



ENERGY STAR® Program Requirements Product Specification for Residential Water Heaters

Eligibility Criteria Final Draft Version 5.0

1 Following is the **Version 5.0** product specification for ENERGY STAR certified water heaters. A product
2 shall meet all the identified criteria if it is to earn the ENERGY STAR.

3
4 **1) Definitions:** Below are the definitions of the relevant terms in this document.

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6 A. **Residential Water Heater (Consumer Water Heater):** A product that utilizes gas, electricity, or
7 solar thermal energy to heat potable water for use outside the heater upon demand, including:
8
9 a. Storage type units designed to heat and store water at a thermostatically-controlled
10 temperature, including: gas-fired storage (gas storage-type) water heaters with a
11 nameplate input of 75,000 Btu per hour or less, containing more than one gallon of water
12 per 4,000 Btu per hour of input; heat pump type units with a maximum current rating of 24
13 amperes at an input voltage 250 volts or less, including all ancillary equipment such as
14 fans, storage tanks, pumps, or controls necessary for the device to perform its function.¹
15
16 b. Instantaneous type units heat water but contain no more than one gallon of water per
17 4,000 Btu per hour of input with an input capacity less than or equal to 200,000 Btu per
18 hour for gas-fired instantaneous.¹
19
20 c. Gas-fired storage residential-duty commercial water heaters include gas-fired storage
21 water heaters that are designed to deliver hot water at a temperature less than or equal
22 to 180°F, with an input rate greater than 75,000 Btu per hour and not exceeding 105,000
23 Btu per hour, containing more than one gallon of water per 4,000 Btu per hour of input,
24 and storage volume less than or equal to 120 gallons. For models requiring electricity, a
25 single-phase external power supply is used.²
26
27 d. Solar water heaters include a collector and storage tank, and use the sun's energy to
28 heat water using one of the five basic types of solar water heating systems:
29
30 i. forced circulation (includes both direct and indirect systems),
31 ii. integrated collector and storage,
32 iii. thermosiphon,
33 iv. self-pumped, or
34 v. photovoltaic (PV).
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36 e. Integrated heat pump water heaters are residential water heaters where the compressor,
37 evaporator, condenser, and storage tank are integrated into the same unit.
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39 f. Split-System heat pump water heaters are residential water heaters where the
40 compressor, evaporator, and/or condenser are separated from a storage tank that is
41 specified by the manufacturer and rated as a single system.

¹ Adapted from 10 CFR Part 430, Subpart A §430.2 *Definitions*; in case of any inconsistencies, definitions in the CFR are authoritative.

² Adapted from 10 CFR Part 431, Subpart G §431.102 *Definitions*; in case of any inconsistencies, definitions in the CFR are authoritative.

- 42 g. Add-on Heat Pump Units are air to water heat pumps designed for use with a storage-
43 type water heater or a storage tank that is not specified or supplied by the manufacturer.
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- 45 B. Uniform Energy Factor³: Uniform Energy Factor (UEF) is the measure of water heater overall
46 efficiency.
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- 48 C. Solar Uniform Energy Factor: Solar Uniform Energy Factor (SUEF) refers to the energy delivered
49 by the total system divided by the electrical or gas energy put into the system.
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- 51 D. First-Hour Rating³: The First-Hour Rating (FHR) is an estimate of the maximum volume of “hot”
52 water that a storage-type water heater can supply within an hour that begins with the water heater
53 fully heated (i.e., with all thermostats satisfied). It is a function of both the storage volume and the
54 recovery rate.
55
- 56 E. Maximum GPM Rating³: Maximum GPM is the maximum gallons per minute of hot water that can
57 be supplied by an instantaneous water heater while maintaining a nominal temperature rise of 67
58 °F (37.3 °C) during steady-state operation.
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- 60 F. Manufacturer Limited Warranty: Manufacturer limited warranty is an assurance by the
61 manufacturer to the consumer that the water heater, including purchased system equipment and
62 components, are guaranteed to work for a defined period of time.
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- 64 G. Basic Model: All units of a given type of covered product (or class thereof) manufactured by one
65 manufacturer and which have the same primary energy source and, which have essentially
66 identical electrical, physical, or functional (or hydraulic) characteristics that affect energy
67 consumption, energy efficiency, water consumption or water efficiency.³ Further, all individual
68 models within a basic model have the same certified rating based on the applicable sampling
69 criteria per U.S. Department of Energy’s (DOE) regulations in Part 429⁴, and this rating must be
70 used for all manufacturer literature, the qualified product list and certification of compliance to
71 DOE standards.
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- 73 H. Lower Compressor Cut-off Temperature: The temperature below which a heat pump water
74 heater’s compressor will no longer operate, such that the unit will only work as a conventional
75 electric resistance water heater.
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- 77 I. Upper Compressor Cut-off Temperature: The temperature above which a heat pump water
78 heater’s compressor will no longer operate, such that the unit will only work as a conventional
79 electric resistance water heater.
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81 **Note:** EPA proposes adding a definition of upper compressor cutoff temperature to support
82 optional reporting for heat pump water heater models with compressors. In stakeholder
83 comments and discussions, EPA learned that in some climates, the places heat pump water
84 heaters are installed can reach as high as 110 °F, which can cause a unit’s compressor to stop
85 operating. The optional reporting requirements would allow purchasers to distinguish units that
86 can operate as heat pumps in this circumstance.
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- 89 J. Combination Space-Heating and Water-Heating Appliance: Appliance that provides both space
90 conditioning (boiler) and hot water heating with one appliance or energy source. The combination
91 appliance circulates hot water from the water heater through a heat exchanger in the air handler.
92 A blower will move the heated air through a standard duct system. In the summer, an air

