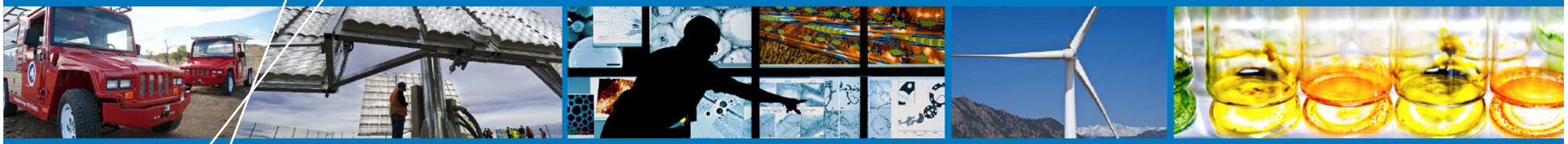
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Regional Variation in Residential Heat Pump Water Heater Performance in the US



Jeff Maguire

4/30/13

Outline

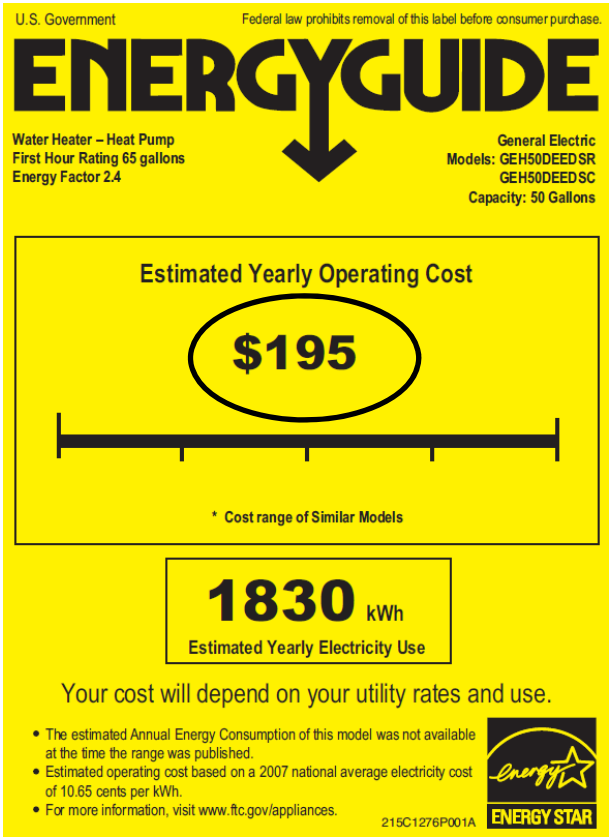
- **Why HPWHs?**
- **US Water Heating Market**
- **Overview of HPWHs**
- **Model Description**
- **Results**
  - HPWH Performance
  - Energy Savings Potential
  - Breakeven Cost

Heat Pump Water Heaters

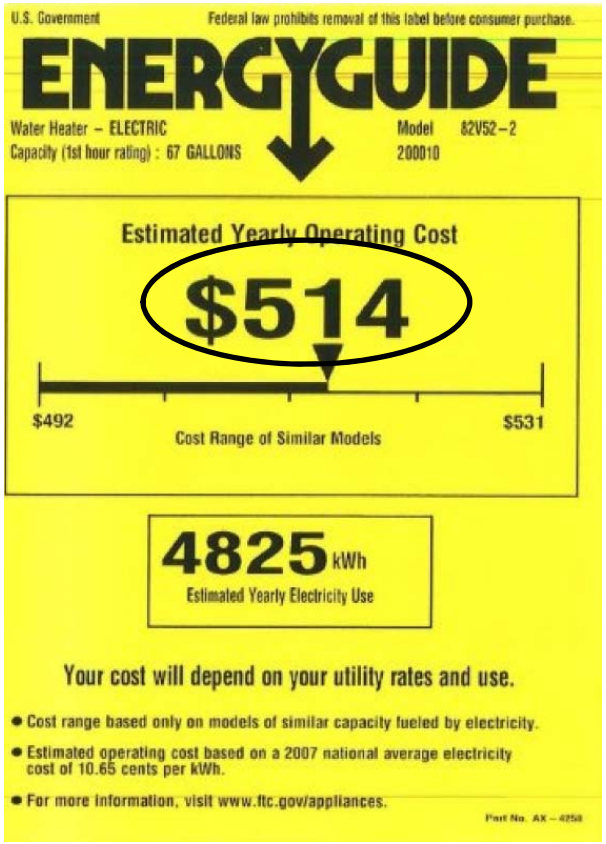
Save **$300** a year over standard electric?

Save **$100** a year over standard gas?

