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Commercial Heat Pump Water Heater

Lab Evaluation of 120-Gallon Integrated Unit

EPRI ELECTRIC POWER RESEARCH INSTITUTE

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Project Objectives

- Evaluate the performance of a new-to-market commercial HPWH and its ability to provide hot water more efficiently
  - Lab testing in a controlled environment
  - Evaluate heating capacity, efficiency, and hot water delivery temperature across a range of test conditions
  - Verify standard metrics published by the manufacturer

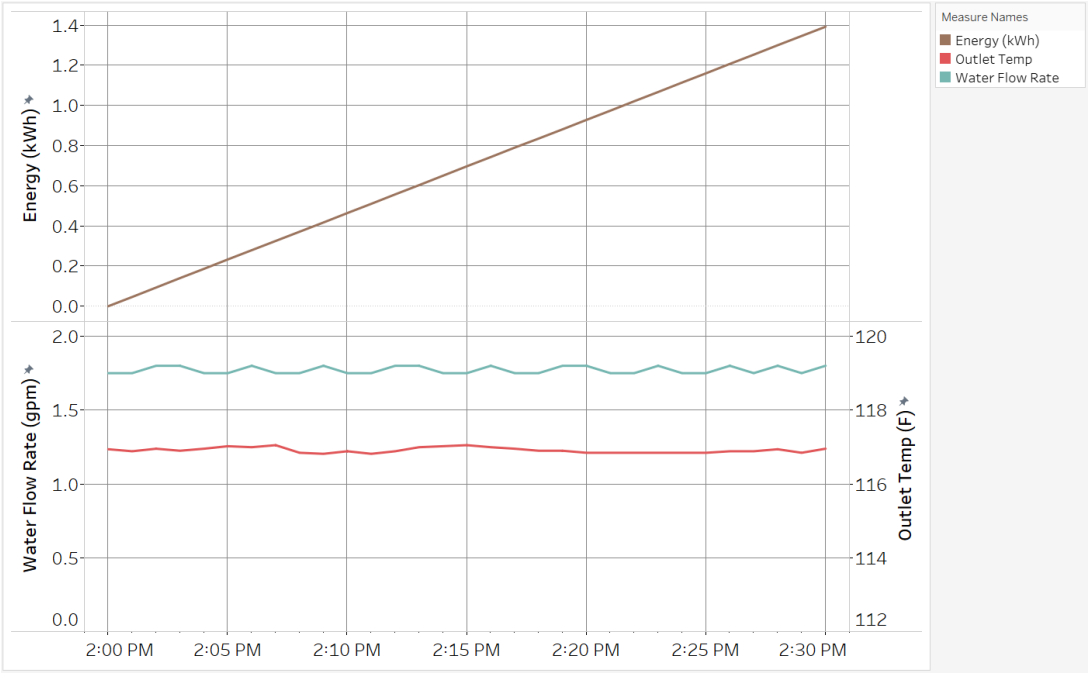
Product Overview

- 120-gallon integrated system
- 208/240 VAC, 1 phase, 80/90 amps
- 2.35 kW compressor/fans
- 12 kW electric resistance elements (2 @ 6 kW each)
- Coefficient of Performance (COP) = 4.2
- First Hour Rating (FHR) = 150 gallons
- Refrigerant 134a (3.3 lb)
- **3 control modes**: Efficiency, Hybrid, Electric-Only
- Maximum water temperature
  - 150°F in Efficiency and Hybrid modes
  - 180°F in Electric mode
- Light commercial applications 100-600 gallons per day (e.g., quick-service restaurants, schools, retail buildings, etc.)