³ 10 CFR Part 430, Subpart B, Appendix E

⁴ 10 CFR Part 429, Subpart B

93 conditioner is connected to the exchanger and the system functions similarly, with cool air being
 94 pushed through the ductwork.

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 96 **2) Scope:**

97 A. Included Products: Only products that meet the definition of a Residential Water Heater, as
 98 specified herein, are eligible for ENERGY STAR certification with exception of those products
 99 listed in Section 2B.

100 B. Excluded Products:

- 101 a. Electric resistance water heaters,
- 102 b. Add-on heat pump units,
- 103 c. Products intended only for commercial applications,
- 104 d. Combination space-heating and water-heating appliances.

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 108 **3) Certification Criteria:**

109 A. Product Performance Requirements for Electric Water Heaters:

110 **Table 1: Criteria for Certified Electric Water Heaters**

Criteria		ENERGY STAR Requirements
Uniform Energy Factor	Integrated HPWH	UEF ≥ 3.30
	Integrated HPWH, 120 Volt / 15 Amp Circuit	UEF ≥ 2.20
	Split-system HPWH	UEF ≥ 2.20
First-Hour Rating		FHR ≥ 45 gallons per hour
Warranty		Warranty ≥ 6 years on sealed system
Safety		UL 174 and UL 1995 or UL 60335-2-40
Lower Compressor Cut-Off Temperature (Reporting Requirement Only)		Report ambient temperature below which the compressor cuts off and electric resistance only operation begins

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112 B. Product Performance Requirements for Gas-Fired Water Heaters:

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114 a. Gas-Fired Storage Water Heaters:

115 **Table 2: Criteria for Certified Gas-Fired Storage Water Heaters**

Criteria		ENERGY STAR Requirements
Uniform Energy Factor	Tank Volume >20 gallons and ≤ 55 gallons	Medium Draw Pattern: UEF ≥ 0.81
		High Draw Pattern: UEF ≥ 0.86

	Tank Volume > 55 gallons	UEF ≥ 0.86
	First-Hour Rating	FHR ≥ 51 gallons per hour
	Warranty	Warranty ≥ 6 years on system (including parts)
	Safety	ANSI Z21.10.1/CSA 4.1

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Note: Following extensive discussions with stakeholders, EPA is lowering its proposed UEF level for gas storage water heaters from a heat pump-equivalent level to a high efficiency condensing-equivalent level.

EPA received an unprecedented number of comments, recommending every possible action from not revising the specification, to several different levels of revision (ranging from a condensing level to a higher heat pump efficiency level), to sunsetting the gas water heater specification entirely. Comments in favor of higher efficiency levels and/or sunsetting pointed out:

- the Biden administration’s commitment to decarbonization and wide public support for it;
- the results of numerous studies showing that switching to electricity for water heating was key to the lowest cost paths to decarbonization; and
- that unlike gas models, electric water heaters must be much higher efficiency than the DOE minimum standard to earn the ENERGY STAR, giving gas an unfair advantage.

Those recommending lower efficiency levels than in Draft 1, or to not revise, argued that:

- high efficiency electric water heaters remain unfamiliar and expensive;
- in some homes, switching fuels requires providing or upgrading electrical service at the location of the water heater, most notably LMI households;
- setting a level that no products on the market can meet is against ENERGY STAR Guiding Principles and practice, and there is no guarantee gas powered heat pumps will be cost effective; and
- a cost-effective gas technology exists, as noted in the [Regional Technical Forum \(RTF\) UES Measure for Residential Water Heaters Workbook Version 2.0](#). The units save energy with a non-powered flue damper, achieve a UEF of 0.65 to 0.70, and can be installed where electricity is not provided.

Several commentors specifically recommended UEF levels corresponding to a high efficiency condensing level, which is how EPA intends to proceed. While there was variance in what that level entails, EPA determined the UEF levels using the DOE technical support document (TSD) for consumer water heaters (March 2022). A small number of existing units currently on the market meet the proposed criteria (0% of medium draw units, 2% of high draw models). This level will be cost effective in some markets, and significantly improves customer payback over current levels in all markets.

