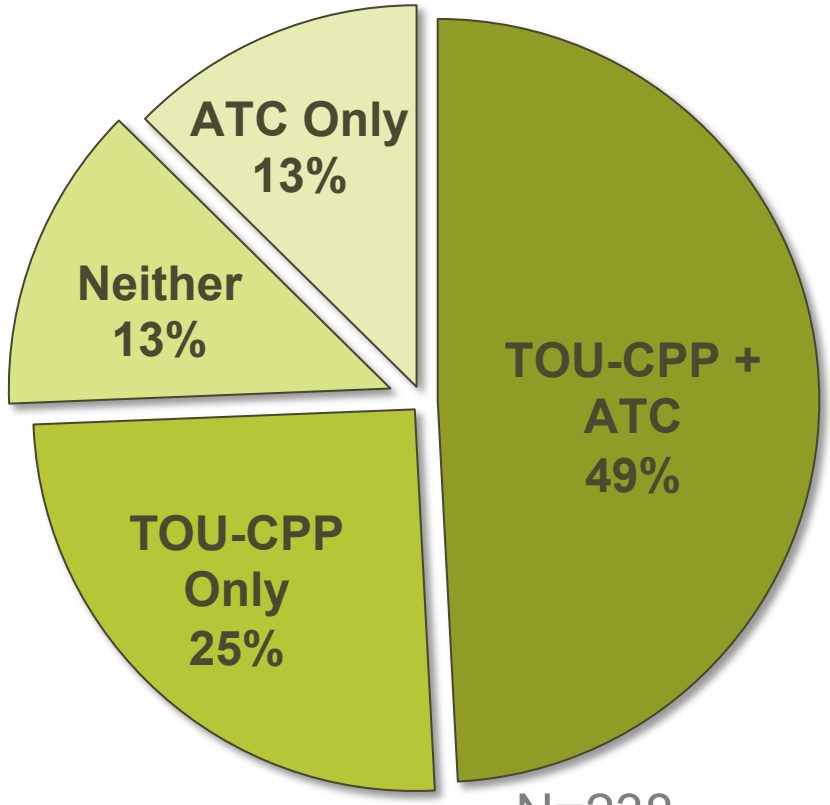
Optional TOU-CPP Rate
vs. standard rate



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

Recruitment – Program Choices
dynamic rate and/or AC control

- Dynamic Rate – **74%**
  - TOU-CPP rate (aka Summer Solutions rate)
  - Customer determines response to high-price events
  - 12 events
- Direct AC Load Control – **62%**
  - ATC (Automatic Temperature Control)
  - 4° set point raise during events
  - One override allowed
  - Same 12 events as TOU-CPP rate



N=238

Education and Outreach

provide a realistic experience

- 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

Event Notifications

- Twelve events from July through September
- Notified 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
- Notified Equipment
  - OpenADR to gateway
  - Z-wave from gateway to thermostat
  - Thermostat initiates Automatic Temperature Control (4°F) or customer-programmed response to events

