January 28, 2015

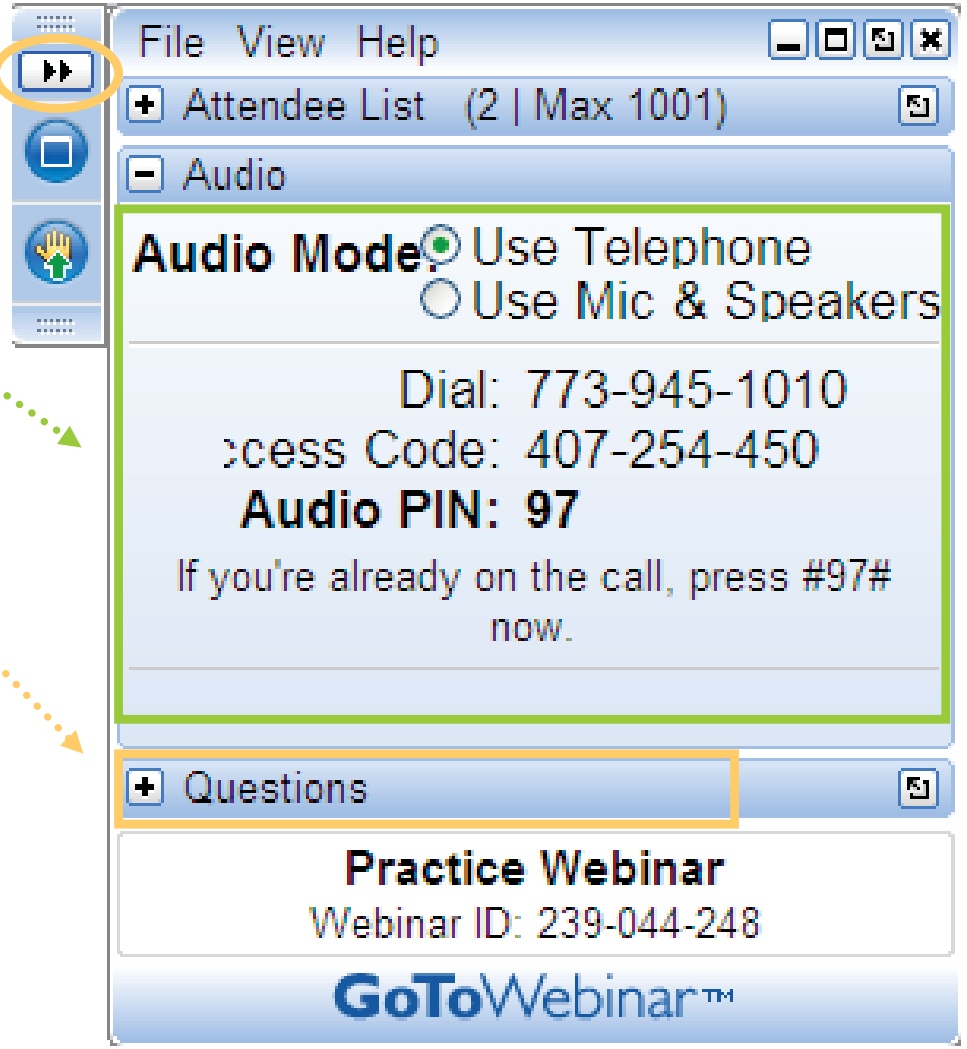
Pacific Gas and Electric Territory

Next Generation Construction: Advanced Residential Water Heating

Using GoToWebinar

- Minimize or expand the pane
- Choose audio mode
- Type questions

Please submit questions through the question toolbar



Sponsored by PG&E

Pacific Gas and Electric Company®

These programs are funded by California utility customers and administered by PG&E under the auspices of the California Public Utilities Commission.

"PG&E" refers to Pacific Gas and Electric Company, a subsidiary of PG&E Corporation.

Program Overviews

Drive energy efficient design and construction through incentives and design assistance

- California Advanced Homes Program (CAHP): single family
- California Multi-Family New Homes (CMFNH): multi-family

Programs target two CPUC goals:

- By 2015: 90% of new homes at least 20% better than 2008 code
- By 2020: 100% of new homes to reach Zero Net Energy (ZNE)

Program is funded under the auspices of the CPUC

- Programs may revise incentive levels and requirements during the program cycle
- Rate-payer funded, public service

Upcoming Events

We look forward to continuing the conversation!

February 16-18: **RESNET Conference:** San Diego, CA
2015 California Building and HERS Professional Conference

Agenda

1. Water heating in California
2. Title 24 and water heating
3. Water heating field performance
4. CAHP incentive analysis

DAVIS ENERGY GROUP
INCORPORATED

Water Heating in California: Focus on Single Family Homes

Usage Data, Title 24, and Field Performance of High Efficiency Gas and Electric Options