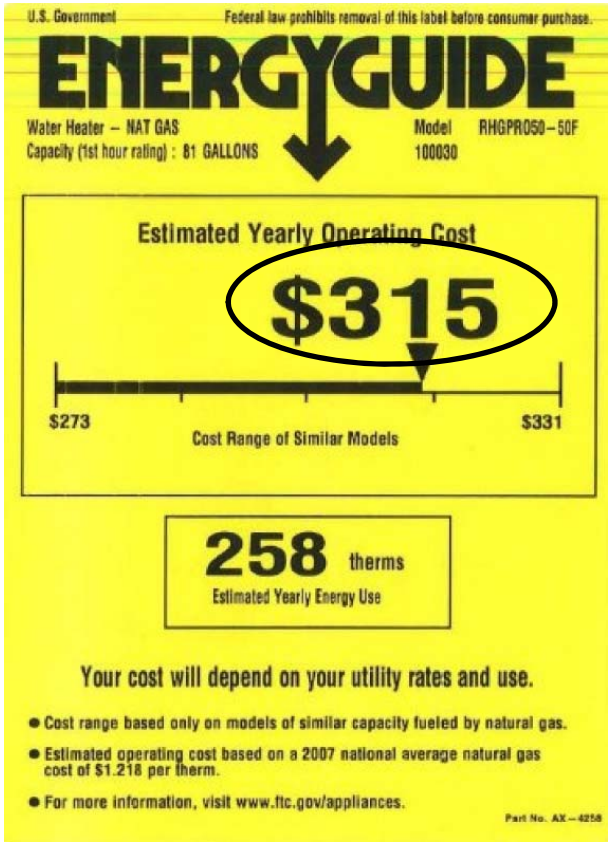
Heat Pump



Electric



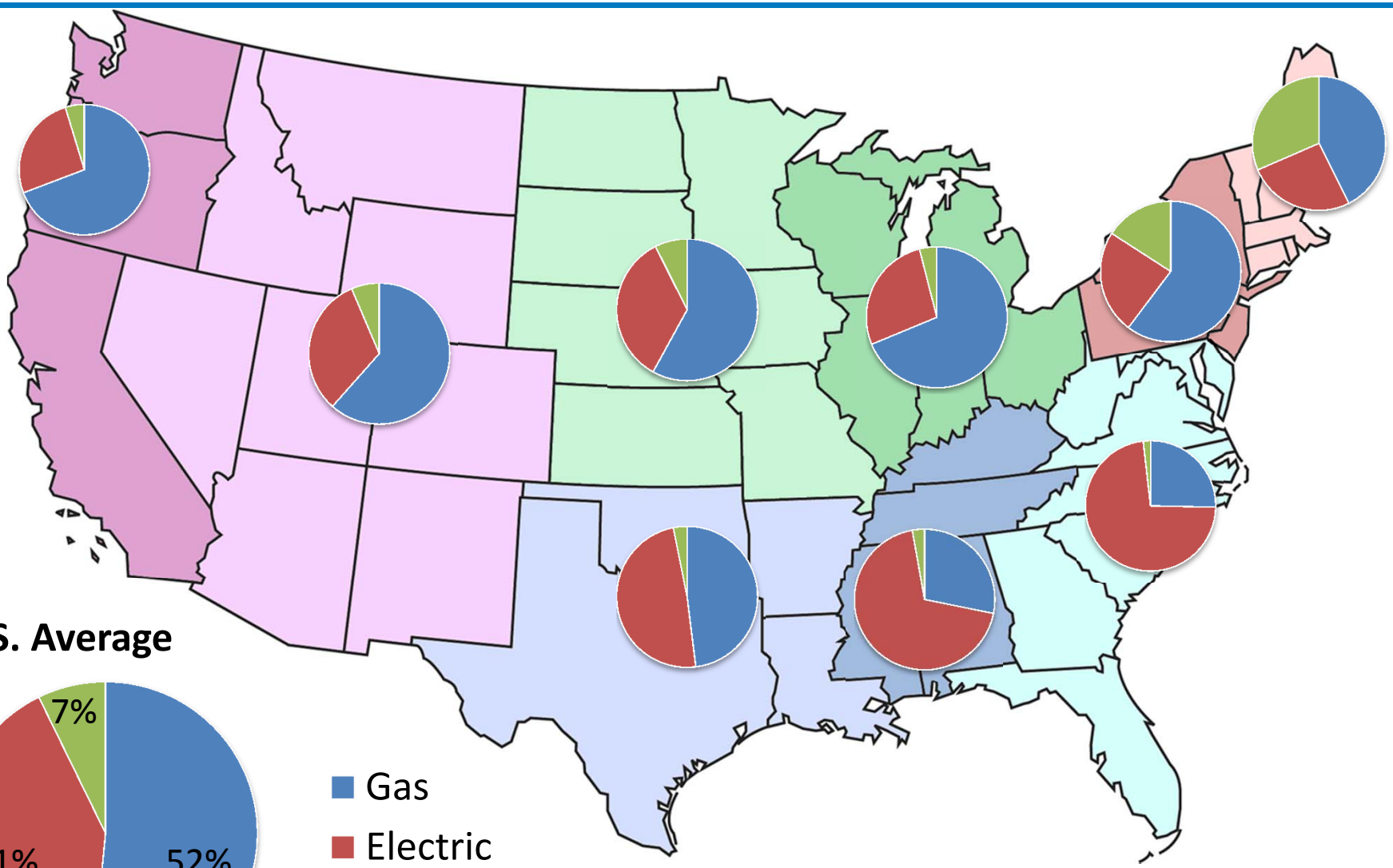
Gas



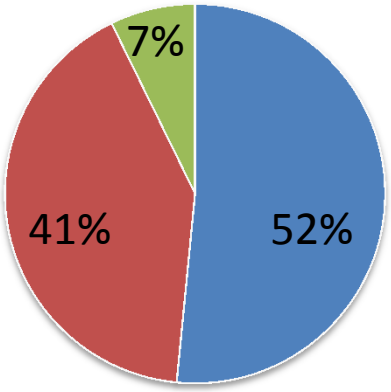
Questions about HPWHs

- **Are HPWHs a good replacement for typical gas and electric storage water heaters?**
  - In different locations across the country?
  - In conditioned/unconditioned space?
  - Source energy savings?
  - Cost effective?

