How well does laboratory performance of heat pump water heaters represent field performance?

Jim Lutz (jdlutz@hotwaterresearch.net)
Jim McMahon (jim@betterclimate.info)
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The Future of HPWH Equipment Modeling

Overview of DOE test procedure for residential heat pump water heaters (HPWHs)

REPRESENTATIVE:

- "Test procedure …shall be reasonably designed to produce test results which measure **energy efficiency**…**during a representative average use cycle or period of use** and not be unduly burdensome to conduct." *(emphasis added)*

KEY VARIABLES

- **Dry-bulb air temperature 67.5F +/-5F**
- **Relative humidity 50%+/-5%**
- **Supply water temperature 58F +/-2F**
- **Outlet water temperature 125F +/-5F**
- **Draw patterns**

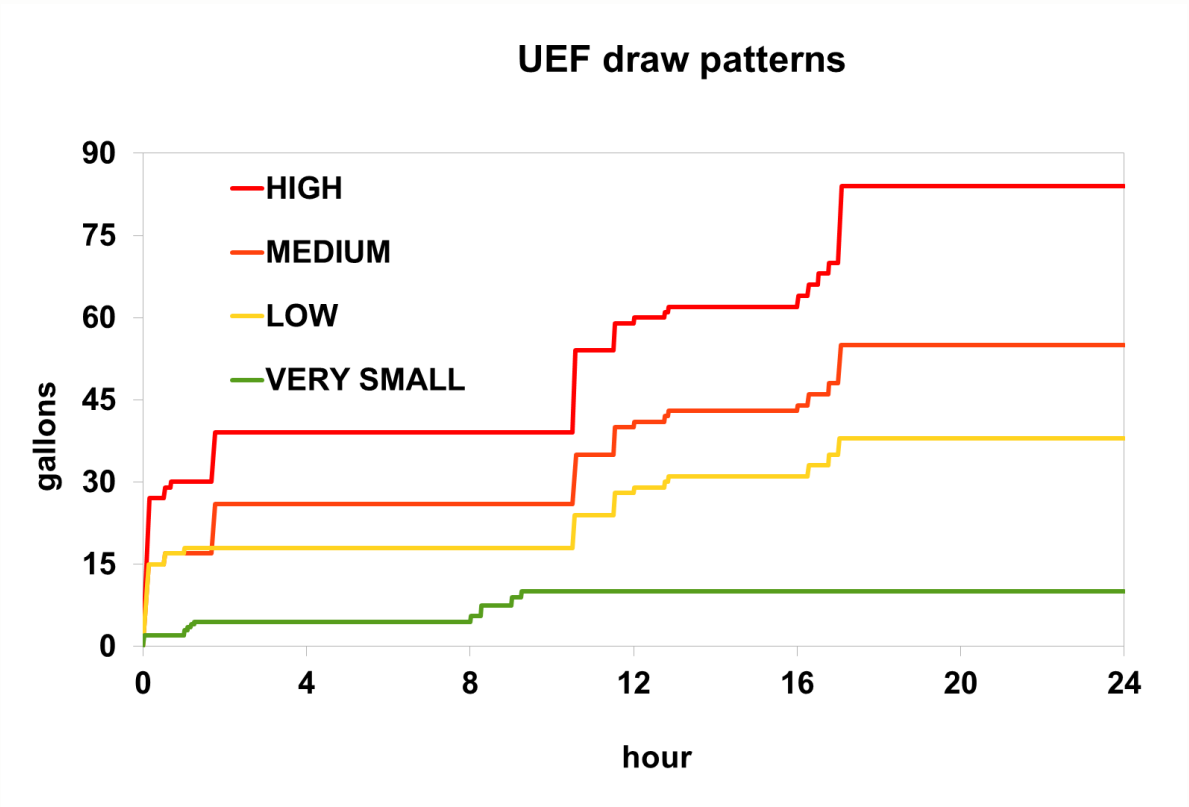
- **RESULT: Uniform Energy Factor from 24-hour simulated energy use**

DOE DRAW PATTERNS

- Y= DRAW VOLUME (gallons)
- X = TIME OF DRAW

Gallons per day bin	volume	draws
high	84	14
medium	55	12
low	38	11
very small	10	9

