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CO2 Combi System Compared to Other Systems in the PNNL Lab Homes

Cheryn Metzger, Joe Petersen, Josh McIntosh
Pacific Northwest National Laboratory

Ken Eklund
Washington State University

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Portland, OR



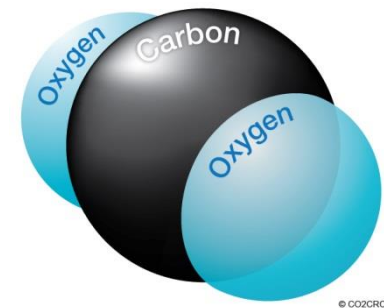
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BACKGROUND

Benefits: CO₂ as a Refrigerant (R744)

- ▶ Thermal lift at cold temperatures exceeds standard refrigerant capacity
- ▶ Flexible in different climate zones
- ▶ Non-flammable
- ▶ Global Warming Potential of 1 (vs 2,088)



Past Lab Home Demand Response Experiments with Sanden CO₂ HPWHs

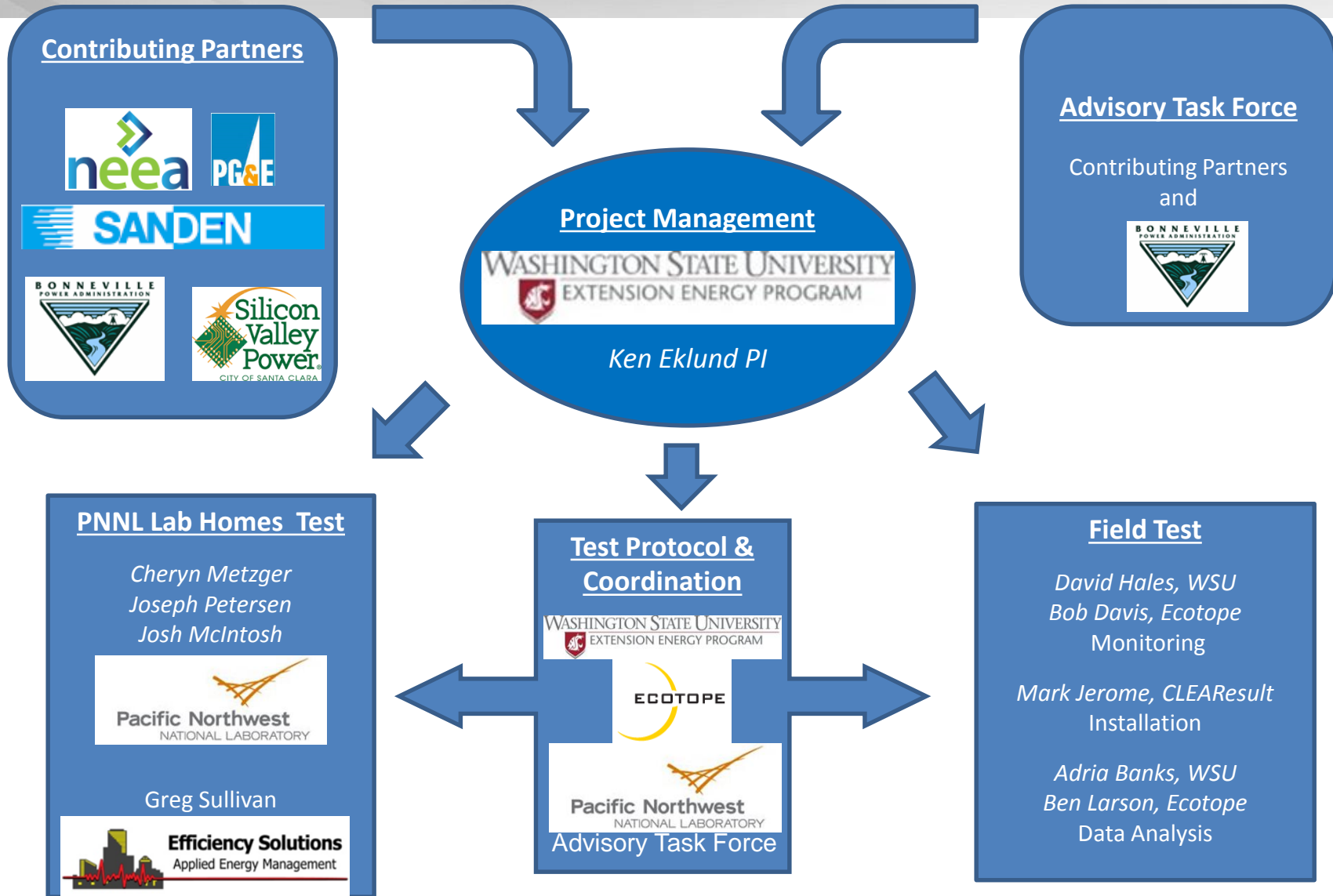
Experiment Metric	Unitary System	Split-System
Dispatchable Power (kW)	1.3	1.2
Recovery Energy Shift (kWh)*	2.65	2.95
Oversupply duration (hours)	6	6
Maximum off period while delivered temperature is met (hours)	6	12