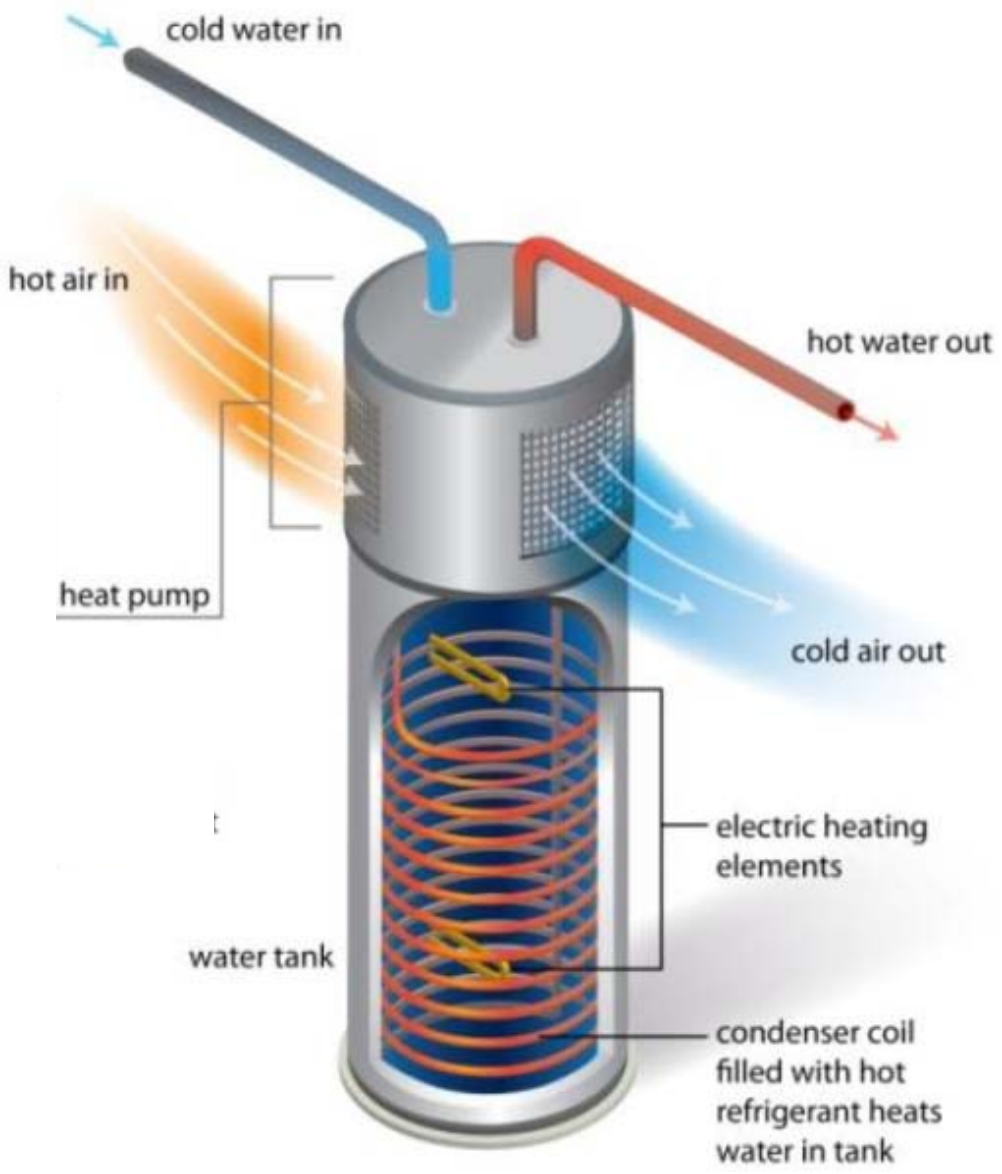
Current U.S. Water Heating Market



U.S. Average



Heat Pump Water Heater

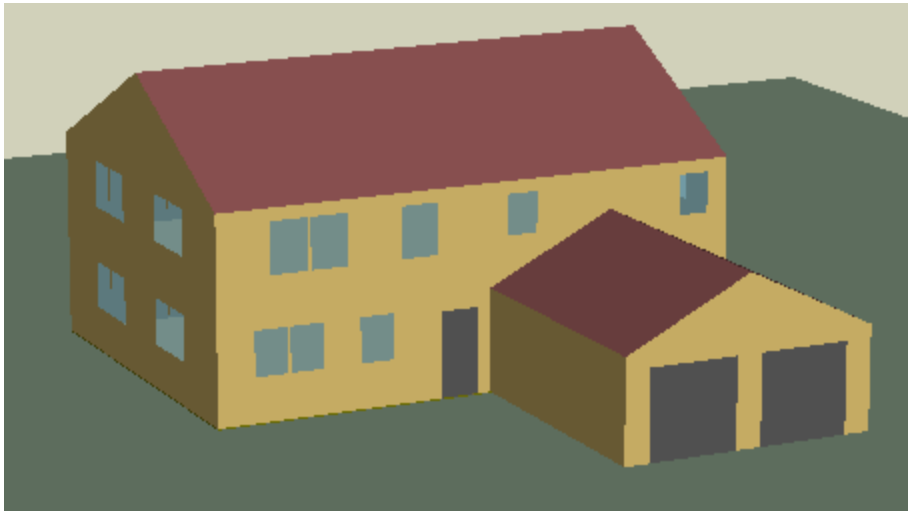


HPWH Models

- **Based on NREL lab testing**
  - 2 manufacturer's HPWH (50 & 80 gallons)
  - Manufacturer specific models (control logic, heat pump performance, ect.)

Annual Simulations: Building Model

- **2500 ft^2 2 story home with attached garage**
- **BA Benchmark-ish home**
- **Foundation consistent with regional building practices**
  - "Unconditioned Space" defined as the basement if a home had one, garage otherwise
- **3 sets of space conditioning equipment:**
  - ASHP
  - Furnace/AC
  - Electric Resistance Heat/AC



