ENERGY STAR® Central Heat Pump Water Heater Systems:

Draft 1 Test Method and Discussion Guide

Webinar - August 15, 2024

United States Environmental Protection Agency

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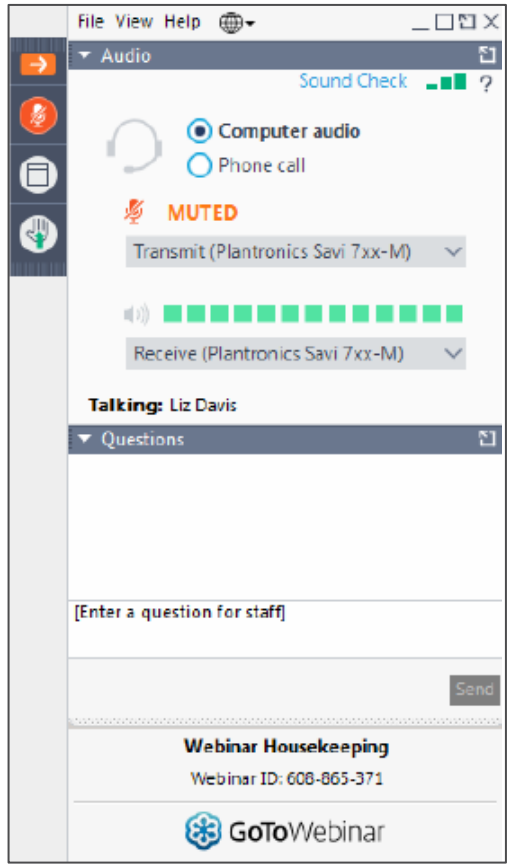


Introductions

Abigail Daken

Daken.Abigail@epa.gov

U.S. Environmental Protection Agency

Julia Hegarty

Julia.Hegarty@ee.doe.gov

U.S. Department of Energy

Megan McNelly

Megan.McNelly@icf.com

ICF

Ethan Hyde

ehyde@guidehouse.com

Guidehouse

Please email **HVAC@energystar.gov** for all ENERGY STAR HVAC-related questions and inquiries.

What is ENERGY STAR?

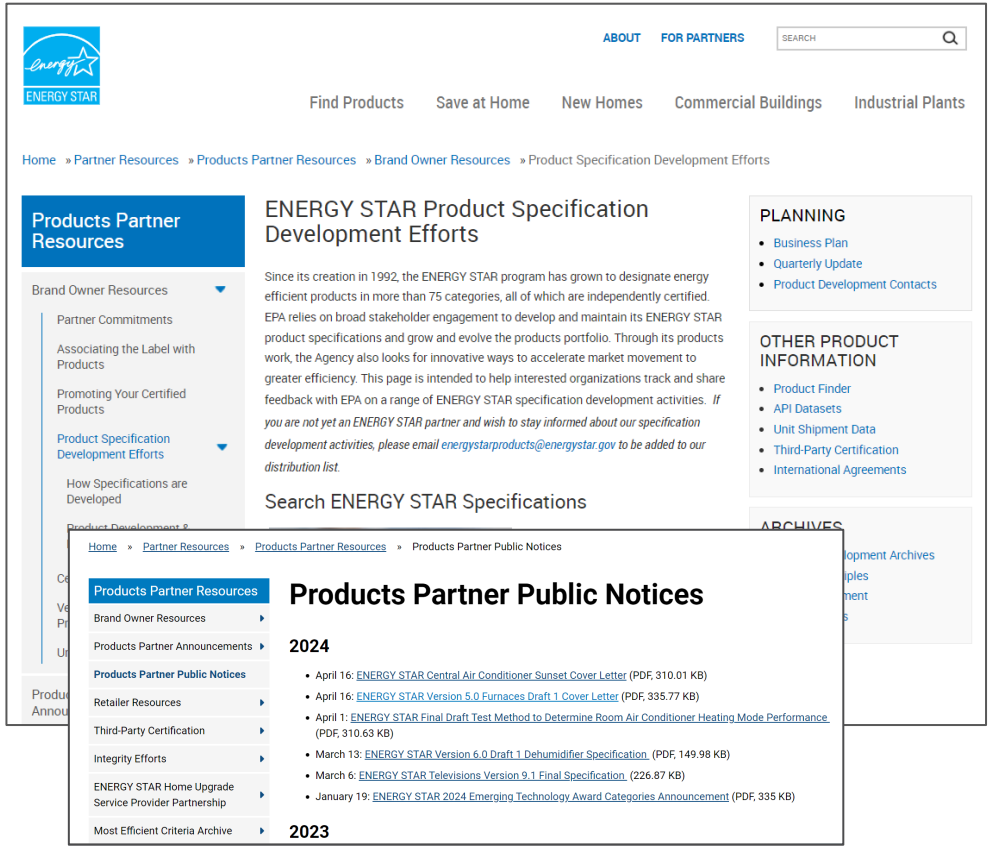
The simple choice for energy efficiency.

