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Evaluating Indoor HPWHs in a Hot/Dry Climate

EEBA Excellence in Building – St. Louis, MO

September 23rd, 2014

Davis Energy Group Incorporated

Building America U.S. Department of Energy

Overview

1. Project Goals & Learning Objectives
2. Project Design (summer only)
3. Monitoring Methods
4. Results
   - Existing Electric Water Heater Performance
   - HPWH performance
   - Space Cooling Impacts
   - Projected Savings
   - Estimated Cost Effectiveness
5. Homeowner Feedback
6. Next Steps

Project Goals and Learning Objectives

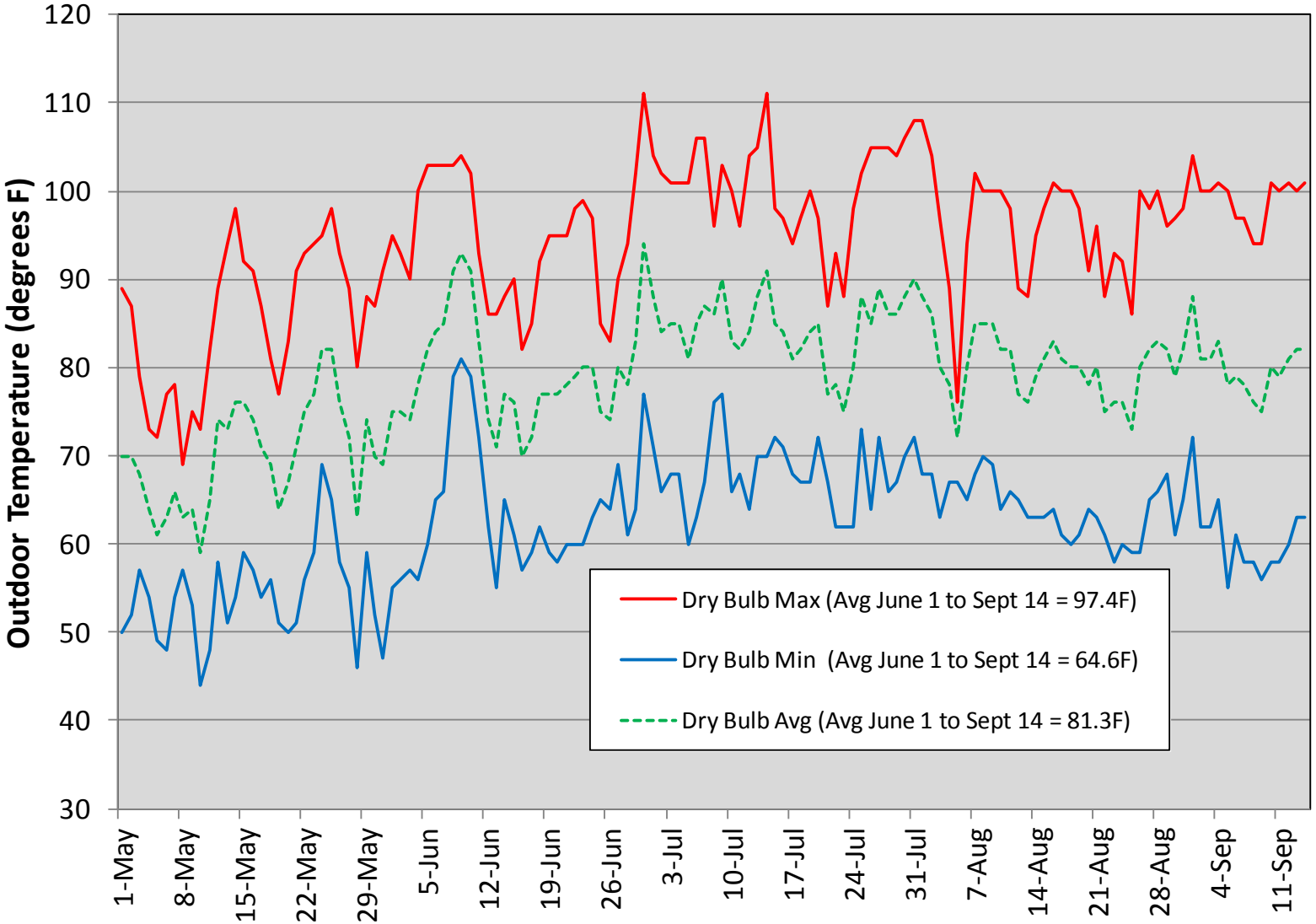
1. What was the measured performance of the HPWHs in the two homes?
2. What is the level of customer satisfaction with the HPWH in terms of hot water capacity, cooling benefit, and noise concerns?
3. How significant are the observed space cooling impacts?
4. What are the economics of retrofitting a HPWH in this climate under different hot water loads and electric rates?

Project Overview

Research Supported By:

- DOE's Building America
- Redding Electric Utility (REU)
- Continued winter monitoring sponsored by PG&E & REU

Why Redding? (Summer '14 NWS Data)



