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Grid-Integrated Water Heating for the Multi-Family Sector

ACEEE Water Heat Forum

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Context: Strategy 4
Teaching the Duck to Fly

Targeted energy efficiency

Peak-oriented renewables

Water pumping

Water heating

Air conditioning

- Rate design
- Battery storage
- Demand Response
- Inter-regional power exchanges
- Retire older inflexible generating units

Teaching the Duck to Fly

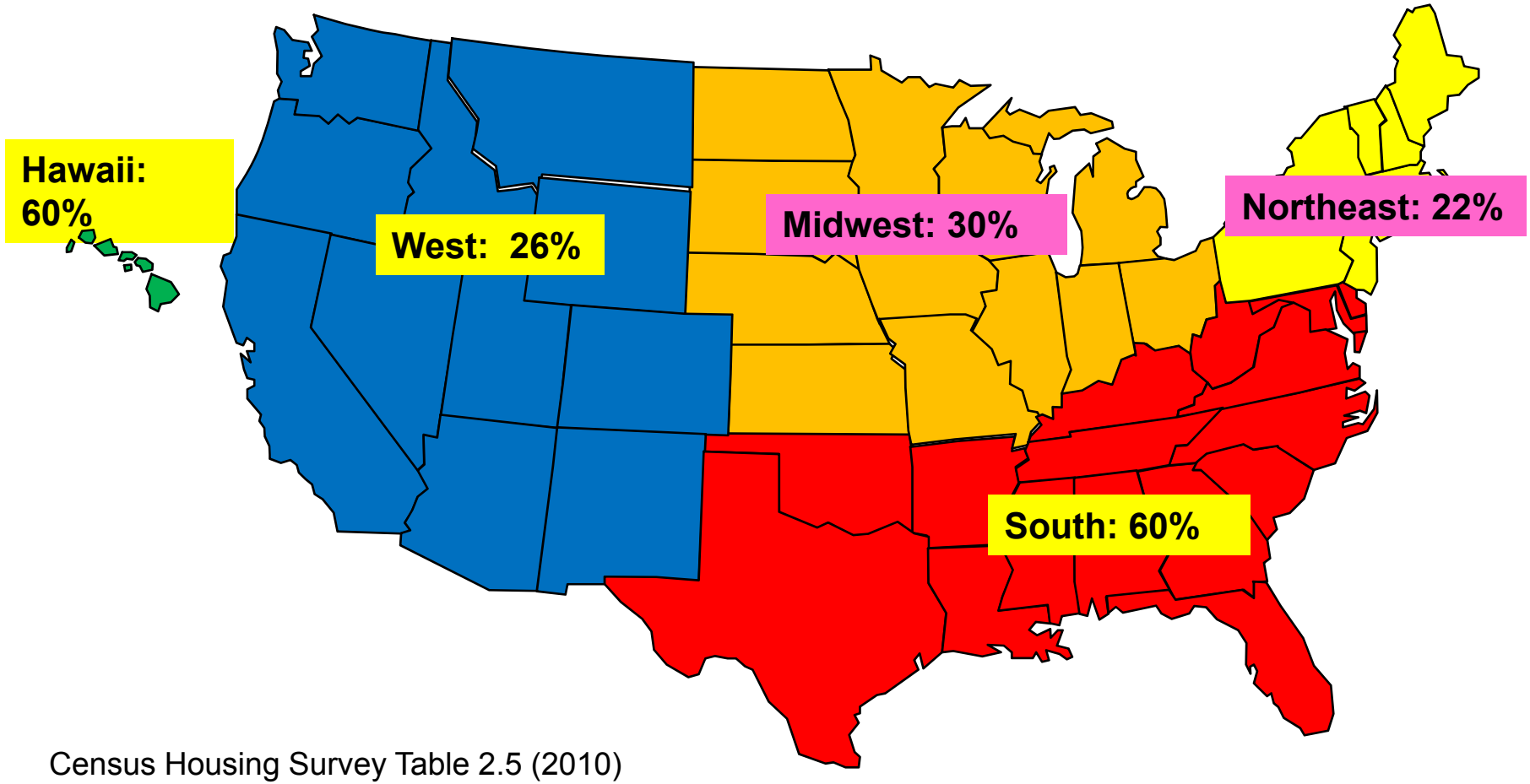
Requesting Permission for Take-Off

Overview

- Why Multi-Family?
- Magnitude of the Opportunity
- Maui as a Laboratory
- **NOT addressing fast-response ancillary services.**

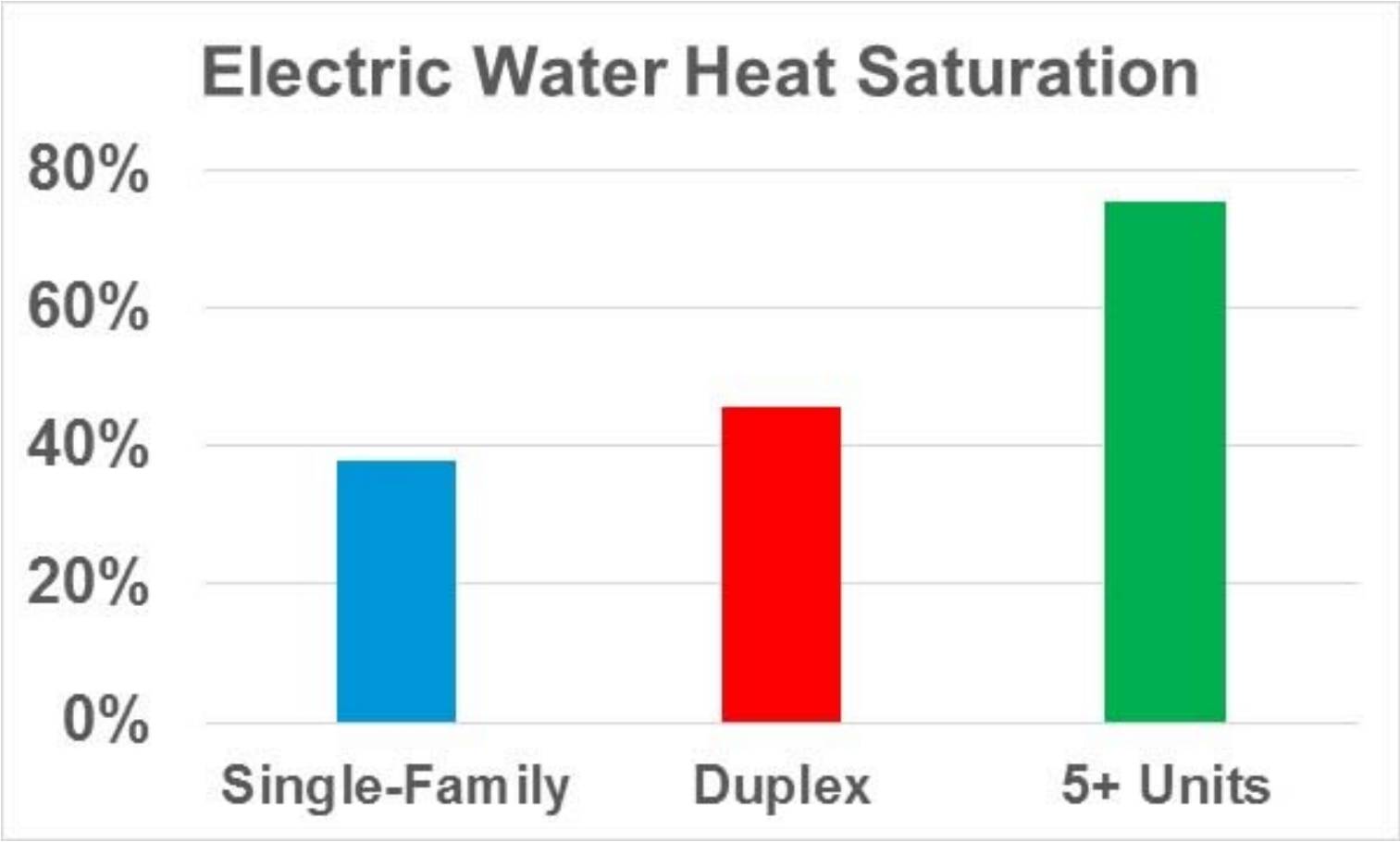
- Larger report on Low-Cost Storage
  - Water Heating
  - Ice-storage air-conditioning
  - Water pumping controls
- Forthcoming 2nd Quarter 2016

