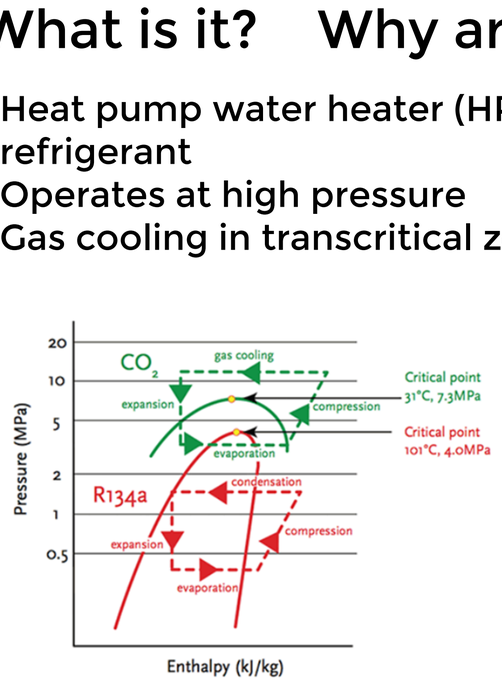
CO_2 HEAT PUMP WATER HEATER RESEARCH

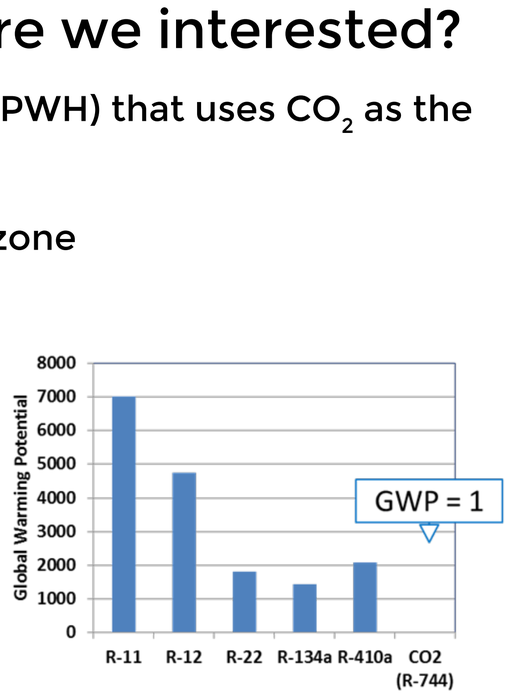
What is the regional value?

Game Changing Technology, Fast Track Development, 2016 Product Rollout, Adapting to US Market

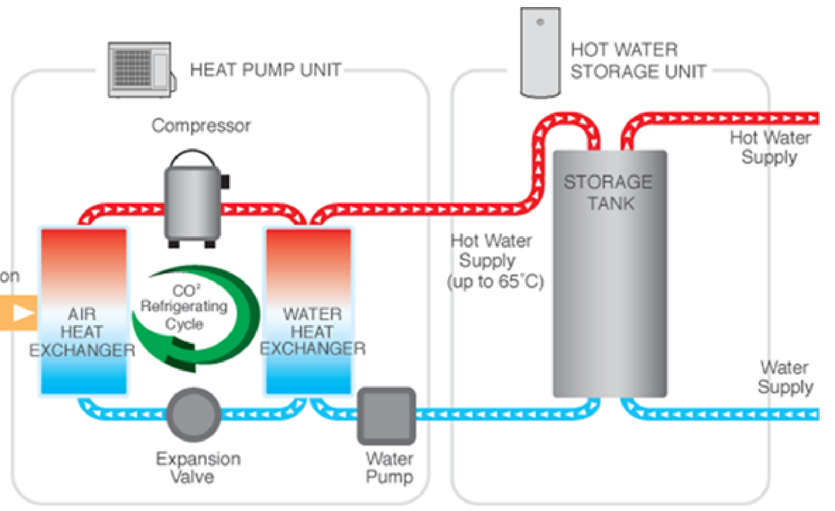
What is it? Why are we interested?