*Energy required to recover tank to set point after DR event

Opportunity!

GP Sullivan and JP Petersen. July 2015. [Demand-Response Performance of Sanden Unitary and Split-System Heat Pump Water Heaters](#) . PNNL - 24224, Pacific Northwest National Laboratory, Richland, WA.

Project Participants





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EXPERIMENTAL PLAN

Lab Homes Characteristics

- ▶ Represent existing homes
 - 3 BR/2BA 1493-ft² double-wide, factory-built to HUD code
 - All-electric with 13 SEER/7.7 HSPF heat pump central HVAC + alternate Cadet fan wall heaters throughout
 - R-22 floors, R-11 walls & R-22 ceiling with composition roof
 - Incandescent lighting
 - Bath, kitchen, whole-house exhaust fans
 - Carpet + vinyl flooring
 - All electric
- ▶ Modifications include end-use metering, sensors, weather station, and three electric vehicle charging stations



During the heating season:

1. Does the system meet common space and water heating loads in these homes?
2. What is the impact on the system's ability to meet space and water heating needs when occupant-controlled variables such as thermostat settings, hot water draws, and hot water temperature settings are moved beyond average?
3. What is the DR oversupply mitigation capability and its ability to meet space and water heating loads?
 - a. When occupant-controlled variables are moved beyond average?

- ▶ Thermostat settings
 - Low: 65°F
 - Medium: 71°F
 - High: 80°F

- ▶ Water Temperature settings:
 - Low: 125°F
 - High: 135°F

- ▶ Water Load settings:
 - Low: 24 gpd
 - Medium: 46 gpd
 - High: 85 gpd



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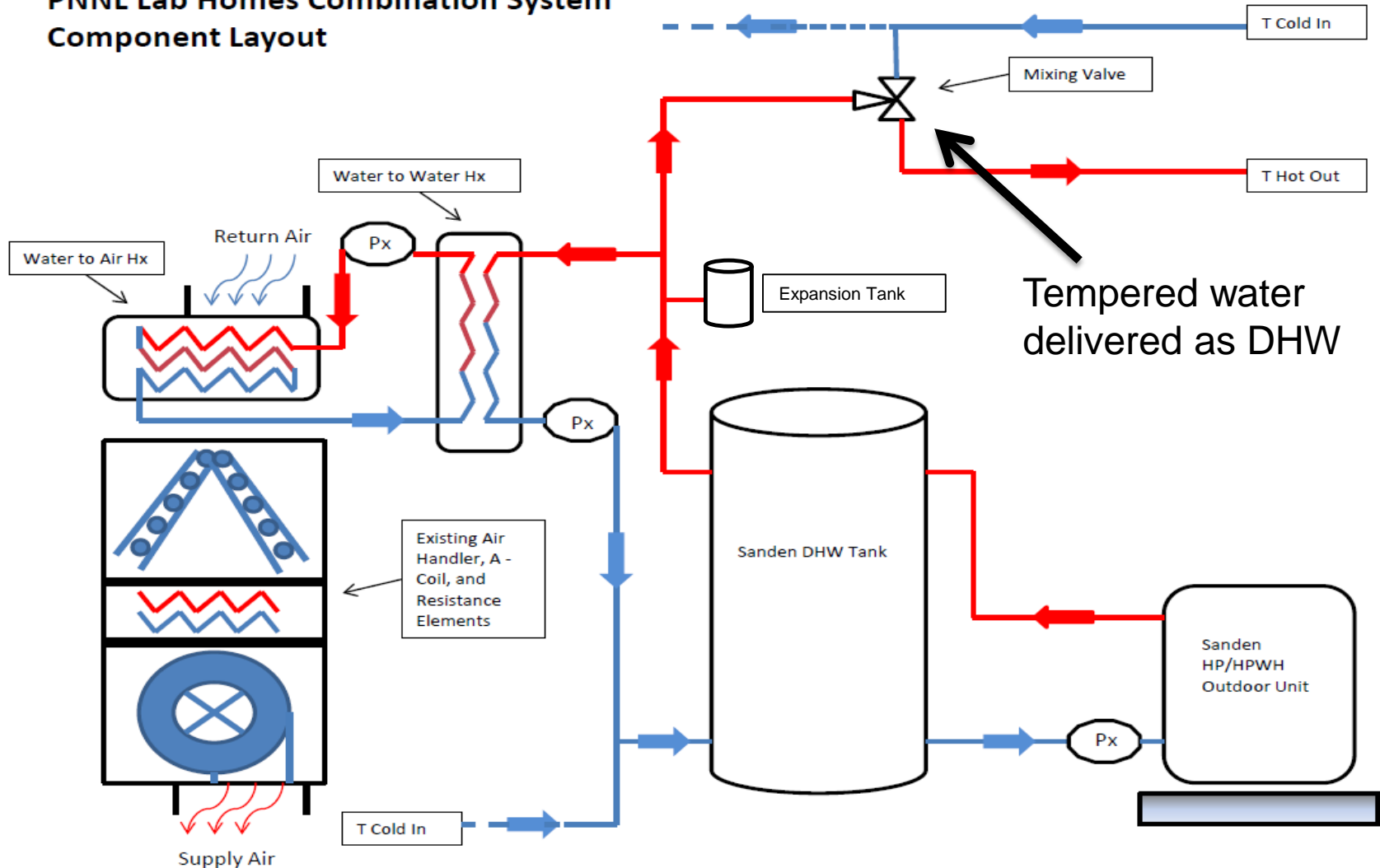
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EXPERIMENTAL SETUP