HPWH Annual Simulations: Foundations

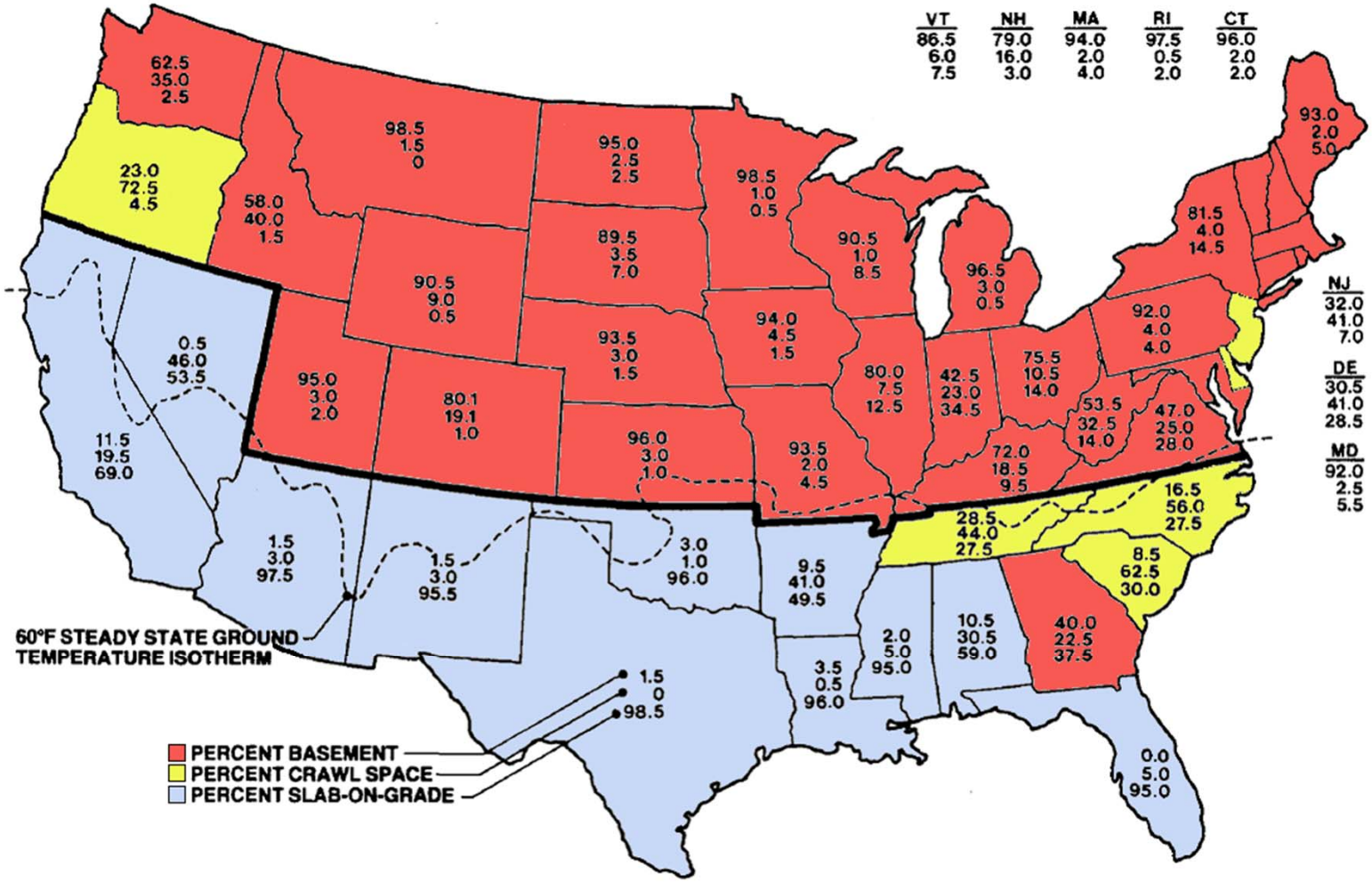


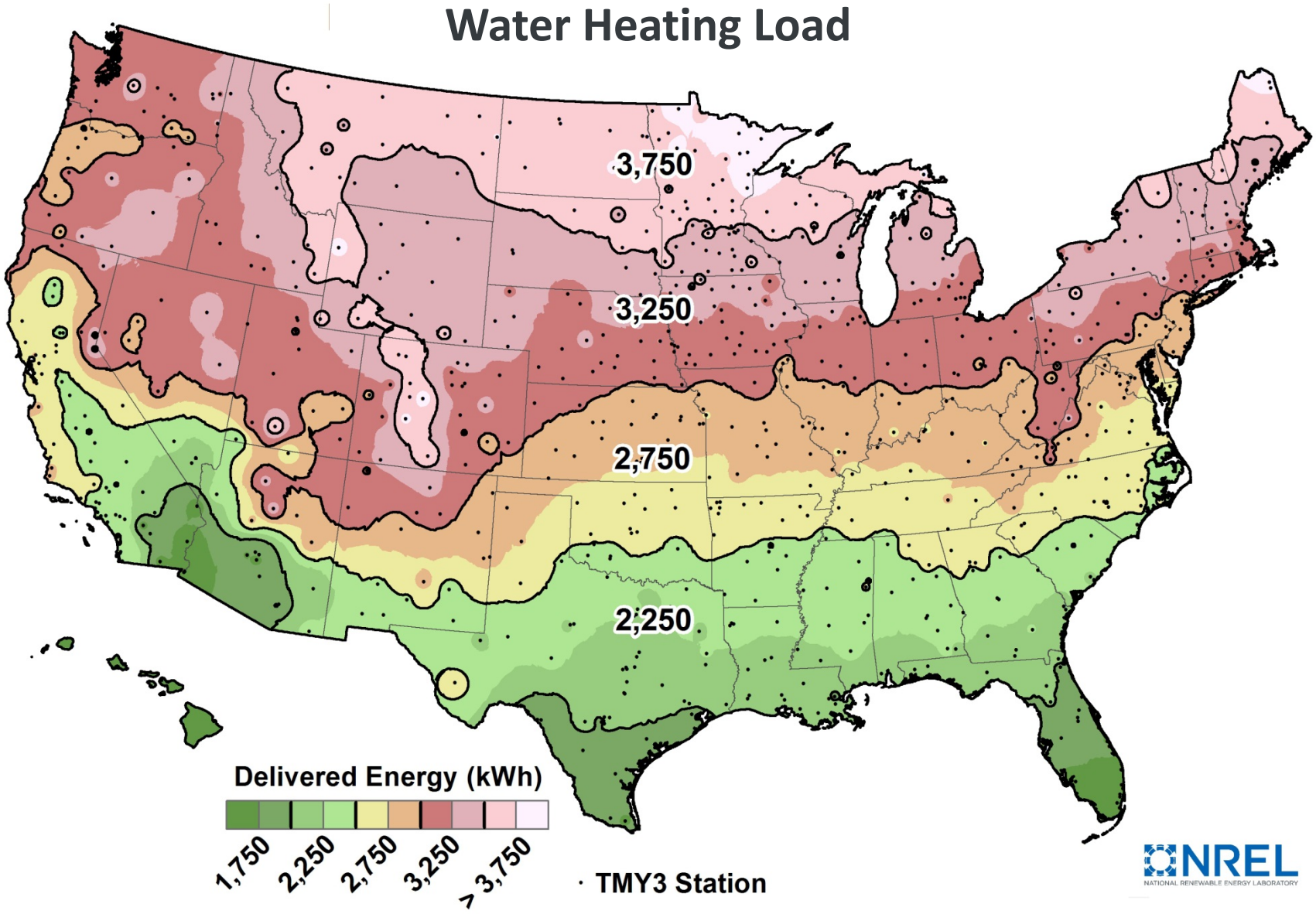
Figure 1-3: Estimated Share of Basement, Crawl Space, and Slab Foundations by State (1979-1983)

**Source: "Building Foundation Design Handbook", K. Labs et al, ORNL, 1988*

HPWH Annual Simulations: Hot Water Usage

- **“Average” hot water use**
  - 45-60 gal/day, from DHWESG
  - Includes hot and tempered draws
- **120 °F set point for all WHs**
- **105 °F mixed draw temperature**
- **Normalization energy used to account for outlet temperature sag below a useful temperature**
  - For all water heaters