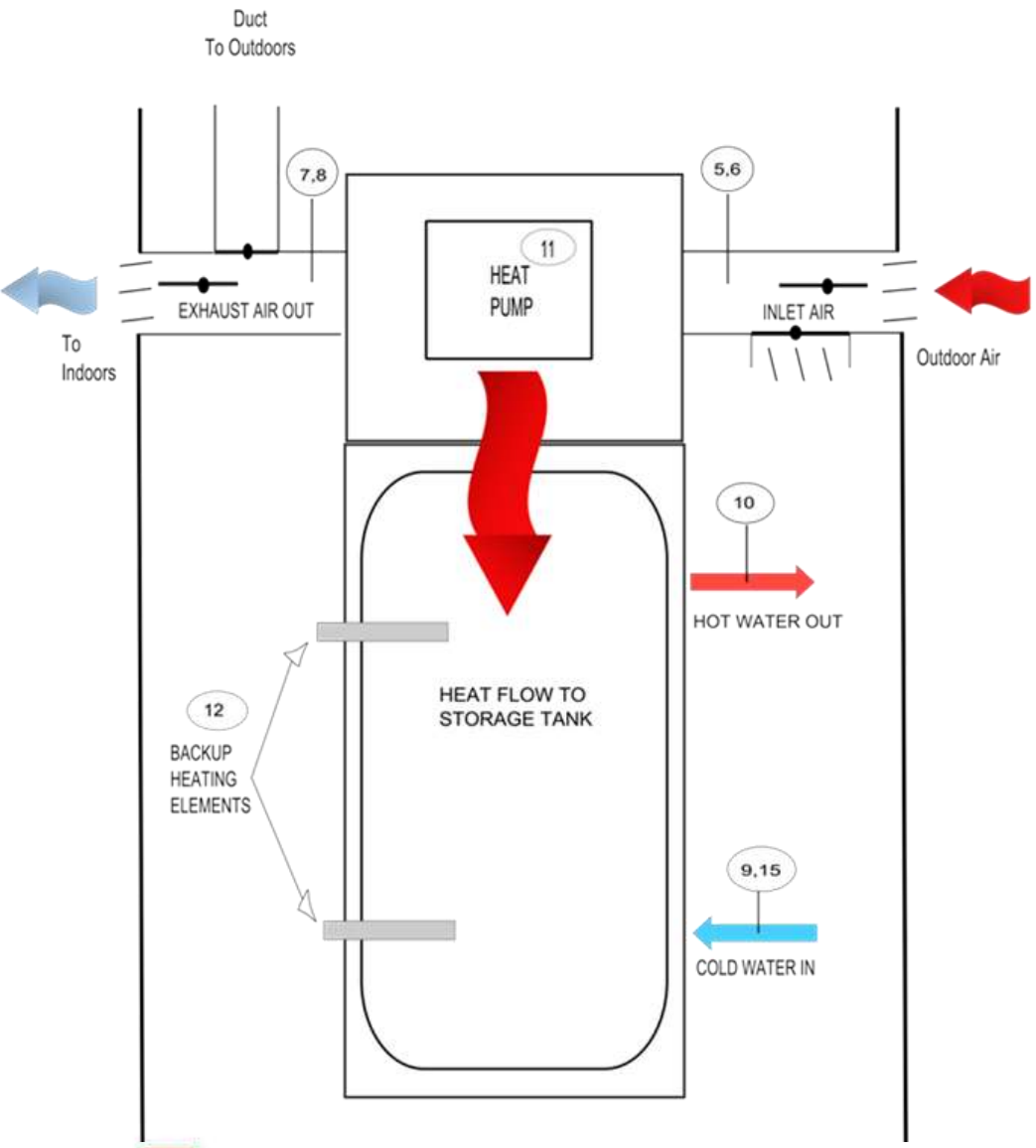
Monitoring Site Characteristics

Parameter	Site 1	Site 2
House floor area (ft^2)	2,037	2,740
Year constructed	~1980	1987
Occupants and ages	Two adults	Six (2 adults, one child < 10, three 10-20 year olds)
Existing electric storage water heater	50 gallon Bradford White	50 gallon Bradford White
HVAC system description	Two packaged heat pumps (age estimated at 20+ years) 1. BDP 542D032HP 2. n/a	2 split system heat pumps (both original equipment) 1. Bryant 663CJ036 2. no nameplate on unit

Air Generate HPWH Specifications

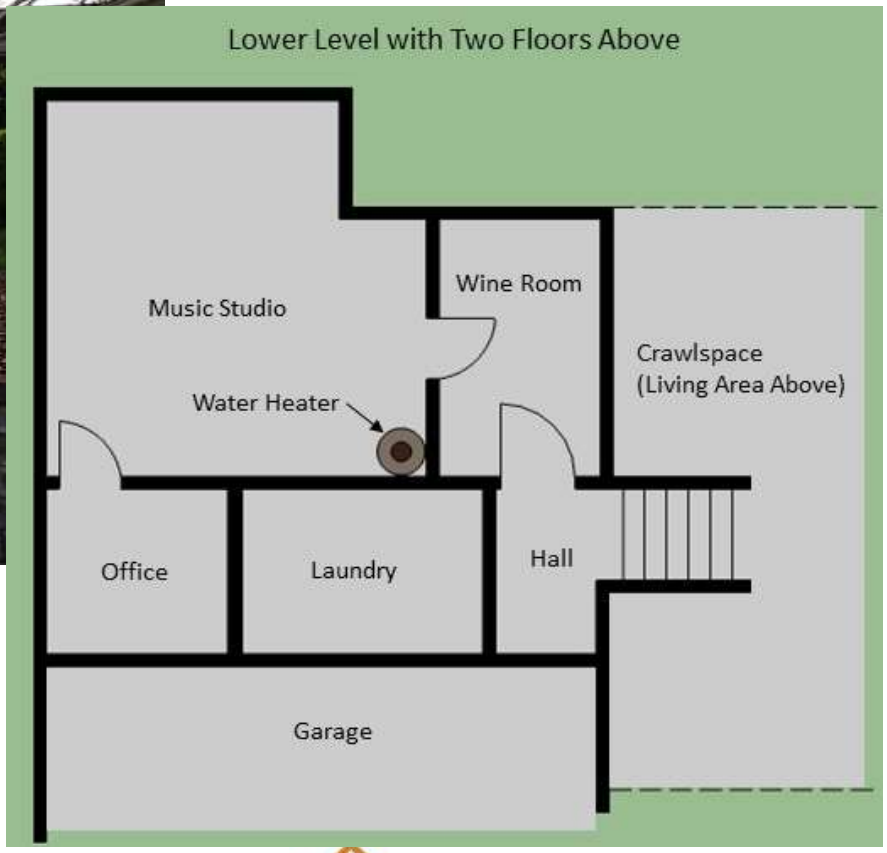
Parameter	ATI66	ATI80
Tank volume	66 gallons	80 gallons
EF (hybrid mode)	2.35	2.2
First Hour Rating (hybrid mode)	70 gallons	80 gallons
Heat Pump Btu Rating	2.5 kW	2.5 kW
Backup Electric Element	4.0 kW	4.0 kW
Refrigerant	R410A	R410A
Tank Height	70.5”	75.5”
Weight	243 lbs	254 lbs
Duct Diameter	6”	6”
Decibel Rating	48 db	48 db