With the momentum toward electrification in the US, EPA is confident that market adoption of electric water heating products will increase over the next few years, given the broad base of market actors driving it. Based on current analyses, it will make sense to sunset the gas water heating criteria in the near future. The small number of products this proposal recognizes will ease the transition for consumers that need it while also encouraging consumers to explore more efficient ENERGY STAR electric water heaters.

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b. Gas-Fired Instantaneous Water Heaters:

Table 3: Criteria for Certified Gas-Fired Instantaneous Water Heaters

Criteria	ENERGY STAR Requirements
Uniform Energy Factor	UEF \geq 0.95
Maximum Gallons Per Minute	Max GPM \geq 2.8 over a 67°F rise
Warranty	Warranty \geq 6 years on heat exchanger and \geq 5 years on parts
Safety	ANSI Z21.10.3/CSA 4.3
NOx Emissions (Reporting Requirement Only)	Report the NOx emissions associated with operation of the water heater

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Note: EPA is maintaining its proposed criteria for gas-fired instantaneous water heaters, which 22% of available instantaneous models meet, though none are medium draw. Units at this level provide considerably better payback than those at the current level.

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The comments and discussion for instantaneous products paralleled those for gas storage products. Several commentors recommended a UEF level of 0.93, noting factors including more robust customer options compared to the 0.95 level and improvements in efficiency/savings at that level compared to the Version 4.0 criteria. While medium draw units are unavailable at 0.95, only one model is available at 0.93, leading to no significant difference in setting the limit for those products at either level. In addition, this level does not provide sufficient differentiation because such a large number of products meet it.

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In addition, several commentors suggested setting a heat pump level for gas instantaneous units. EPA notes that unlike for storage products, it is unlikely it will ever be economically viable to use a gas or electric heat pump for instantaneous water heating.

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As for gas-fired storage water heaters, EPA proposes adding a NOx emissions reporting requirement.

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c. Gas-Fired Storage Residential-duty Commercial Water Heaters:

Table 4: Criteria for Certified Gas-Fired Storage Residential-duty Commercial Water Heaters

Criteria	ENERGY STAR Requirements
Uniform Energy Factor	UEF \geq 0.86
Warranty	Warranty \geq 6 years on system
Safety	ANSI Z21.10.3/CSA 4.3
NOx Emissions (Reporting Requirement Only)	Report the NOx emissions associated with operation of the water heater

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Note: Similar to storage water heaters, EPA is revising its proposal for residential duty commercial water heaters to a high-efficiency condensing level, which 11% of existing models can meet. The reasoning for this is the same as for gas storage products.

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C. Product Performance Requirements for Solar Water Heaters:

Table 5: Criteria for Certified Solar Water Heaters

Criteria	ENERGY STAR Requirements
Solar Uniform Energy Factor	SUEF ≥ 3.00 for electric backup SUEF ≥ 1.80 for gas backup
Warranty	Warranty ≥ 10 years on collector, ≥ 6 years sealed system, ≥ 2 years on controls, ≥ 1 year on parts

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4) Connected Product Criteria – Optional:

This section presents connected criteria for ENERGY STAR certified water heaters. Compliance with Section 4 criteria is optional. ENERGY STAR certified water heaters that comply with all Section 4 criteria will be identified on the ENERGY STAR website as having ‘Connected’ functionality. As for all ENERGY STAR products, these criteria define products which provide a combination of additional user functionality and grid services, as appropriate for the product type.

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A. Definitions

- a. Communication Link: As shown in Figure 1, the mechanism for bi-directional data transfers between the Connected Water Heater Product and one or more external applications, devices or systems.
- b. Connected Water Heater Product (CWHP): As shown in Figure 1, includes the ENERGY STAR certified water heater, integrated or separate communications hardware, and additional hardware and software required to enable connected functionality.

