Emerging Heat Pump Technologies

for Utility Programs

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Agenda

- Heat pump water heaters
- Cold climate heat pumps
- Smart diagnostic tools

Heat Pump Water Heaters

- High efficiency domestic water heating
  - EF around 4.0
- Hybrid HPWH (240V/30A) is the standard technology for residential applications
  - All electric (uses heat pump and electric resistance)
  - Other options are available for electrically-constrained systems
- Requires some new design considerations
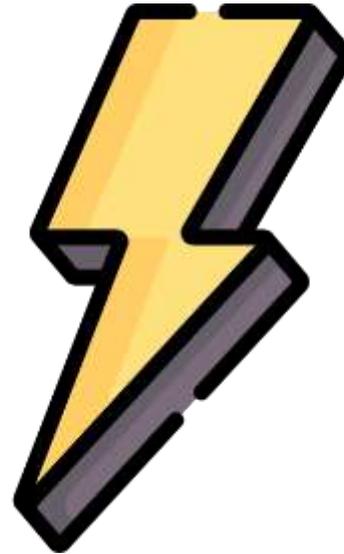- Load shifting potential
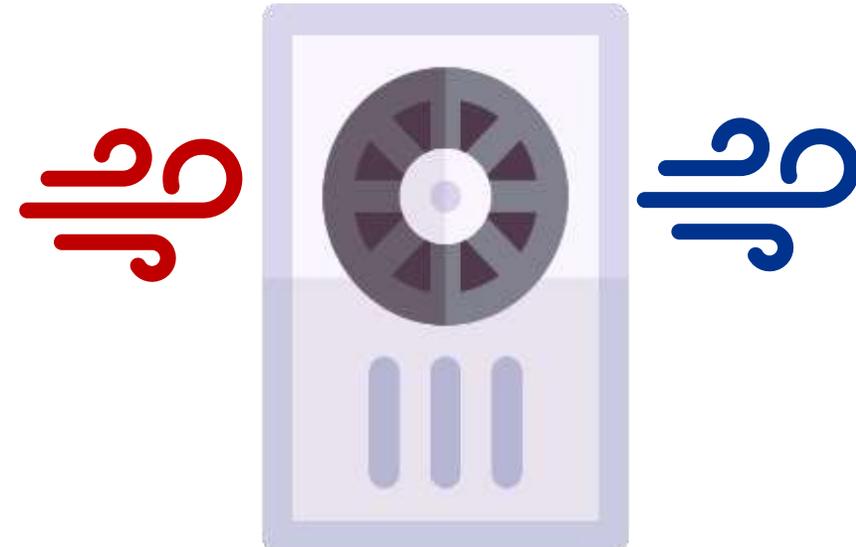
Example operating costs and savings

Gas / Oil

- Initial Price : $500
- EF : 0.58
- Estimated Fuel Usage : 0.41 therm/day
- Fuel Cost : $1.82/therm
- 1 Year Cost : $970
- 10 Year Cost : $5196

Electric

- Initial Price : $500
- EF : 1.0
- Estimated Fuel Usage : 12 kWh/day
- Fuel Cost : $0.17/kWh
- 1 Year Cost : $1238
- 10 Year Cost : $7877

Heat Pump

- Initial Price : $1,500
- EF : 4.0
- Estimated Fuel Usage : 3 kWh/day
- Fuel Cost : $0.17/kWh
- 1 Year Cost : $1684
- 10 Year Cost : $3344