Monitoring Setup



Type	Application	Mfg/Model
Duct temperature/RH	HPWH inlet and outlet air	Vaisala HMD42
Wall mount temperature/RH	Indoor air temperature and RH	Vaisala HMW82
Outdoor air temperature/RH	Shielded outdoor sensor	RM Young model 41372
Power Monitors	HPWH and AC power	Wattnode/ WNA-1-P-240-P
Flow meter	Flow to water heater (cold)	Onicon F-1300
Immersion thermocouple	Hot and cold side temps	Gordon 20CTOUH

Site 1: Exterior View, Water Heater Location



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Site 1 Photos

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Site 1 HPWH Install

Display Panel

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HPWH Air Inlet and Outlets

Site 2: Exterior View

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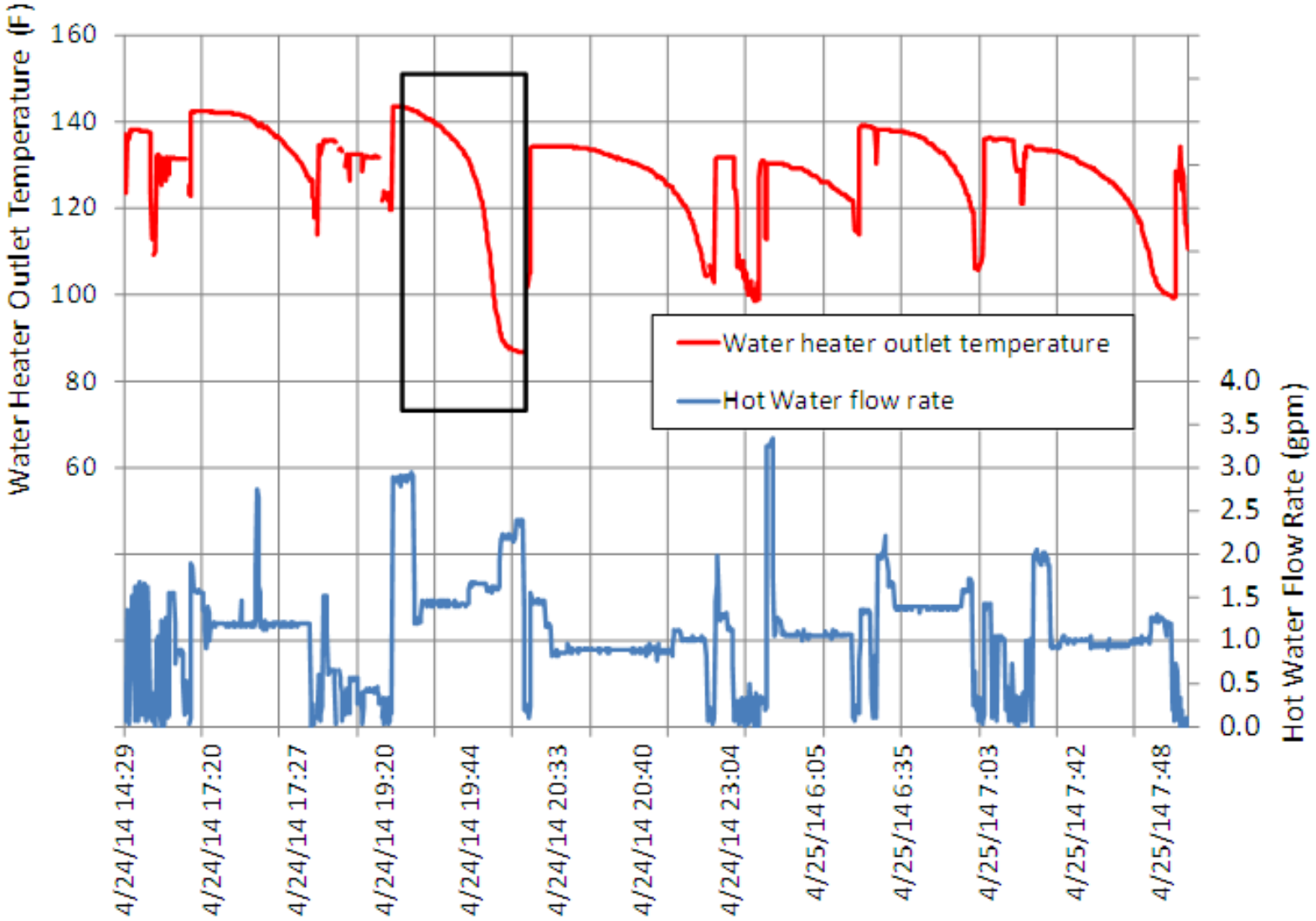
Site 2: WH Location & Proposed Ducting