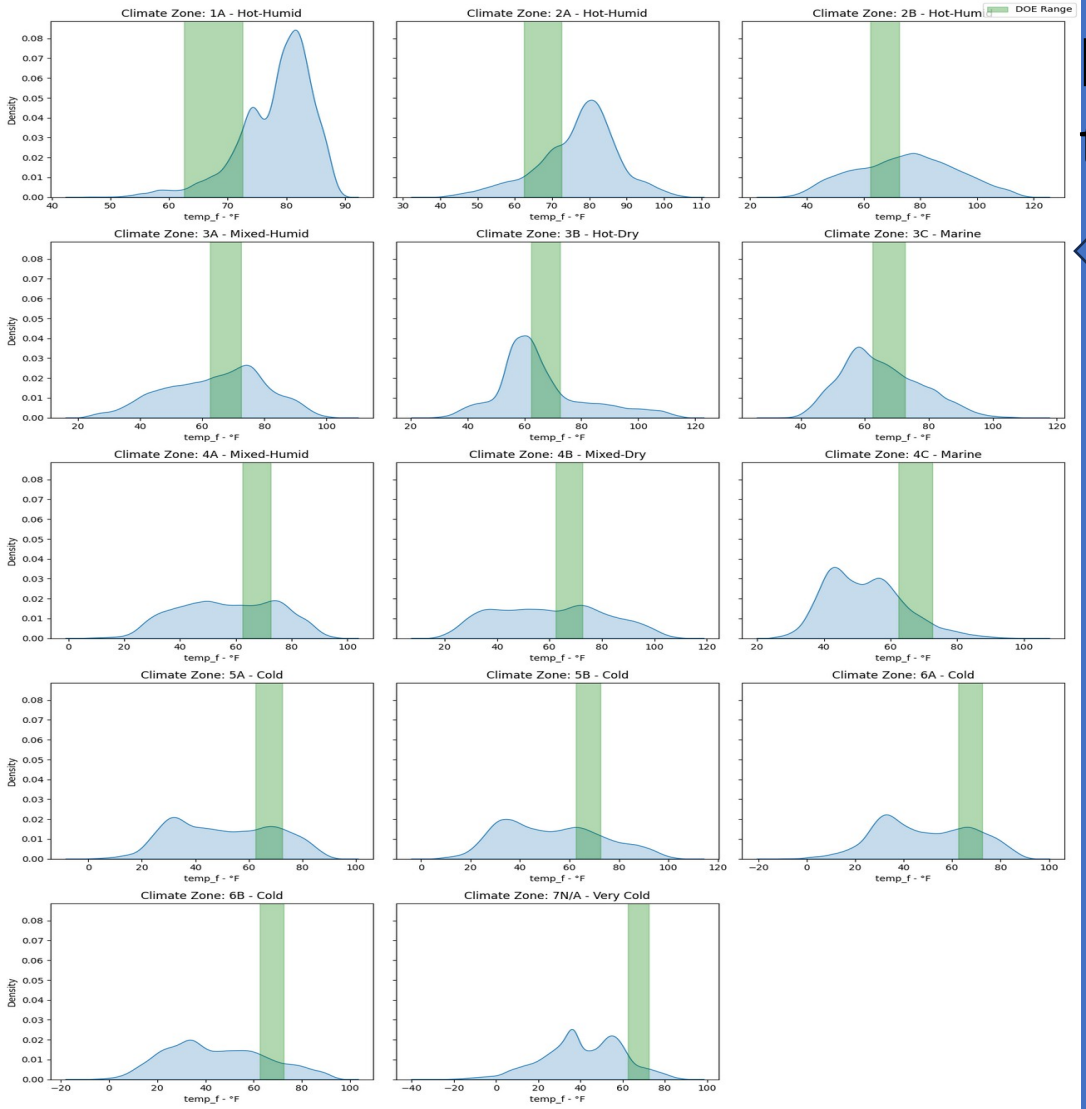
The hot water draw pattern is assigned based upon how much hot water the water heater can provide in one hour (First Hour Rating).