Installation Considerations

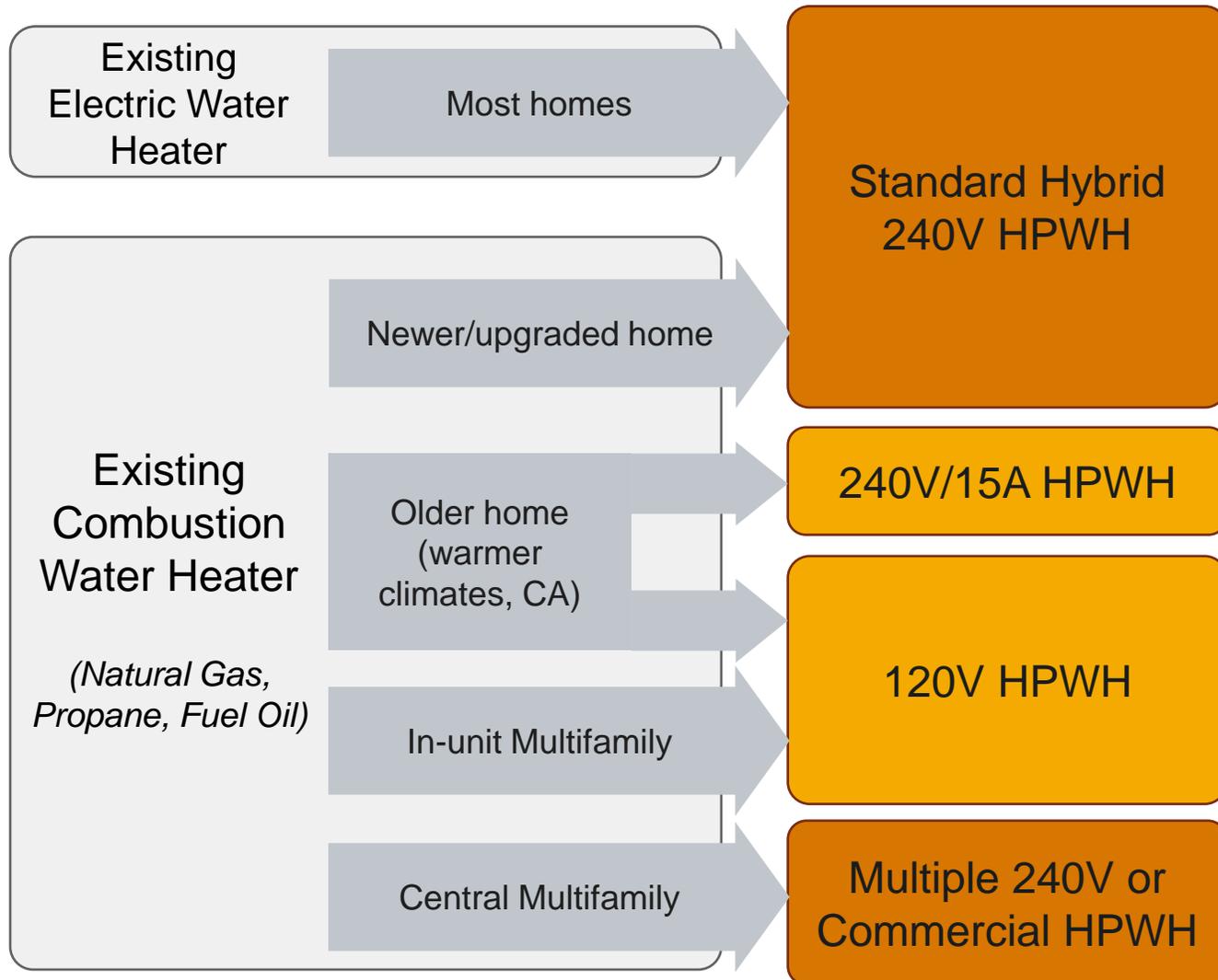|	
Electrical	• 240 volts and 30 amps are required
Plumbing Connections	• Location of inlet and outlet may differ from old water heater
Condensate Drain	• Floor or sink drain should be located nearby • Condensate pump can be used
Temperature	• Space should be able to maintain a temperature range of 40º–90ºF (4.4º–32.2ºC)
Clearance	• HPWH should be installed in a space with 700-cubic feet (28.3-cubic meters) of air space around the water heater
Noise	• Sound generated tends to run between 40 dBA to 80 dBA, where the majority of HPWHs are below 59 dBA

Applications

Existing Electric Water Heater

Most homes → **Standard Hybrid 240V HPWH**

Existing Combustion Water Heater

(Natural Gas, Propane, Fuel Oil)

- Newer/upgraded home → **Standard Hybrid 240V HPWH**
- Older home (warmer climates, CA) → **240V/15A HPWH**
- In-unit Multifamily → **120V HPWH**
- Central Multifamily → **Multiple 240V or Commercial HPWH**

Demand Reduction and Response

- Demand Reduction
  - Frequent operation in heat pump mode means significantly lower typical water heating demand.
  - Electric resistance backup can still create higher demand

- Grid Interactivity
  - CTA-2045 compatible device sends "shed" and "load" signals
  - Most shedding operation is flexible based on the thermal profile of the tank
  - Homeowners can override