41% Electric Water Heat Saturation



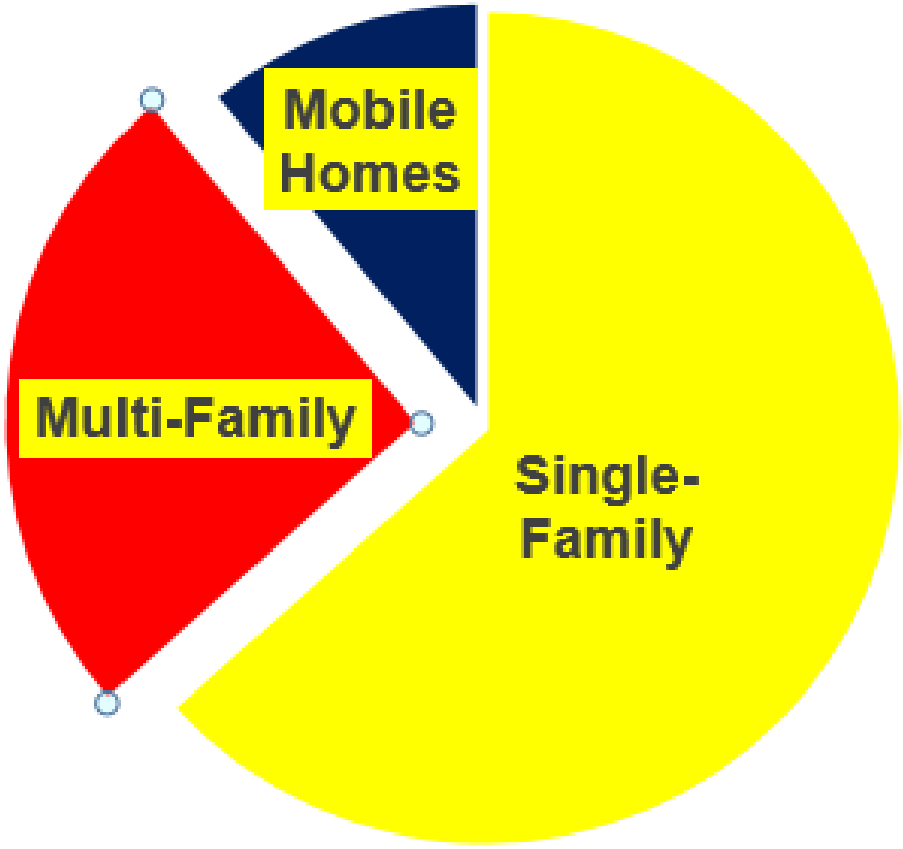
Census Housing Survey Table 2.5 (2010)

Most Apartments Have Electric Water Heaters



Magnitude of the Potential

- 45 million electric water heaters
  - 12 million in multi-family
  - ~3,800 kWh/year/water heater in single-family
  - ~2,600 kWh/year in multi-family
- ~36 TWh/year



Why Multi-Family

- Fewer Options
  - **Gas:** No gas piping and venting
  - **Solar:** Cold water only plumbing
  - **HPWH:** Space limitations; indoor installs

Why Multi-Family

- Access and Crew Efficiency
- Communications and Controls
- Renters with few money-saving options

Why Multi-Family

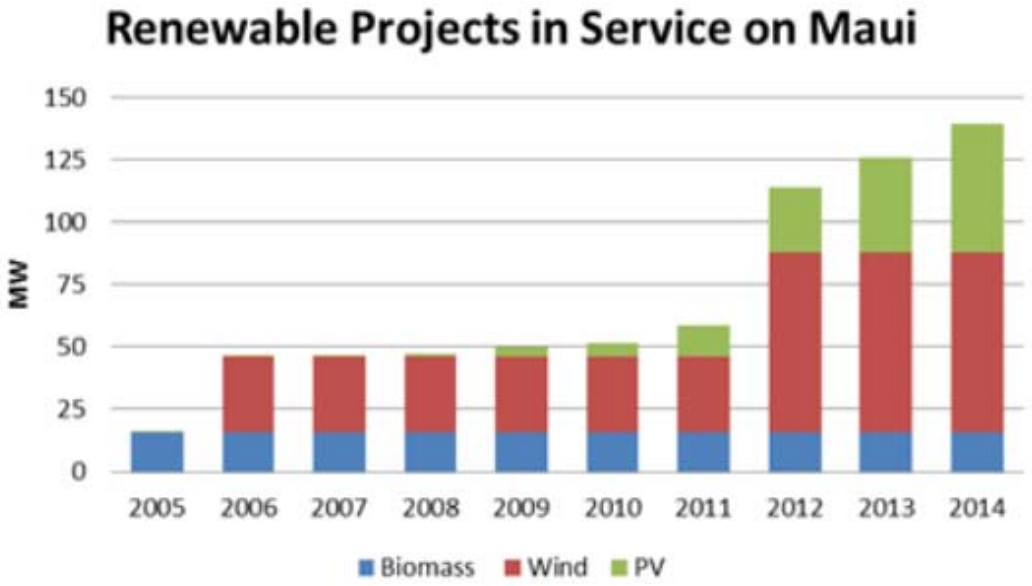
52 gallon tank
= 24 hours storage

Family Size	Minimum Gallon Capacity Recommended		
	Electric	Natural Gas	Propane Gas
5+	80	50	
3-4	50	40	
2-3	40	40	
1-2	30	30	

Lowe's

Illustrative Deployment: Maui

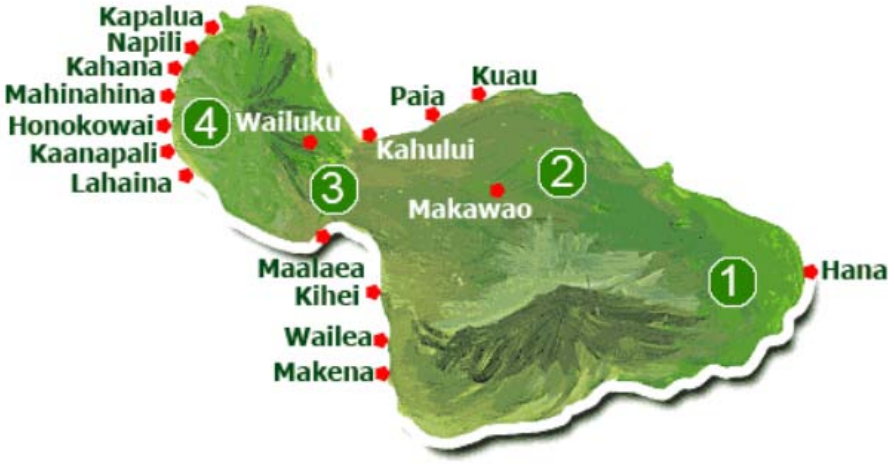
- Maui Electric
  - 68,000 customers
  - ~200 MW peak
  - 1.2 TWh total sales
  - 62 MW wind
  - 50 MW PV