- Influential and trusted symbol of **energy efficiency**
- Available across **75+ product categories**
- Since 1992, a voluntary **partnership** among government, business, and consumers
- Products are independently certified to meet strict energy-efficiency guidelines set by the **U.S. EPA**
- **Utilities** offer **rebates** on ENERGY STAR certified equipment
- **Saves** end-users **energy**, **water**, and **money**
- Helps protect the **climate**

Specification Development

- ENERGY STAR follows EPA's Standard Operating Procedure through the specification development or revisions process, balancing:
  - The need to keep pace with evolution among leading products and continue to effectively differentiate for consumers
  - Production cycles, other factors important to the industry

- Key elements of the stakeholder process:
  - Consistency, transparency, inclusiveness, responsiveness, and clarity
  - Stakeholder engagement is a vital aspect to the success of the ENERGY STAR program



ENERGY STAR Product Specification Development Efforts

Products Partner Public Notices

Meeting Agenda

1. Background
2. Discussion Guide: Scope and Definitions
3. Test Method
   a) Definitions
   b) Applicability
   c) Test Set Up and Apparatus
   d) Test Conditions
   e) Test Results and Metric
4. Discussion Guide: Specification requirements and remaining questions
5. Timeline

Background

- Current Spec: Air source Central HPWHs in scope but coverage is inadequate
  - Heat pump unit performance is only characterized at a single set of conditions and in one configuration
  - Only covers the performance of the heat pump unit itself, not the system it's part of
  - Outdated definition of commercial HPWH excludes units if they don't have electric resistance elements included
- Proposed test method includes testing at several conditions and configurations
- Discussion guide sets the framework for how the EPA envisions capturing system performance in the Version 3.0 specification


We are here
Specification Development Cycle
1 Complete Market and Engineering Analysis
2 Analyze Savings Potential and Consumer Payback
3 Identification and Validation of Test Procedures
4 Assemble Data
5 Release Draft Specification; Host Stakeholder Meeting
6 Release Subsequent Drafts; Host Stakeholder Meetings
7 Post Drafts and Stakeholder Comments to Website
8 Issue Final Draft Specification for Stakeholder Comment
9 Finalize Specification
10 Specification Effective (new spec) or Specification Transition Begins (revised spec)
11 Brand Owner Partners Begin Certifying Products
12 Monitor Market Developments on Energy and Performance & Market Response To ENERGY STAR
13 Revise Specification, when needed

Scope and Definitions

- DOE updated the definition of CHPWH and EPA will follow suit

  "A commercial heat pump water heater (CHPWH) is defined as a water heater (including all ancillary equipment such as fans, blowers, pumps, storage tanks, piping, and controls, as applicable) that uses a refrigeration cycle, such as vapor compression, to transfer heat from a low-temperature source to a higher-temperature sink for the purpose of heating potable water, and operates with a current rating greater than 24 amperes or a voltage greater than 250 volts. Such equipment includes, but is not limited to, air-source heat pump water heaters, water-source heat pump water heaters, and direct geo-exchange heat pump water heaters."

- Other than as results from this definition change, EPA does not propose changing the scope of the specification.
- The proposed test method applies to central systems; integrated systems would continue to use the current Federal test method only.

10 CFR § 431.102

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Scope and Definitions

The updated definition:

- Clarifies that all ancillary equipment (tanks, pumps, etc.) are part of the CHPWH, and provides the opportunity for the ENERGY STAR specification to address the impact of system design on performance
- Makes no distinction between an integrated, residential-style HPWH and the heat pump unit used as part of a field-built system including tanks, pumps, and other equipment which may be from other manufacturers

Definitions

- **Central heat pump water heater system**: A commercial heat pump water heater in which the heat pump unit is not contained within the same casing as the storage tank(s) and thus is not an integrated heat pump water heater. A central heat pump water heater system can include products that come pre-mounted on a skid or pallet with multiple components and may require infield plumbing between components.
  - Air-source commercial heat-pump water heater: A commercial heat pump water heater that utilizes indoor or outdoor air as the heat source.
  - Direct geo-exchange commercial heat-pump water heater: A commercial heat pump water heater that utilizes the earth as a heat source and allows for direct exchange of heat between the earth and the refrigerant in the evaporator coils
  - Water-source commercial heat pump water heater: A commercial heat pump water heater that utilizes water or a brine solution as the heat source. For the purposes of this test procedure, it refers to ground-source closed-loop commercial heat pump water heaters, ground water-source commercial heat pump water heaters, and indoor water-source commercial heat pump water heaters