Findings

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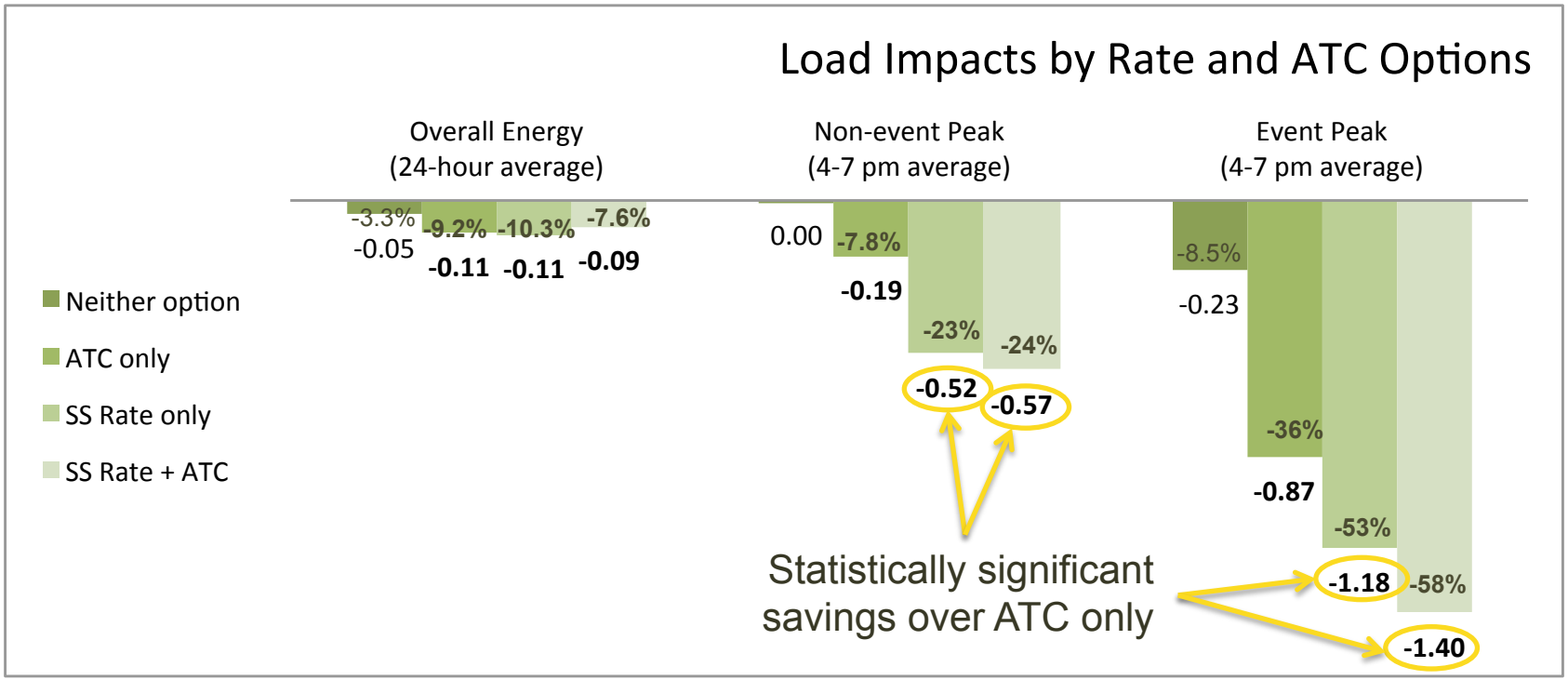
Dynamic Rate vs. AC Control
by program option

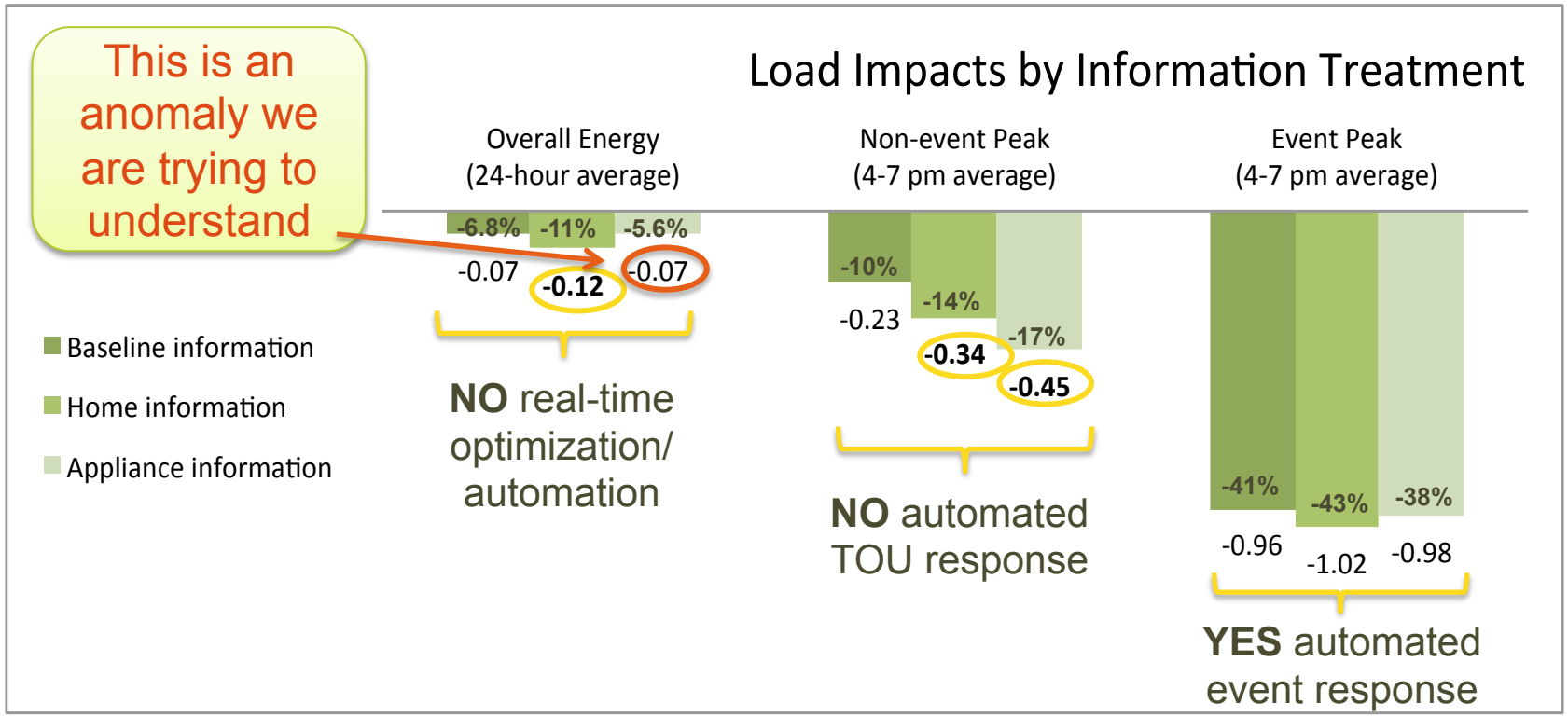
- Energy savings are the same for SS rate and ATC options
- Peak savings are greater for the SS rate options