Low-Rise Tourist Condos

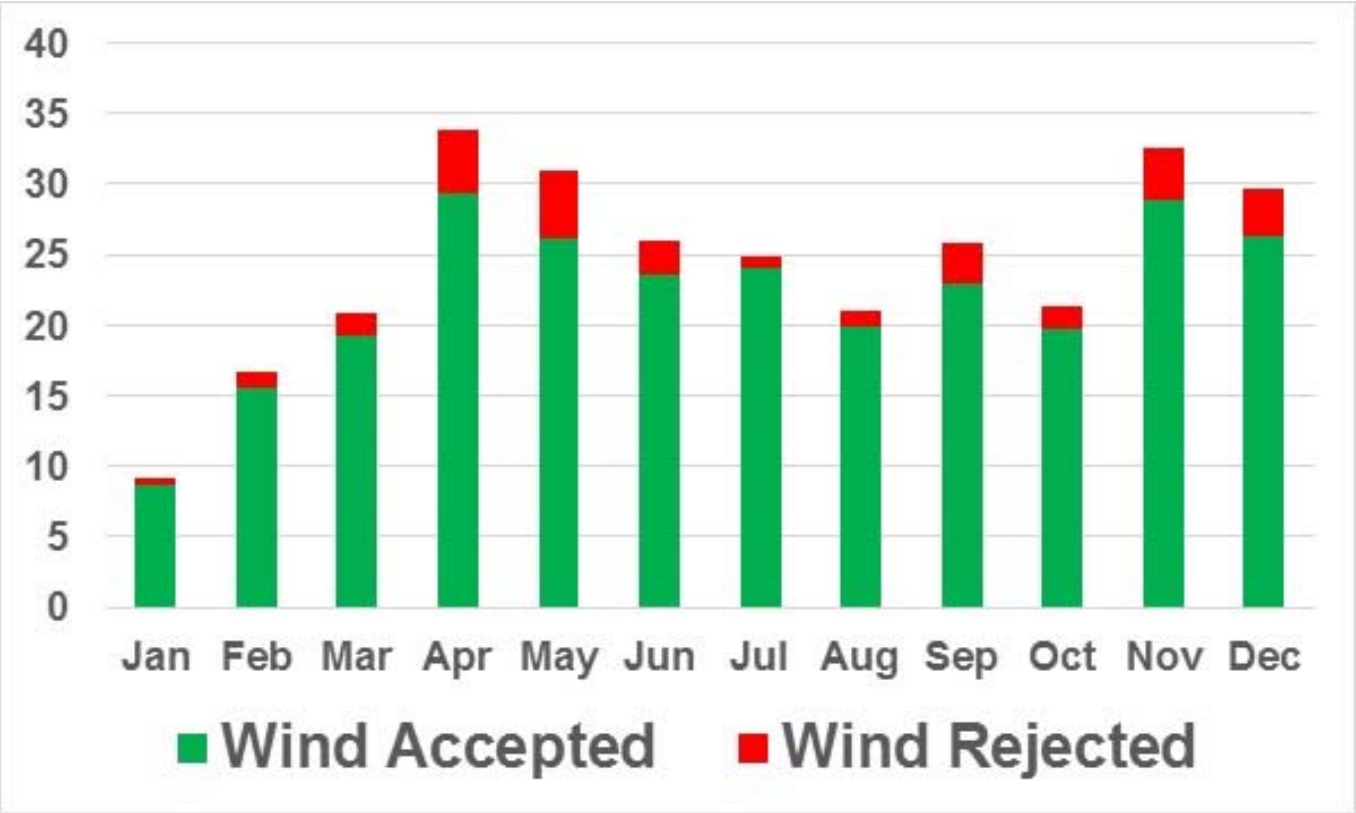
How Big Is The Potential Fleet?

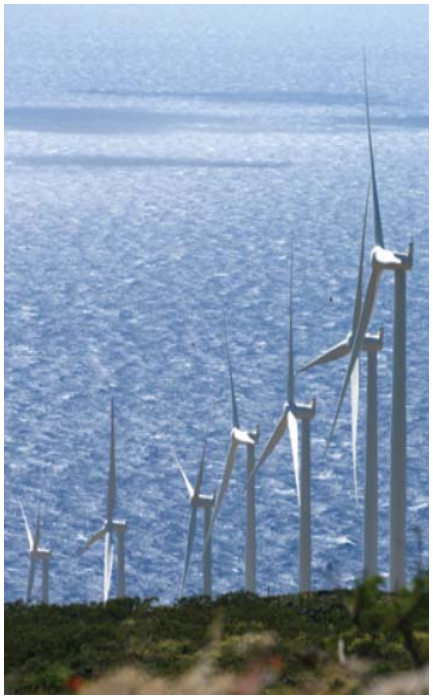
	Total Condos		Estimated Low-Rise
Honokowai / Kapalua	4,352		3,348
Kaanapali / Lahaina	5,016		2,523
North Kihei / Maalaea	3,776		3,228
South Kihei / Wailea	4,442		3,885
Total:	17,586		12,984



Maui's Challenge #1: Wind Curtailment

- 28 GWh of wind rejected
- 10% of total wind energy





Maui: Fast Response Is Valuable

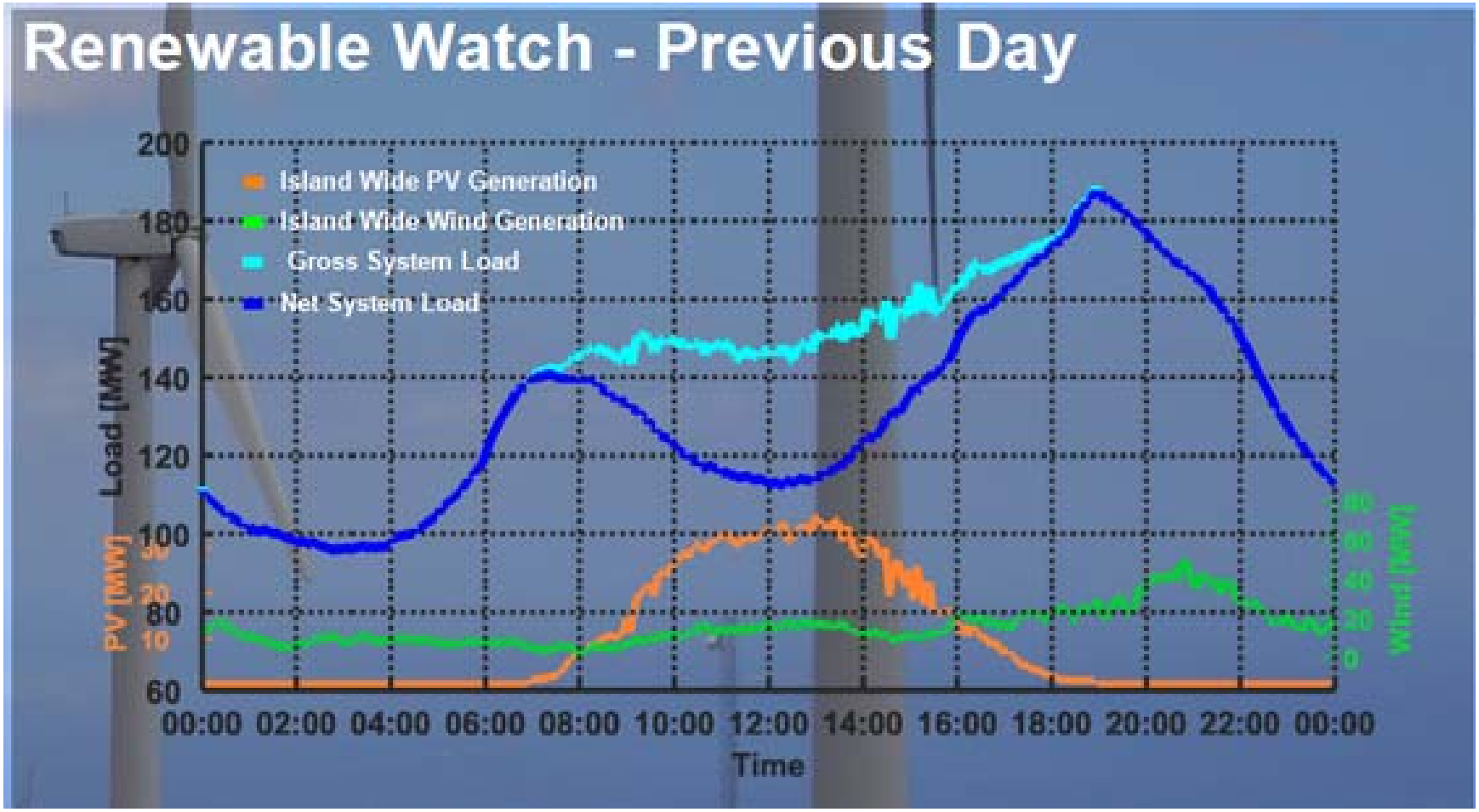
Table 3: Net Benefits Summary ($ per Customer per Year)

Water Heater	Strategy	PJM East (2014)	MISO (2014)	MISO (2028)
ERWH 50-gal	Peak Shaving	13	-15	29
	Thermal Storage	15	-20	25
	Fast Response	162	39	195