DOE 30-minute COP Test Results

- Measured COP = 4.35
- Manufacturer's documentation indicates 4.2 COP

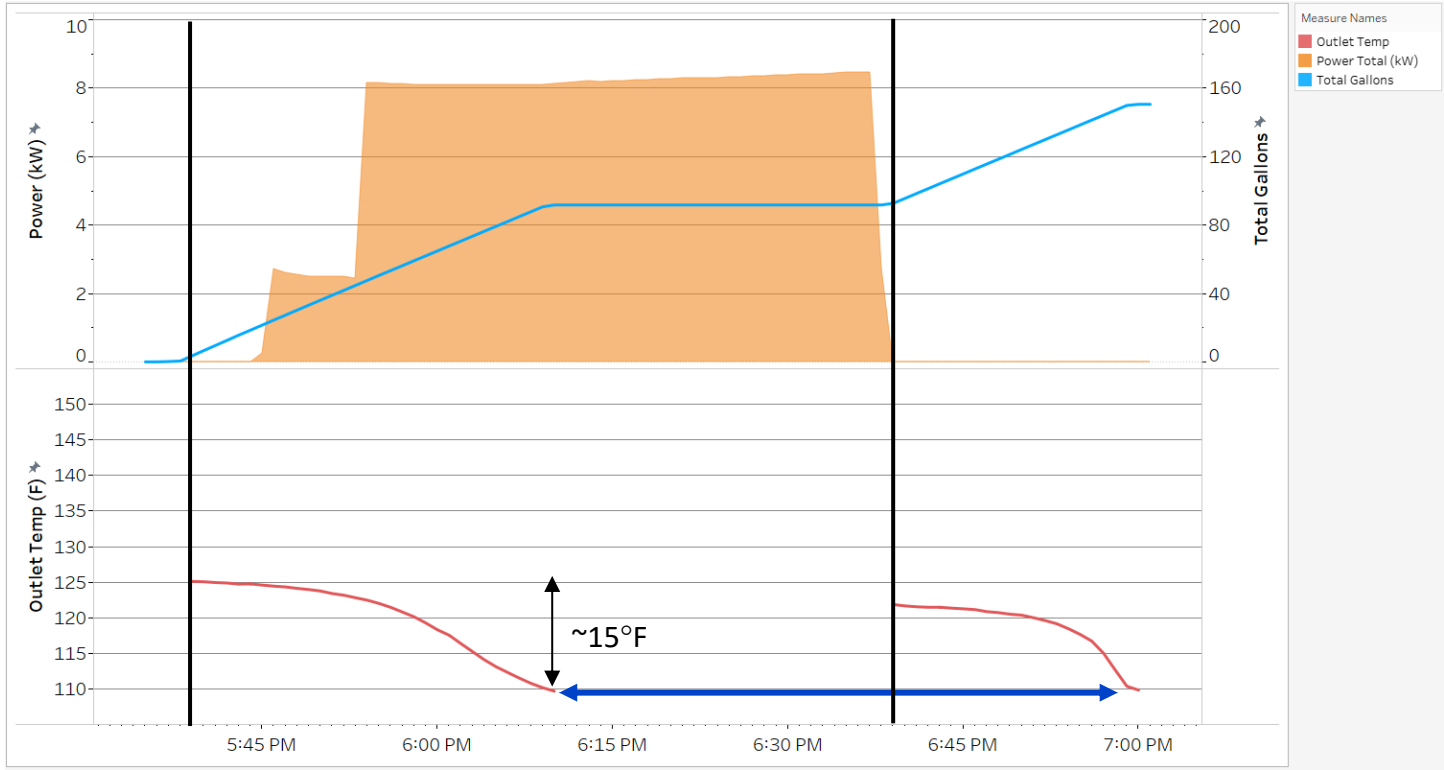
Parameter	Value
Flow Rate (gpm)	1.75
Outlet temperature (°F)*	117
Heat Delivered (BTU)	20,651
Electricity Consumed (kWh)	1.392
COP over 30-min test	**4.35**



*Test requires outlet water temperature of 120°F ± 5°F, and outlet temperature must not change by more than 2°F over a 3-minute period. Inlet water temperature of 70°F ±1°F.

First Hour Rating (FHR) Tests

- FHR is <u>not</u> required by DOE for *commercial* heat pump water heaters
- Replicated FHR test for residential HPWHs to compare with manufacturer claims