Values in bold indicate a statistically significant difference from 'Neither option'

Real-time Information Effects
by treatment group and automation

- Home data improved energy savings and daily peak
- Appliance data improved daily peak savings but not energy savings
- Automation during peak events overshadows information effects



Summer Solutions Findings Overall

For all participant groups

- Energy use is lower: **Yes**,:8% overall, 10% for program options, 11% for whole-house info, ***6% for both appliance info and on-line billing info***

The implication of this finding is that we may not need expensive equipment

- Weekday peak demand is lower: **Yes:** 20 % overall: 16% for real-time info, 8% for AC control, 24% for TOU-CPP rate
- Peak demand on event days is lower: **Yes:** 59% overall: 36% for AC control, 53% TOU-CPP, 58% for both; info makes no difference
- Electricity bills are lower: **Yes:** TOU-CPP participants saved twice as standard

Savings are greater for customers who

- have more information: **Yes** for non-event peak, **No** for event peak, **No** for energy savings
- chose more program options: **Yes:** for non-event and event peaks
- are on the dynamic rate, compared to direct load control: **Yes,** for peaks
- have higher energy use: **Yes**
- have higher satisfaction levels: **Mixed;** all groups generally equally satisfied, but depends on feature
- claim certain self-reported behaviors: **Yes:** pre-cooling, peak offset, peak shift
- have certain dwelling characteristics: **Yes:** swimming pools
- have certain demographic characteristics: **No**

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Possible Explanations

- The equipment for the appliance group is more complex and less reliable, resulting in less information viewing
  - No data on gateway or monitor connectivity were available in 2011
  - A review of 2012 gateway connectivity data reveals no difference in offline events among information treatment groups
- There are structural differences between the appliance subsample and other participants that account for the difference in savings
- There are behavioral differences between the appliance subsample and other participants that account for the difference in savings

New Hypotheses

- The appliance group has different dwelling characteristics and appliances than other information groups that account for low energy savings
- The appliance group engages in fewer behaviors that result in overall energy savings than other information groups
- The appliance group engages in more energy behaviors across the peak than other information groups

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Participant Profile
from pre- and post-surveys

- Participants on average are middle-aged, educated, prosperous and living in large homes
  - 51 years old
  - 5 years of college
  - Make >$100k a year
  - Live in a 2,100 sq ft home, 26% with swimming pools
- Average number of occupants from 4-7pm in summer is 2.7
- Average summer monthly use is 1,000 kWh, with an average summer monthly bill of $135
- Saving money and benefiting the environment are the two most important reasons for participating in Summer Solutions