Applicability

- Included components:
  - Heat Pump Unit (Air Source, Water Source, and Direct Geo-Exchange)
    - Supplied without a matching storage tank (Type IV)
    - Supplied with a matching storage tank (Type V) that is not integrated (*i.e.,* the matching storage tank is supplied as a separate assembly)
  - Auxiliary Water Storage Tanks
    - Unfired hot water storage tanks
    - Electric Storage water heaters
  - Circulator Pumps

The DOE and EPA welcome comment on whether any other components of central HPWH systems not included in this test procedure would have significant impacts on the energy efficiency of the system.

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Test Set Up and Apparatus

- References section 6.1, 6.2 and 6.5 of ANSI/ASHRAE 118.1-2022 for instrument accuracy and thermocouple/flowmeter specifications.
- References certain parts of section 7 of ANSI/ASHRAE 118.1-2022, including figures 6-14, for the setup of the psychrometric chamber, heat pump unit, thermocouples, temperature sensors, and water piping.
- For air source HPWHs that can be installed in either ducted or nonducted configurations, test in the ducted configuration

The DOE and EPA welcome comment on whether referencing ANSI/ASHRAE 118.1-2022 (as opposed to ANSI/ASHRAE 118.1-2012, or any other existing test method) is appropriate for this test procedure and if any additional modifications to its reference in this test procedure are necessary.

Discussion – Test Setup

- DOE is aware of certain HPWH models that have plumbing connections to connect to a separate tank (or tanks) that are oriented in a way that does not match the figures in ASHRAE 118.1-2022.
  - This test procedure proposes to test these units as Type IV (i.e., without a matching storage tank)
  - The DOE and EPA request comment on whether this approach is sufficiently representative, and on how manufacturers test according to ANSI/ASHRAE 118.1-2022 if their equipment is incompatible with the plumbing configurations in ANSI/ASHRAE 118.1-2022.
- The DOE and EPA request comment on its proposal to test units that can be set up in either ducted or nonducted configurations in only the ducted configuration.
  - The ducted configuration will likely result in the most conservative rating
  - The DOE and EPA request comment on whether the ducted configuration is representative of typical performance of such units, or if separate tests should be conducted in both configurations.

Test Conditions – Air Source Central HPWH

Test Number	Evaporator Entering Air Temperature °F (± 1 °F)	
	Dry-bulb temperature	Wet-bulb temperature
1	95.0	75
2	80.6	71.2
3	50.0	44.3
4	17.0	15.0
5	5.0	4.0

- All evaporator test conditions above the manufacturer specified compressor cutout temperature are required to be tested.
- Tests are intended to be dry tests where frost does not form.
- Test condition dry-bulb and wet-bulb temperatures were chosen based on a review of the available product literature for commercial HPWHs and other heat pump product test procedures.

The DOE and EPA welcome comment on how many products will be able to meet these evaporator entering air temperatures and whether additional evaporator conditions should be included as required test conditions.

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Test Conditions – Other types of Central HPWHs

Central HPWH Type	Test Condition
DG-central HPWHs	Maintain the evaporator refrigerant temperature at 32.0 °F ± 1 °F.
Indoor WS-central HPWHs	Maintain the evaporator entering water temperature at 68.0 °F ± 1 °F.
Ground WS-central HPWHs	Maintain the evaporator entering water temperature at 50.0 °F ± 1 °F.
Ground-Source Closed-Loop central HPWHs*	Maintain the evaporator entering water temperature at 32.0 °F ± 1 °F.

* For ground-source closed-loop central HPWHs, the evaporator water must be mixed with 15-percent methanol by-weight to allow the solution to achieve the required rating conditions.

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Test Conditions – Condenser Entering Water Temperature and Temperature Rise

Single-Pass Test	Multi-Pass Test
Adjust the target mean outlet water temperature to 70°F ± 2°F above the mean condenser entering water temperature of 70°F ± 1°F. If the tested model is unable to achieve the required mean outlet water temperature condition, omit this test.	Adjust the target mean outlet water temperature to 15°F ± 2°F above the mean condenser entering water temperature of 125°F ± 1°F.

