

Impacts of Flexible Demand Events by Residential Heat Pump Water Heaters in San Joaquin Valley

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Field Evaluation Objectives

- Evaluate the impact of JA13 Flexible Demand (FD) strategies—Light Shed (LS) and Deep Shed (DS)—on peak electric demand, hot water performance, and customer bills by comparing FD event days to non-FD Control days.
- FD Strategy Definitions (JA13)
 - **Light Shed:** The System will defer complete recovery for the duration of the shed event unless user needs cannot be met; The water heater shall avoid use of electric resistance elements **during and immediately** after the event unless user needs cannot be met;
 - **Deep Shed:** same as Light Shed, but the System will completely avoid use of electric resistance elements during the event; and
 - **Full Shed:** *same as Light Shed, but the System will completely avoid use of both compressor and electric resistance element during the event.*

JA 13 Control Flexible Demand Strategy

- **Basic Load Up:** The System will store extra thermal energy without exceeding the user set point temperature. It will avoid use of electric resistance elements unless user needs cannot be met.
- **Advanced Load Up:** The System stores extra thermal energy, where some or all of the tank may exceed the set point temperature chosen by the user, within safe operating conditions... It will avoid use of electric resistance elements unless user needs cannot be met.

Site Info & FD Event Schedule

- Ten Heat Pump Water Heaters Occupied Residential Homes in San Joaquin Valley
- Two HPWH Models by Two Manufacturers
 - Model A – 6 Units
 - Model B – 4 Units
- Testing Schedule over Two Months

FD Event Type	M	T	W	Th	F	S	S
Light Shed	9/8	9/9	9/10	9/11	9/12	9/13	9/14
Deep Shed	9/15	9/16	9/17	9/18	9/19	9/20	9/21
Alternate LS and DS	10/20	10/21	10/22	10/23	10/24	10/25	10/26

- Data Sample Rate: 1 min., kW, gpm, temp, etc.

Key Observations

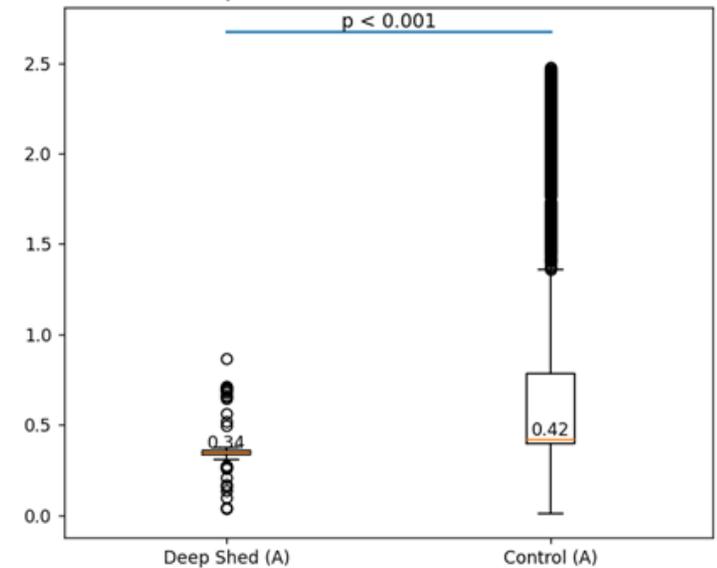
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Flexible Demand Impacts of Light Shed and Deep Shed Events

Group A (6 HPWHs)	4 - 9 p.m. Only (Average Values)		
	15min-Demand (kW) ⁵	Avg. kW per Heating Cycle (kW)	Operation (min)
Baseline	0.386	0.390	53
Light Shed	0.375	0.376	83
Deep Shed	0.341	0.339	45

Group B (4 HPWHs)	4 - 9 p.m. Only (Average Values)		
	15min-Demand (kW)	Avg. kW per Heating Cycle (kW)	Operation (Min)
Baseline	0.506	0.519	126
Light Shed	0.647	0.891	131
Deep Shed	1.368	1.835	153



- Modest Demand Reduction Observed (Model A, 4 – 9 pm only)
 - LS: 11 Watts (Average) DS: 45 Watts (Average)
- Aggregate and Difference ~ Avg. 80 Watts Demand Reduction for DS Events
- **Model B does not appear to implement JA13 event response requirements properly.**

Coincident Operating Probability

No. of Heat Pumps On	24.hr Window	4-9 p.m. Window
0	22%	19%
1	33%	25%
2	23%	22%
3	12%	17%
4	5%	10%
5	2%	5%
6	1%	1%
7	0%	1%
8	0%	0%
9	0%	0%
10	0%	0%