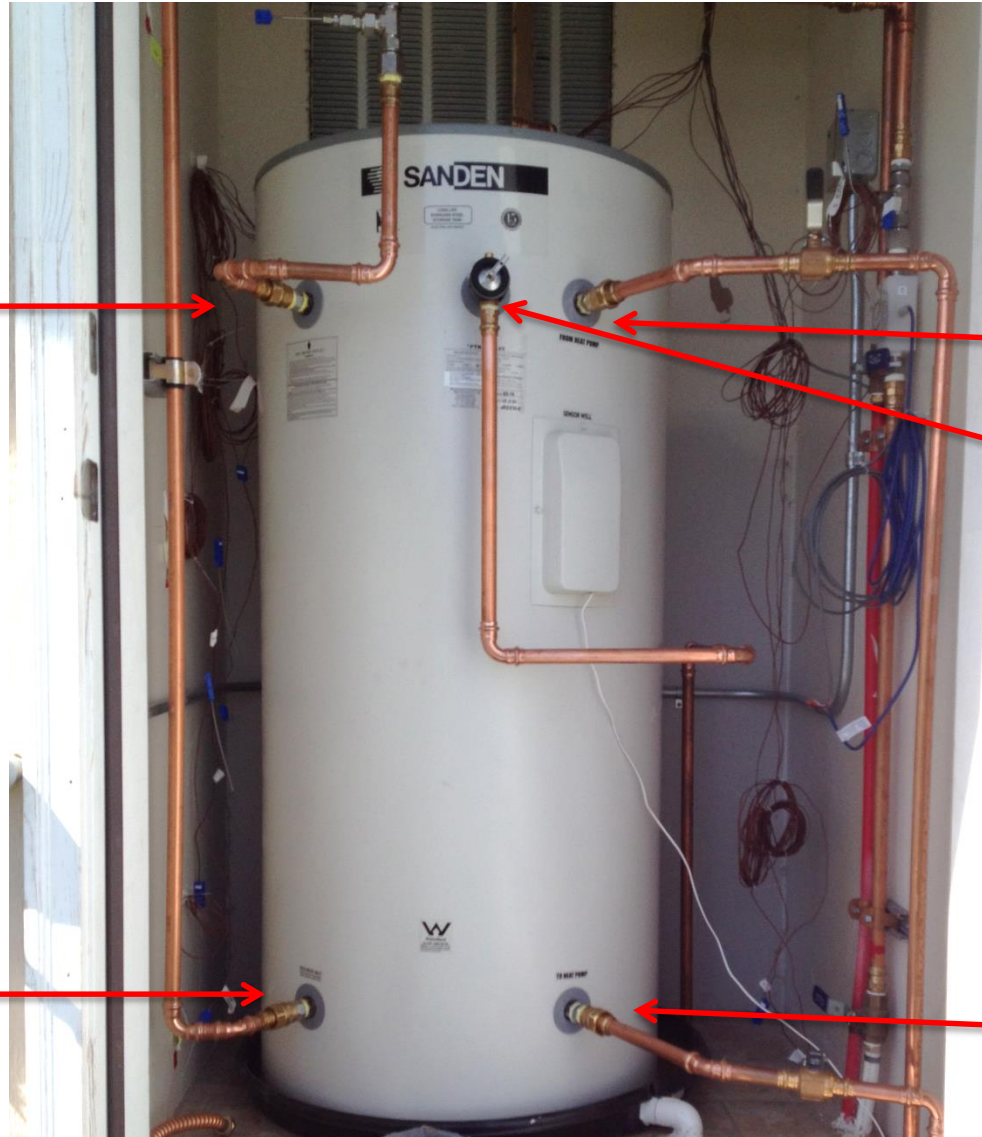


Experimental Setup

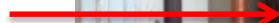
PNNL Lab Homes Combination System Component Layout