- Single-pass units test each of the evaporator test conditions (as applicable) with both the Single-Pass and Multi-Pass test conditions.
- For multi-pass units test each of the evaporator test conditions (as applicable) with just the Multi-Pass test condition.

The DOE and EPA welcome comment on whether the proposed water temperature rise will be difficult to meet while using the proposed evaporator ambient test conditions and whether additional entering water temperature conditions should be included as required test conditions.

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Test Results and Metric – Heat Pump Unit

- During testing at each test condition, the following measured values are recorded in 1-minute intervals over a 30-minute period:
  - Electric power input
  - Outlet water temperature
  - Supply water temperature
  - Water flow rate
  - Pressure differential between entering and leaving water flow
  - Dry-bulb and Wet-bulb temperatures
- For each combination of evaporator test condition and water temperature rise condition the following metrics will be calculated:
  - Water heating capacity
  - Average rate of energy input
  - Coefficient of performance
- This results up to 10 different COPs if all combinations of test conditions are applicable.

Discussion – Integrated Metric

The DOE and EPA are considering developing an integrated heating metric for the heat pump unit represent the seasonal efficiency of this equipment, which might entail:

- Using bins across the range of outdoor air operating temperatures, with weighting to represent climate conditions
- Comparing unit capacity and load, and applying an electric resistance performance factor to make up the difference for bins with load greater than the highest stage unit capacity
- Interpolating capacity between compressor stages for bins where the highest stage capacity is greater than the bin load, but the load is less than the lowest stage capacity
- Applying cyclic degradation where the lowest stage capacity is greater than the load
- Multiple outdoor air temperatures and part-load testing for units with multiple compressor stages
- Using different provisions depending on the intended operating conditions for heat pumps (e.g., whether models have defrost mode)
- Varying the water heating load with outdoor air temperature to reflect variation in ground water temp

The DOE and EPA welcome comment and information on using a seasonal metric for heat pump units, especially feedback on the considerations listed above.

Test Method – Unfired Storage Tanks

- Test method is based largely on a test procedure that was proposed on May 9, 2016, in the test procedure Notice of Proposed Rulemaking ("NOPR") for Commercial Water Heating Equipment. 81 FR 28587
- Determines the standby losses of Unfired Hot Water Storage Tanks by referencing certain sections of GAMA Testing Standard IWH-TS-1 (March 2003 Edition).
- Maintains ambient room conditions while measuring time, ambient room temperature, and mean tank temperature.
- Includes an initial soak-in period which takes place for at least 12 hours before standby loss testing.
- The standby loss test is conducted between 142 °F and 138°F mean tank temperature.
- Measurements are used to calculate a mean tank water temperature decay rate, DR, in °F/h and standby loss, SL, in Btu/h.

The DOE and EPA welcome comment on the representativeness of this method for measuring standby loss of unfired hot water storage tanks, as well as any alternative metrics and/or test methods it should consider. As well as how unfired hot water storage tank standby losses are impacted by using a stratified tank and interactions with the central HPWH.

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Test Method – Electric Storage Water Heaters and Circulator Pumps

Electric Storage Water Heaters Test Method

- References appendix B to subpart G of 10 CFR 431
- Calculates the rate of energy input to the electric resistance element by measuring the energy consumed by the water heater during the duration of the test.
- Calculates the standby loss of the electric storage water heater by measuring the difference between the rate of change of the tank and the electric resistance element.

Energy Consumption of Circulator Pumps

- Uses sections 0-5 of appendix D to subpart Y of 10 CFR 431 to set-up, test, and collected data.
- Results in circulator energy rating (CER), in hp.

Specification Requirements

- Goal: address central HPWHs as systems
  - Challenge: unmanageable variety of combinations due to a product "model" including reference to all components of the system
  - The EPA will focus on the heat pump units, but include other accompanying equipment necessary for performance/certification
    - Could apply the label to a group of system designs rather than a single component

The EPA is considering the following and welcomes comment:

- What components must be addressed for adequate performance in the intended application;
- Whether the test method cover all of the components that are critical to the performance of the system and that require understanding to accurately predict the system performance;
- What variations of system configurations should a single product certification include.

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Single-Pass vs. Multi-Pass Configurations

- The test method distinguishes configuration types based on their ability to meet a 140F LWT
- Configuration doesn't significantly affect efficiency for gas and electric resistance systems, but it appears that heat pumps are more efficient in single pass
  - Many buildings have multi-pass WH systems which are well suited to large buildings with recirculation loops
  - The equivalent single-pass central HPWH system can also include a swing tank, not a heat pump, specifically for reheating the recirculation loop

The EPA is considering the following and welcomes comment:

- Whether the use of single pass vs. multi-pass configurations based on application or efficiency;
- Whether configuration type be a reasonable requirement for system certification;
- The extent to which certain design differences in heat pump units support single-pass configurations.