HPWH Resources

|	
Consumer and Contractor Guides	Hot Water Solutions NW (NEEA) hotwatersolutionsnw.org
Promotion and Coordination	Advanced Water Heating Initiative advancedwaterheatinginitiative.org
Instructor Resources	Building Science Education bsesc.energy.gov

HPWH Resources

- [Heat Pump Water Heaters | Department of Energy](#)
- [Estimating Costs and Efficiency of Storage, Demand, and Heat Pump Water Heaters | Department of Energy](#)
- [New Infographic and Projects to Keep Your Energy Bills Out of Hot Water | Department of Energy](#)
- [Sizing a New Water Heater | Department of Energy](#)
- [Selecting a New Water Heater | Department of Energy](#)

- [ENERGY STAR Ask the Experts | Products | ENERGY STAR](#)
- [Special Offers and Rebates from ENERGY STAR Partners | EPA ENERGY STAR](#)
- [Considerations – Heat Pump Water Heaters (HPWHs) | ENERGY STAR](#)

- [HotWaterSolutionsNW.org | Heat Pump Water Heaters Cut Electric Bills |](#)
- [PG&E Energy Education Classes (docebosaas.com)](#)
- [Craft Details (nccer.org)](#)
- [Replacing your Water Heater | Smarter House](#)
- [Northwest Energy Efficiency Alliance (NEEA) | Northwest Heat Pump…](#)

Cold Climate Heat Pumps

- Heat pumps are highly efficient electric heating systems

- Conventional heat pump:
  - Typically not used below 30-35°F outdoor temp.
  - Uses electric resistance or fossil fuel backup.