CAHP Webinar

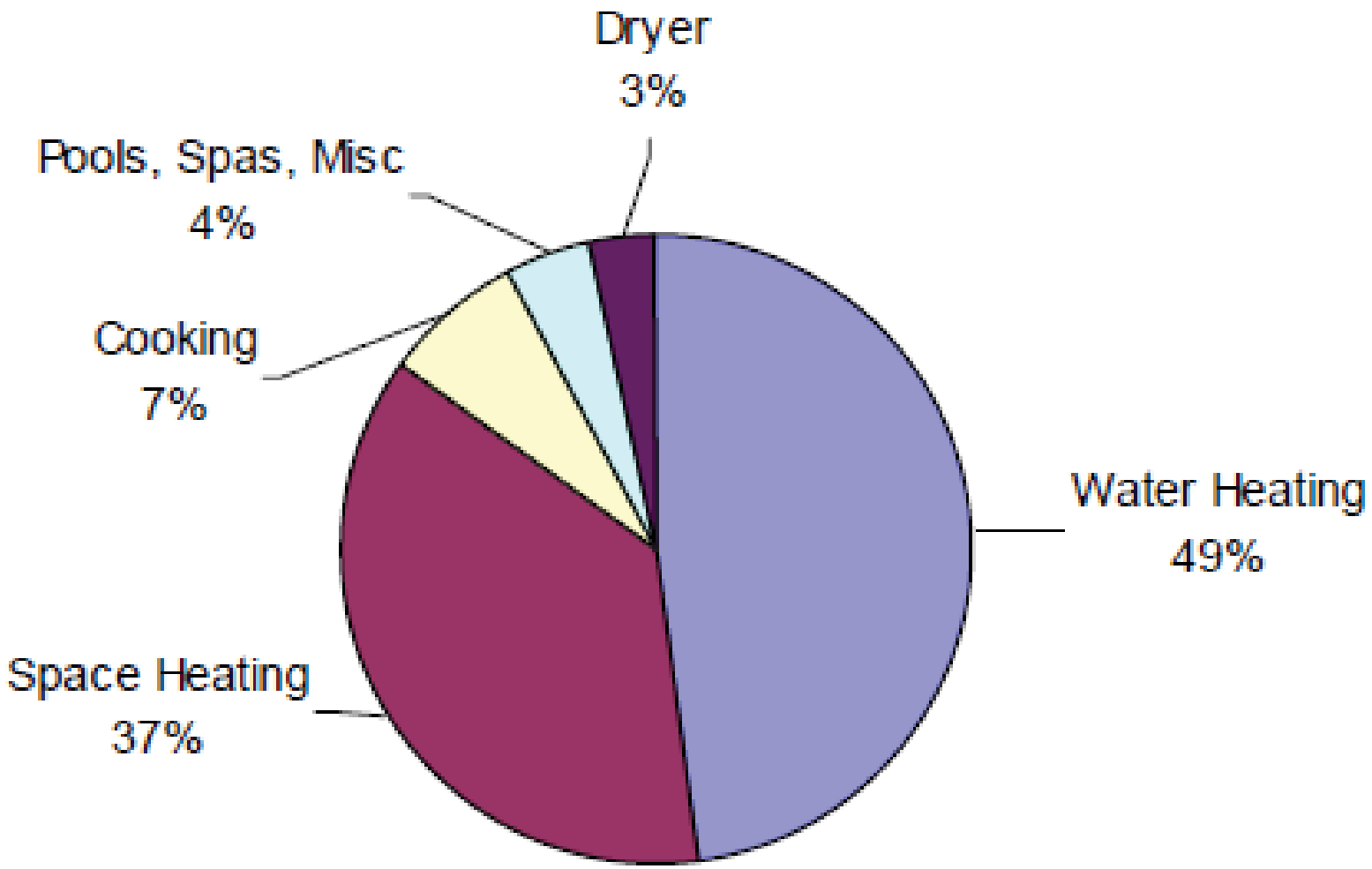
January 28, 2015

Marc Hoeschele, Davis Energy Group

Overview

- How significant is water heating in California households?
- Understanding the workings of Title 24
- California field performance of advanced technologies
  - Gas water heating research
  - HPWH research