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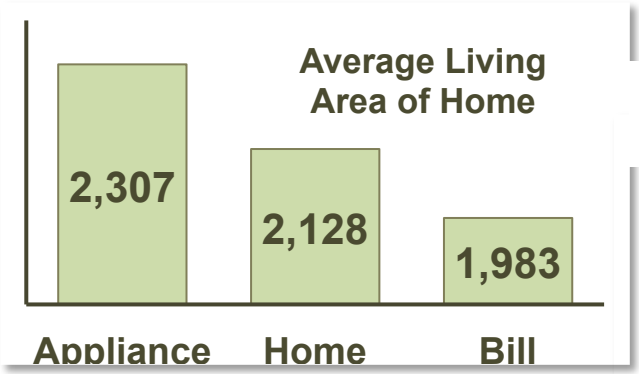
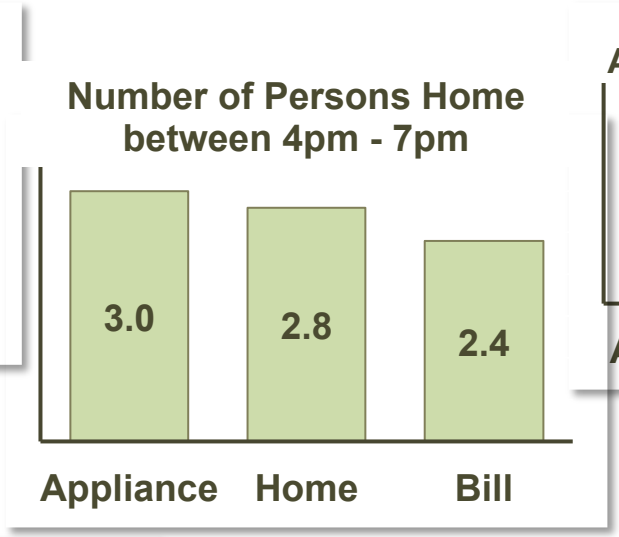
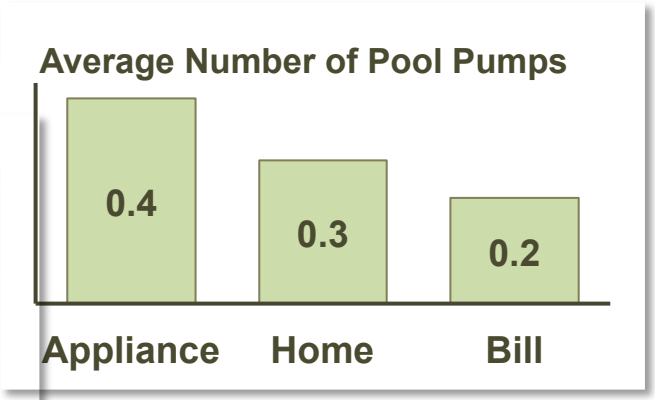
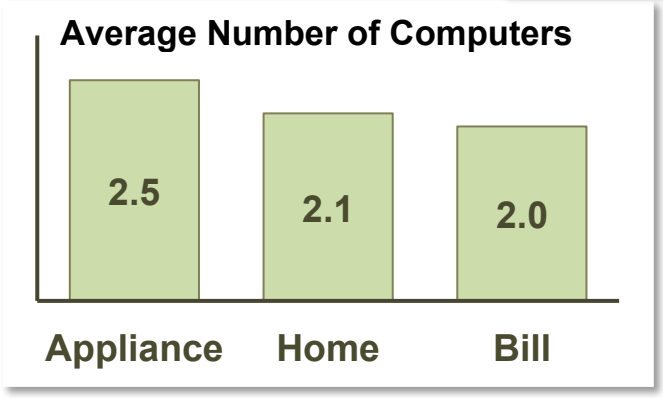
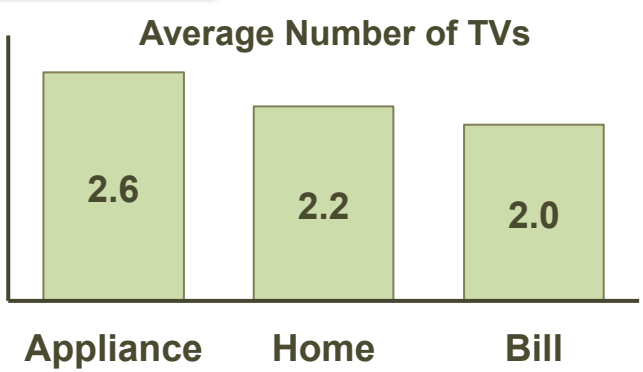
Structural Differences Among Information Groups