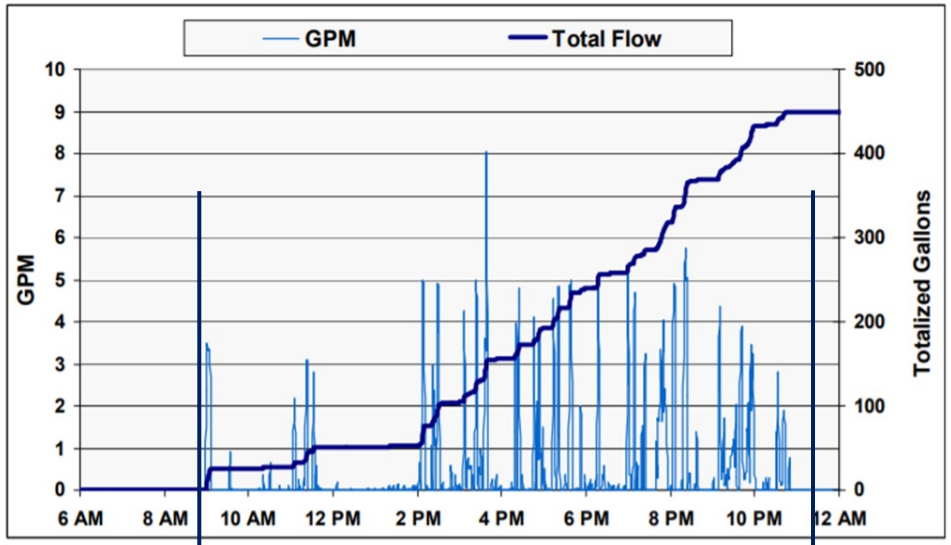
FHR Test Results

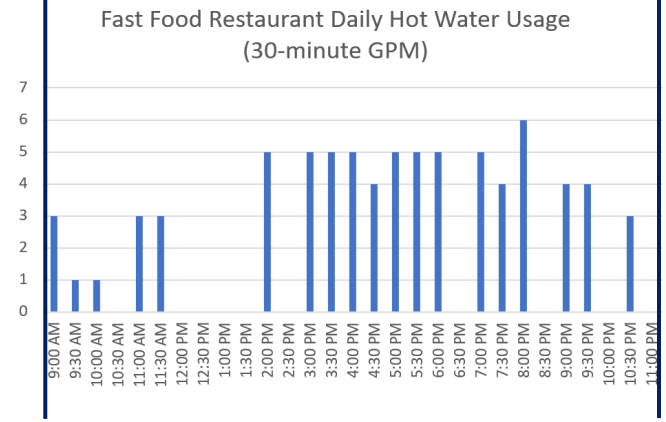
- DOE Residential FHR Test: 151 gallons (manufacturer claim 150 gallons)
- Slightly warmer inlet water and ambient conditions used in DOE's COP test (80°F/63% RH) yielded higher FHR of 168 gallons
- California quick-service restaurant (QSR) application:
  - Higher setpoint and water flow rate at average CA inlet water temp yielded FHR of 141

Tank Setpoint	Ambient Air	Inlet Water	Water Flow Rate	Measured FHR
120°F	68°F/50% RH	58°F	3 gpm	151
120°F	80.6°F/63% RH	60°F	3 gpm	168
140°F	80.6°F/63% RH	63°F	6 gpm	141

Average Efficiency for Quick-Service Restaurant Application

- DOE does not define a Uniform Energy Factor (UEF) test for commercial HPWHs
- Developed a 14-hour load profile from measured hot water usage from QSR in California, 450 gallons per day
- Conducted test with range of inlet water temperatures
- Tests completed with HPWH in hybrid mode and efficiency mode





Test Results for Quick-Service Restaurant Application

Tank Setpoint	Ambient Air	Operating Mode	Inlet Water Temp	Gallons Below Setpoint	Peak Demand	Measured Average COP
140°F	80.6°F/63% RH	Hybrid	52°F	42	9.0	2.66
		Hybrid	63°F	12	9.0	2.60
		Hybrid	74°F	0	9.0	2.72
		Efficiency	63°F	63	3.4	3.43

- Average COP is *hybrid* mode 2.6-2.72 (2.7 - 2.9x more efficient than resistance @ 0.95)
- Gallons below setpoint is small for 63F and 74F inlet water temps in *hybrid* mode
- Efficiency mode has highest COP, but 15% of hot water load delivered below setpoint temp

Summary of Results

- Measured COP near manufacturer's claim (4.35 measured vs. 4.2 claim)
- FHR is **not** a required performance metric for commercial HPWHs:
  - Test using residential HPWH procedure for FHR confirmed manufacturer claim of 150 gallons
  - For typical QSR conditions, FHR was measured at 141 gallons
  - FHR increases with increasing surrounding air temperature and humidity
  - FHR decreases with higher tank setpoint temperature
- 14-hour hot water draw test (quick-service restaurant, 450 gallons/day, hybrid mode):
  - **Integrated COP of 2.72** with 74°F inlet water temperature
  - **Integrated COP of 2.60** with 63°F inlet water temperature
  - COP reduced when electric resistance is used to assist with quick recovery from large hot water draws
- Delivered air cooling can help in kitchen applications

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