

Results from a 23-Site Study of HPWHs in Central California

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Powering forward. Together.



Overview

- Findings from online survey
 - Demographics, satisfaction
- Findings of the ADM field study
 - Energy performance, draws
- Findings from internal cost study
 - Cost, location, eqpt. age, size, who installed
- Greenhouse gas impacts
 - Compared to other water heaters
- Current R&D work
 - Scheduling project with GE and Virtual Peaker

Survey Results

- 71 people had received a HPWH incentive from SMUD at time of survey
 - Average age 55
 - Average household income \$125,000 (Sac County average \$56,000)
 - Average household size 2.27 (CA average 2.90, field study 2.35)
- 34 people completed the online survey. 2 surveys six months apart.
 - All customers “satisfied” or “extremely satisfied” overall
 - 91% “satisfied” or “extremely satisfied” with installers
 - 94% used “hybrid” or “HP only” mode
 - Some used “resistance” in winter due to misperception
 - No decline in “HP only” in 6 mos between surveys
 - 79% had changed mode “never” or “only once”
 - 21% reported “sometimes” running out of hot water
 - Noise perceived as “noticeable” but not “annoying”
 - 61% considered cool air in the garage a benefit

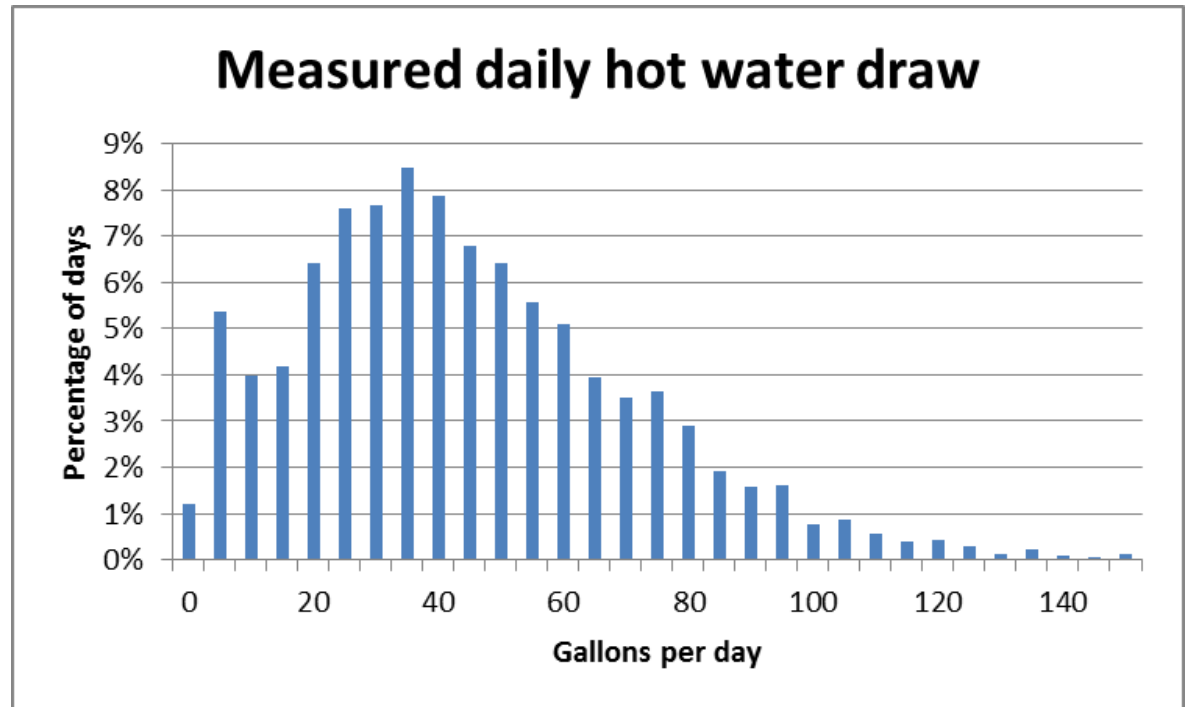
Overview of Field Study

- 23 water heaters monitored for one year
 - Water and air temps
 - Water flow rates
 - 1-minute interval data
 - Engineering models of energy performance
 - Participants selected by stratified sample based on household size
 - \$250 incentive for participation
 - Conducted by ADM Energy, Rancho Cordova
 - Almost all units were 50 gallon Geosprings