Site 2: Laundry Room Install

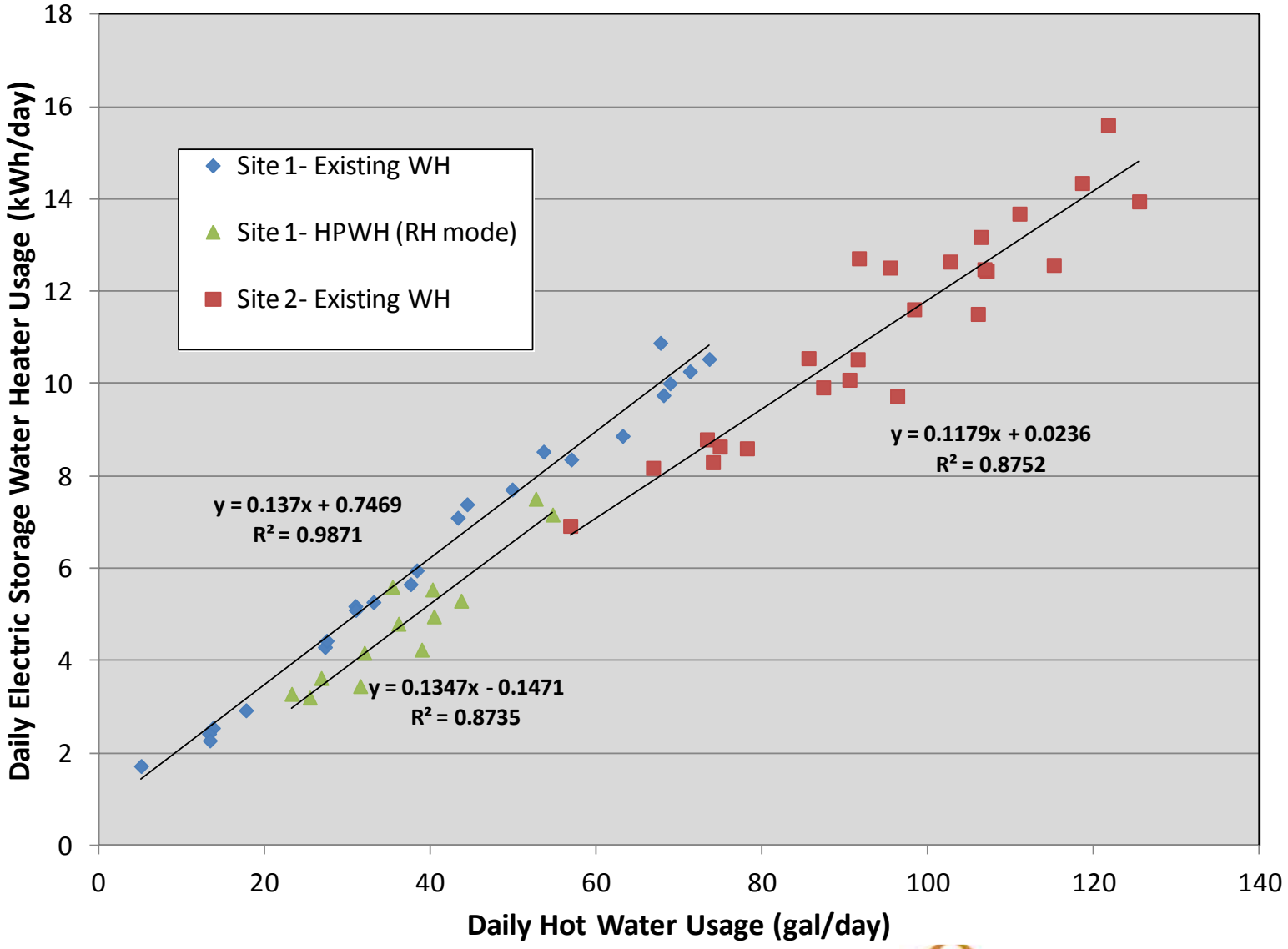
Site 2: Ducting to Outside

Site 2: Exhaust Air Delivery to Kitchen

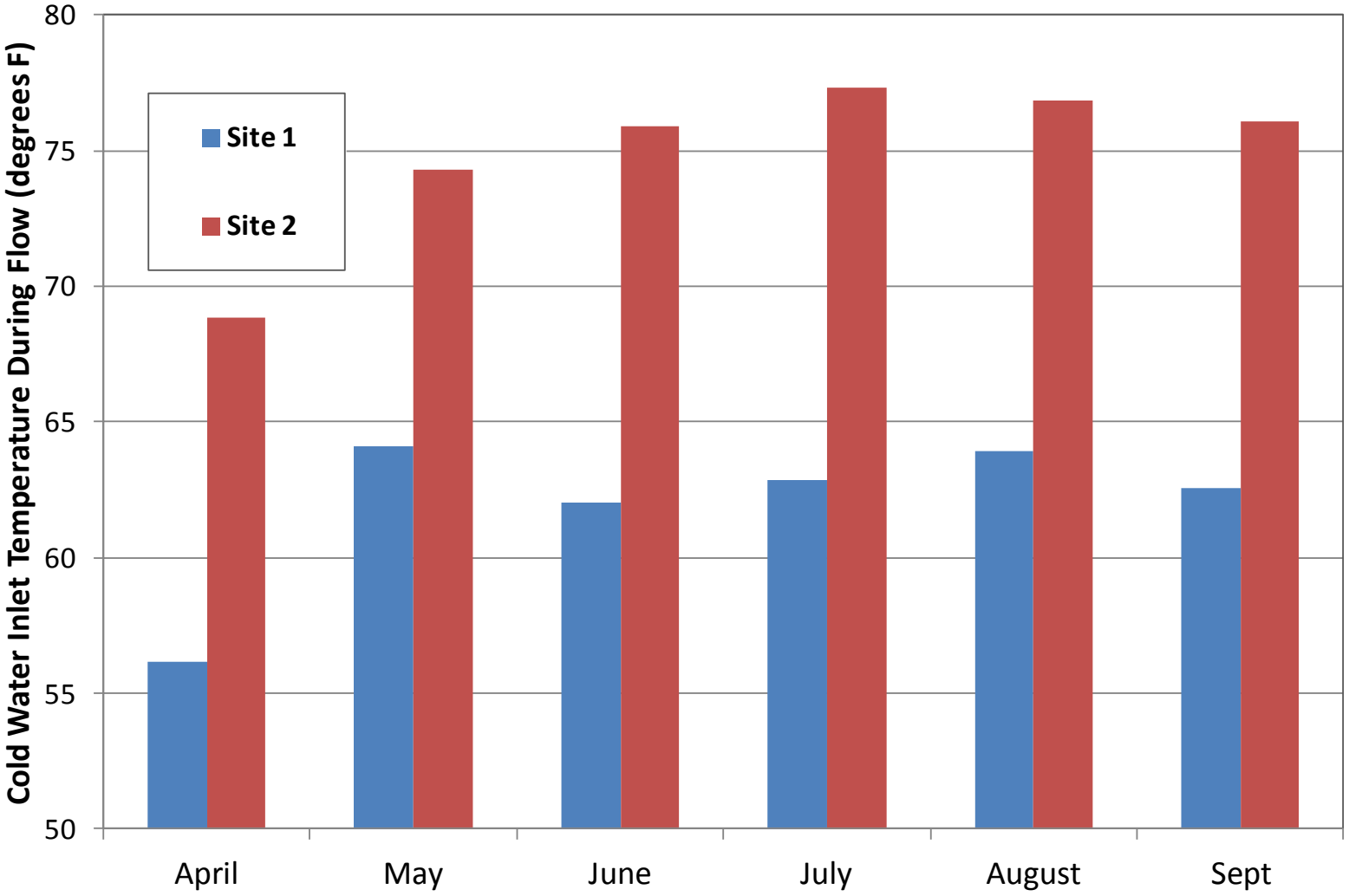
Site 2: Existing WH Pre-Monitoring