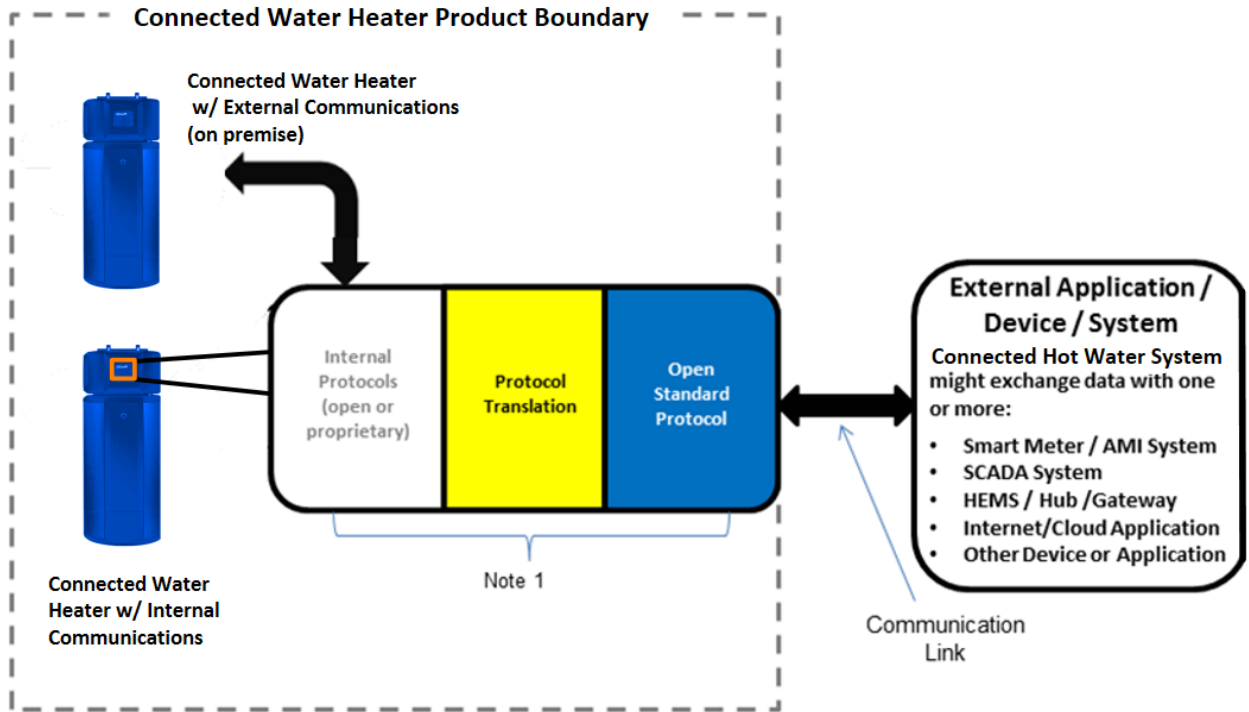


Figure 1: Connected Water Heater Product (CWHP)

Note 1: Communication device(s), link(s) and/or processing that enables Open Standards-based communication between the CWHP and external application / device / system(s). These elements, either individually or together, could be within the water heater/controller, and/or an external communication module, a hub/gateway, or in the Internet/cloud.

- c. Consumer Authorized Third Party: Any entity for which the consumer has provided explicit permission to access the CWHP connected functionality, in whole or in part, via a Communication Link. *Example: A consumer may allow a Home Energy Management System (HEMS) or a Demand Response Management System (DRMS) access to the CWHP connected functionality.*
- d. Demand Response (DR): Changes in electric or gas usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity or gas over time, or to incentive payments designed to induce lower electricity or gas use at times of high wholesale market prices or when system reliability is jeopardized⁵.
- e. Demand Response Management System (DRMS): The system operated by a consumer authorized program administrator, such as the utility or third party, which dispatches signals with DR instructions and/or price signals to the CWHP products and receives messages from the CWHP product.
- f. Interface Specification: A document or collection of documents that contains detailed technical information to facilitate access to relevant data and product capabilities over a communications interface.

⁵ Modified to apply to gas as well, based on Federal Energy Regulatory Commission, <https://www.ferc.gov/electric/industry-activity/demand-response/national-assessment-and-action-plan-demand-response>

- 231 g. Load Management Entity: Consumer authorized DRMS, home energy management
232 system, or the like.
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- 234 h. Open Standards: Communication with entities outside the CWHP that use, for all
235 communication layers, standards:
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237 • included in the Smart Grid Interoperability Panel (SGIP) Catalog of Standards,⁶ and/or
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239 • included in the NIST Smart Grid Framework Tables 4.1 and 4.2, and/or
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241 • adopted by the American National Standards Institute (ANSI) or another well-
242 established international standards organization such as the International Organization
243 for Standardization (ISO), International Electrotechnical Commission (IEC), International
244 Telecommunication Union (ITU), Institute of Electrical and Electronics Engineers (IEEE)
245 or Internet Engineering Task Force (IETF).⁶
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- 247 i. On-Premises: Refers to a function that relies only on equipment present at the physical
248 installed location of the ENERGY STAR certified device/equipment.
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- 250 j. Load Shift: A load shift operation moves energy that would have been used by a device
251 within a time interval under normal operating conditions, to occur outside that time
252 interval. Load shifting can be performed by a combination of load up and curtailment
253 requests.
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255 B. Communications
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- 257 a. The CWHP Communication Link, in Figure 1, shall use Open Standards for all
258 communication layers to enable functions listed in Sections 4B) and 4C).
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- 260 b. An Interface Control Document (ICD), Application Programming Interface (API), or other
261 documentation shall be made available to interested parties that, at minimum, allows
262 access to the functions listed in Sections 4B) and 4C).
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264 C. Remote Management and Consumer Feedback
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266 The CWHP shall provide the following functionality:
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268 a. **Remote Management:**

269 The product shall be capable of receiving and responding to consumer authorized remote
270 requests (not including third-party remote management which may be made available
271 solely at the discretion of the manufacturer), via a communication link, similar to
272 consumer controllable functions on the product.