- Cold climate heat pump:
  - Can operate at or near 100% capacity at 5°F outdoor temp. *(Performance depends on specific model)*
  - Can retain significant capacity down to -15°F and lower.
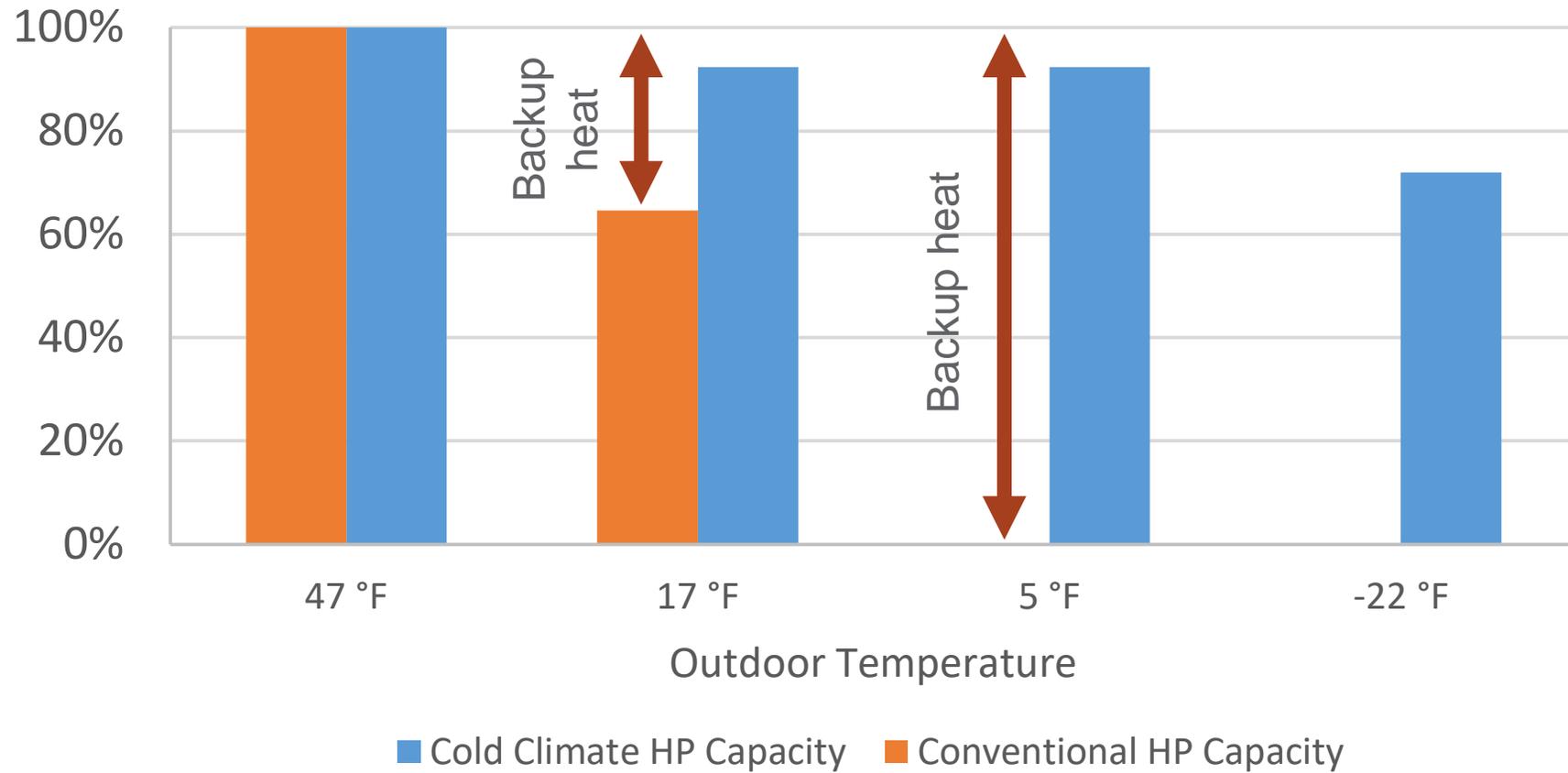 - Needs less or (in some cases) no backup heating
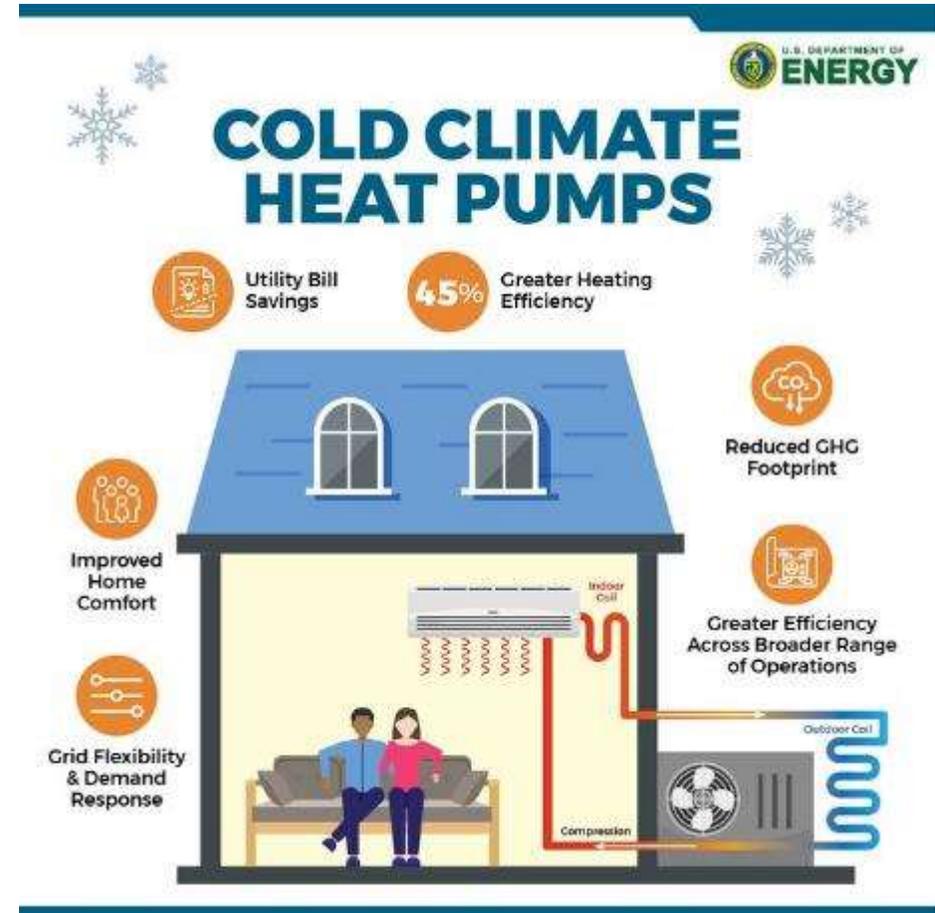
What's new?