Daily Electric Storage WH Energy Use



Cold Water Inlet Temperatures to WH



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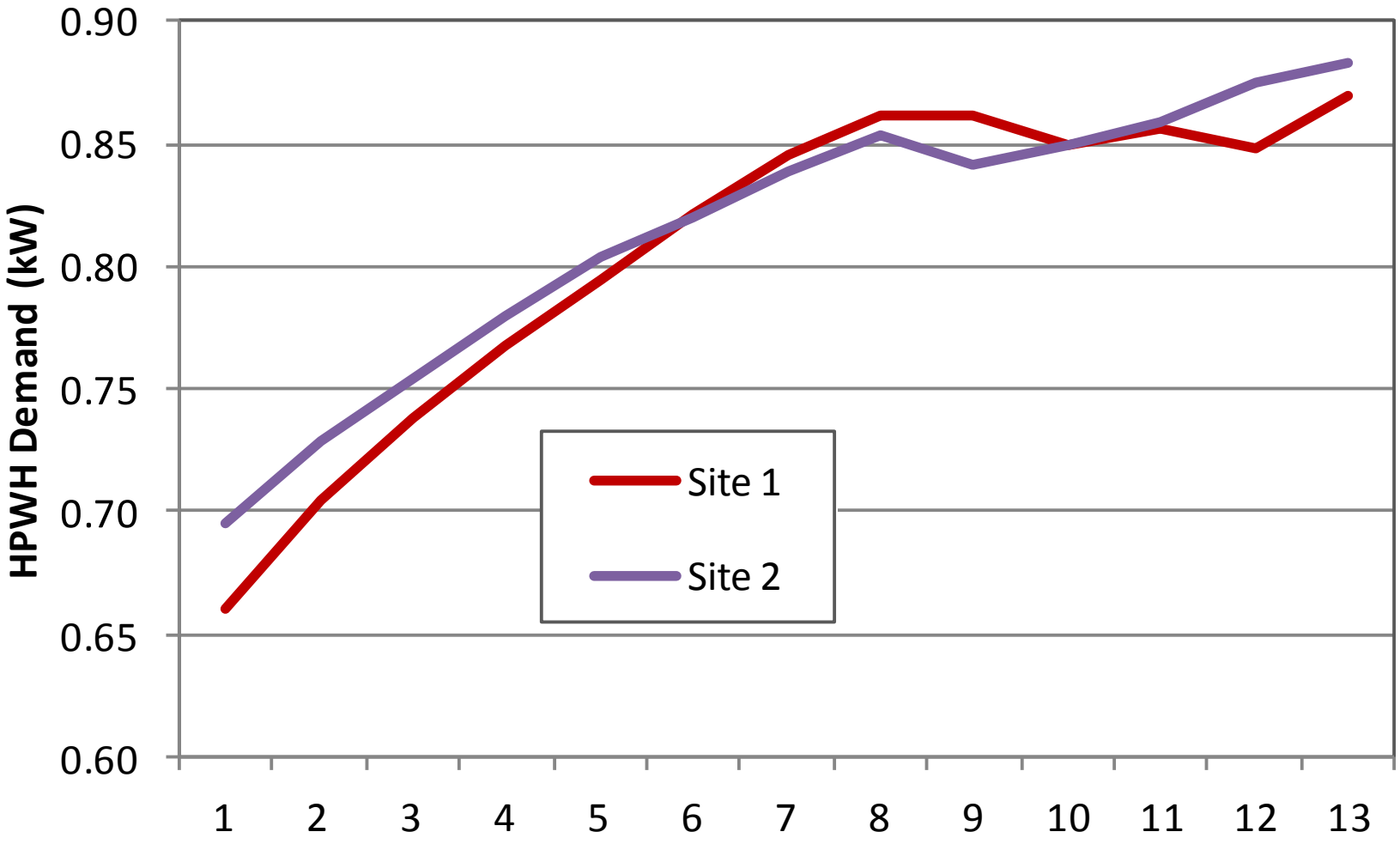
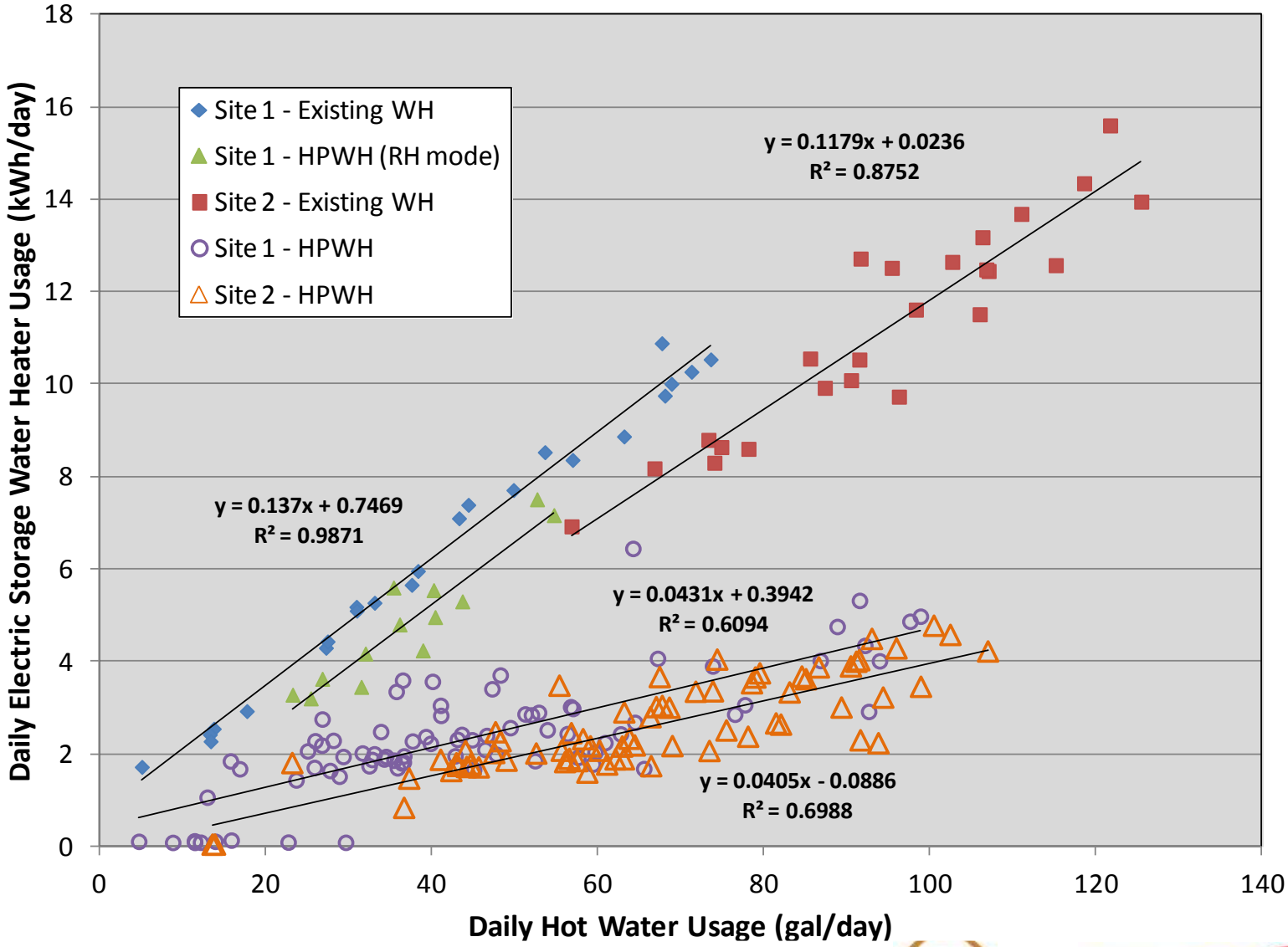
Comparison of kW vs. Cycle Length