System design credit to Mark Jerome, CLEARResult



Hot water out



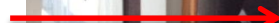
From heat pump



Pressure relief valve



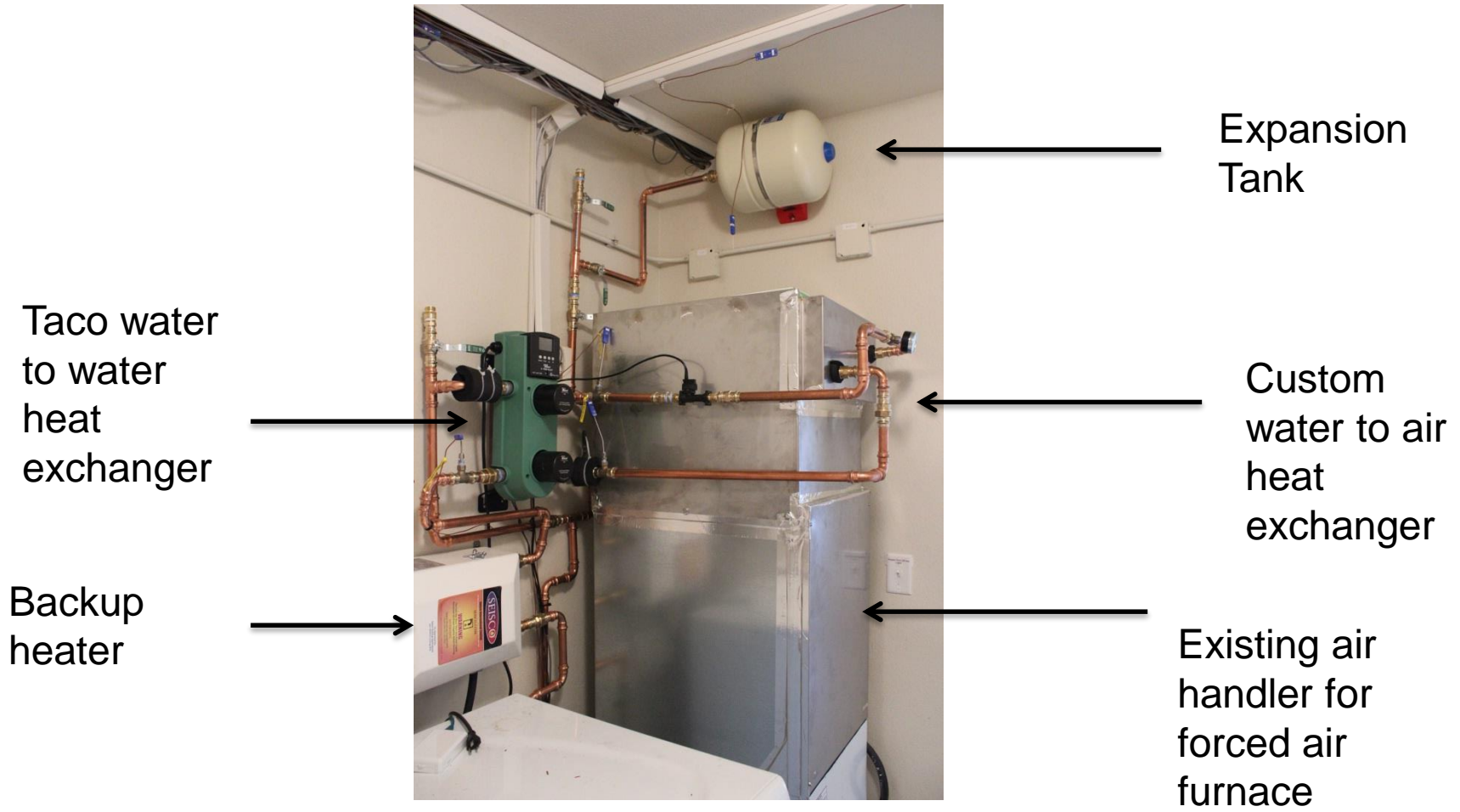
Cold water supply



To heat pump



Interior Heat Exchange System with Electric Forced Air Furnace





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HIGH LEVEL RESULTS

Occupancy Load Results

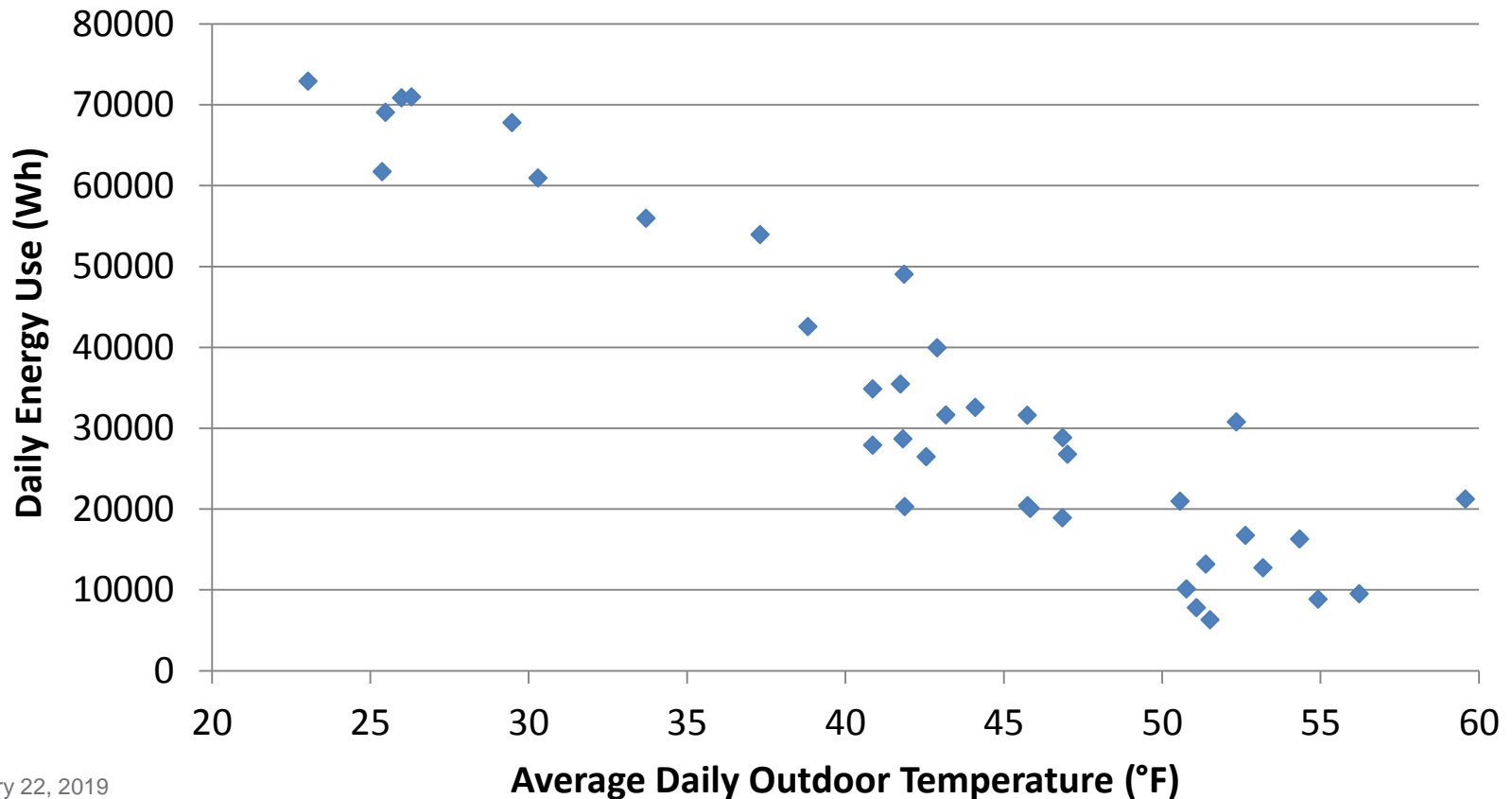
- ▶ When outdoor temp is above 40°F, system can meet loads:
 - 85 GPD
 - 80°F thermostat set point
 - 135°F water heater set point
- ▶ System cannot meet loads consistently:
 - When outdoor temperature is below 40°F
- ▶ Inconclusive if system can meet loads consistently following a DR event if temperatures are above 40°F
- ▶ System favors space conditioning temperature over water heating temperature