High efficiency heat pumps that work in all climates:

- Cold Climate
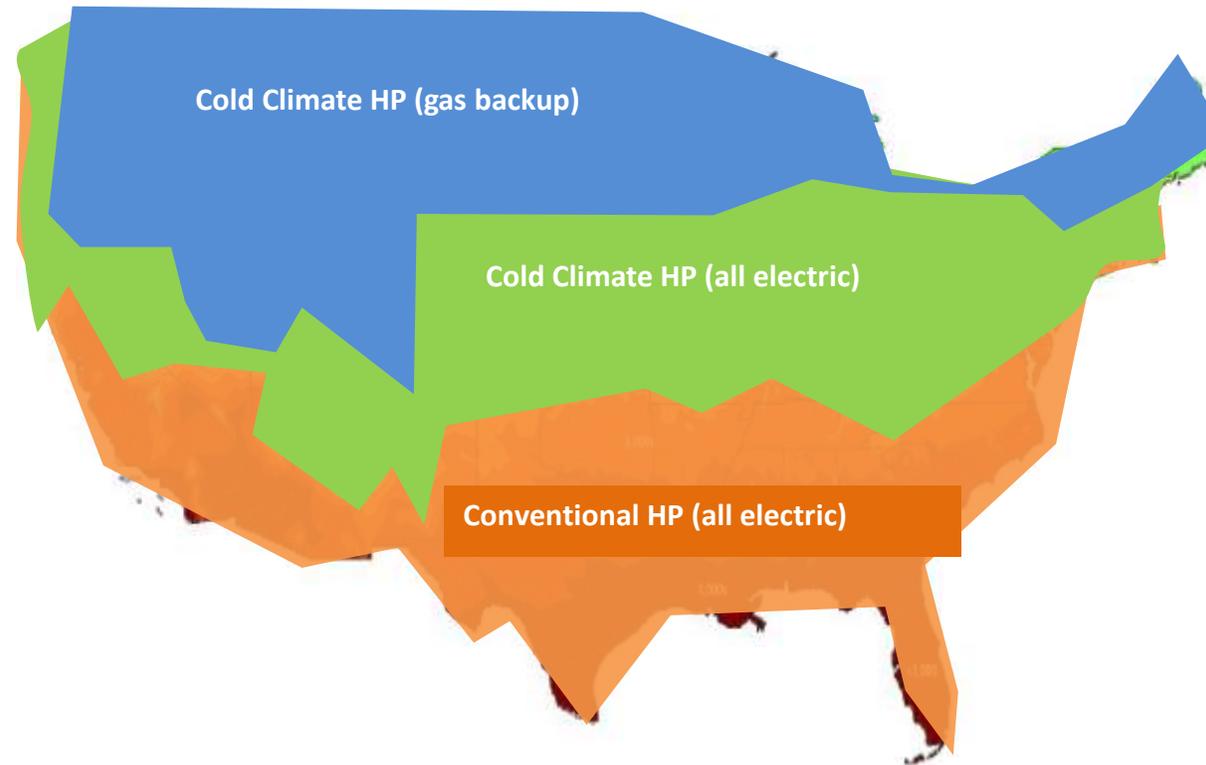- Inverter-Driven