- 273 i. Higher energy mode settings shall be temporary: If a remote management signal
274 puts the CWHP into a mode that uses more energy than the mode selected
275 locally, the product shall revert to the locally set mode within 72 hours if no
276 additional user input is received.
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278 b. **User Alerts:**

279 The CWHP shall be capable of providing at least two types of messages relevant to
280 optimizing its energy consumption, either:

- 281 i. On the product (e.g. water heater and/or controller), and/or

⁶ <https://sepapower.org/knowledge/catalog-of-standards/>

282 ii. Transmitted to consumers and consumer authorized third parties via a
283 communication link. This link can include open standards protocols used for
284 Demand Response or could use a secondary communication link.

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286 *For example, messages relevant to energy consumption for water heaters might address*
287 *a fault condition, a reminder to descale heating elements, heat pump refrigerant charge,*
288 *or a report of energy consumption that is outside the product's normal range*

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290 c. **Energy Reporting:**

291 The product shall be capable of transmitting measured or estimated instantaneous power
292 draw in current conditions via a communication link to a Load Management Entity and
293 other consumer authorized devices, services, or applications. Products compliant with the
294 Demand Response criteria in Section 4C) meet this criterion through energy reporting
295 there.

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297 D. Demand Response (DR)

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299 Gas-fired Instantaneous Water Heaters are exempt from this functionality and may be recognized
300 as connected without meeting the criteria in this subsection. Solar water heaters are anticipated
301 to only respond to demand response signals while using grid power.

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303 a. **DR Communications Protocols:**

304 The CWHP shall meet the communication and equipment performance standards for
305 CTA-2045 or OpenADR 2.0b (Virtual End Node), or both.

306
307 b. **Override:**

308 The product shall provide an easily accessible means for consumers to override demand
309 response events during the event, except potentially for Grid Emergency/Off Mode
310 events. When the event is overridden, the CPWH shall return to normal operation as set
311 by the customer. Temporary overrides shall be limited to a duration up to 72 hours
312 without additional user input; after this time, the CPWH will return to its previous
313 operating mode.

314 **Note:** EPA received feedback that the requirement to provide capability to override scheduled events will
315 be a barrier to ENERGY STAR connected water heaters in the short term. In fact, further discussion
316 revealed that CTA-2045 compliance doesn't require water heaters to support scheduled events at all.
317 Manufacturers that have designed to minimum CTA-2045 criteria may not have this capability.

318 Despite the potential to keep products coming to market from getting recognized as ENERGY STAR
319 connected, EPA has not changed the requirement to support scheduled events because we consider it
320 important. We are interested in stakeholder feedback about how necessary this capability is in the short
321 term.

322 However, we do not feel the capability to override events ahead of time is immediately important and
323 have removed that requirement. EPA and DOE have proposed a new ENERGY STAR Final Draft
324 Connected Residential Water Heaters Test Method to Validate Demand Response, Version 1.2, reflecting
325 this change.

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327 c. **Loss of connectivity:**

328 A 'loss of connectivity' event is defined as 15 minutes without connection. The CWHP
329 shall respond as follows:

- 330 i. If a 'loss of connectivity' event occurs while processing a DR event with a set
331 duration or end time, product may complete DR event as planned, returning to
332 normal operation as set by the customer afterwards, or if over-ridden.
333 ii. If a 'loss of connectivity' event occurs while processing a DR event without a set
334 duration or end time, product will resume normal operation within 30 minutes.
335 iii. If the CWHP is capable of storing and operating with a time of use schedule, the
336 unit may continue operating on that schedule during a 'loss of connectivity' event.
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338 d. **Minimum Load Shift:**

339 CWHP shall be capable of load shifting either:

- 340 i. Basic Load Shift: 0.5 kWh or more via a combination of Basic Load Up and
341 General Curtailment responses defined in 4)D.f. under the conditions defined in
342 the ENERGY STAR Test Procedure for Water Heater Demand Response, or
343 ii. Advanced Load Shift: 1.0 kWh or more via a combination of Advanced Load Up
344 and General Curtailment responses defined in section 4)D.f. under the conditions
345 as defined in the ENERGY STAR Test Procedure for Water Heater Demand
346 Response.