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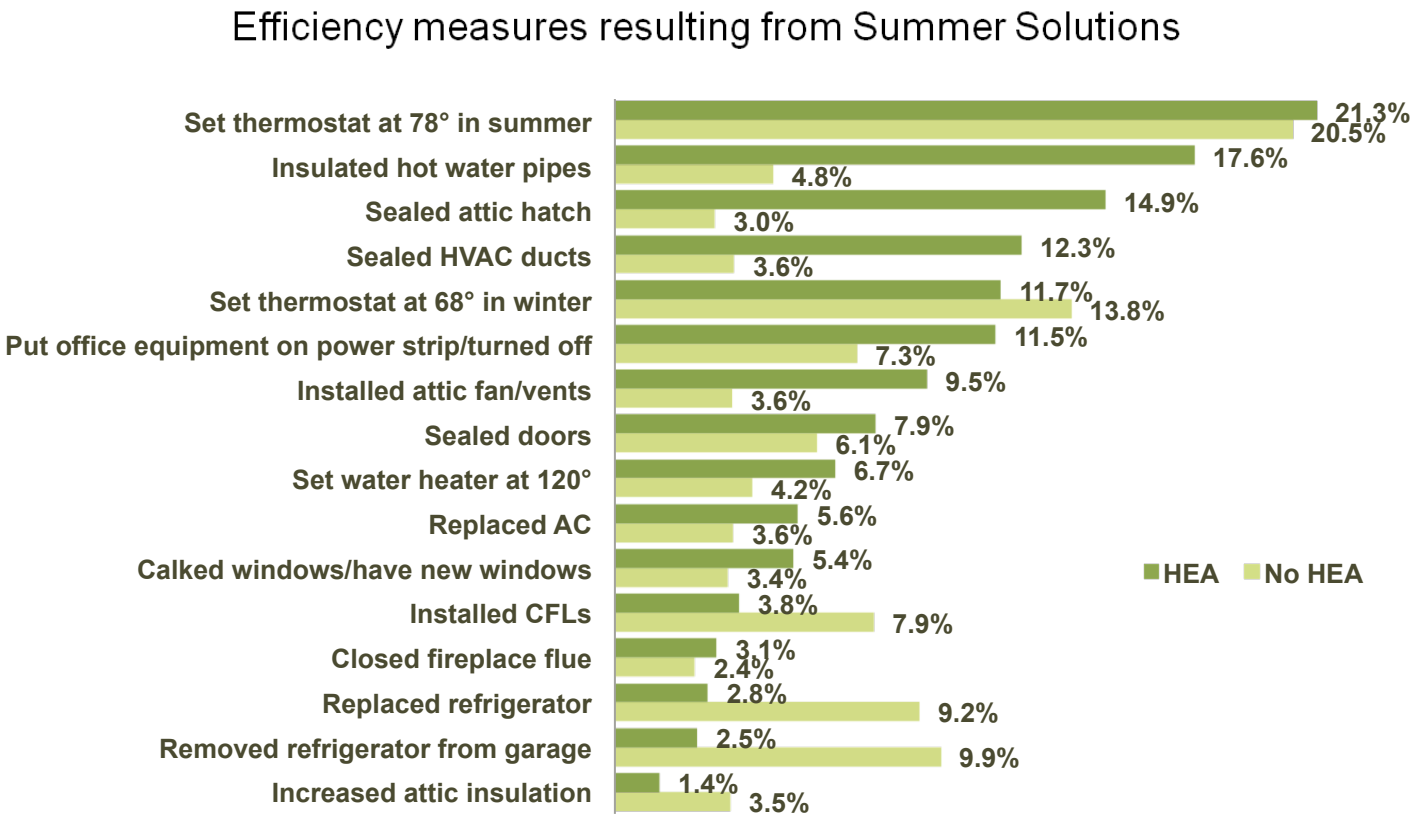
Behaviors - Energy Efficiency
without/with Home Energy Assessment