- Variable Capacity
- Variable Speed Compressor
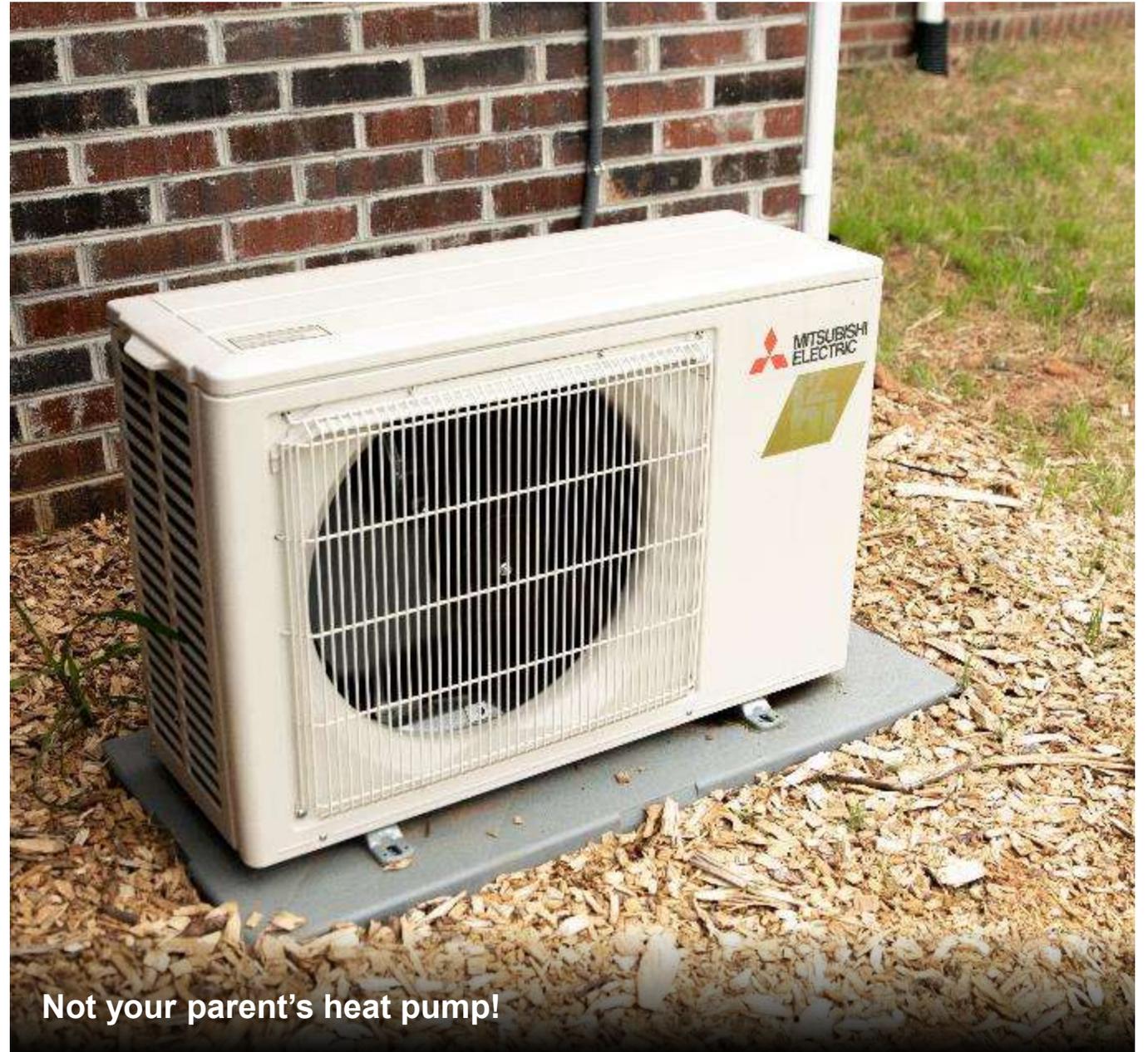
Not your parent's heat pump!