HPWH and Base Daily kWh vs. gpd



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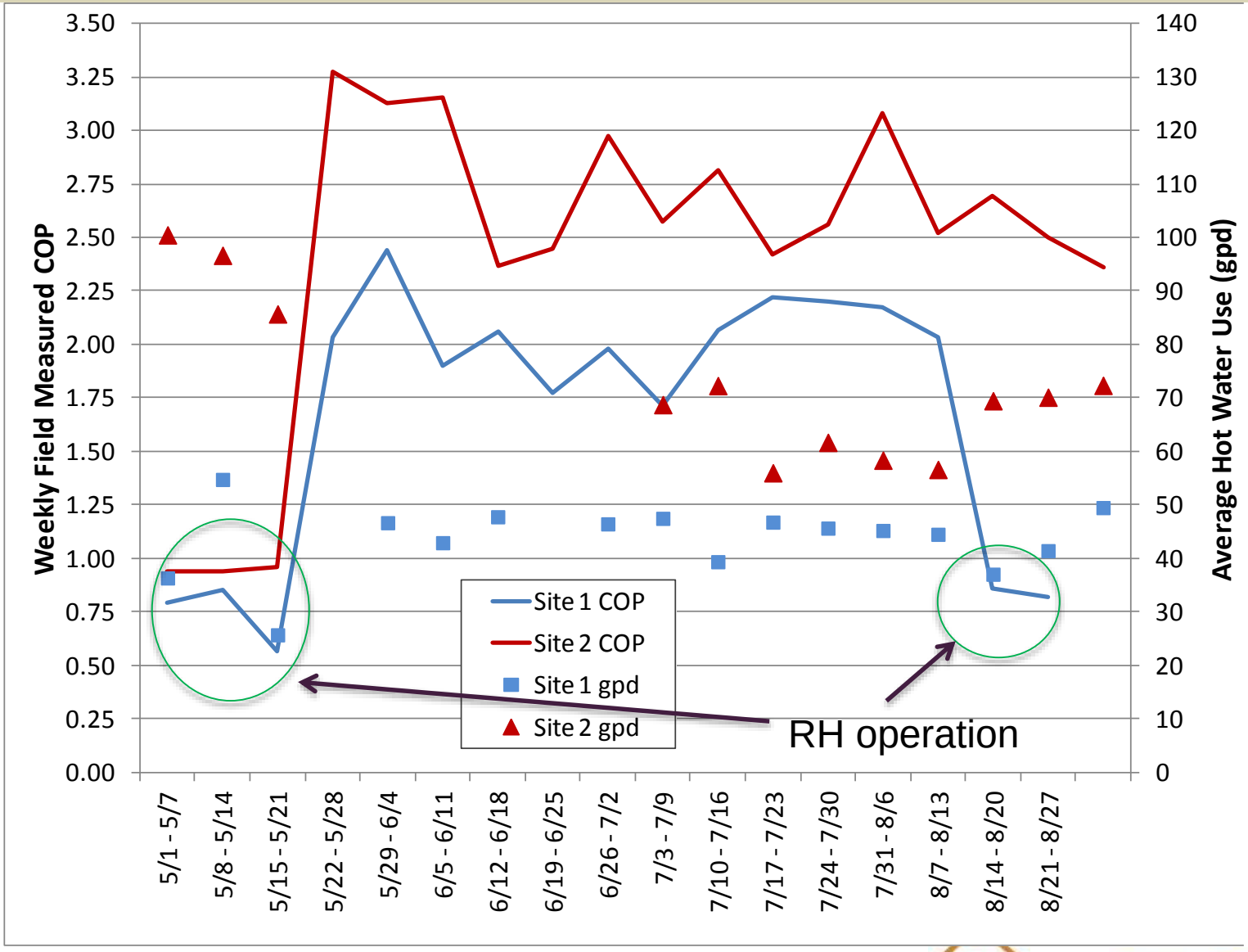
Monitoring Summary- Aggregated Weekly