- Energy Assessments increased most behaviors



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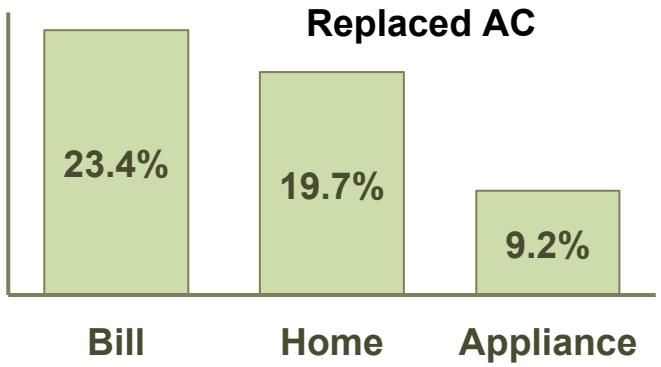
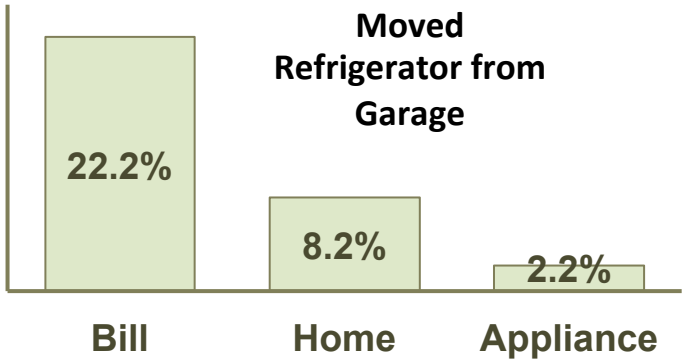
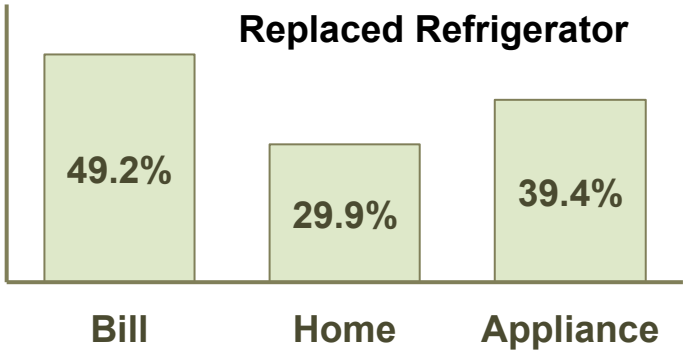
Efficiency Behaviors Prior to Study







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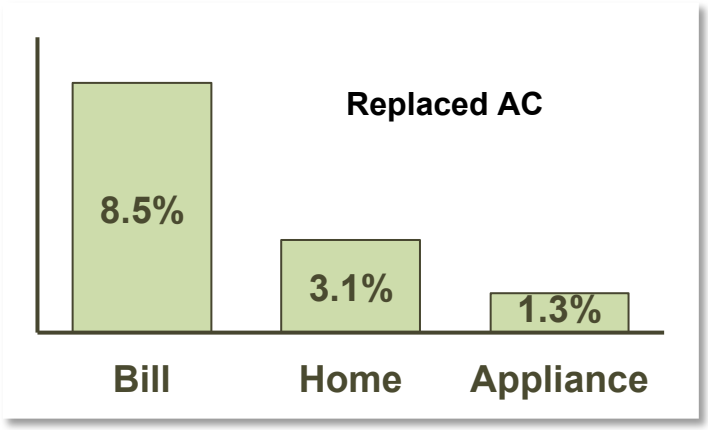
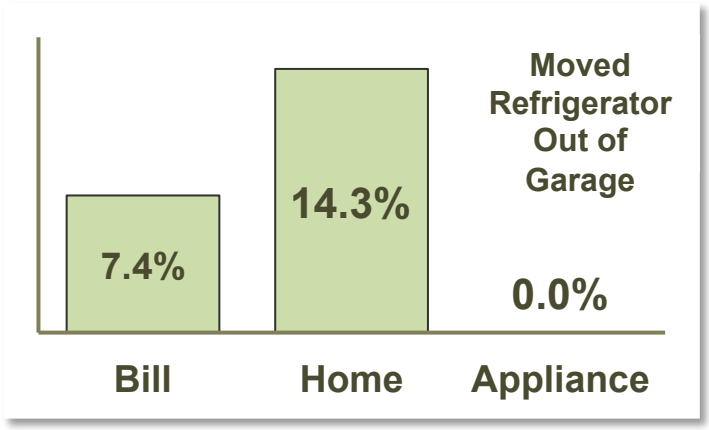
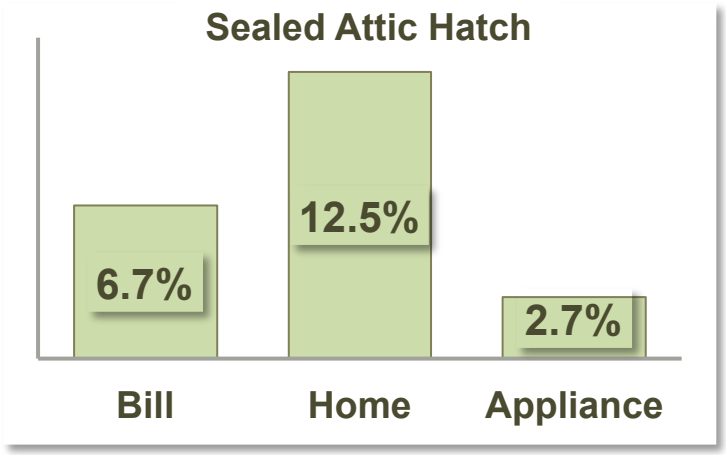
Efficiency Behaviors During Study