Cost-effective Single-Family Heat Pump Installations

Report: ACEEE 2022 *https://www.aceee.org/research-report/b2205*

Cold Climate HP (gas backup)

Cold Climate HP (all electric)

Conventional HP (all electric)

- Heat pumps are most appropriate with efficient envelopes
- basc.pnnl.gov/retrofit_decision_tool

Resources

Instructor Resources	Building Science Education bsesc.energy.gov
Guides & More	Building America Solution Center basc.pnnl.gov
HP System Design & Selection	NEEP Cold Climate Air Source Heat Pump List ashp.neep.org
Envelope Assessment	BASC Retrofit Decision Tool basc.pnnl.gov/retrofit_decision_tool

Campaign (noun)
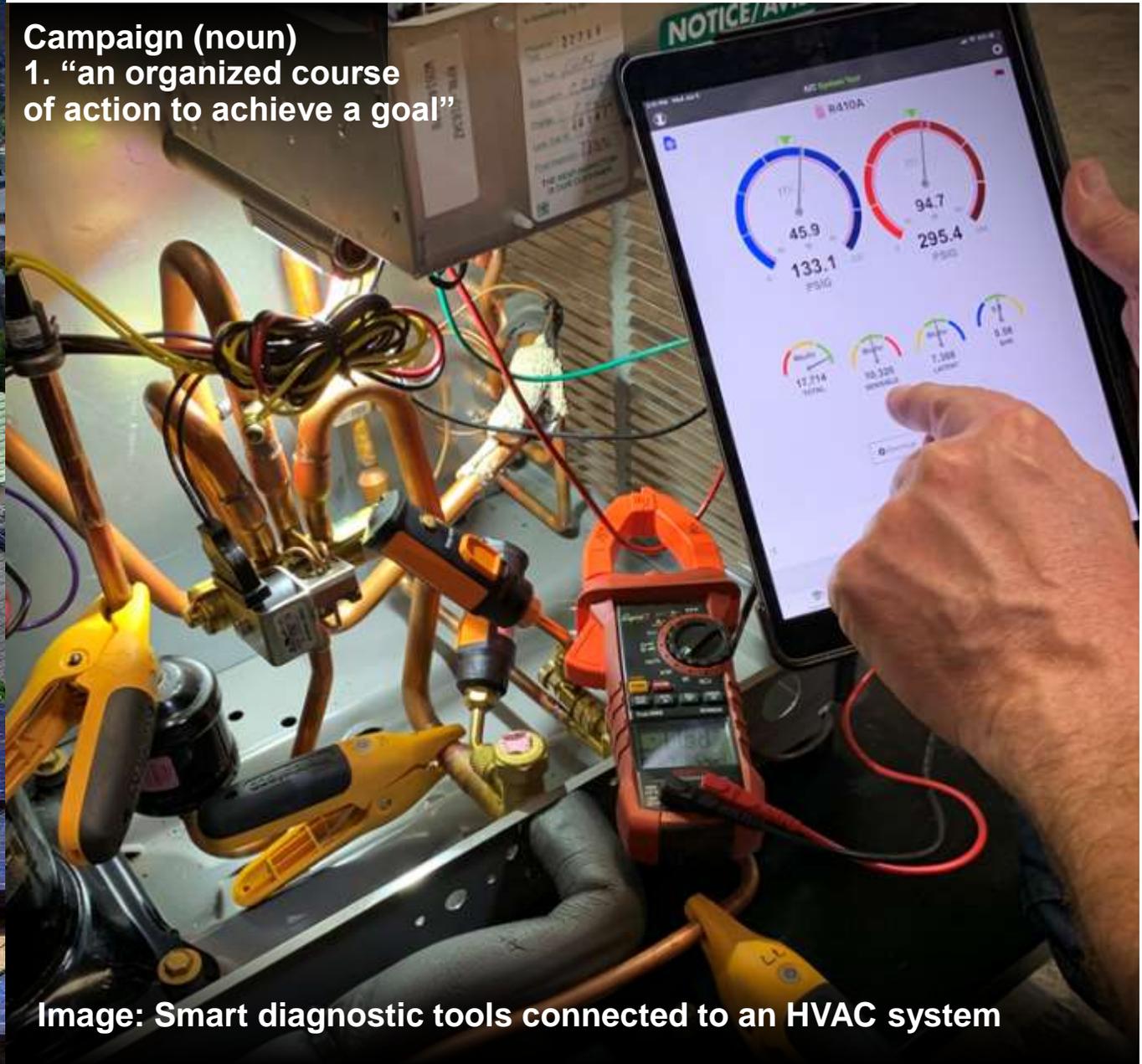1. "an organized course of action to achieve a goal"

Image: Smart diagnostic tools connected to an HVAC system

Smart Tools for Efficient HVAC Performance Campaign

Organizing Partners

Heat Pumps, an Asterisk, and a Solution

Q: How do we decarbonize residential heating loads?

A: Heat Pumps*

*Improper installations reduce system performance, resulting in energy waste and comfort issues:

- One or more energy-wasting HVAC fault in 70–90% of homes[1]
- Estimated 9% residential HVAC energy waste nationally due to installation faults in CAC/ASHP[2]

Solution: Smart diagnostic tools help ensure heat pumps are installed properly, resulting in realized energy-efficiency and reduced energy waste.

1.   EERE, 2019. Residential HVAC Installation Practices: A Review of Research Findings
2.   Winkler et al. 2020. Impact of installation faults in air conditioners and heat pumps in single-family homes on U.S. energy usage. Applied Energy, Volume 278

Smart Diagnostic and Commissioning Tools
A Game Changer for the HVAC Industry

Diagnostic / Commissioning Smartphone Application **+** **Wireless Digital Probes and Sensors**

- Calculate HVAC system operating performance

- Detect faults, suggest corrective actions

- Workflows for consistent practices

- Third-party verification

- Provide feedback loop for technician, leading to continuous improvement

How Does The STEP Campaign Work With Utilities?