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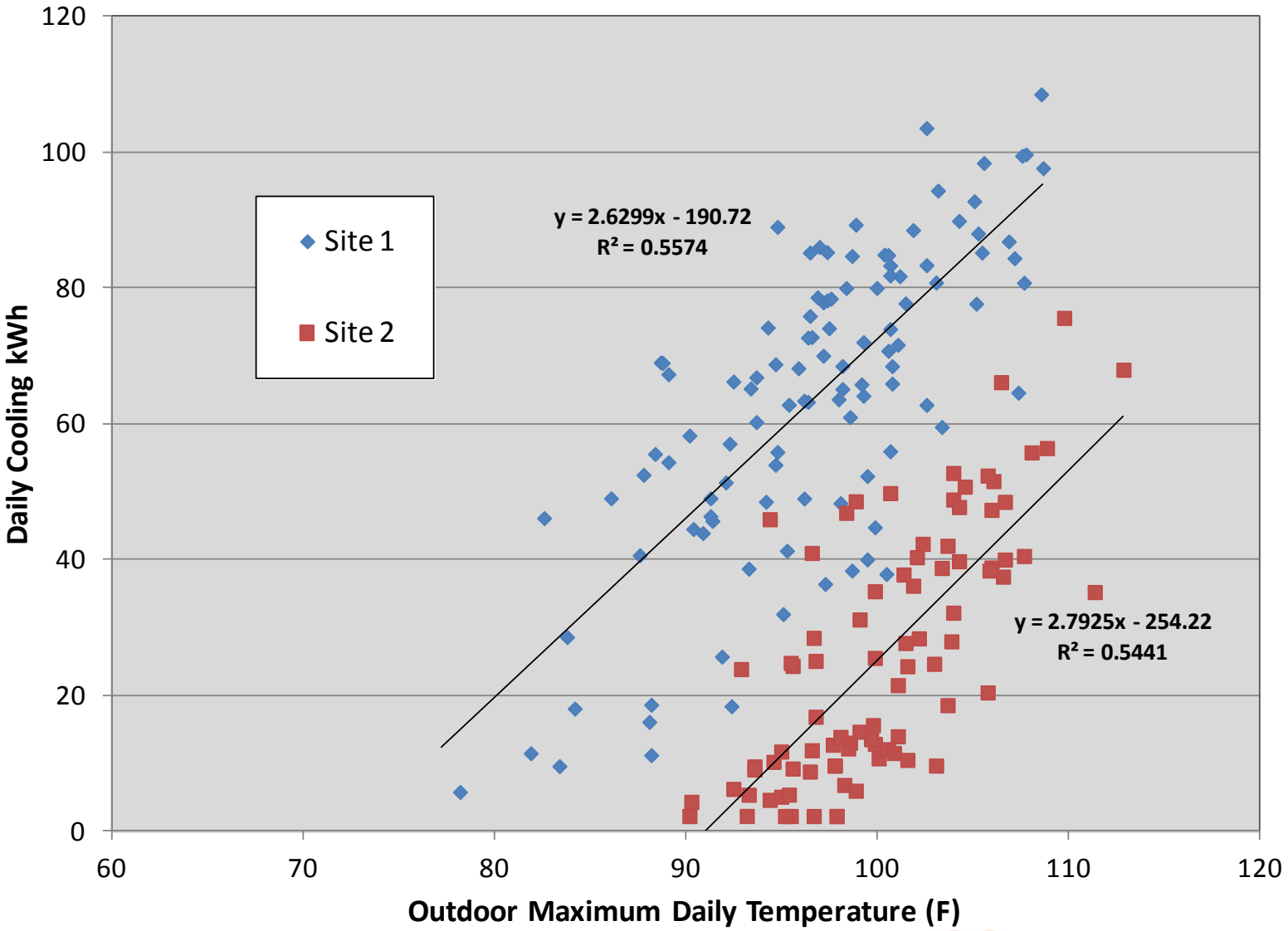
Household Daily Cooling kWh vs Tout



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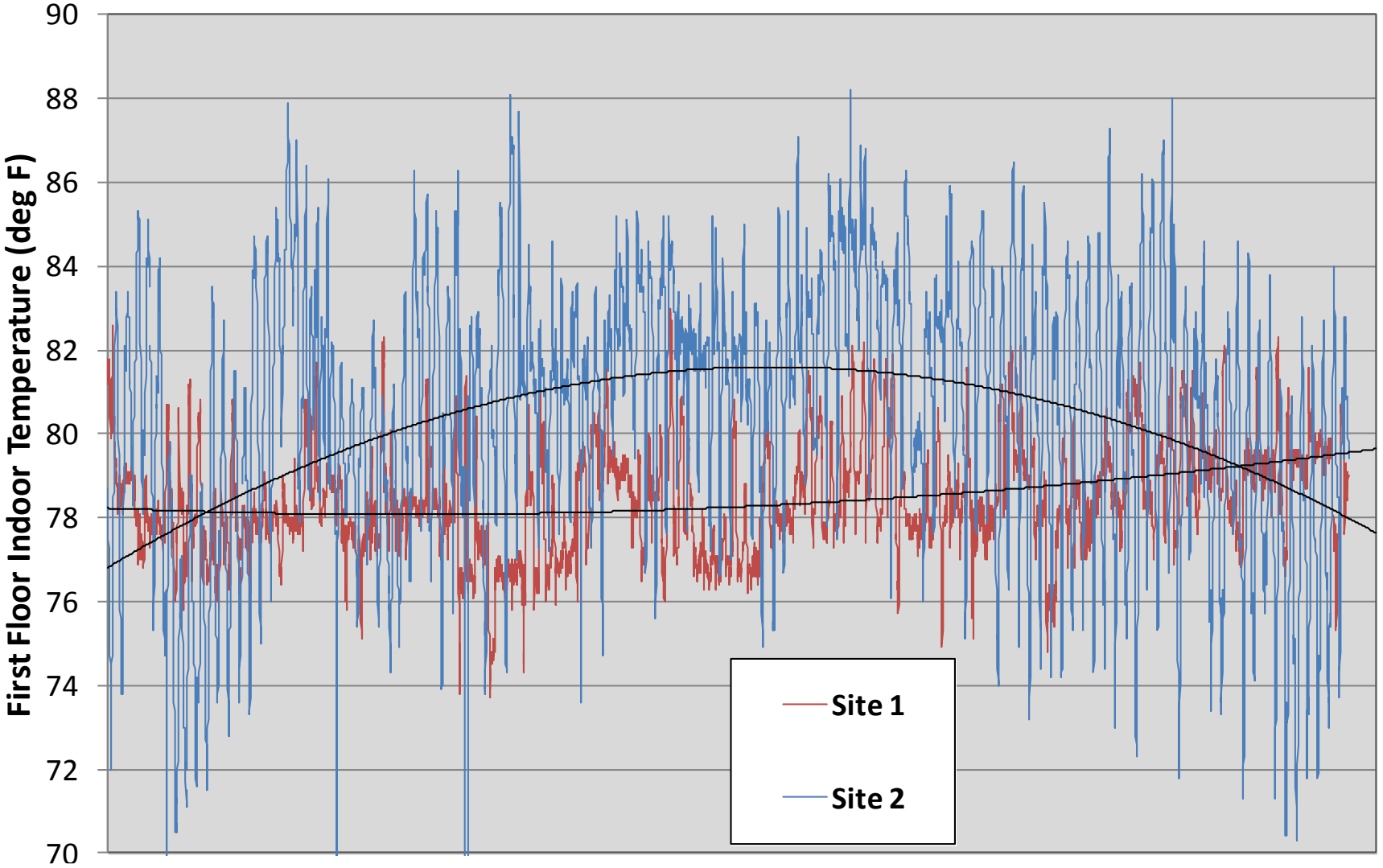
Monitored Indoor Temperature- 1st Floor