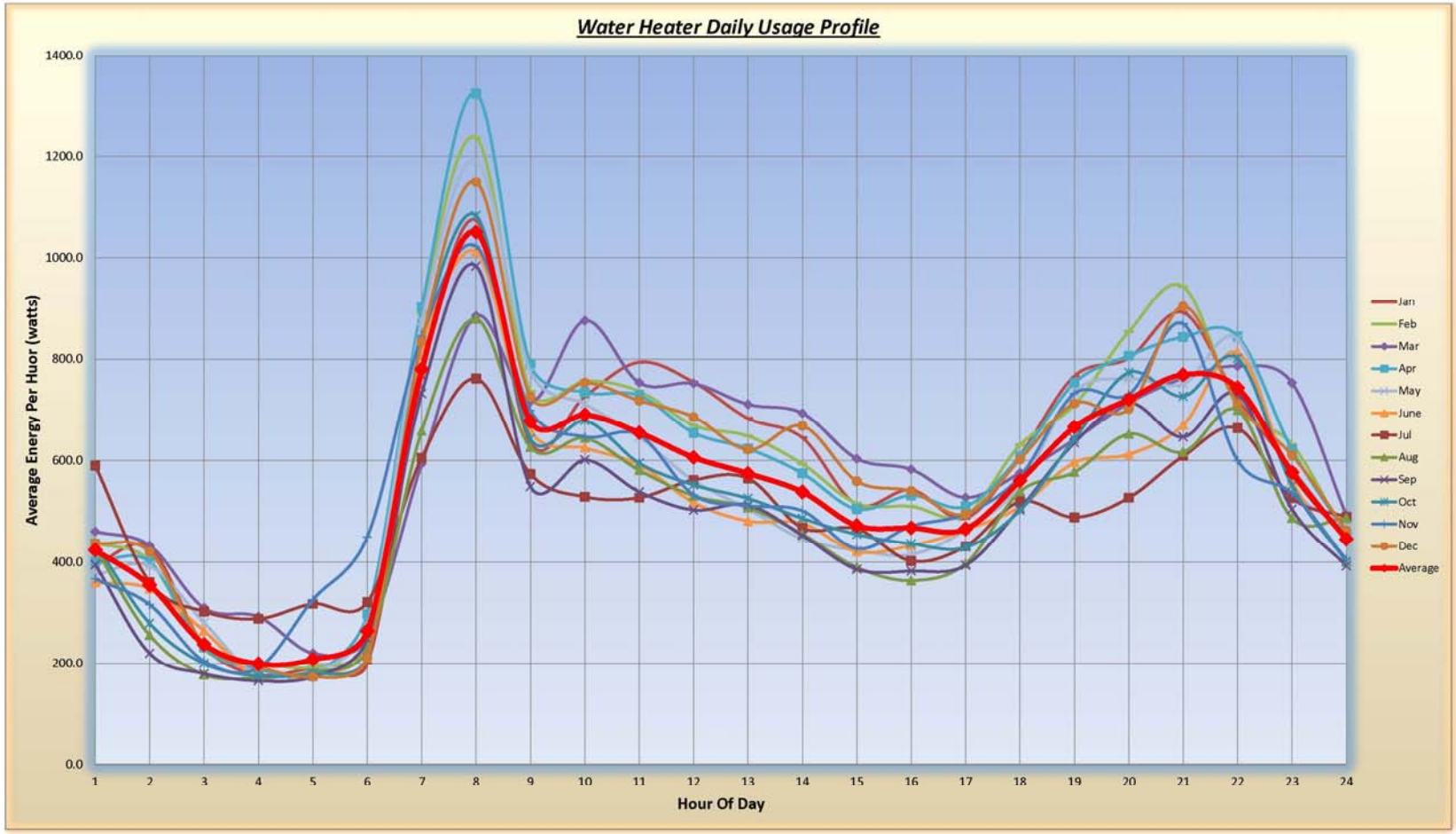
Brattle/NRECA/NRDC/PLMA 2016

Maui:
13,000 MF water heaters potential
6,300: needed for frequency control for wind
(MECO DR Report, P. 64)

Maui's Challenge #2: Mid-Day Solar Bulge



When Do People Use Hot Water?



Source: Steffes Energy

Hawaii Water Use Is Evening-Peaking

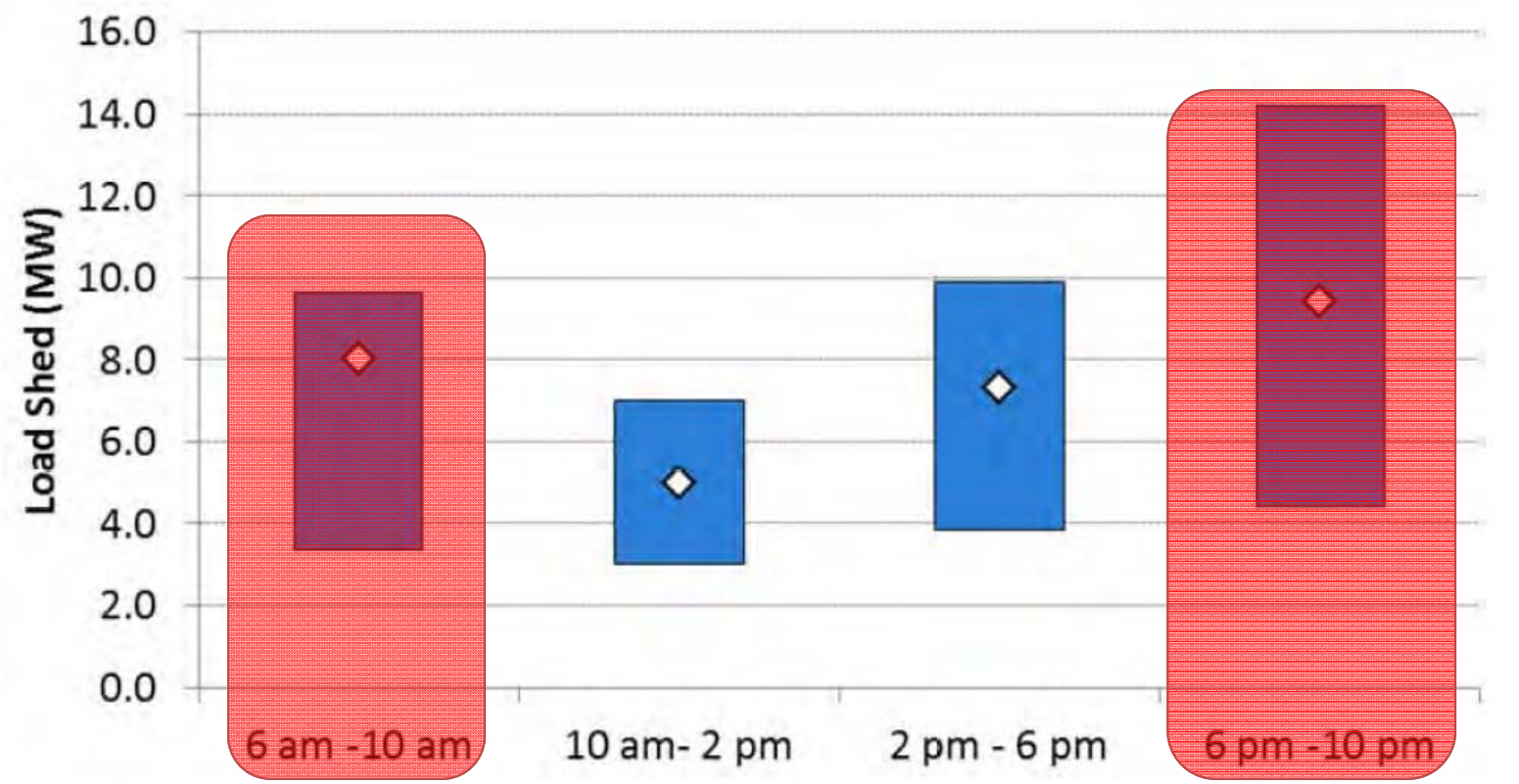
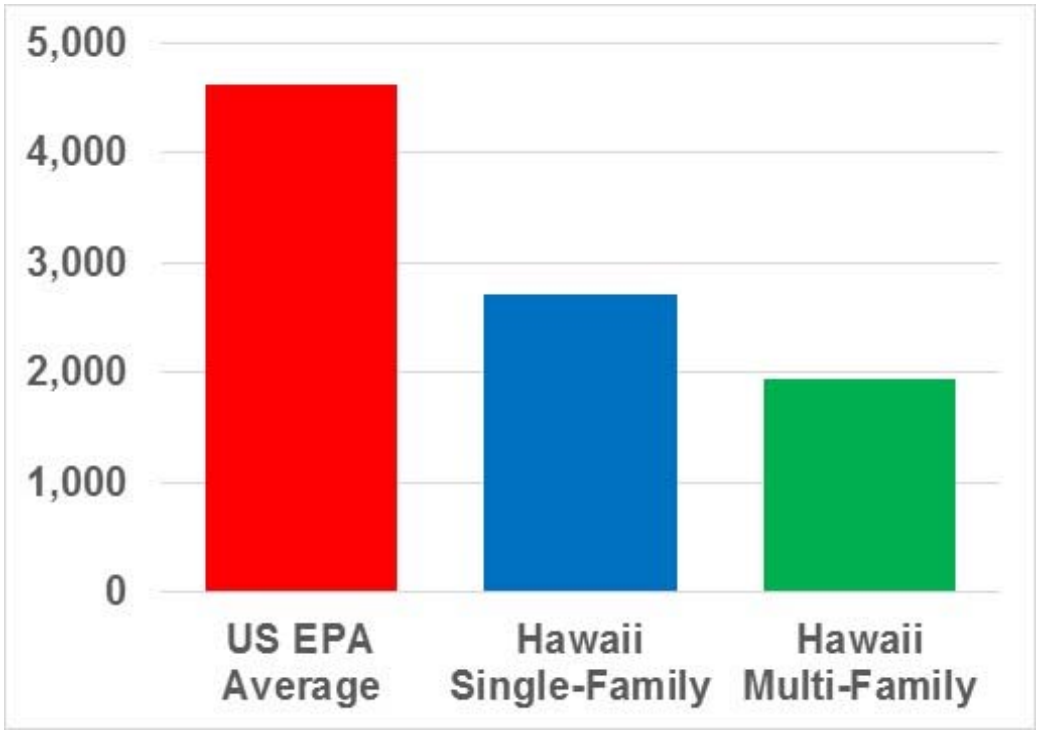
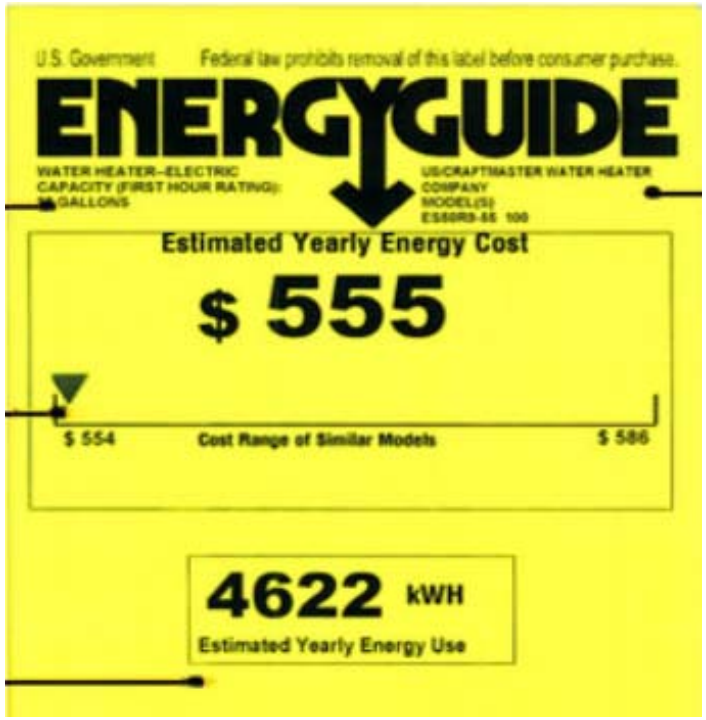