ENERGY USE DATA

Combi Energy Use

- ▶ 71°F Indoor temperature set point
- ▶ 125°F Hot water set point
- ▶ 46 gallons per day



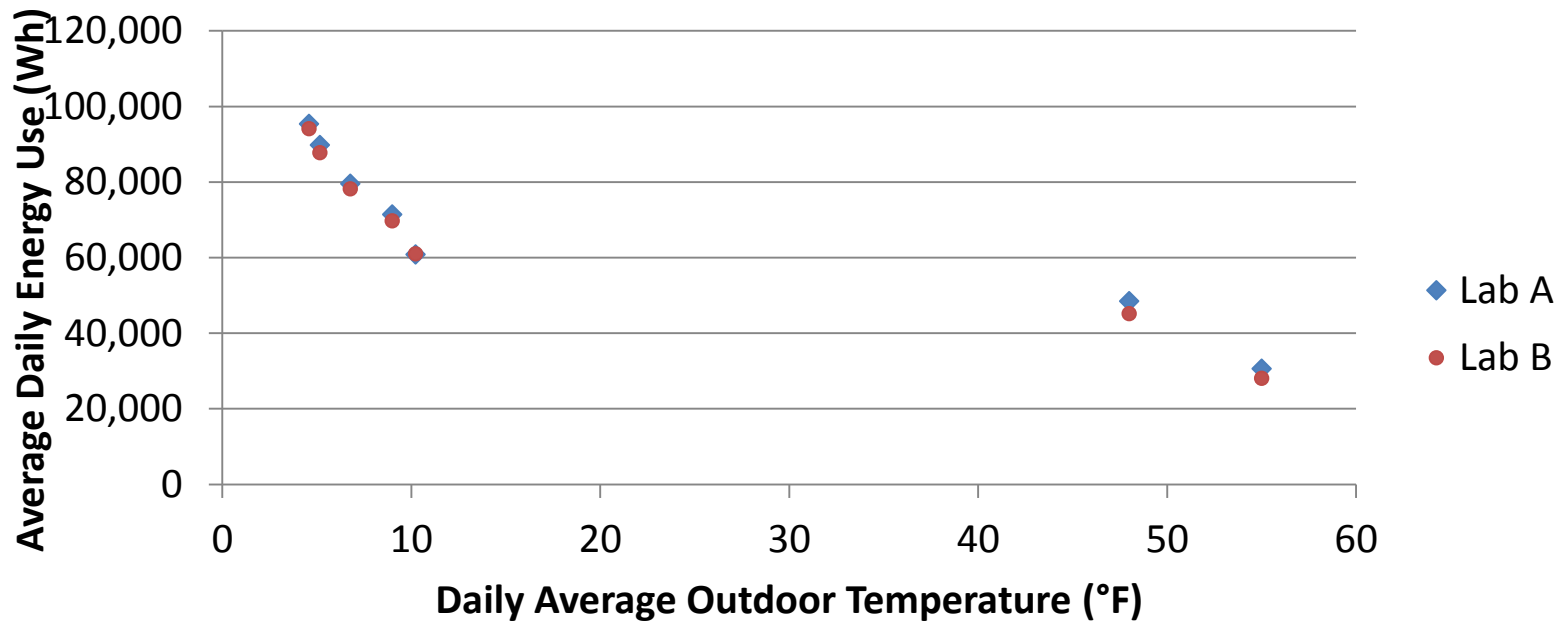


COMPARED TO PAST DATA