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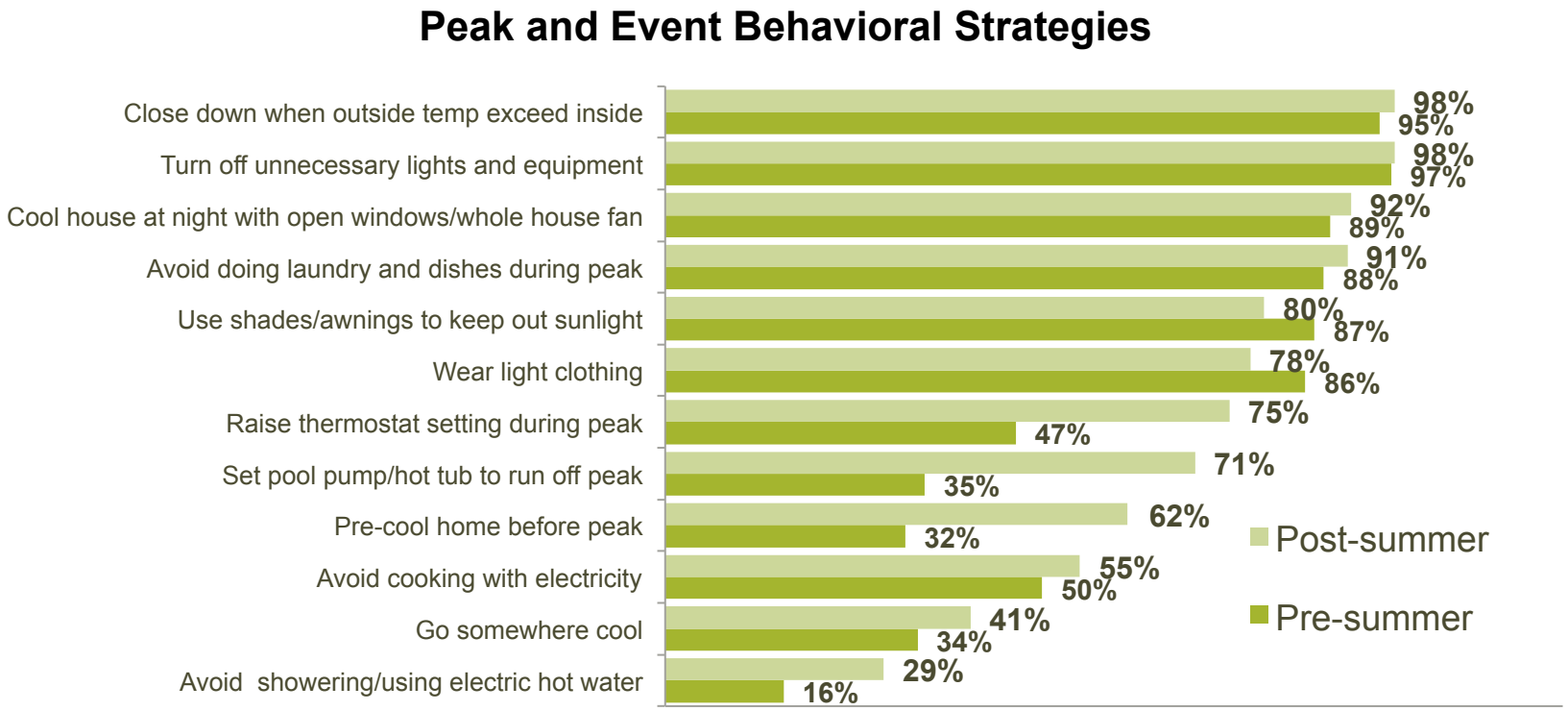
Behaviors - Peak and Event
before/after Summer Solutions