347 Manufacturers shall report which load shift test was used for each model.
348

349 e. **DR Information and Messaging:**

350 The CWHP shall support the following upstream messaging from the device when
351 available and may support the additional (optional) messaging capabilities. Support for
352 these messaging signals is implemented via the open standards protocol used in the
353 product. The required mapping for these events is described in *Appendix B*. While the
354 required or optional functionality may vary based on product type and either protocol may
355 be used, the messaging must be communicated via the specified protocol command
356 within this appendix.
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358 Data provided by below messaging functions shall be calculated from product state no
359 older than 60 seconds from request.
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361 Required Messaging I/O
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- 363 • **Device Type** – Electric Resistance / Gas-fired Storage / Heat Pump.
- 364 • **Operational State** – Information on product running state, DR conditions
365 operating on product, opt in/out state, and fault conditions. The following states
366 will be able to be reported, as applicable to the chosen DR protocol:
 - 367 ○ **Idle Normal** – Water heater is not heating but is in a normal mode of
368 operation.
 - 369 ○ **Running Normal** – Water heater is in a Normal Operating Mode and the
370 water heater is presently heating (heat pump compressor or any heating
371 elements are energized).
 - 372 ○ **Running Curtailed Grid** – Water heater is running in a grid service
373 mode of operation and the water heater is presently heating (heat pump
374 compressor or any heating elements are energized).
 - 375 ○ **Running Heightened Grid** – Water heater is processing a load up
376 request and water is being heated.
 - 377 ○ **Idle Grid** – Water heater is in a grid service operational mode and the
378 water heater is not heating water.
 - 379 ○ **Water Heater Error** – Device is malfunctioning. Recommended use:
380 Failure of heat pump or element.
 - 381 ○ **Idle Heightened** – Water heater is processing a Load Up request and
382 water is not being heated.

- 383 ○ **Idle Opted Out** – Water heater is overridden has no/insignificant energy
- 384 consumption.
- 385 ○ **Running, Opted Out** – Water heater is overridden and is consuming
- 386 energy.
- 387 • **Current Available Energy Storage Capacity** – The amount of grid energy that
- 388 the end device can take now (kWh or therms). It is recognized that under some
- 389 extraordinary circumstances, the Current Available Energy Storage could exceed
- 390 the Total. For example, if a water heater temperature has fallen well below the
- 391 normal minimum regulation range.⁷
- 392 • **Power/Demand (Instantaneous)** – Measured or estimated power consumption
- 393 in current conditions (kW, Btu/hr, or therms).
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395 Optional Messaging I/O:

- 397 • **Energy Use** – Measured or estimated cumulative energy use of product (kWh or
- 398 Btu, therms).
- 399 • **Current Total Energy Storage Capacity** – The total amount of grid energy
- 400 storage that the end device represents. For example, the energy capacity of a
- 401 water heater would be the total amount of energy (kWh or therms) supplied to
- 402 move the tank from its minimum operating temperature (e.g. what it would allow
- 403 itself to drop to during a curtailment event) to its maximum operating temperature
- 404 (e.g. what it could run up to when asked “Load Up” before shutting off).⁷

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406 f. **DR Requests and Responses:**

407 The CWHP shall also support the required DR operational modes listed below and may

408 support additional open standard defined DR signals. Support for these requests is

409 implemented via the open standards protocol used in the product. The required mapping

410 for these events is described in *Appendix B*. While the required or optional functionality

411 may vary based on product type and either protocol may be used, the messaging must

412 be communicated via the specified protocol command within this appendix.

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414 Required Operational Mode Functionality:

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Required Operational Mode Functionality			
Operational Mode Request	Required for which products	Expected use and consumer impact	Response
General Curtailment (Shed/Light Shed)	All product types	Daily, several hours long; minimal impact	Avoids using energy that the device otherwise would have used under normal operating conditions, up to allowing the stored thermal energy in the tank to reduce moderately. For Heat Pump Water Heaters with resistive elements, the water heater shall avoid use of electric resistance elements during and immediately after the event unless user needs cannot be met. ¹

⁷ CTA-2045-A

Required Operational Mode Functionality			
Operational Mode Request	Required for which products	Expected use and consumer impact	Response
Emergency Curtailment (Critical Curtailment/ Deep Shed))	Electric storage and Solar ERWH	Daily, less than 1 hour; may be some consumer impact	Avoids using energy that the device otherwise would have used under normal operating conditions, up to allowing the stored thermal energy in the tank to deplete to a very low level, less than that for a General Curtailment request. For Heat Pump Water Heaters with resistive elements, this request would result in heat pump only operation during the request period. ¹
Grid Emergency (Off Mode/Full Shed)	Electric storage and Solar ERWH	Annually or less; consumer impact may be significant	Immediately, stop using energy for water heating when safe to do so. ¹
Load Up: Basic or Advanced	Basic: All product types Advanced: Optional	Daily, several hours long	Use and/or store additional thermal energy that device otherwise would not have used/stored under normal operation. Allows the stored thermal energy to increase, within safety parameters as determined by the manufacturer up to user set point for Basic Load Up. For Advanced Load Up, the device may exceed user set point. ² For heat pump water heaters with resistive heating elements, the use of the elements should be avoided as much as possible to satisfy this request. ¹
Return to Normal Operation	All product types	Daily	In the event an ongoing event is canceled for any reason, the product shall return to normal operation. ¹

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1. For all commands both immediate events and events scheduled in advance will be supported.
2. **Advanced Load Up** response is anticipated to be used on installations with a mixing valve, and is anticipated to require a user action to enable this request for the first time.