Hours by ambient air temperature (F) and humidity by climate zone

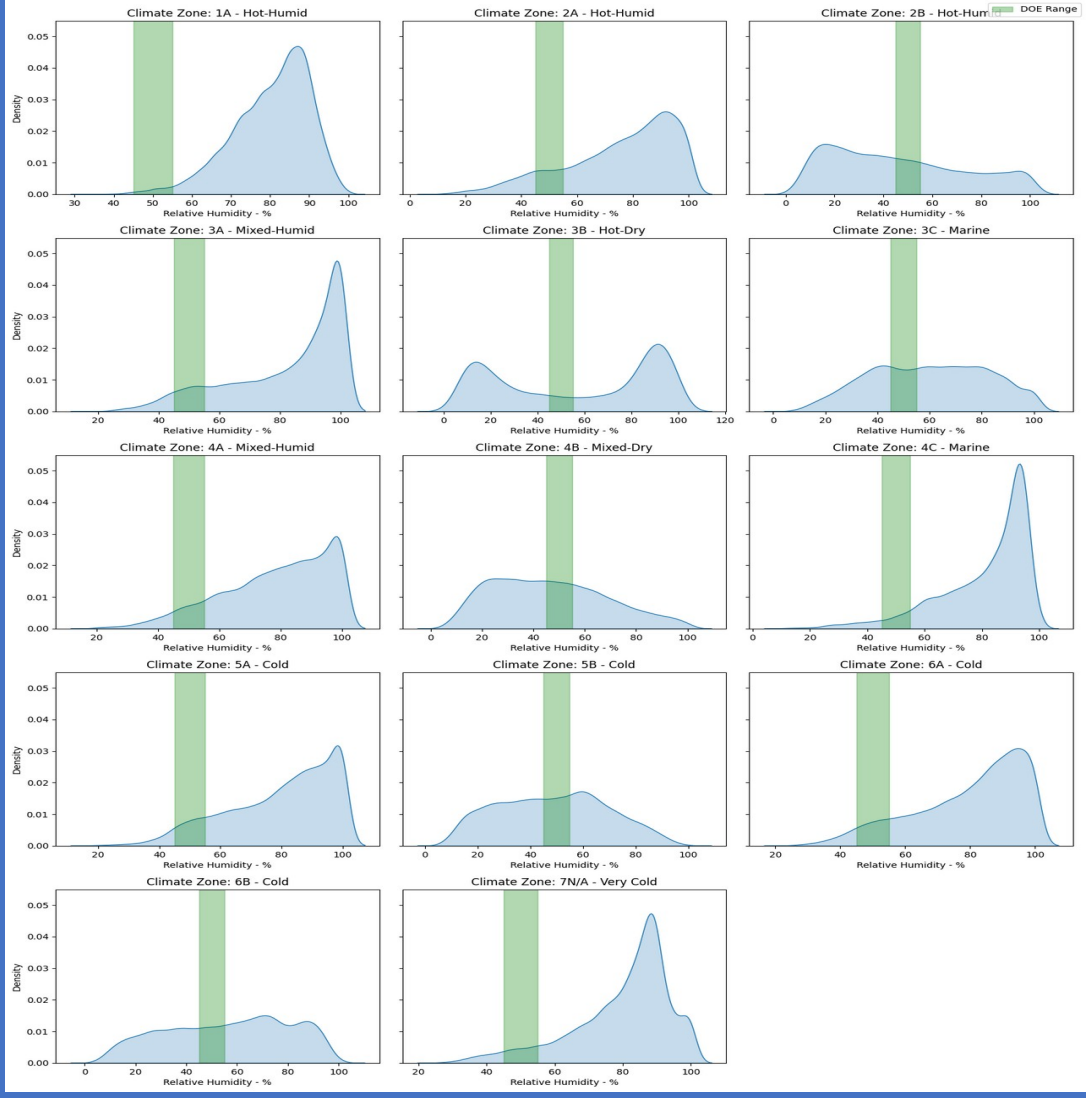
GREEN = test conditions

(PRELIMINARY: one city and year per zone)



Hourly temperature

Relative humidity



PROPOSED EVALUATION OF REPRESENTATIVENESS

METHOD

- Generate a representative national sample of residential households
- Generate hot water draw patterns for each household
  - By fixture or appliance
  - Time, duration, and flow rate
- Simulate HPWH energy to calculate daily COPs

TOOLS

NREL ResStock based on RECS and Energy Plus

Probabilistic hot water events for 365 days based on field studies

HPWHsim in CSE

- RESULT: Compare daily COPs to tested Uniform Energy Factor
- What proportion of HPWH days are represented by test?