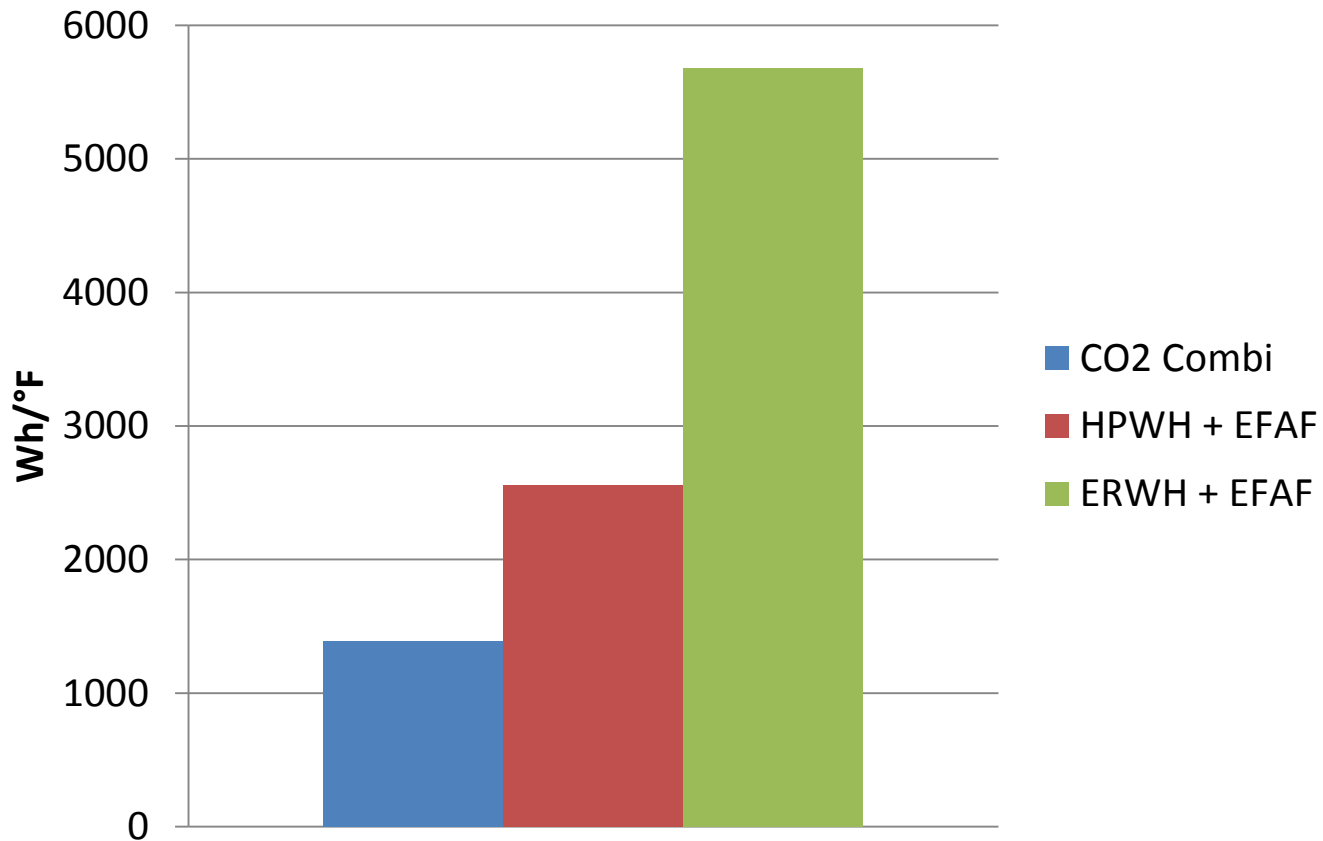
Past Experiment Results

- ▶ 71°F Indoor temperature set point
- ▶ 125°F Hot water set point
- ▶ 130 gallons per day

Electric Forced Air Furnace and HPWH (in different modes)