Optional Operational Mode Functionality:

Optional Operational Mode Functionality		
Operational Mode Request	Required for which products	Response
Set Point Adjustment	Optional	Adjusts product thermostat set point up or down if safe to do so.
Relative Price Signal(s)	Optional	Communicates information to endpoint on current energy cost and upcoming changes, to allow consumer configuration of when grid energy should be used and when it should be curtailed if possible.

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E. Additional Information for Consumers

- a. If additional modules, devices, services, and/or supporting infrastructure are required in order to activate the CWHP’s communications capabilities, installation instructions and a list of these requirements shall be made available at the point of purchase and prominently displayed in the product literature. It is also suggested that information be provided on the product packaging and on the product. These instructions shall provide specific information on what must be done to activate these capabilities (e.g. a product package or product label might briefly state, “This product has Wi-Fi capability and requires Internet connectivity and a wireless router to enable interconnection with external devices, systems or applications.”).

5) Test Requirements:

- A. One of the following sampling plans shall be used to test energy performance for qualification to ENERGY STAR:
 - a. A single unit is selected, obtained, and tested. The measured performance of this unit and of each subsequent unit manufactured must be equal to or better than the ENERGY STAR specification requirements. Results of the tested unit may be used to certify additional individual model variations within a basic model as long as the definition for basic model provided in Section 1, above, is met; or
 - b. Units are selected for testing and results are calculated according to the sampling requirements defined in 10 CFR Part 429, Subpart B §429.17. The certified rating must be equal to or better than the ENERGY STAR specification requirements. Results of the tested unit may be used to certify additional variations within a basic model as long as the definition for basic model provided in Section 1, above, is met. Further, all individual models within a basic model must have the same certified rating based on the applicable sampling criteria. This rating must be used for all manufacturer literature, the qualified products list, and certification of compliance to DOE standards.
- B. When testing residential water heaters, the following test methods shall be used to determine ENERGY STAR certification:

Table 6: Test Methods for ENERGY STAR Certification

Applicable Products	ENERGY STAR Requirement	Test Method Reference
Gas and Electric products (not including gas-fired storage residential-duty commercial water heaters); FHR is applicable to storage products and Maximum GPM is applicable to instantaneous products.	Uniform Energy Factor (UEF)	10 CFR Part 430, Subpart B, Appendix E*
	First Hour Rating (FHR)	
	Maximum GPM Rating	
Gas-fired Storage Residential-duty Commercial products	Uniform Energy Factor (UEF)	10 CFR Part 430, Subpart B, Appendix E*
Gas-fired products	NOx Emissions for reporting	[add test method here]
Whole-home solar units	Solar Universal Energy Factor (SUEF)	ICC 900/SRCC 300-2020 Solar Thermal System Standard, Appendix A: Solar Uniform Energy Factor Procedure for Solar Water Heating Systems
Connected Products	Demand Response	Test Method to Validate Demand Response V1.2

* Includes any applicable guidance that DOE has issued regarding the testing of these products (See <http://www1.eere.energy.gov/guidance/default.aspx?pid=2&spid=1>).

C. Compliance with Connected Criteria

- a. Aside from demand response functionality, compliance with connected criteria, as specified in Section 4.D.f, shall be through examination of product and/or product documentation.

D. Significant Digits and Rounding:

- a. All calculations shall be carried out with actual measured (unrounded) values. Only the final result of a calculation shall be rounded.
- b. Unless otherwise noted in this section, compliance with specification limits shall be evaluated using exact values without any benefit from rounding.
- c. Reporting on the ENERGY STAR website shall be performed using calculation results or measured values that are rounded to the nearest unit in the last right-hand digit as specified in the corresponding specification requirement below.

Note: EPA will release a revised test method (Version 1.2) incorporating the change to not test override of scheduled events if the change to requirements is included in the Final Version 5 specification.

6) Effective Date:

The ENERGY STAR Version 5.0 Residential Water Heaters specification shall take effect on **April 5, 2023**. To qualify for ENERGY STAR, a product model shall meet the ENERGY STAR specification in effect on the model's date of manufacture. The date of manufacture is specific to each unit and is the date on which a unit is considered to be completely assembled.

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Note: The anticipated effective date of Version 5.0 reflects an expectation that it will be finalized by July 5, 2022.

7) Future Specification Revisions:

EPA reserves the right to change the specification should technological and/or market changes affect its usefulness to consumers, industry, or the environment. In keeping with current policy, revisions to the specification are arrived at through industry discussions. In the event of a specification revision, please note that the ENERGY STAR certification is not automatically granted for the life of a product model.