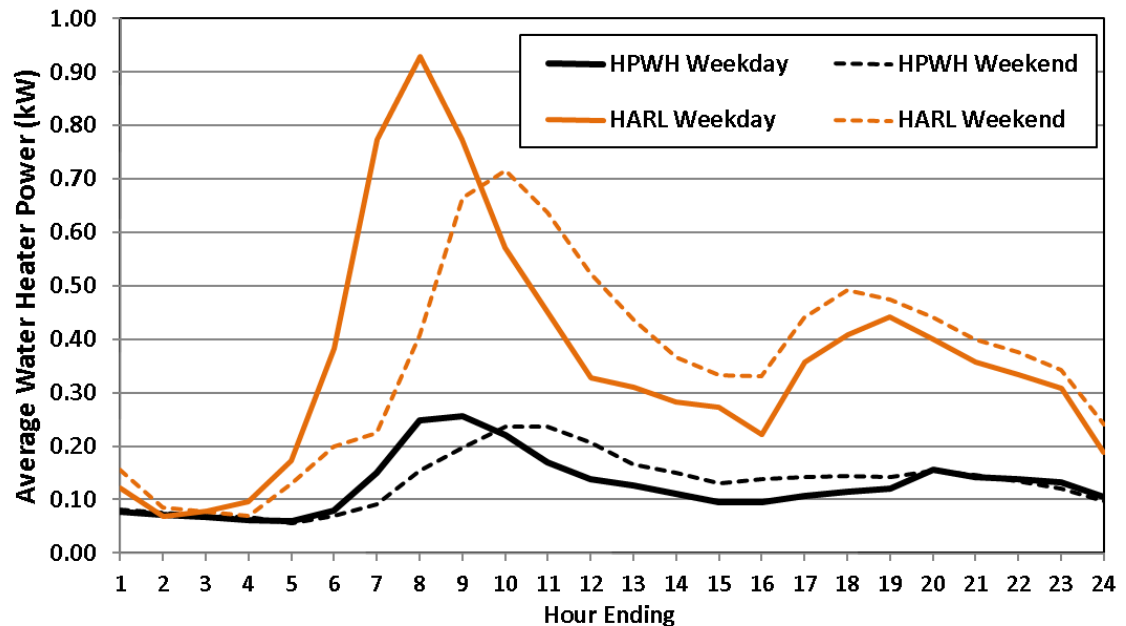
Field Study Results—draws

- Average water draws
 - 34.5 gallons (weekday),
 - 37.1 gallons (weekend)
- Diversity of draws is very high
- Winter draws 25% higher than summer (ground temp)
- Weekends 8% higher than weekdays



Field Study Results—energy use

- Draw pattern in the study was very similar to CEC HARL
- Lower peaks
- Approx one hour delay
- Average supply temp 122F



Average HPWH and HARL Power Profiles for Weekdays and Weekends

Field Study Results—Energy Use

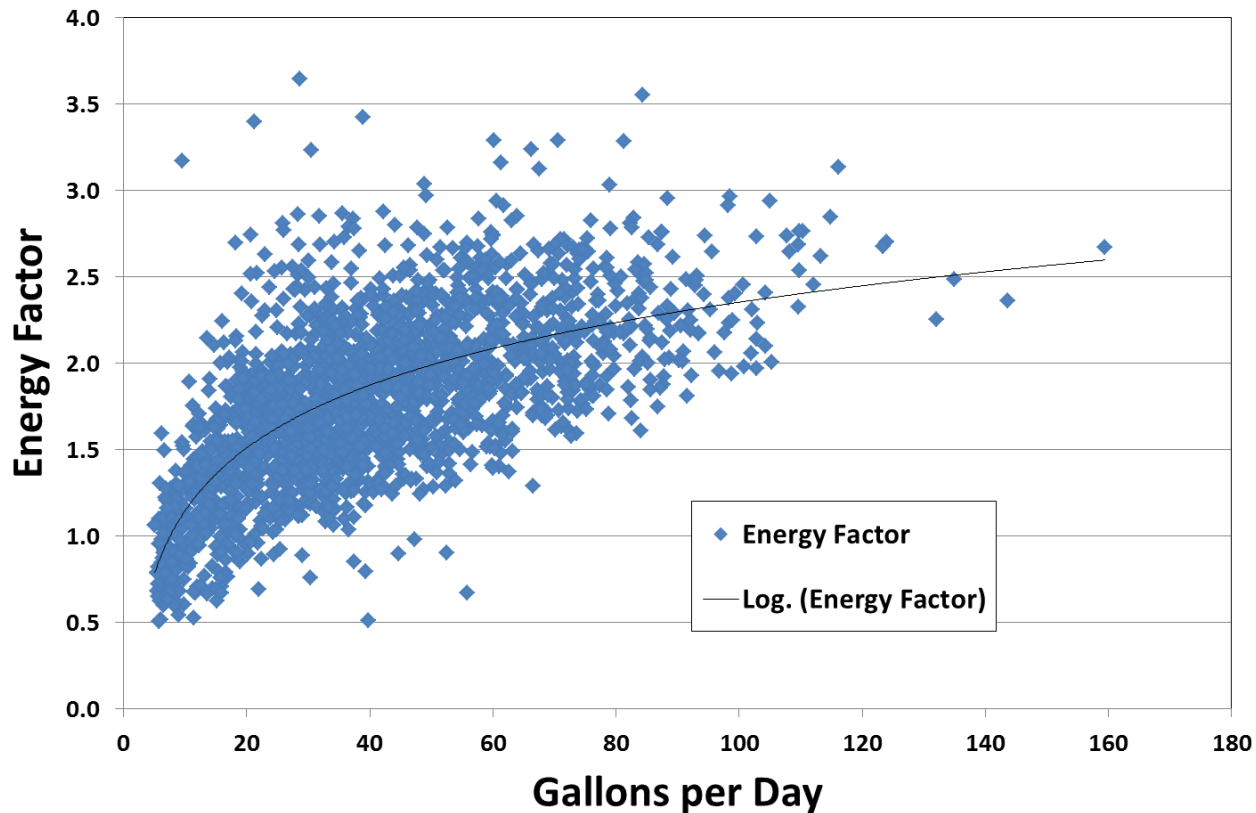
- Average “real world” Energy Factor 1.77
 - Nameplate EF of GE Geosprings in study was 2.40
 - EF on days with no resistance energy use was 1.84
 - Multivariate regression to DOE conditions estimated EF as 2.12
 - COP during heat pump use was 2.60
 - Standard deviation of daily EF 0.26
 - EF is higher when draws are higher
 - Homes with recirculation pumps had EF 0.77
 - Comparing 2.6 with 1.84 implies energy use is 29% higher due to storage losses, compared to “perfect” storage
 - Comparing 1.84 to 1.77 implies energy use is 4% higher due to electric resistance use, compared to heat pump only. A different analysis of the same data by ADM put this number at 14%.