Utility Program Case Study

- Outreach to utilities through conferences and webinars

- Provide technical assistance and support for utilities adopting tools into their programs

- Recognize successful adoption of tools into program

- Scale through partnerships program implementers

Smart Tools for Efficient HVAC Performance (STEP) Campaign

STEP CAMPAIGN

Scan this QR code to visit our website

The STEP Campaign aims to increase adoption of smart diagnostic tools to streamline HVAC system performance testing and troubleshooting, reducing energy-wasting faults and improving occupant comfort.

Join the Campaign today and STEP UP your HVAC installations

HVAC Contractors and Technicians
- Reduce callbacks, improve consistency and quality, streamline processes
- Find out where to get training on smart diagnostic tools
- Be recognized for successful adoption of smart diagnostic tools!

Utilities and Program Implementers
- Streamline quality installation and quality maintenance programs
- Improve engagement with your contractors
- Be recognized for programs that utilize smart diagnostic tools!

HVAC Training Organizations
- Offer qualified training on System Performance with smart diagnostic tools
- Be recognized for providing training!

Weatherization Organizations
- Ensure your ASHP/CAC installations are operating at optimized efficiency
- Work with PNNL team to develop a pilot
- Be recognized!

ORGANIZING PARTNERS

Contact: christian.valoria@pnnl.gov

ACCA   BUILDING PERFORMANCE ASSOCIATION   CEE Working Together Advancing Efficiency   HVAC Excellence   NATE   neea   U.S. DEPARTMENT OF ENERGY

HPwES Remote QA Tool

- Documents heat pump installation through an easy-to-use web application

- Promotes best practices

- Hold installers accountable for following best practices

- Beta version available now: contact edward.louie@pnnl.gov
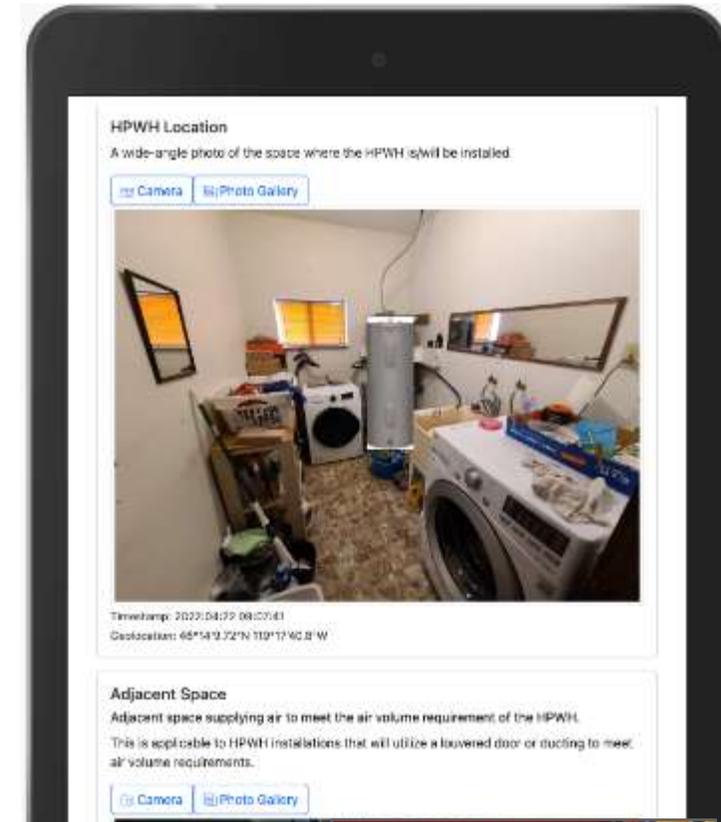
Resources

Smart Diagnostic Tools

Smart Tools for Efficient HVAC Performance
Christian.valoria@pnnl.gov

Install Documentation

Remote Quality Assurance Tool
Edward.louie@pnnl.gov

Thank You!

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Heat Pump
Water Heaters

Cold Climate
Heat Pumps

Smart
Diagnostic Tools