Figure 11. RDLC water heater program load shed statistics, 2013

Hawaii Hot Water Use is Lower

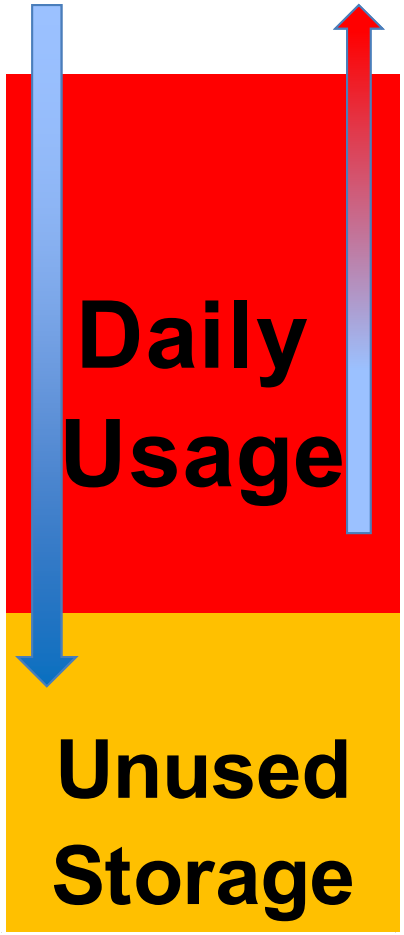




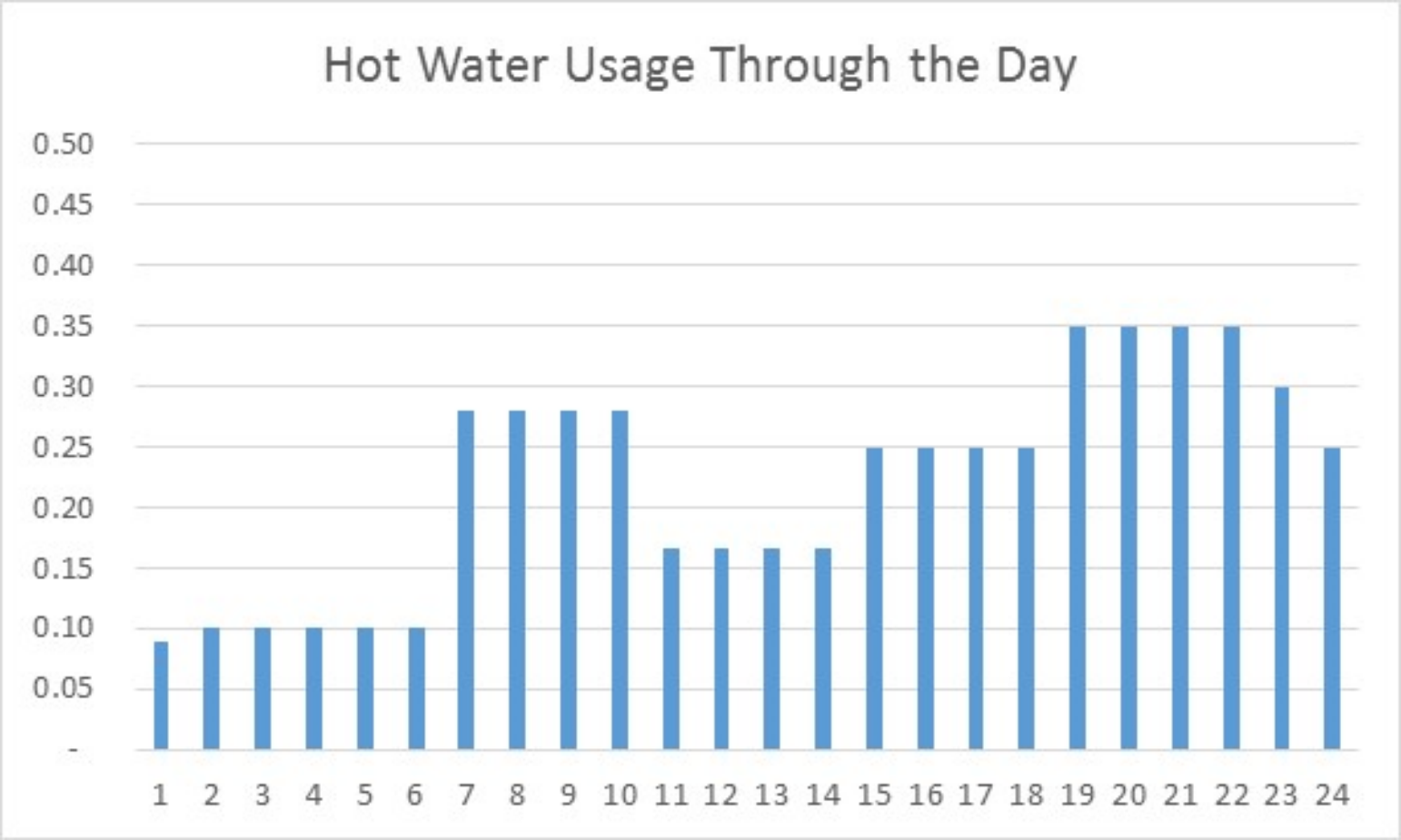
Multi-Family Daily Use is Within Capacity of a 52 Gallon Tank