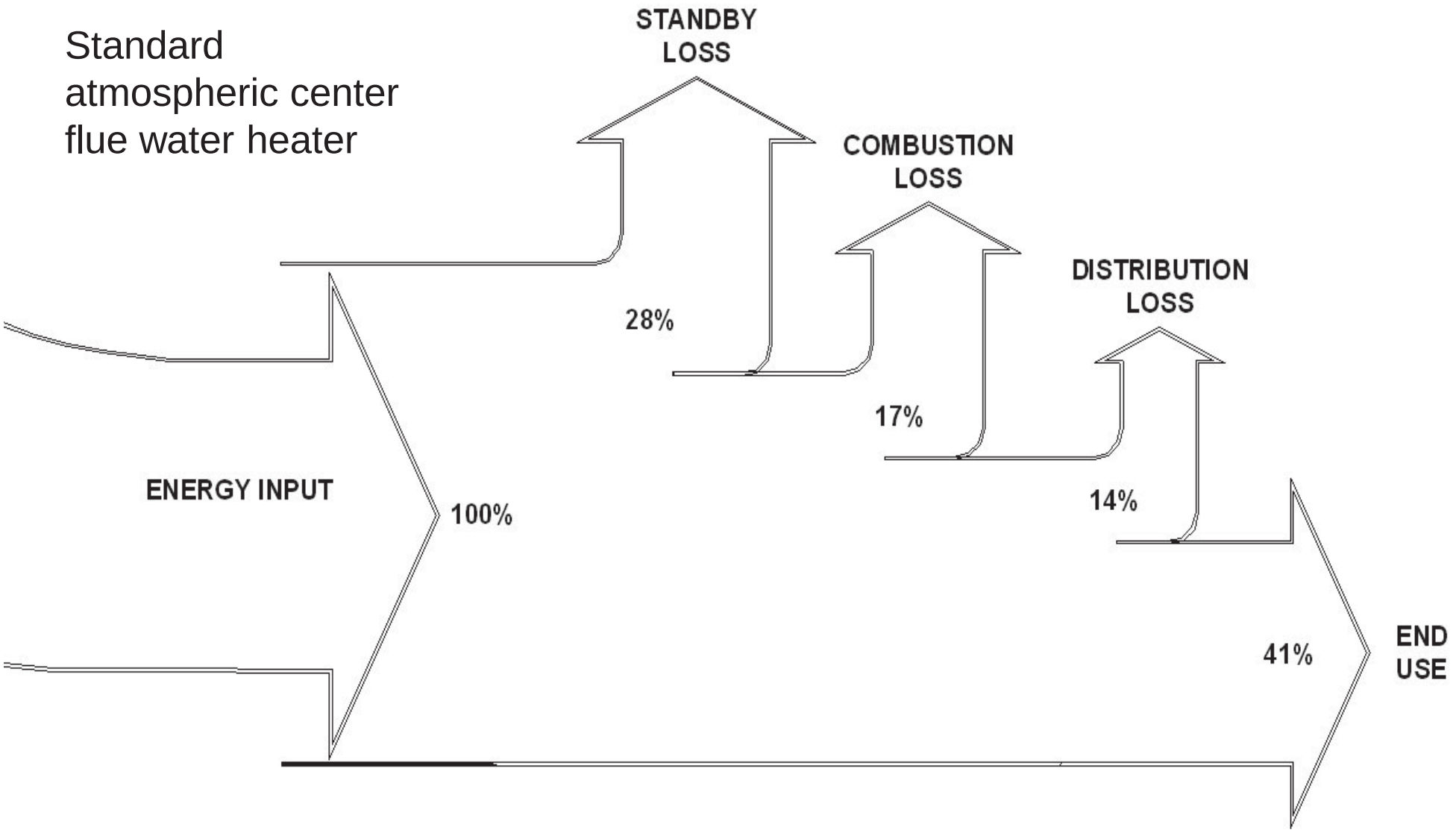
California Residential Gas Consumption



Source: *2010 California Residential Appliance Saturation Survey*

Example Energy Flows for Standard Gas WH

Standard
atmospheric center
flue water heater



Reader's Digest Version: Title 24 DHW

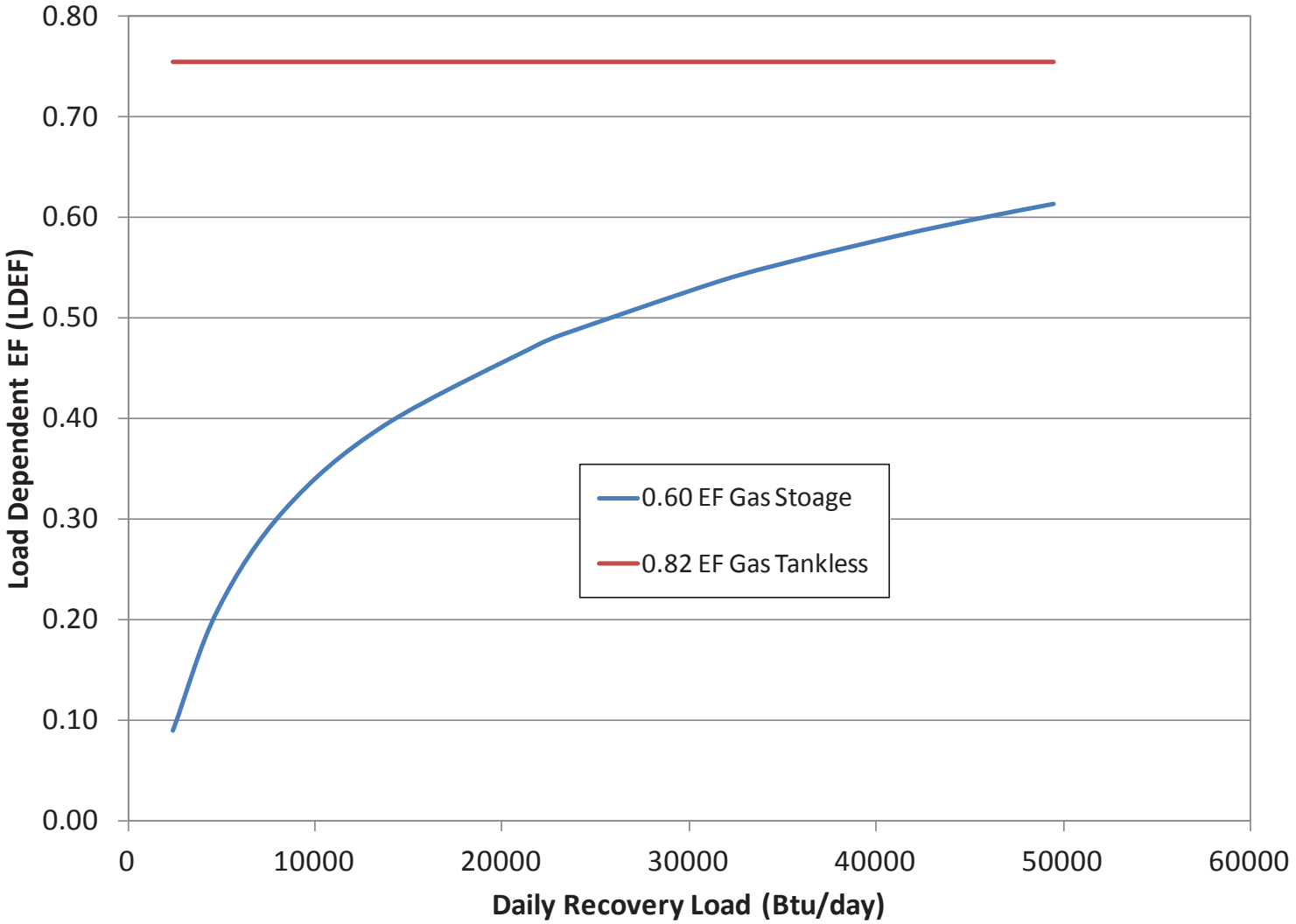
1. Hot water usage (at the tap) is dependent upon floor area
2. Distribution losses based on assumption of "standard" distribution system and adjusted based on distribution system type (energy loss + water waste)
3. Recovery load = sum of items 1 & 2 above (recovery load varies by climate zone– cold water temp.)
4. Energy Factor is the performance metric for the vast majority of compliance applications. Within Title 24, the rated EF is adjusted based on the recovery load.
5. "Proposed" design ("what you want to install") is compared to "Standard" budget scenario of a minimum efficiency gas storage water heater with a standard distribution system.