- Behaviors that increased the most across the summer are increasing the thermostat set point during peak, running the pool pump off peak, and pre-cooling



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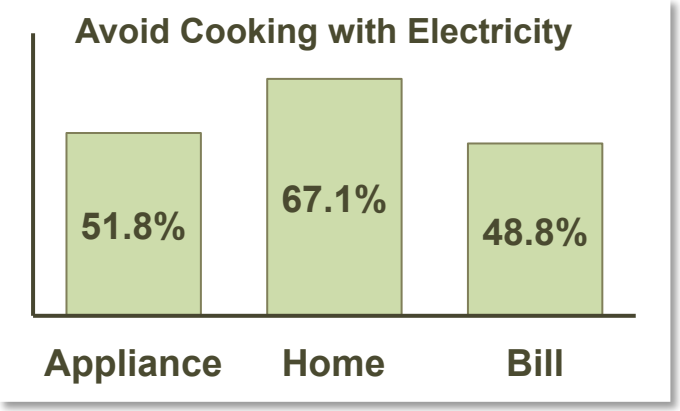
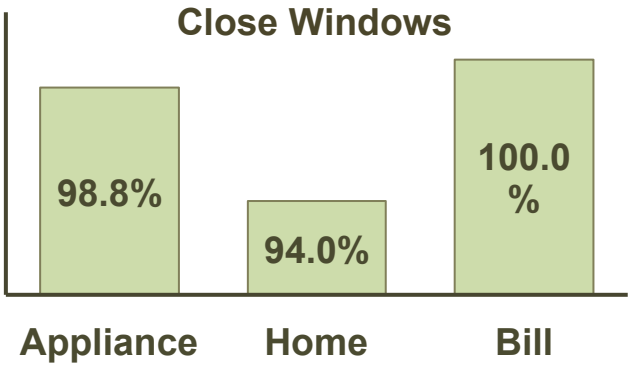
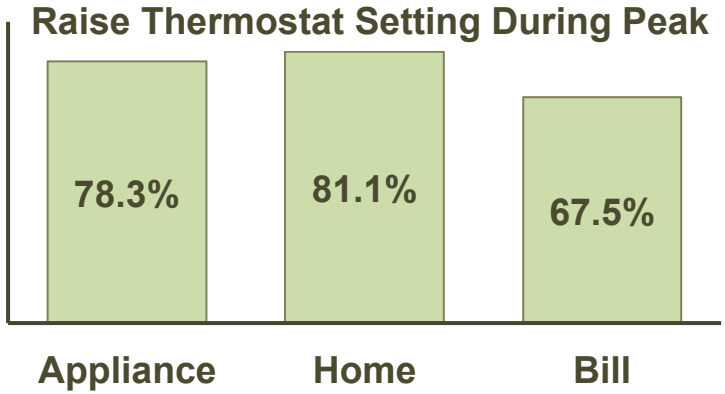
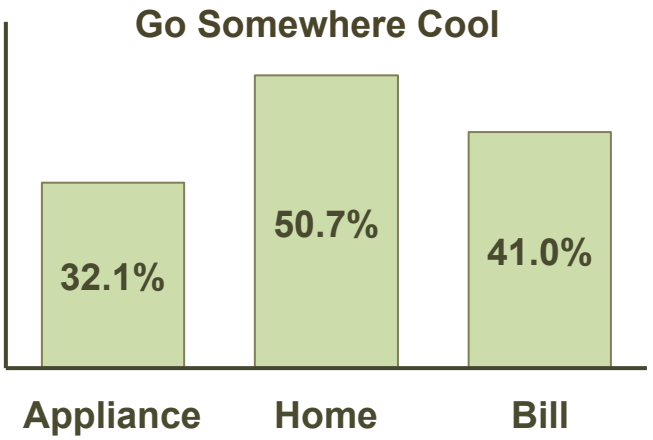
Peak Behaviors During Study









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Recommendations
for research and programs

New Hypotheses

- The appliance group has different dwelling characteristics and appliances than other information groups that account for low energy savings: **Yes**
- The appliance group engages in fewer behaviors that result in overall energy savings than other information groups: **Yes**
- The appliance group engages in more energy behaviors across the peak than other information groups: Yes

Research Recommendations

- Continue to examine the question of whether appliance level energy information increases energy and peak savings
- Continue to mine the rich amount of data that comes out of these kinds of studies
- Pursue emerging technologies and the possibility of cheaper ways of obtaining appliance level information

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