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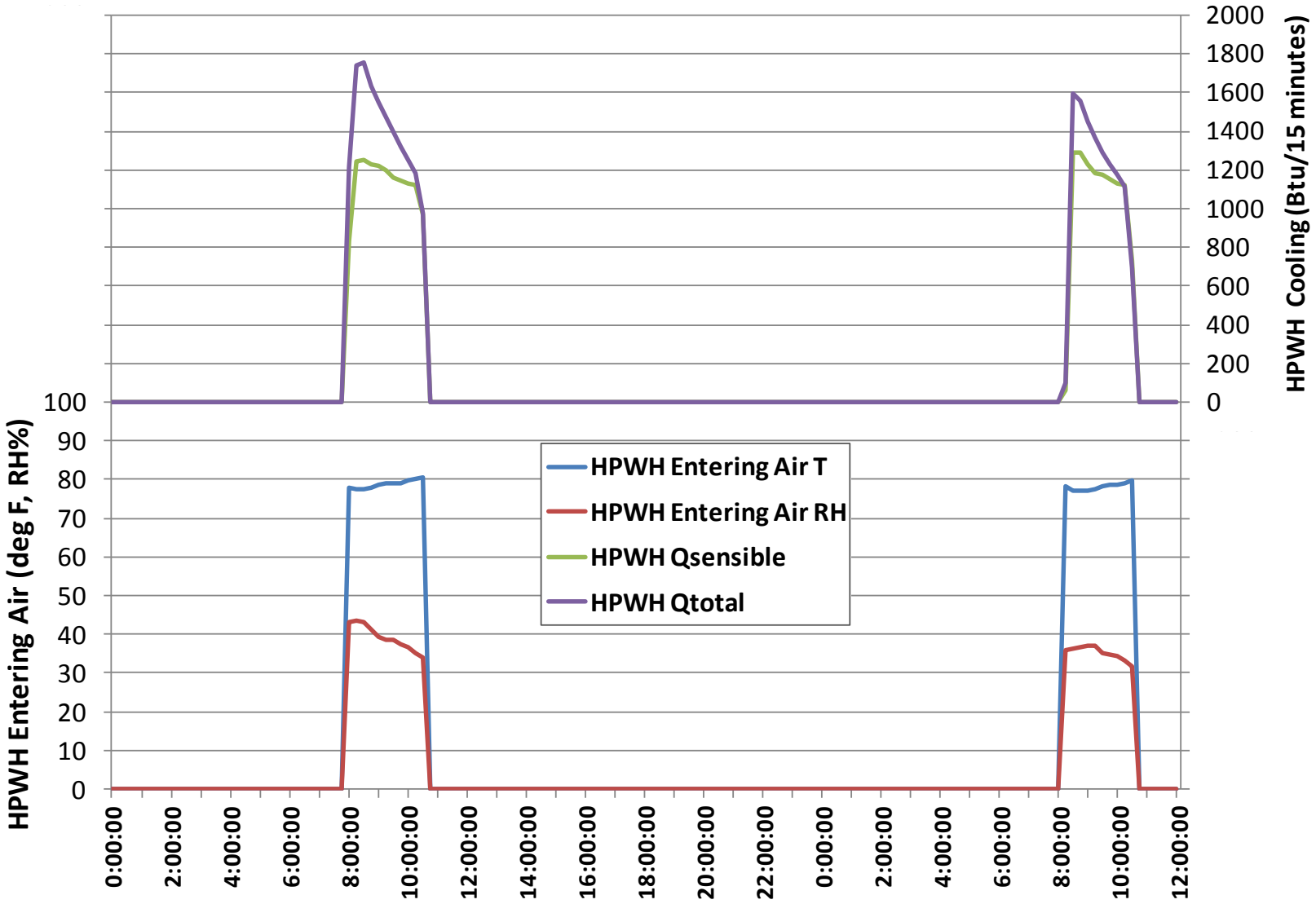
HPWH Delivered Exhaust Air Cooling



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Extrapolated Annual Savings

	Site 1	Site 2
Monitored gal/day	44.5	65.6
Estimated annual base kWh	2393	3923
Assumed Annual COP	2.35	2.20
Estimated annual HPWH kWh	927	1623
DHW Savings, kWh	1466	2300
Cooling Savings, kWh	135	120
Approx % of Annual Cooling Savings	2%	5%
Total Annual Savings , kWh	1601	2421

Estimated Savings and Payback

	Site 1	Site 2
Annual $ Savings, REU rate ($.153/kWh)	$245	$370
Simple Payback, years	7.3	4.9
Annual $ Savings, SDG&E rate ($.18/kWh)	$288	$436
Simple Payback, years	6.2	4.1
Annual $ Savings, AZ/NV rate ($.113/kWh)	$179	$271
Simple Payback, years	10.0	6.6

Feedback From Homeowners

What is the level of customer satisfaction in terms of hot water capacity, cooling benefit, and noise?

Site 1:

- Overall 3 of 5 satisfaction …" seems to be a nice unit, but problems with control panel….." (mode switching issues)
- "The space that the unit is located gets very warm, and the cool air is great."
- "The noise levels have not been an issue. It is understandable to hear the movement of cold air"

Site 2:

- "more hot water…. way better hot water delivery"
- "cool air to kitchen is great"
- no noise concerns
- Thinks bills are higher
- Overall "4 on a 5 point scale"; only downside is higher bills

How Does This Support ZER Homes?

- Indoor HPWHs in hot/dry climates allow for:
  - High efficiency water heating
  - Consistently better economics than solar thermal (prior NREL study)
  - Small space cooling kWh benefit , diminishing as → ZER
  - More compact hot water distribution system saving energy and water
  - HPWH operation could be biased to match with PV output

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