Load Dependent Energy Factor Concept (LDEF)

$$LDEF_j = e \times \left(\ln\left(\frac{HARL_j \times 24}{1000} \right) (a \times EF_j + b) + (c \times EF_j + d) \right)$$

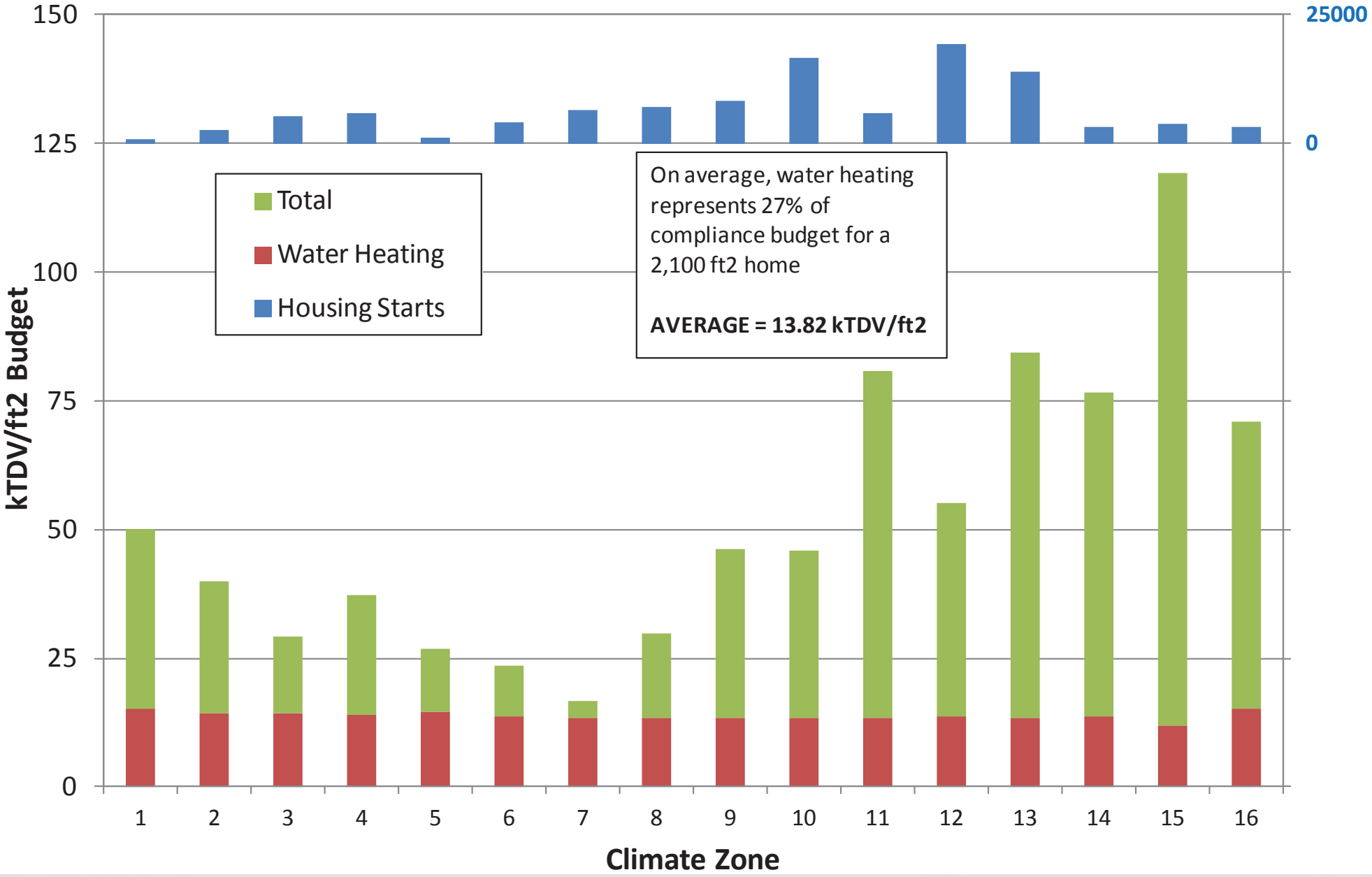
For gas tankless water heaters, the rated EF is derated by a fixed 8%.

Important Outcome: Tankless water heater benefit increases as the dwelling size gets smaller !!!!