- Daily Usage:
  5.33 kWh

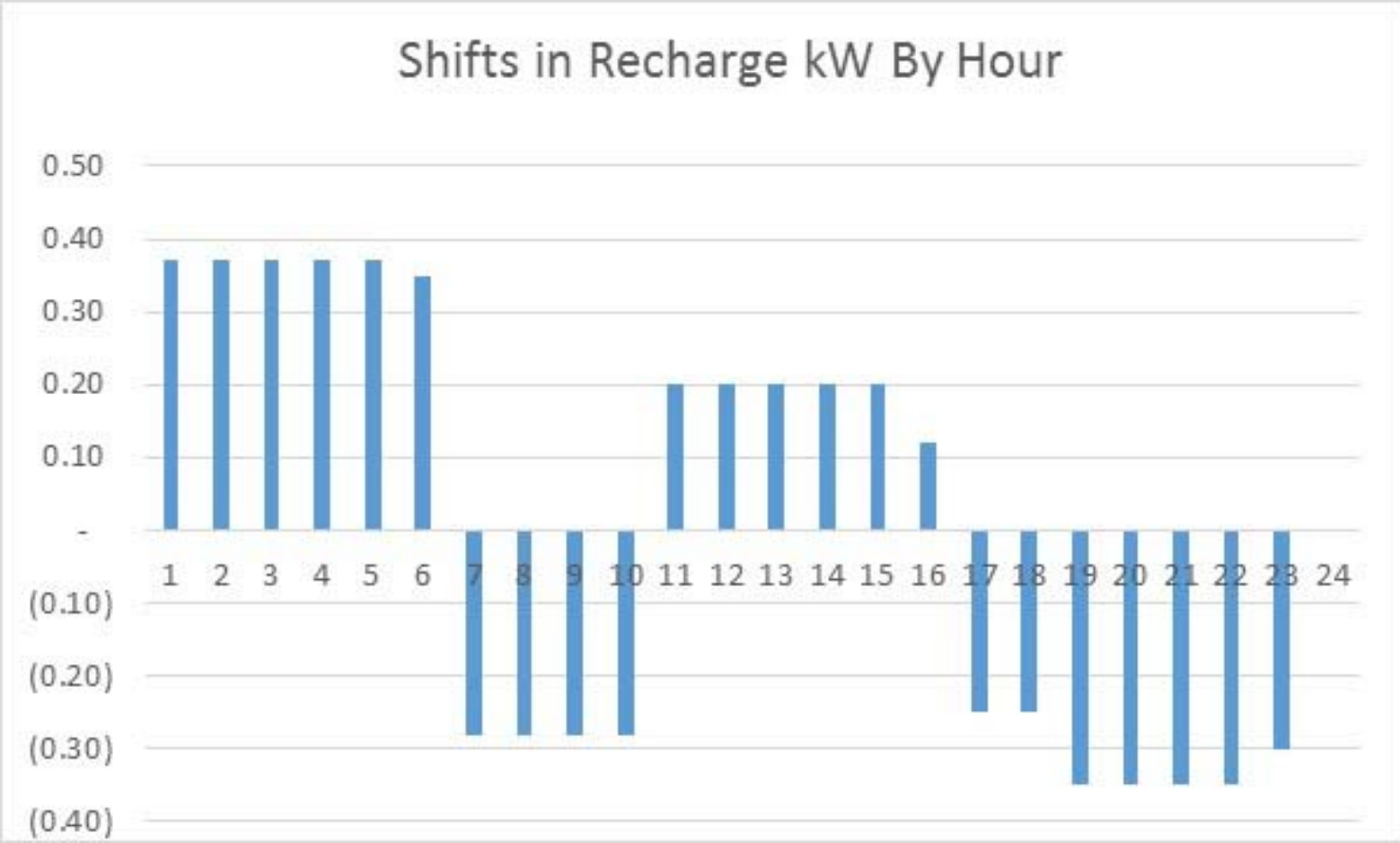
- 52 Gallon Tank Capacity:
  7.92 kWh
  @ 140° Max &
  75° inlet water temp.



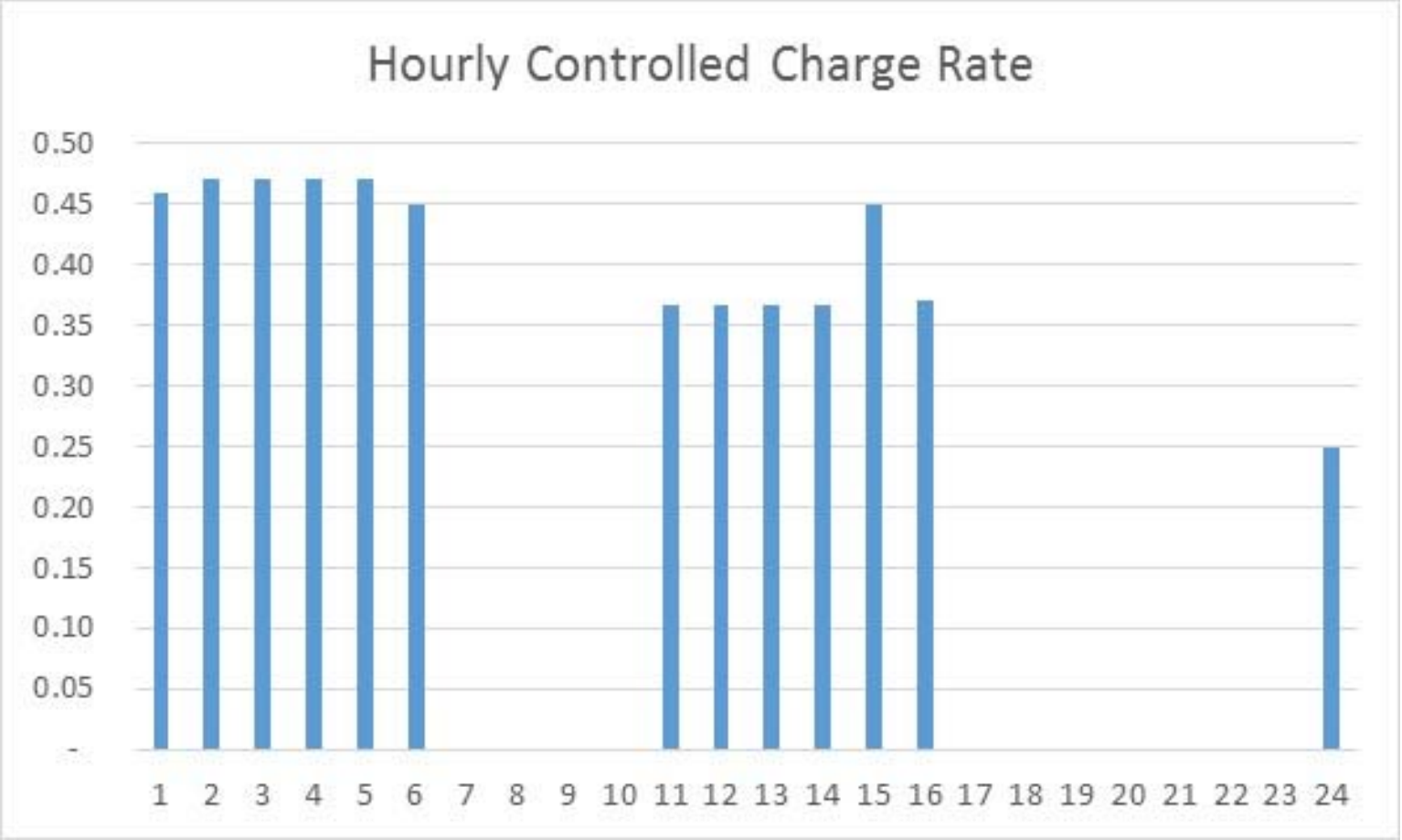
Evening Peak Water Use in Hawaii Matches Post-Solar Day Challenge