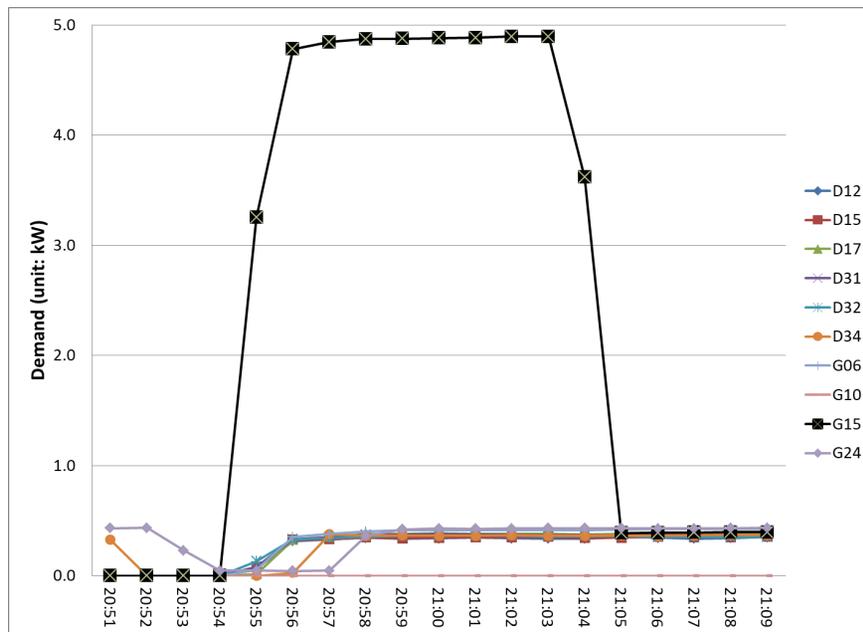
- Estimation of flexible demand potential should account for Coincident Operating Probability

Simple Bill Savings for FD Events – Model A Only

Events	15min-Demand (kW)	Operation (min)	TOU-D 4 – 9 p.m. (\$/kWh)	Bill (\$)
Baseline	0.386	53	0.59	0.20
LS	0.375	83		0.31
DS	0.341	45		0.15

- Approximately \$0.05 savings per DS Event
 - For LS, negative bill saving due to extended operating hours
- *Note: The simplified bill impact analysis for Model B was not performed, as there were no apparent benefits from participating in FD events.*

Snapback or Recovery

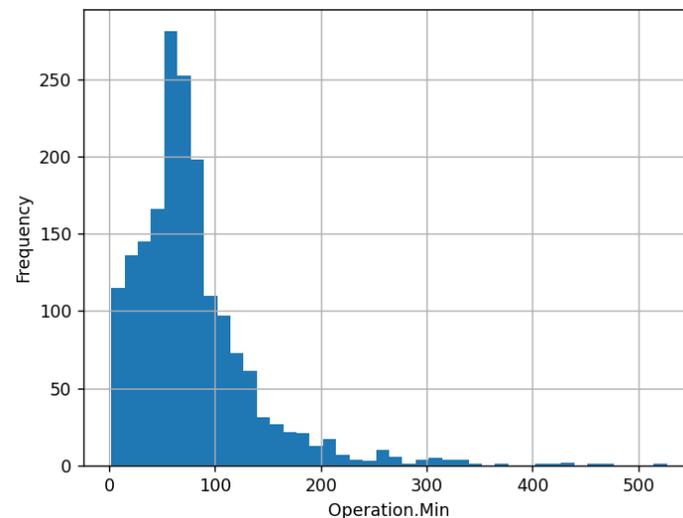


- Example – After an LS event, 8 HPWHs initiated “snapback” or “recovery” operation almost immediately after the LS event.
 - More impacts on the Grid compared to normal operations
 - One unit activated the electric resistance heating, about 5 kW demand (for 11 minutes).
 - Similar behaviors were observed on all FD events.

Other Findings

- **Average Heating Cycle Per Day**
 - 3 heating Cycles per Day
 - 91 heating Cycles per Month
- **Overall Peak Demand** (10 HPWHs)
 - 8.7 kW
 - Model A only: 0.496 kW
- **Coincident Factor:** 0.47
- None of the participants reported running out of water during FD events.

- **Average Heating Cycle Duration**
 - 78 Min \pm 59 min (wide variations)



Recommendations

- Limited dataset (only 10 homes observed); similar methods should be applied with larger samples to reach definitive conclusions
- Pilot study needed with a significantly larger participant base
- JA 13 compliance: Additional laboratory studies required on HPWH logic controls during FD events
- Address and mitigate “snapback” impacts on the grid
- Evaluate cost of implementing CTA-2045 modules relative to customer bill savings
 - Low-cost (“\$1”) connectivity solution needed
 - High-efficiency and heat-pump-mode-only units may not need to participate in LS or DS events
- Consider temperature modulation strategies (e.g., 120°F–140°F before peak periods; 115°F during overnight/sleeping hours)