Water Heating Load



HPWH Annual Simulations: Metrics

- **System COP:**

$$COP_{sys} = \frac{E_{del}}{E_{cons}}$$

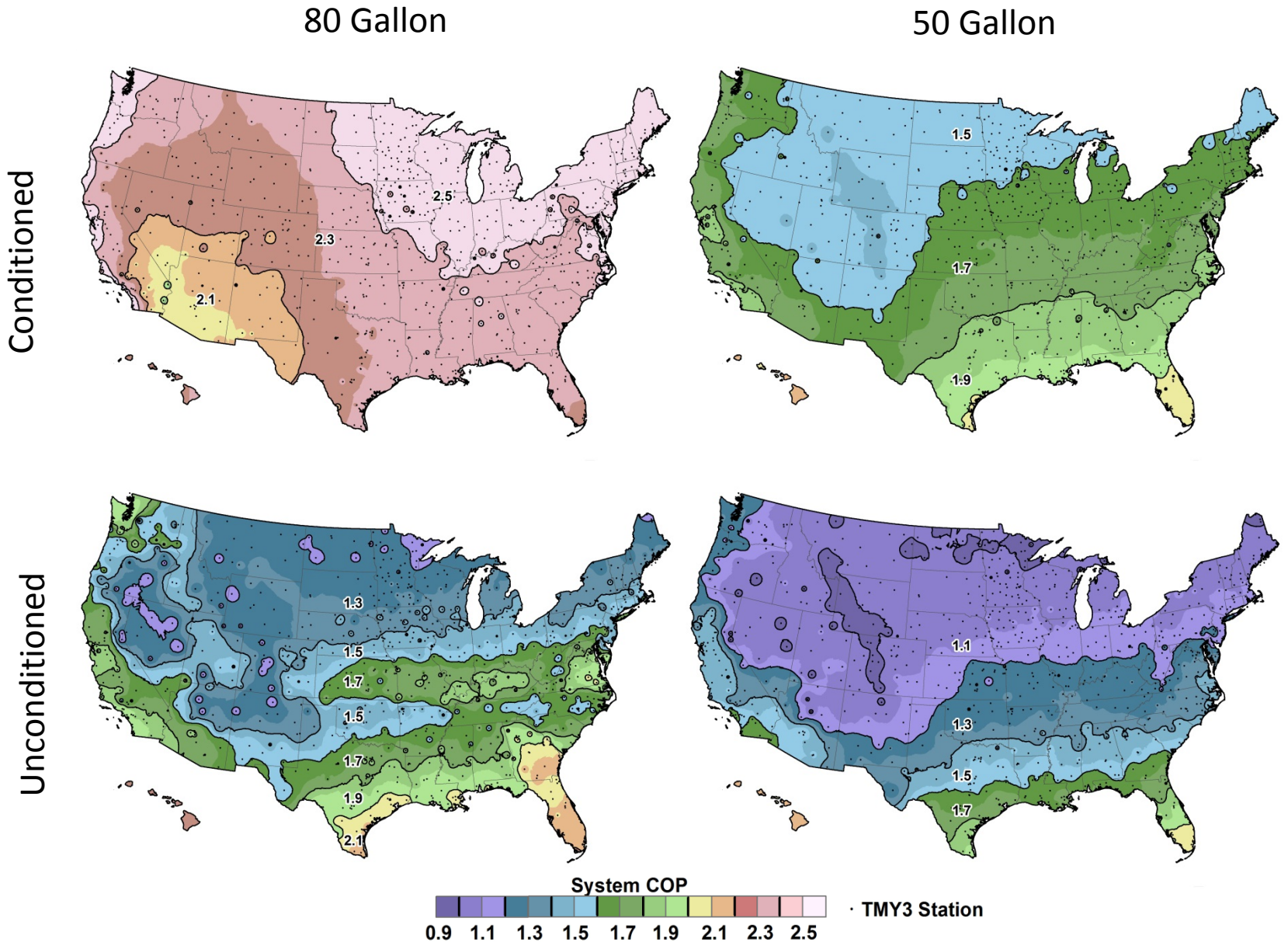
  - System COP is an efficiency metric that can be directly compared to the rated performance (EF)