- Heat pump water heater (HPWH) that uses CO_2 as the refrigerant
- Operates at high pressure
- Gas cooling in transcritical zone





Basic comparison of CO_2 and $R134_a$ refrigeration cycles



Split system

- Heat pump unit outdoors; storage tank indoors
  - No noise indoors
  - No energy impact on heated space
- Makes 149 F hot water efficiently
  - Only 0.05 kWh/gal of water delivered at 125 F

Water Heating Performance

- Almost 2 years monitoring at 4 sites
- Average savings of 2436 kWh/yr
- Can produce hot water down to -20 F
- 4 X more efficient than ERWH
- 2 X more efficient than current HPWH

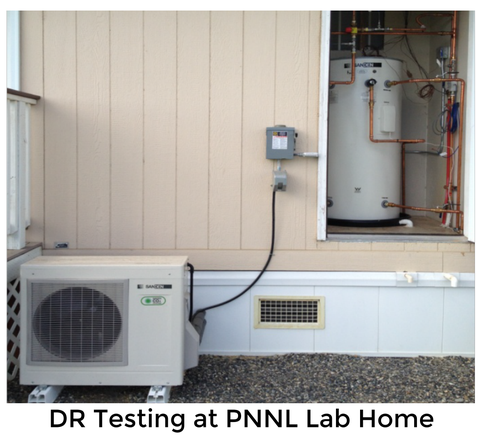
Field & Lab Test Results

Standard		ERWH	Std. HPWH	CO2 HPWH
First Hour Rating (gal)	How much useable hot water the heater makes in one hour	58	58	97.8
Energy Factor (DOE)	How much input energy is needed to generate 64.3 gallons of hot water used in a simulated 24-hour period	0.93	2.0	3.4
Northern Climate EF (NEEA)	Weighted combination of the EF at 67°F and 50°F		2.0	3.2
Delivery Rating	The number of efficient hot showers the HPWH is capable of providing		2.5	7.5
kWh per Gallon	Results from field monitoring	0.23	0.11	0.05

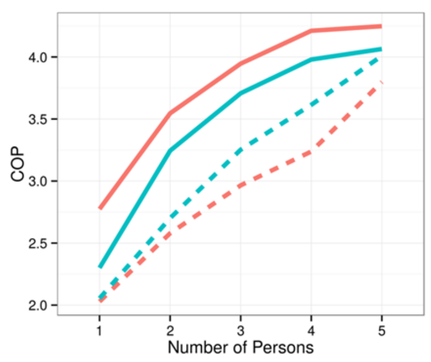
Demand Response Potential

- Controlled field study and lab testing
- Balancing INC and Oversupply DR events

A thousand split systems with average water use could provide approximately 2.5 MWh of energy storage.



DR Testing at PNNL Lab Home

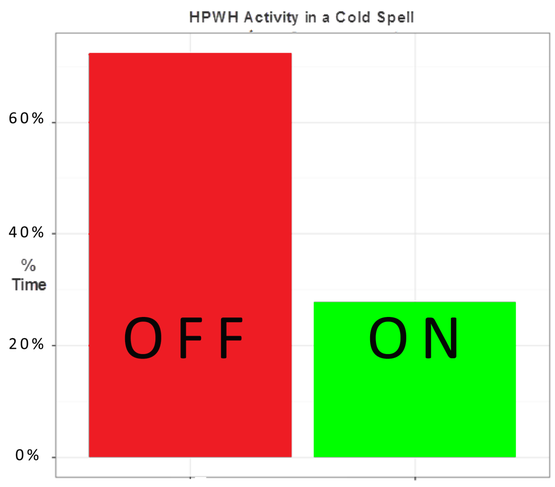


Comparison of system COP with and without DR

An Unexpected Result

- Demand response services increased system efficiency
- Reduced heat loss because of lower tank temperatures
- Shows the potential value of DHW thermostat control

Space and Water Heating



The 'Combi' Concept

- The performance field tests showed that the HPWH met DHW loads with minimal operation even in cold weather
- During a 7-day cold spell in Montana, the system was OFF 75% of the time

- Currently testing combination systems for retrofit and new construction
- Engineered designs with off-the-shelf components
- 9 New Homes
  - Underfloor hydronic heating
  - Design heat load < 4 kW
  - Report September 2016
- 10 Existing Homes
  - Variety of system types
  - Project ends September 2017

First New Construction Site in Bellingham, WA

Conclusions & Next Steps

- Outstanding opportunities for efficiency and DR
- Anticipated installed cost of $2,300
- Payback of 7.8 years at $0.12/kWh, before incentives
- Limited 2016 program rollout in Pacific Northwest
  - UL Listed product expected in May
  - Testing to the Northern Climate Specification
  - Determine program savings and incentive levels

Research Partners

Washington State University Extension Energy Program

SANDEN

Pacific Northwest National Laboratory

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