Field Study Results—Energy Use

- Energy savings 52% (1,038kWh/yr)
 - Compared to estimated energy use of resistance water heater
- 4-8pm savings averaged 0.19kW
- Resistance element was used to deliver 8% of heat to water, heat pump delivered 92%.

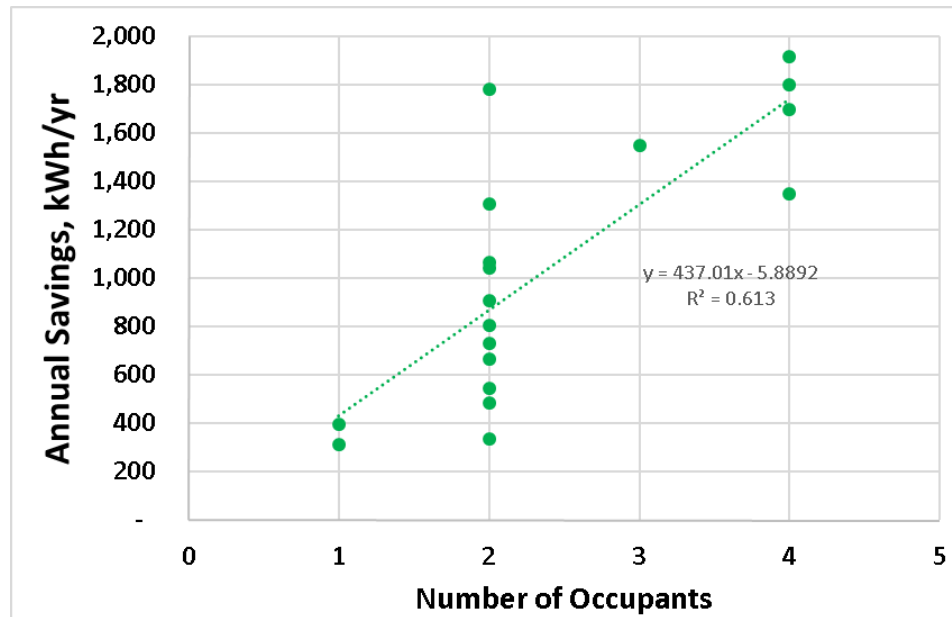
Field Study Results—EF vs Draw

Variation of Energy Factor with Draw



Energy factor is calculated on a daily basis

Field Study Results—program savings

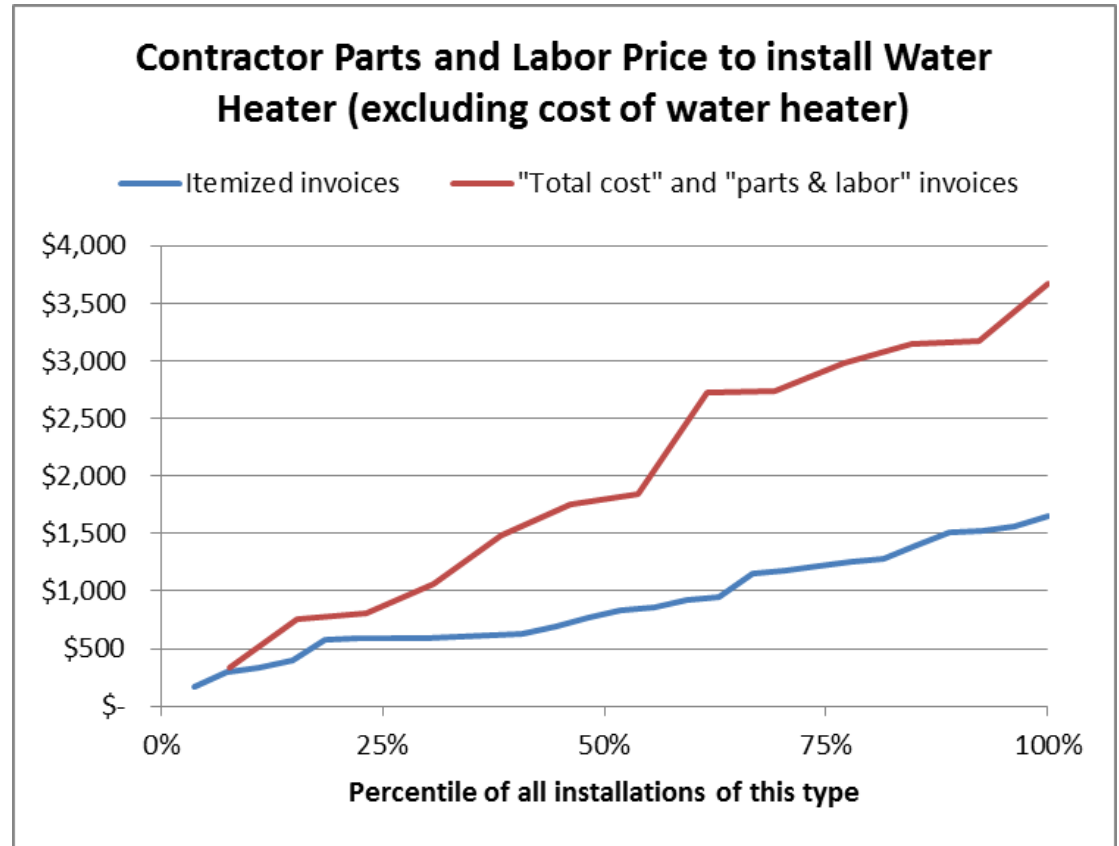


	Number of Occupants						Total
	1	2	3	4	5	7	
Savings per Home, kWh/yr	431	868	1305	1742	2179	3053	na

Baseline is electric resistance WH with $EF = 0.95 * (1.77/2.12)$

Cost Study Conducted by SMUD

- Average parts and labor excl. water heater was \$1,265. High variance.
- 60% contractor installs, 40% self-installs
- Average age of water heater being replaced 17.4 years
- We need more detailed cost data for electrification.



Cost Study—Payback

	Incremental cost of water heater	Incremental cost of labor	Total incremental cost	Simple payback (years)	Net present value (\$)
Self-install	-\$373	\$0	-\$373	0	\$1,753
Contractor install at \$1,265	-\$373	\$855	\$482	3.60	\$898
Contractor install at \$800	-\$373	\$390	\$17	0.13	\$1,363
Average across program	-\$373	\$397	\$24	0.18	\$1,356

Assumes: Electricity price \$0.13/kWh
15-year EUL for NPV
\$1,000 incentive (now \$1,500 for gas switching)

Greenhouse Gas Impacts

Simple 8760 model using HARL with no heating delays. Electric WH emissions will decrease over time as Renewable Portfolio Standard increases

Water Heater Type	Greenhouse Gas Emissions (kgCO ₂ e)	
	At 2.4 nameplate EF	At 3.5 nameplate EF
Tankless gas (0.82 EF)	576	
Gas storage (0.62 EF)	994	
Electric Resistance (0.95 EF)	962	
Heat pump	396	271

Assumes marginal GHG emissions off/peak/super are 525/695/865 lb₂CO₂/MWh
Assumes that all storage water heaters experience the same derating of EF due to “real world” storage conditions

Current R&D Work

- HPWH automatic scheduling study
 - GE Firstbuild
 - Virtual Peaker