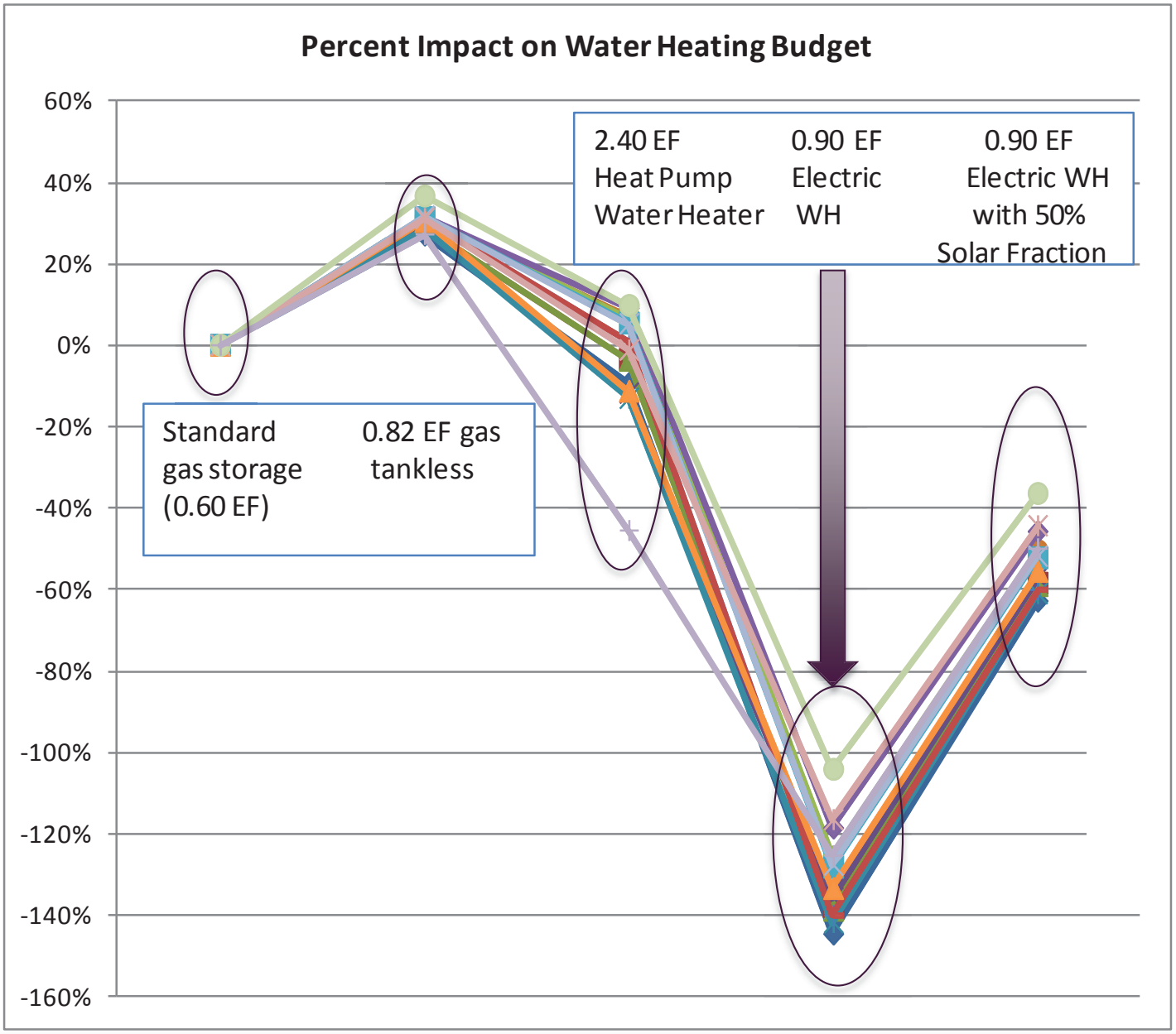
DHW Budget Significance in Title 24

Standard DHW and total budget for 2,100 ft2 prescriptive home



Different WH Options in all 16 Climate Zones

2,100 ft2 prototype home, prescriptive budget



What's the Latest California News….

- GTI PIER Residential Water Heating Program

  "Facilitating the Market Transformation to Higher Efficiency Gas-Fired Water Heating" (2013)

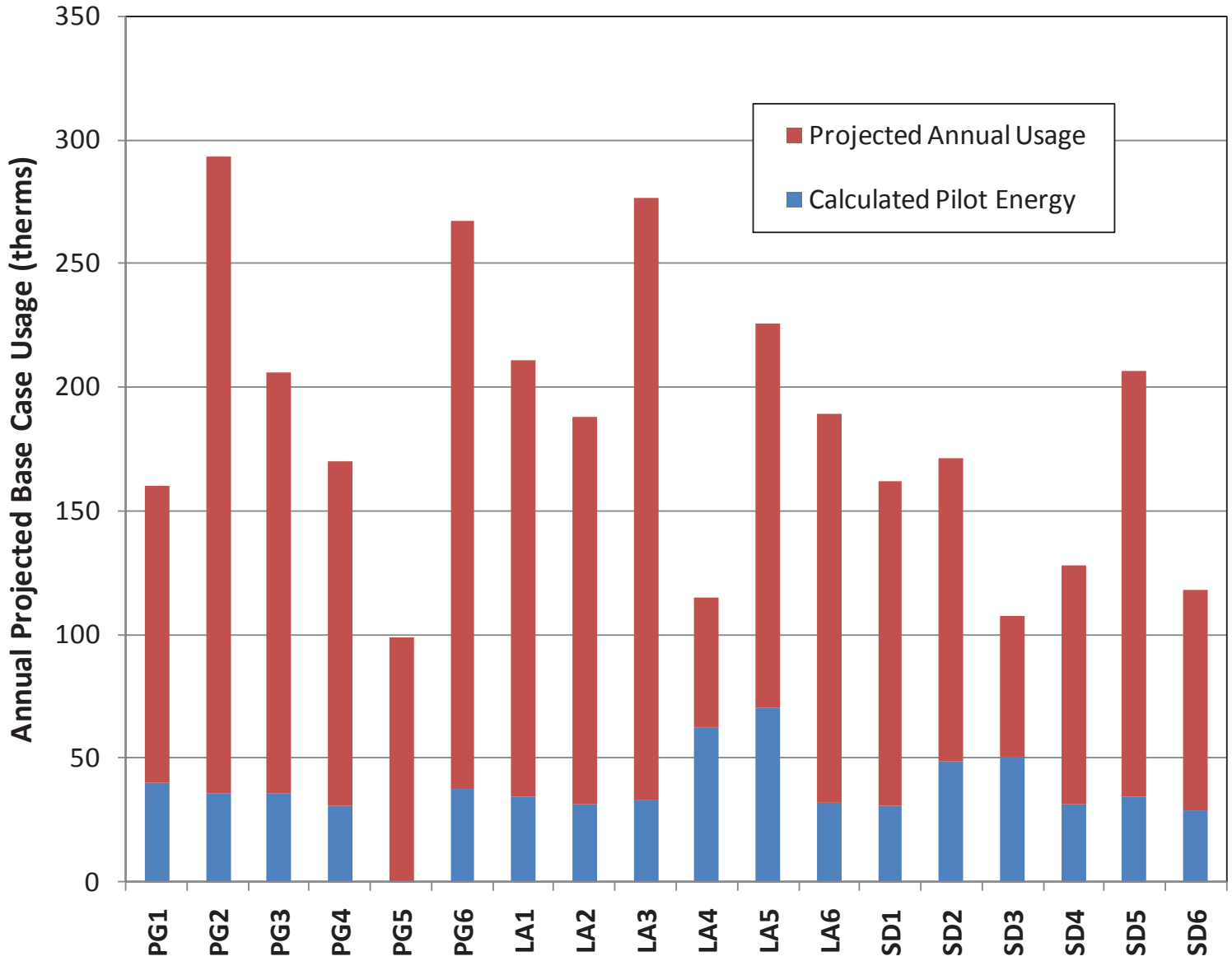
- Key element of the project:
  - DEG field monitoring at 18 homes (6 northern CA, 12 southern CA) with pre- and post-retrofit monitoring over a 14 month period
  - Evaluated advanced gas water heating technologies
    - Entry level EnergyStar storage water heaters (0.67-0.70 EF)
    - Condensing and hybrid storage water heaters
    - Condensing and non-condensing gas tankless