Reduce Charging: 6 – 10 AM; 4 – 10 PM
Increase Charging at Other Hours



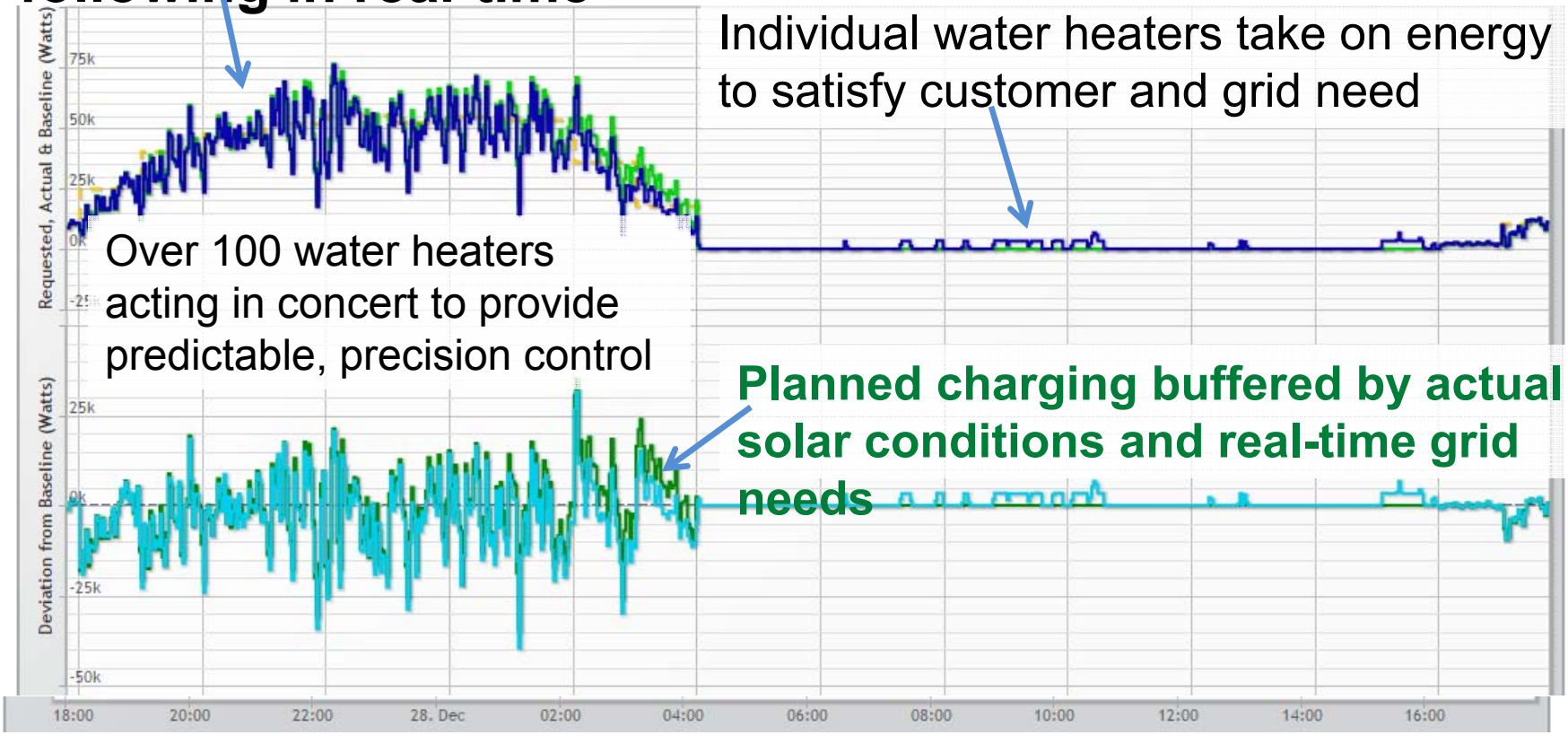
Charging Occurs Mid-Day and Mid-Nite



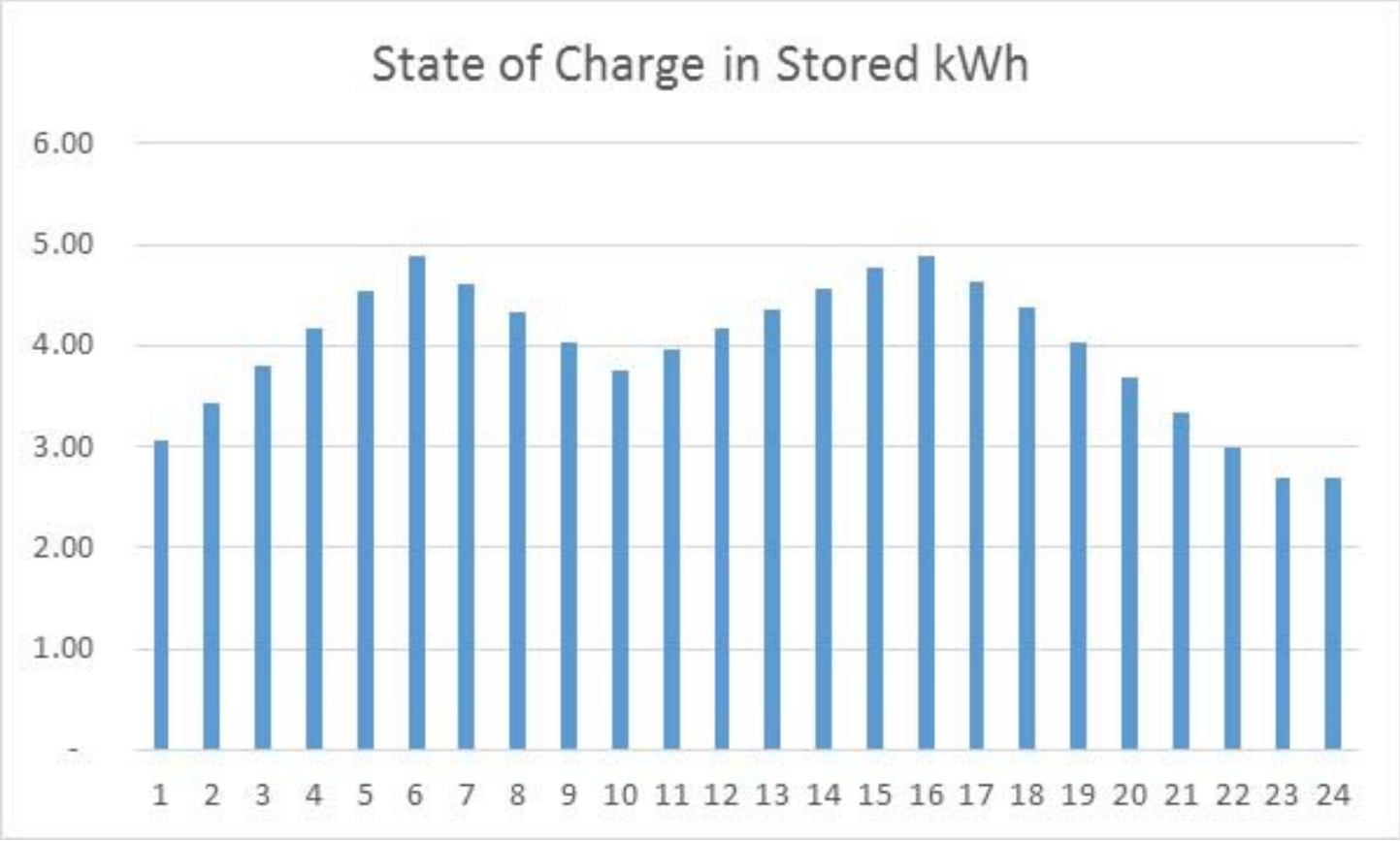
Paul Steffes Slide: Smooth the Ramps

Power Request (Green) – Ramps UP or DOWN based on need

Measured Power (Dark Blue) – Confirms high-accuracy following in real-time



We Only Use Half The Available Storage



Net Shifts Per Water Heater
kWh/day per Water Heater

		Before	After	Change
Night Usage		0.84	3.04	2.20
Peak Usage		3.32	-	(3.32)
Solar Bulge Usage		1.17	2.29	1.12
Total:		5.33	5.33	

Shiftable Water Heat Load as % of Wind Curtailment

	2015 Curtailment		Increased Night WH Load		% of Curtailment
Jan	600		846		141%
Feb	1,100		764		69%
Mar	1,700		846		50%
Apr	4,400		818		19%
May	4,900		846		17%
Jun	2,400		818		34%
July	800		846		106%
Aug	1,100		846		77%
Sep	2,900		818		28%
Oct	1,500		846		56%
Nov	3,800		818		22%
Dec	3,400		846		25%
Annual	28,600		9,956		35%