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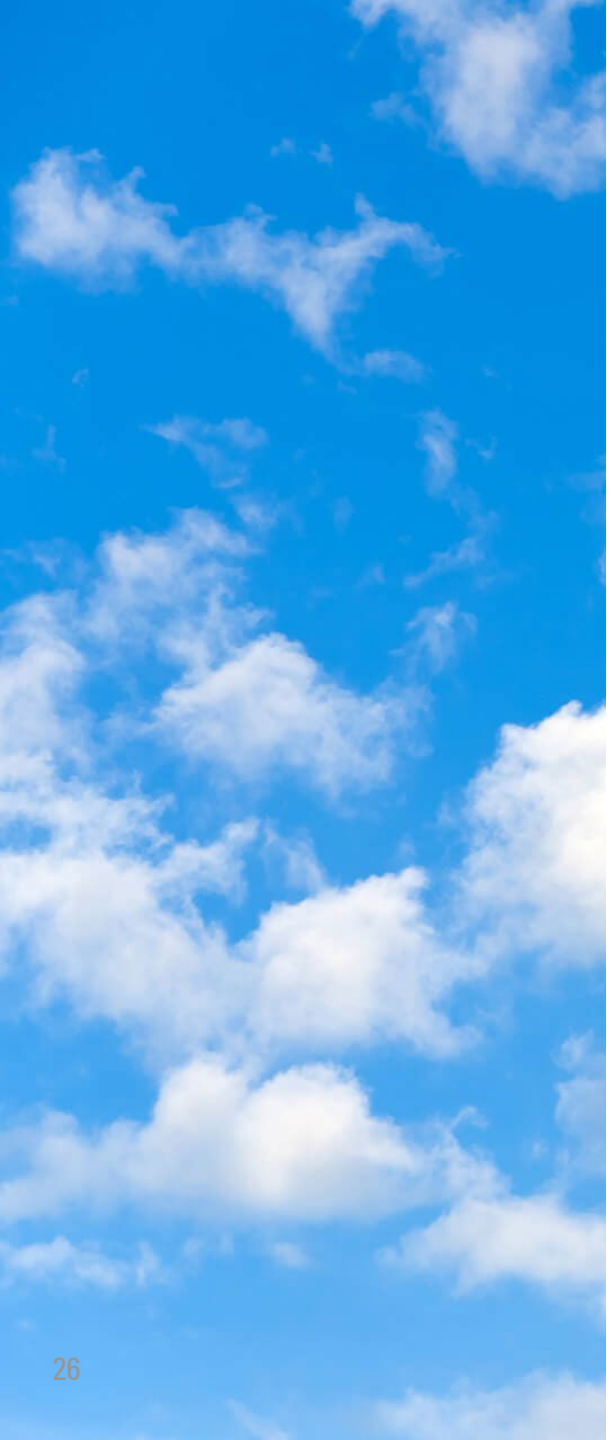
Remaining Questions

The EPA is considering the following and welcomes comment:

- The effect of high efficiency pumps on energy consumption and their relative cost;
- Adoption of a reliable pump efficiency metric and the appropriate level;
- Limitations of requiring high efficiency pumps in ENERGY STAR certified systems;
- Tank characteristics that affect system performance and should be addressed in the model definition and other effective methods of defining models;
- Whether and how to include flexible demand requirements such as excess energy storage capacity or ability to use specific DR protocols;
- Other system design savings opportunities;
- Method and manner of product performance reporting, including those that might benefit purchasers and incentive programs.

Timeline

Event	Date
Draft 1 Test Method & Discussion Guide	July 31, 2024
Draft 1 Test Method & Discussion Guide Webinar	**August 15, 2024**
Draft 1 Test Method & Discussion Guide Comments Due	September 13, 2024
Final Test Method & Draft 1 Version 3.0 Specification	*Q4 2024*
Final Version 3.0 Specification *(V2 products will remain on the QPL until V3 goes into effect; effective date is 9 months after release)*	*Q1 2025*



Thank you!
Questions?

Please submit comments on the discussion guide and draft 1 test method by **September 13, 2024**.

ENERGY STAR HVAC In-box:

HVAC@energystar.gov

Slides will be posted to the Commercial Water Heaters Specification Version 3 development page by COB Friday, August 16.