http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-500-2013-060

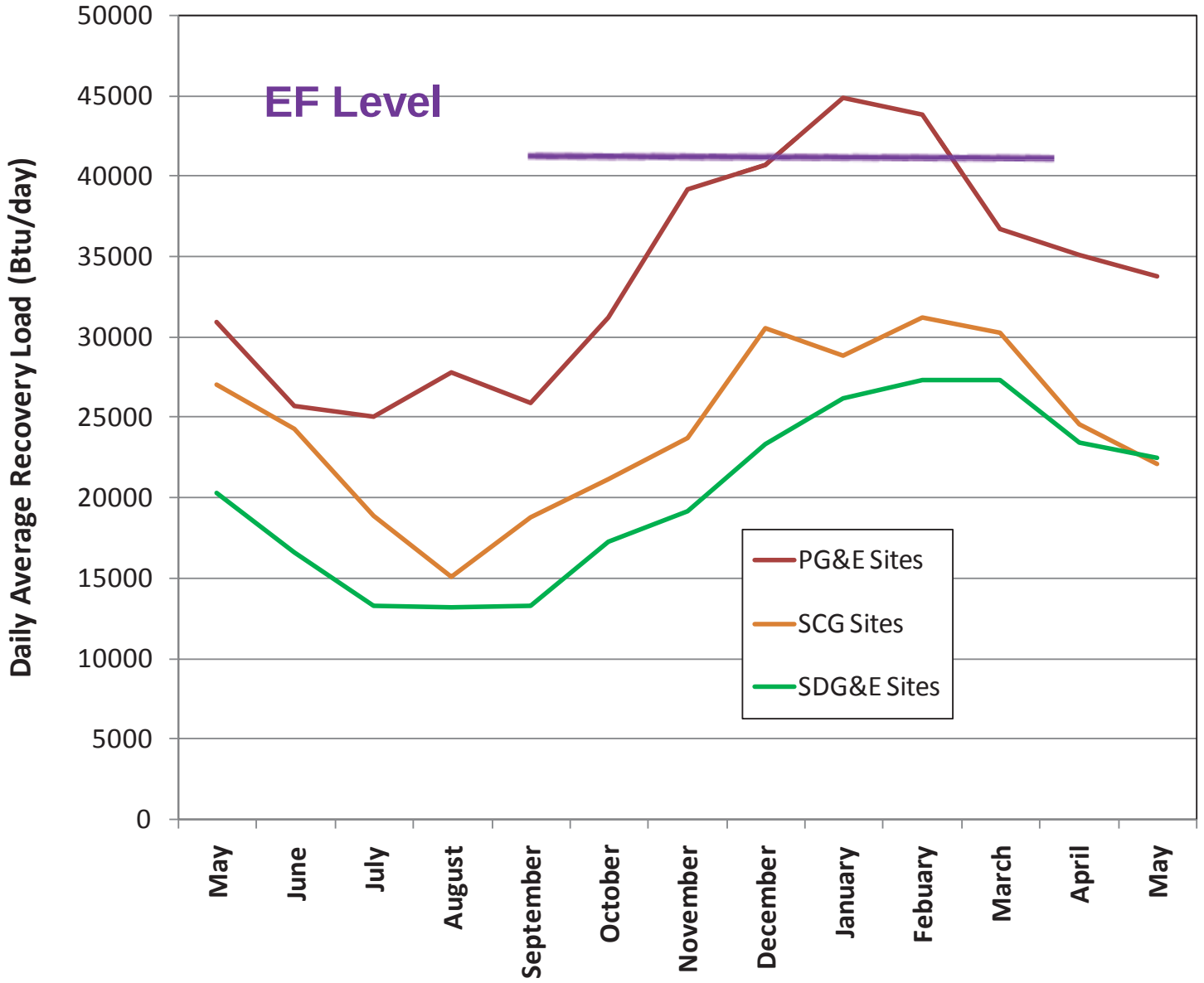
Installed Water Heaters by Product Type

- 18 existing water heaters in homes were monitored and then replaced by:
  - Six Energy Star non-condensing storage water heaters (0.67 – 0.70 EF)
  - Two condensing storage water heaters
  - Three (0.82 EF) Energy Star non-condensing tankless water heaters
  - Five condensing tankless water heaters
  - One hybrid water heater (tankless with 30 gallonl tank)

Key Takeaways: Base case use varies considerably, standby important in low load situations