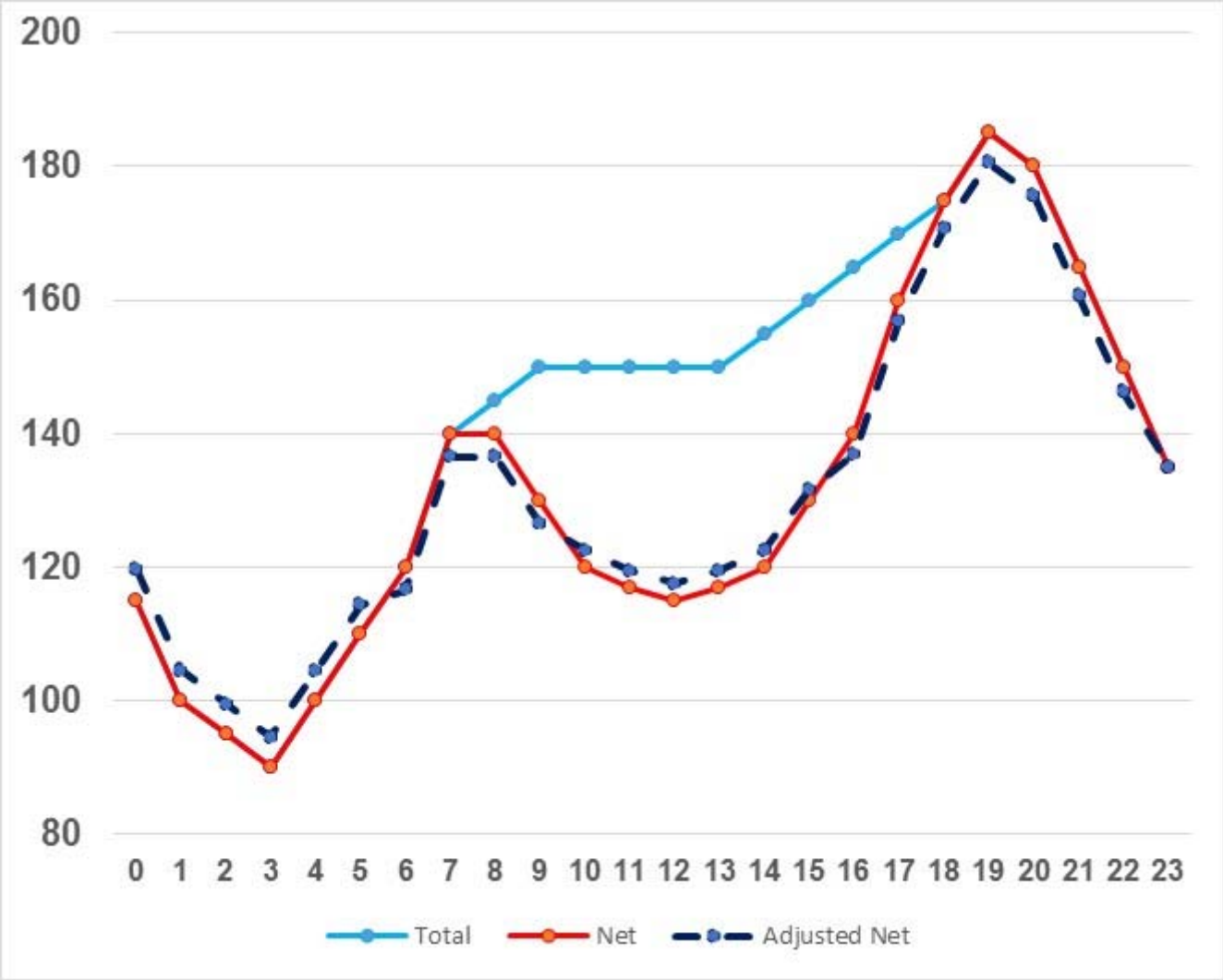
Shiftable Water Heat Load
As % of Mid-Day Solar Bulge

	Total	Net	Deviation From Average	WH Shift	%
10	150	120	(11.2)	2.5	22%
11	150	117	(14.2)	2.5	17%
12	150	115	(16.2)	2.5	15%
13	150	117	(14.2)	2.5	17%
14	155	120	(11.2)	2.5	22%

Shiftable Water Heat Load as % of Evening Peak

	Total	Net	Deviation From Average	WH Shift	%
16	165	140	8.8	(3.1)	35%
17	170	160	28.8	(3.1)	11%
18	175	175	43.8	(4.3)	10%
19	185	185	53.8	(4.3)	8%
20	180	180	48.8	(4.3)	9%
21	165	165	33.8	(4.3)	13%
22	150	150	18.8	(3.7)	20%

Effect on Net Load



What About Standby Losses?

- Higher Delta-T means higher losses.

  EF .95 Tank:

  – 5% losses @ 120F

  – 7% losses @ 140F

    - **Cost** of about **2%** in annual kWh at meter

- BUT: Lower Distribution Line Losses

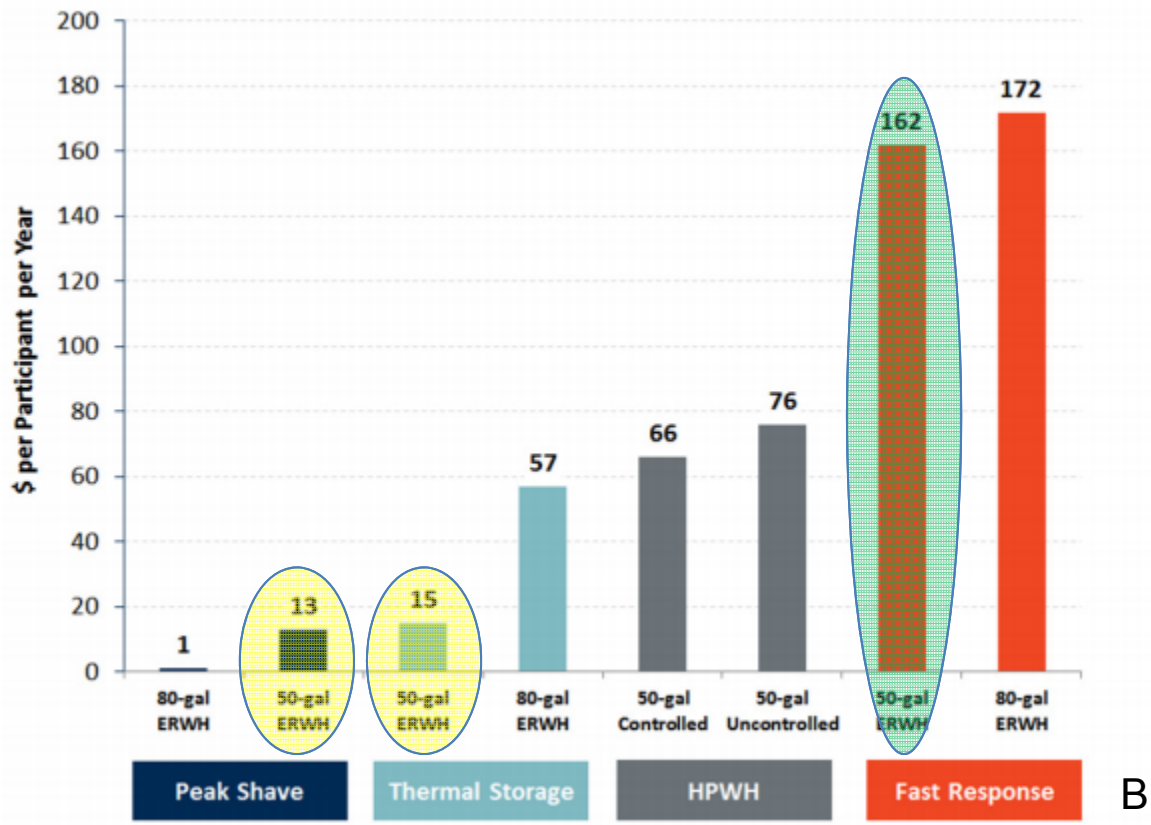
  – Uncontrolled: 41% on-peak

  – Controlled: ~0% on-peak

    - **Savings** of about **3%** on underlying line losses.

This Only Addresses Part of the GIWH Benefit Stream

Figure ES-1: Annualized Net Benefits of Water Heating Strategies (PJM 2014)



No attempt to quantify the fast response value. It should be a part of the value proposition.

Brattle/NRECA/NRDC/PLMA 2016

Summary

- Multi-family electric water heaters will remain commonplace.
- 55 gallon DOE limit not a factor
- Savings per water heater are relatively small.
- Efficiencies of deployment and control are very good.
- Fast response is needed, and is valuable.
- Potential value is very high.

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