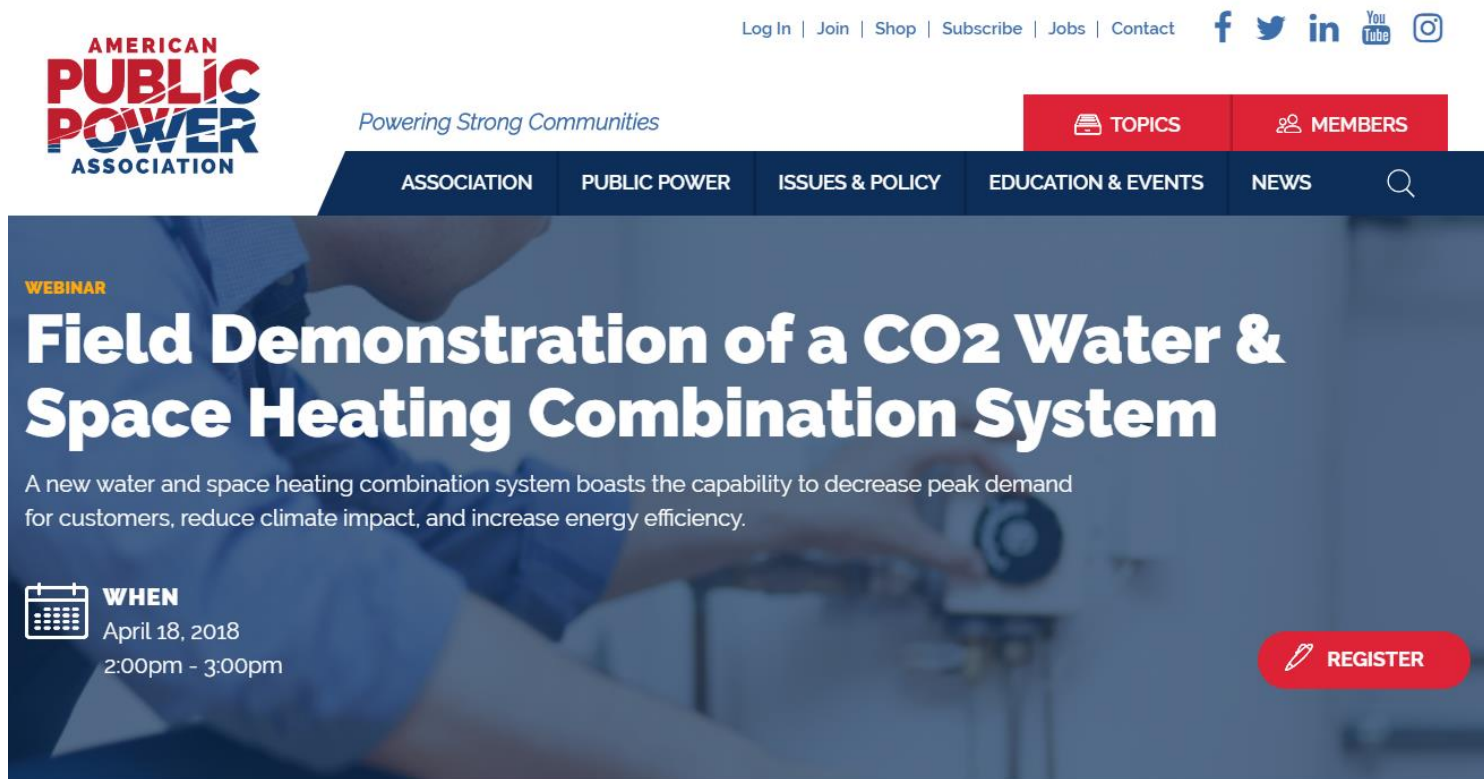


▶ Total energy use per degree increases



Upcoming Webinar!

- ▶ <https://www.publicpower.org/event/field-demonstration-co2-water-space-heating-combination-system>



The screenshot shows the American Public Power Association website. At the top left is the logo for the American Public Power Association with the tagline "Powering Strong Communities". To the right are navigation links: "Log In | Join | Shop | Subscribe | Jobs | Contact" and social media icons for Facebook, Twitter, LinkedIn, YouTube, and Instagram. Below these are two red buttons: "TOPICS" and "MEMBERS". A dark blue navigation bar contains the following menu items: "ASSOCIATION", "PUBLIC POWER", "ISSUES & POLICY", "EDUCATION & EVENTS", "NEWS", and a search icon. The main content area features a large banner for a webinar. The banner includes the word "WEBINAR" in orange, the title "Field Demonstration of a CO₂ Water & Space Heating Combination System" in large white text, and a description: "A new water and space heating combination system boasts the capability to decrease peak demand for customers, reduce climate impact, and increase energy efficiency." Below the description is a calendar icon and the text "WHEN April 18, 2018 2:00pm - 3:00pm". A red "REGISTER" button with a pencil icon is located in the bottom right corner of the banner.

THANK YOU!

Contact Information:

Cheryn Metzger PE PMP LEED AP

Cheryn.metzger@pnnl.gov

707-623-7091

<https://labhomes.pnnl.gov/>

Let me know if you would like to be added to the Lab Homes Newsletter!