Key Takeaways: Loads vary seasonally with implications for solar and HPWH



Impact of Typical CA Loads on Performance

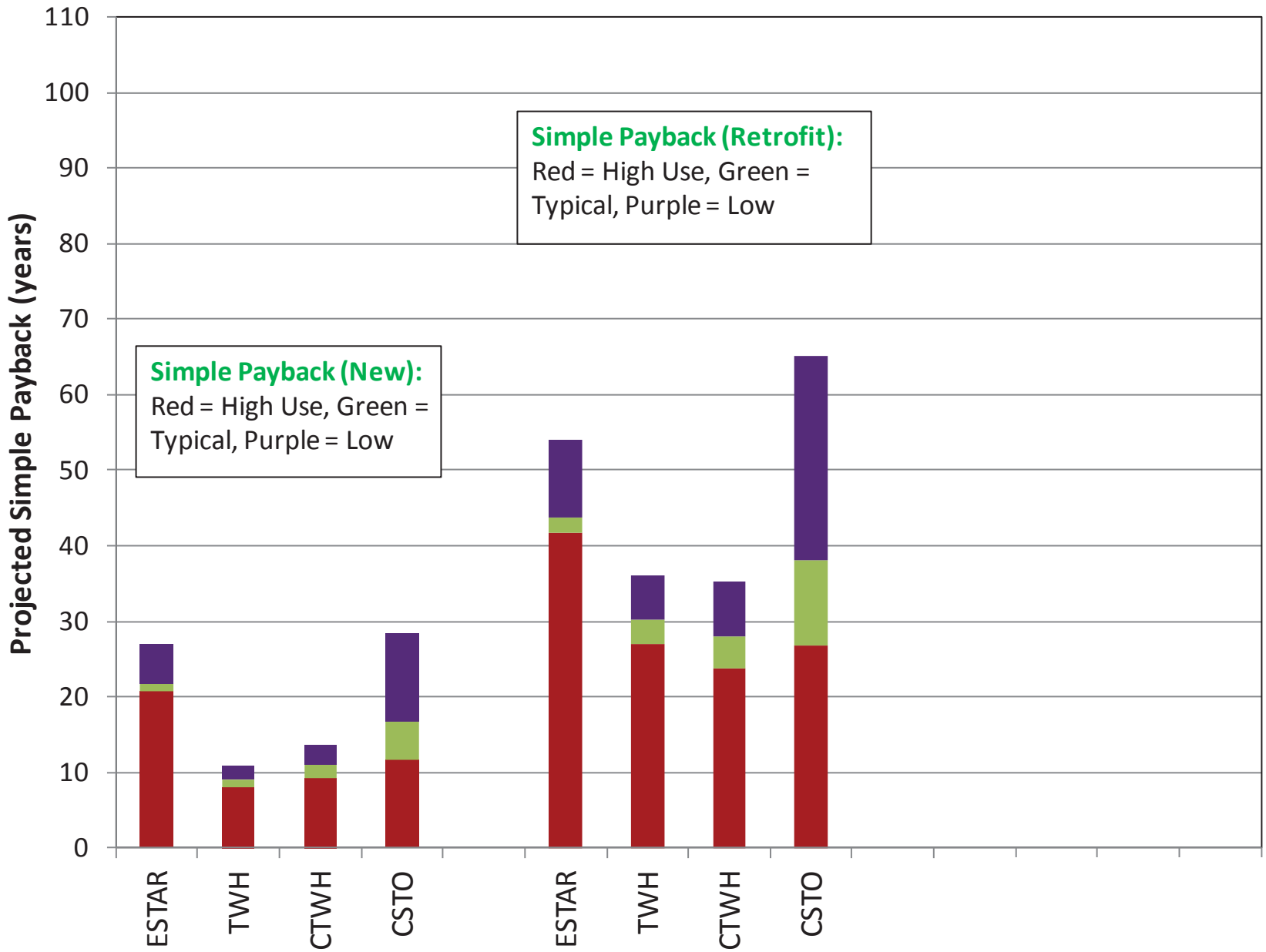
- Lower loads in CA reduce rated efficiencies by:
  - ~10% for standard atmospheric gas storage water heaters and new Energy Star (0.67-0.70 EF) WHs.
  - ~8-10% for non-condensing gas tankless water heaters
  - ~15% for condensing gas tankless water heaters
  - ~20% for condensing gas storage water heaters that are rated by thermal efficiency instead of EF

Estimated Typical Incremental Costs

WH Type	Est. Incremental Cost	
	New	Retrofit
EnergyStar	$400	$800
TWH	$600	$2,000
CTWH	$900	$2,300
CSTO	$700	$1,600

TWH = gas tankless water heater
CTWH = condensing gas TWH
CSTO = condensing gas storage WH

Projected Simple Paybacks (no rebates,$1.30/therm)



HPWH Retrofit Assessment

Working with PG&E and Redding Electric

Why HPWHs?

- Nationally just under half of residential WHs are electric and HPWHs offer a significant efficiency opportunity
- In California, could be a component of an all-electric ZNE strategy
- Need to understand HPWH performance characteristics (sensitivity to loads, impact of cold water temperatures, modes, controls, etc.)
- Lots of field studies in other regions (Pacific NW, EPRI national study, New England, DOE Building America), but little CA field data

Why not HPWHs?

- Title 24 assumptions and TDV valuation for electric and gas is fairly punitive
- California has expensive electricity (6th out of all US states) and cheap gas (45th), so generally not a favorable situation for homeowners if natural gas is available.