- **Source Energy Savings:**

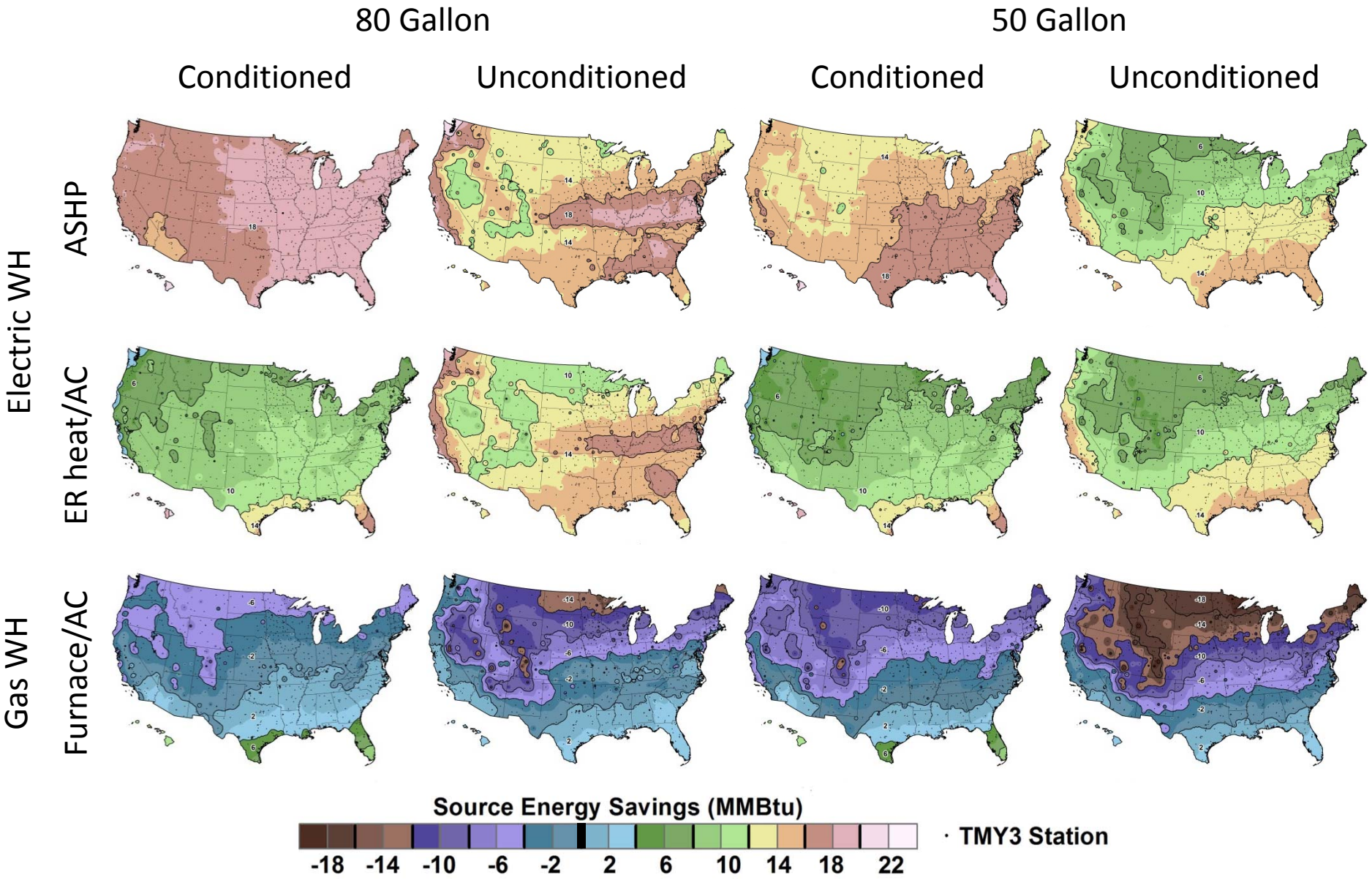
$$E_{saved} = \Delta E_{WH} + \Delta E_{nrmlz} + \Delta E_{heat} + \Delta E_{cool}$$

  - Source energy savings provides a fairer comparison for fuel switching scenarios

HPWH Results: System COP (efficiency)



Source Energy Savings



HPWH Economic Analysis

- **Economic analysis was done using breakeven cost.**
- **Breakeven is HPWH net installed cost where:**

NPB = NPC

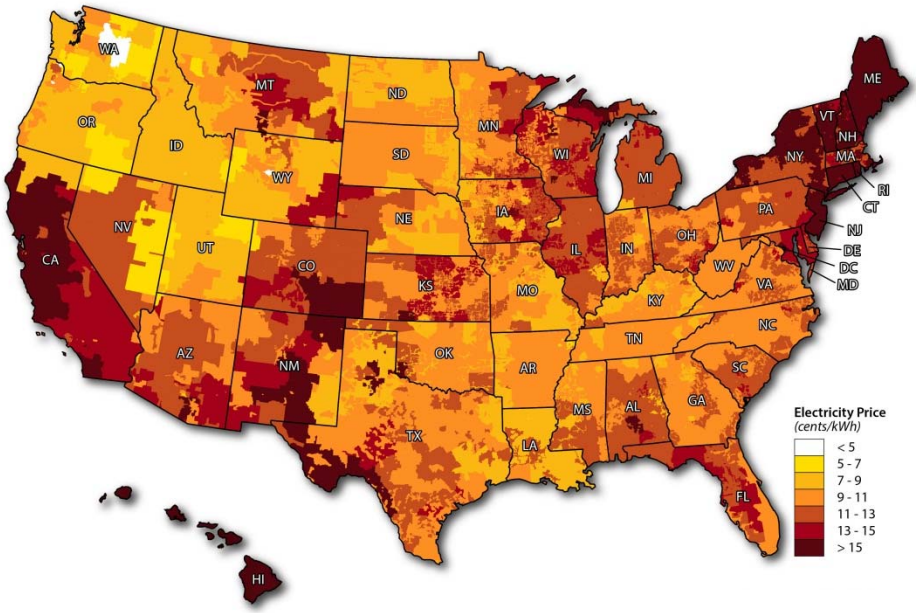
  - NPC includes cost premium of upgrading to a HPWH from another gas or electric WH, maintenance costs
  - NPB includes utility bill savings (& incentives)

Current HPWH Net Installed Cost*	
50 gallon HPWH	$1250-$2000
80 gallon HPWH	$2000-$2750

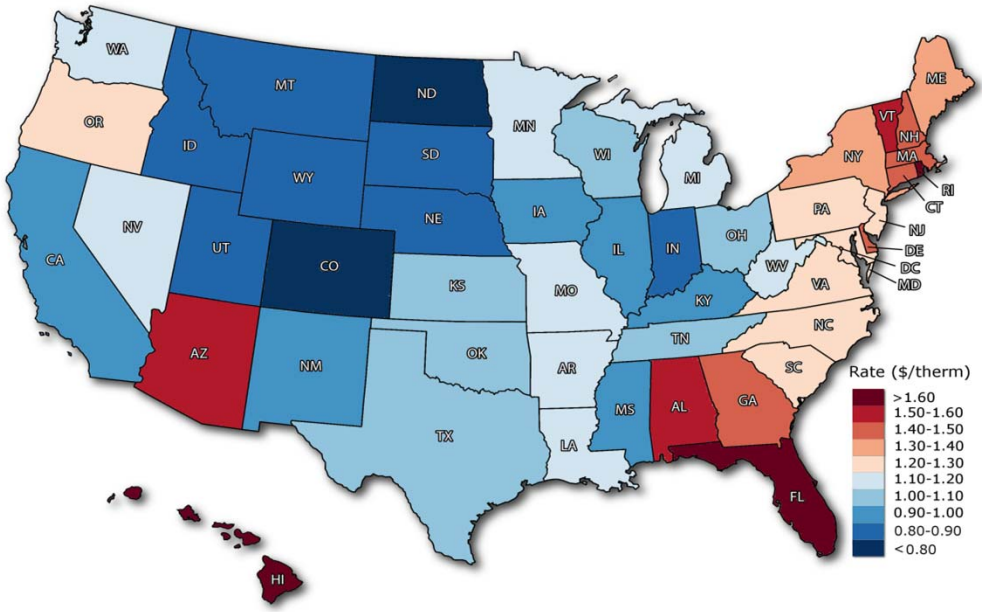
*Actual costs (especially installation costs) may vary significantly, does not include incentives