HPWH Findings to Date

- Summer
  - Measured average COPs at the two sites range from 2.60 to 2.85, exceeding the rated EF.
  - Electric resistance heat usage was small during the summer (4-13%)
  - (Cooling benefit provided ~ 121-135 kWh/yr for indoor unit)
- Continuing winter monitoring ongoing
  - Mid-winter hot water loads 2-2.3 x higher than summer
  - Efficiency lower (colder inlet air and water, higher loads)
  - Electric resistance heat usage higher (12-19%)
  - COPs ranging from 2.05 to 2.16

Conclusions

- Water heating loads in California are significant as a fraction of total household gas use and a critical component of Title 24 compliance
- CA loads are much lower than reflected in the EF test procedure (updated test procedure effective April 2015)
- Standby effects of storage WH's are increasingly significant as loads diminish
- Efficient gas options (especially tankless) save energy, but first costs may be high (especially in retrofit)
- HPWHs are an efficient alternative vs. electric, but
  - CA utility rates and TDV assumptions work against you
  - Controls are complex and have different impacts under different usage patterns; More needs to be learned to optimize operation
- Need to better understand distribution system impacts

Thank you!

www.davisenergy.com

Marc Hoeschele

mhoesch@davisenergy.com

CAHP Incentive Analysis

1. Tankless
2. Heat pump

CAHP Score and Incentive Analysis

TRC team evaluated impact of various system types on the CAHP Score and incentives

- Standard model compared with higher efficiency
- Typical single family energy model
- All PG&E climate zones

Gas Storage

Tankless

Heat Pump

Incentive Analysis: Tankless System

System type comparison baseline:

– .65 EF storage tank DHW

System types considered:

– .82 EF tankless DHW
– .93 EF tankless DHW

Analysis findings:

– Average CAHP point benefit of 2 – 4 points, resulting in $200 to $800 in additional CAHP incentives per lot
– Greatest energy savings in climate zones 2 – 5, and 12

Incentive Analysis: Tankless System

.82 EF tankless DHW

Climate Zone	1	2	3	4	5	11	12	13	16	Overall Climate Zone Avg.
Avg. CAHP Point Benefit	2	3	3	3	3	2	3	2	2	3
Adtl. CAHP Incentive Value (per lot)*	$200 - $400	$300 - $600	$300 - $600	$300 - $600	$300 - $600	$200 - $400	$300 - $600	$200 - $400	$200 - $400	$300 - $600

.93 EF tankless DHW

Climate Zone	1	2	3	4	5	11	12	13	16	Overall Climate Zone Avg.
Avg. CAHP Point Benefit	3	4	4	4	4	2	4	3	3	4
Adtl. CAHP Incentive Value (per lot)*	$300 - $600	$400 - $800	$400 - $800	$400 - $800	$400 - $800	$200 - $400	$400 - $800	$300 - $600	$300 - $600	$400 - $800

*CAHP offers incentives of $100 for each point ranging from 83 – 75, and $200 for each point 74 and below

Incentive Analysis: Heat Pump Water Heater

2013 Building Energy Efficiency Standards

- If gas *is* available on site: compares Heat Pump Water Heater (HPWH) to 0.60 EF gas water heater
- If gas *is not* available on site: compares HPWH to a 0.945 EF electric resistance DHW system with a 50% solar fraction

System types considered

- 2.3 COP HPWH
- 2.7 COP HPWH

Incentive Analysis: Heat Pump Water Heater

Analysis findings

- The 2013 Standards are much tougher on HPWHs compared to the 2008 Standards.
- If natural gas is available:
  - HPWHs can hurt CAHP score by 1 to 11 points; HPWHs use more TDV energy than the standard gas water heater
  - HPWH impact: minor in climate zones 11 and 13; most negative effects in climate zones 4, 5, and 16
- If natural gas is not available
  - HPWHs with COP ≥ 2.3 improve the CAHP score in most climate zones (no solar thermal)
- Future investigation needed to understand HPWH performance in 2013 Standards and to identify potential paths to increase energy savings of DHW systems

Questions?

Thank you!

CMFNH:

info@cmfnh.com

Sophia Hartkopf

Scott Kessler

Shannon Todd

CAHP:

cahp@trcsolutions.com

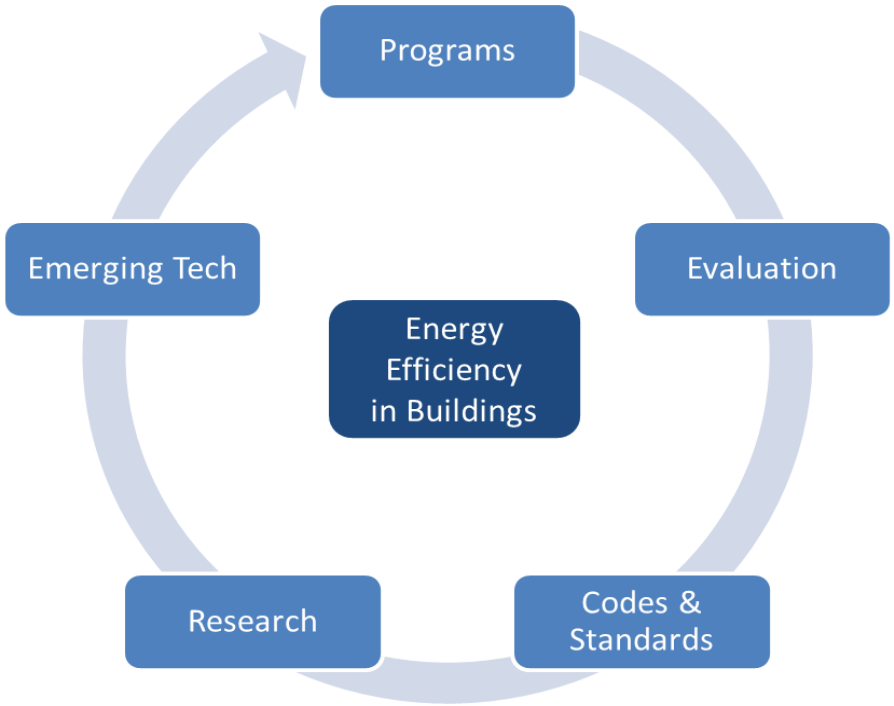
Matthew Christie

Kevin Robison

Michelle Waffle-Otero

Deborah Hayman

(866) 352-7457



PG&E

TRC
Results you can rely on

CALIFORNIA MULTI-FAMILY NEW HOMES

california advanced homes