Utility Rates

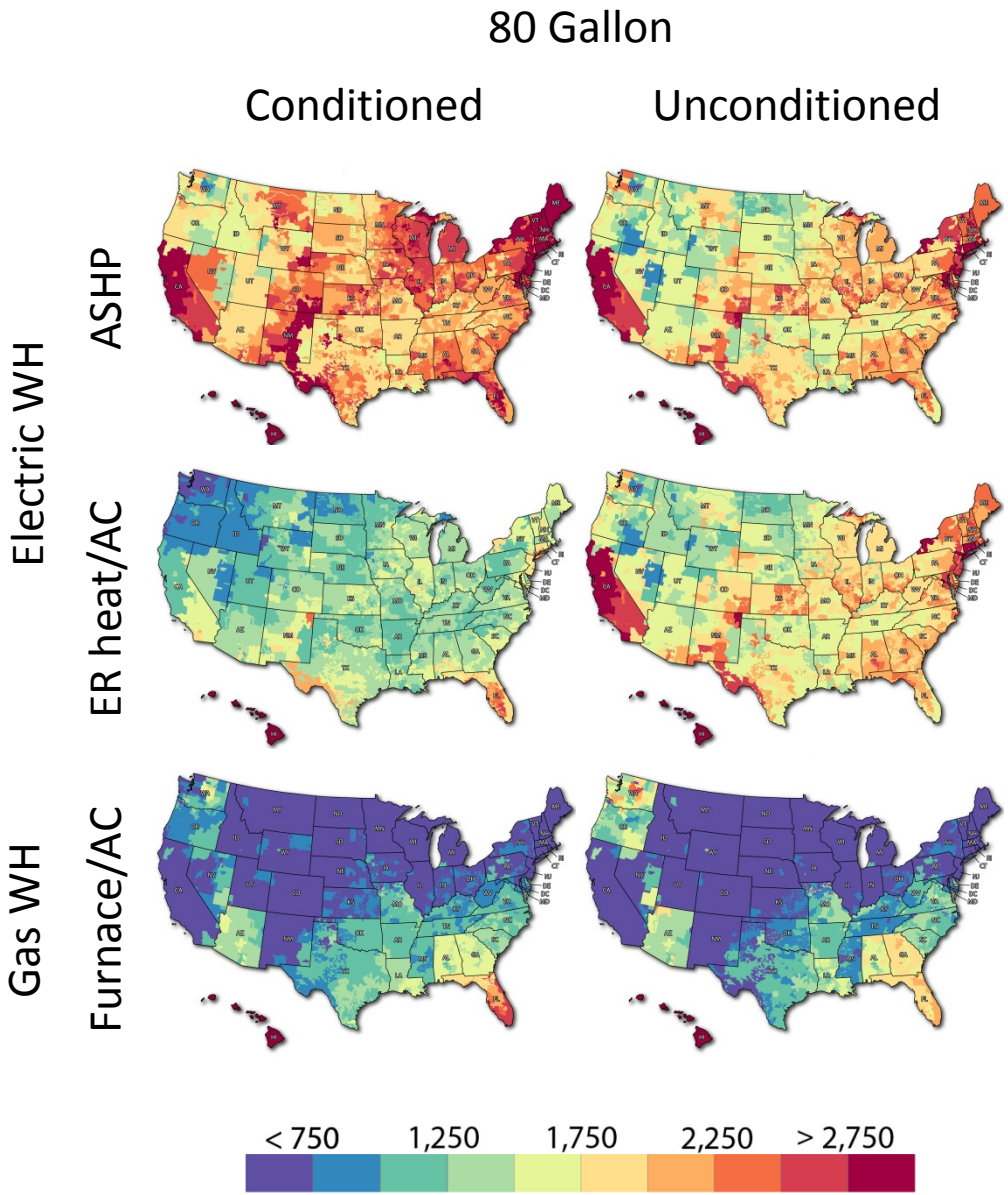
Electricity



Natural Gas



Breakeven Cost



Breakeven Cost

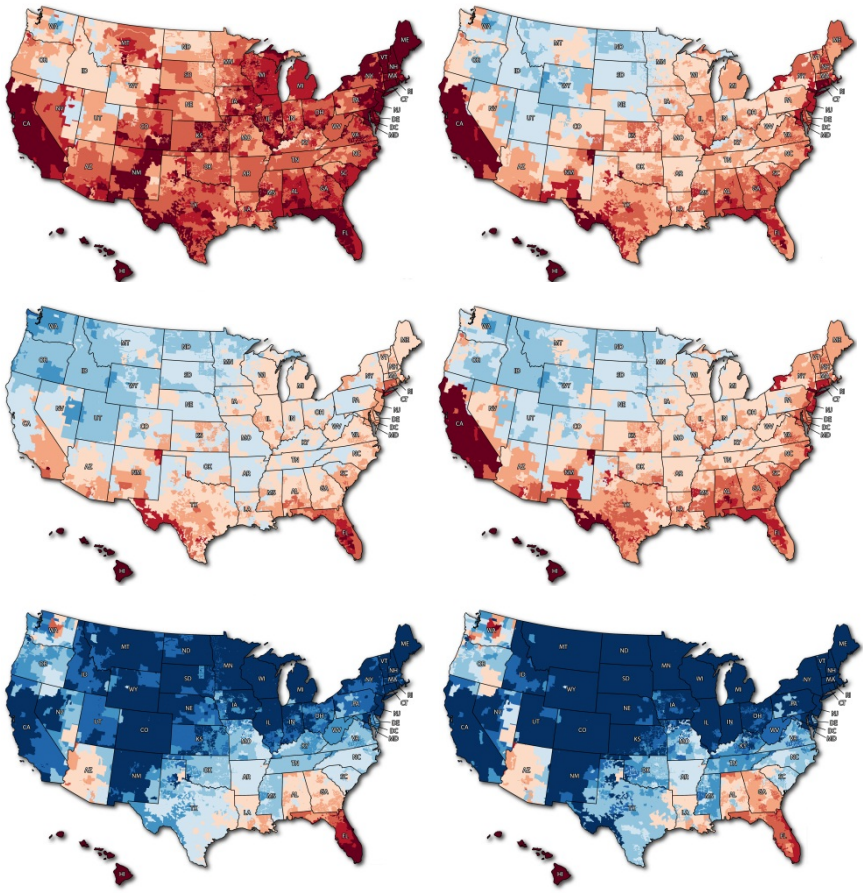
50 Gallon

Conditioned Unconditioned

Electric WH ASHP

ER heat/AC

Gas WH Furnace/AC



< 250 750 1,250 1,750 > 2,250

Conclusions

- **In many cases, HPWH are not likely to achieve rated performance (especially 50 gallon)**
- **HPWHs save some energy over electric WHs, but rarely over gas WHs**
  - Highest savings in regions with low number of gas WHs
- **HPWHs may be cost effective in several regions when replacing ELECTRIC WHs**
  - California
  - Hawaii
  - New England
  - Southeast

Conclusions

- **Factors that influence HPWH savings NOT considered here:**
  - Draw volume and usage pattern
  - Variation between manufacturers in HPWHs
  - Variations between homes
  - Other installation locations (attic, crawlspace ect.)

More information coming soon!

- For details and additional maps, look for the upcoming technical report:

  "Energy Savings and Breakeven Cost for Residential Heat Pump Water Heaters in the United States"

  By: Jeff Maguire, Jay Burch, Tim Merrigan, and Sean Ong

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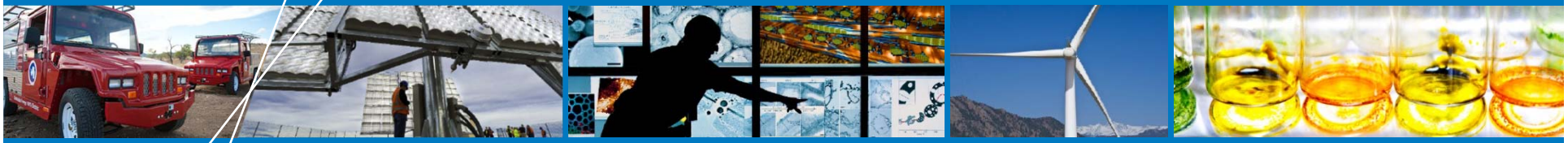
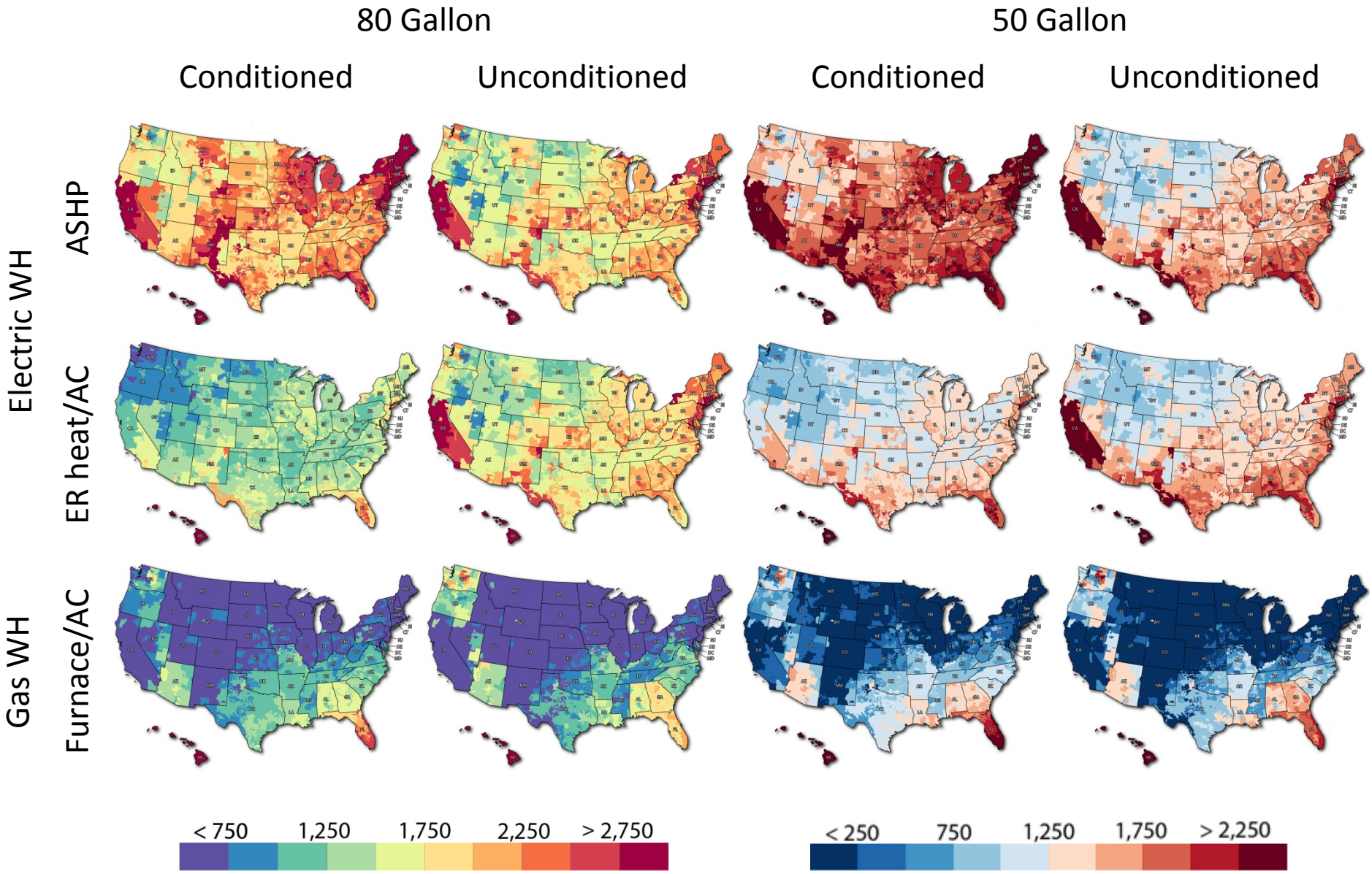


Questions?

Breakeven Cost



Breakeven Cost