- A. EPA is in discussion with the Northwest Energy Efficiency Alliance on their Advanced Water Heating Specification and with the Advanced Water Heating Initiative as they expand to national action, seeking to harmonize specifications as much as possible in the future. This may include adding reporting or performance requirements similar to those in the other specifications.
- B. EPA anticipates the continued growth of the market for high efficiency electric water heaters. As states and localities nationwide move toward decarbonization, we expect gas water heating to become less common and more expensive. EPA anticipates eventually sunseting criteria for gas water heaters, in line with this trend and the need for cost-effective decarbonization.

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Note: Appendix A in the Version 4.0 specification contained criteria in terms of EF and TE, as a courtesy for the specification to be used by Natural Resources Canada for products sold only in Canada. As this is no longer necessary, the entire appendix has been removed, meaning that all products certified to Version 5 must use UEF or SUEF. The remaining appendices have been re-numbered.

510 **Appendix A – Demand Response Message Mapping**

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Table 7: Normative DR Message Mapping

Category	Subtype	Demand Response Messaging	Response Result	ANSI/CTA (2045-A)	OpenADR (2.0b)
Basic Signals	Curtailment	General Curtailment	Reduce load (moderate)	Shed ⁸	oadrDistributeEvent: SIMPLE level 1. ⁹
		Emergency Curtailment	Reduce load (major)	Critical Peak Event ⁸	oadrDistributeEvent: SIMPLE level 2. ⁹
		Grid Emergency	Turn off (if possible)	Grid Emergency ⁸	oadrDistributeEvent: SIMPLE level 3. ⁹
	Load Up	Load Up	Use more energy (if possible)	Load Up ⁸	oadrDistributeEvent: NEAR / FAR flag, CHARGE STATE, LOAD_DISPATCH. ⁹
	Run Normal	Return to Normal Operation	Return to defaults	End Shed / Run Normal ⁸	oadrDistributeEvent: CANCELLED. ⁹
Advanced Signals	Device State	Set Point Adjustment	Adjust water setpoint (if possible)	Get / Set SetPoint ¹⁰ [Section 9.1.6]	oadrDistributeEvent: LOAD_CONTROL. ⁹
	Real Time / Device Logic	Real Time System Load	Use / do not use energy when appropriate (follow programming)	Request for Power Level ¹⁰ [Section 8.2.1]	
		Utility Peak Load Price Signal		Present Relative Price ¹⁰ , [Section 9.1.3]	oadrDistributeEvent: ELECTRICITY_PRICE ⁹
		Excess Capacity(DER)		Grid Guidance ⁸	
Device Properties & Enrollment	Opt Out	Consumer Override	Skip response to event within opt out	Customer Override Message, in response to Operational State Query or load reduction request ⁸	oadrCreateOpt: device sends upstream opt message ¹¹
	Dev. Info	Device Information	Indicates all mandatory product information	Info Request ¹⁰ [Section 9.1.1]	Ei:eiTargetType (endDeviceAsset)

⁸ CTA-2045-A: Table 8-2

⁹ Section 8.1, OpenADR 2.0b EiEvent Service; Figures 4 & 5, EiEvent Patterns; Section 8.2.2, OpenADR 2.0b Signal Definitions; Table 1, Signals

¹⁰ CTA-2045-A: Table 9-2

¹¹ Section 8.5, OpenADR 2.0b EiOpt Service; Figure 17, Interaction Diagram: Create Opt

	Status	State Reporting Requirements	Provide state information to requestor	Operational State Query ⁸ [Section 8.2.4] (see Table 8)	EiReport. oadrPayloadResource Status (see Table 8 and 9)
	Hardware	Hardware Requirements	Design of product & comms.	DC or AC Form Factor ¹²	
Device Energy	Energy	Power (Instantaneous)	Demand of product (W)	GetCommodity Read, code 0	oadrPayloadResource Status: energyReal
		Energy (Cumulative)	Energy used by product (kWh)	GetCommodity Read, code 0	oadrPayloadResource Status: energyReal
	Storage	Current Energy Storage Capacity	Available energy storage (Wh)	GetCommodity Read, Code 7	oadrPayloadResource Status: oadrCapacity: oadrCurrent
		Total Energy Storage Capacity	Energy storage under ideal conditions (Wh)	GetCommodity Read, Code 6	oadrPayloadResource Status: oadrCapacity: oadrNormal

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Table 8: Operational State Codes

Op State Code	Name
0	Idle Normal
1	Running Normal
2	Running Curtailed Grid
3	Running Heightened Grid
4	Idle Grid
5	Water Heater Error
6	Idle Heightened
11	Idle, Opted Out
12	Running, Opted Out

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Table 9: OpenADR 2.0b Operational State Reporting¹³

OpenADR 2.0b EiReport Service			
REQ	Report Name	x-CTA2045_Status	
M1.1	Report Structure	Status	Interval
	rID	OperationalState	1-min
	Report Type	Reading	
	Reading Type	Direct Read	
	Units	customUnit	
ANSI/CTA-2045-A Message			
Message		Operational State Query Response	
Element Mapped to rID		Opcode 2 of Basic 0x13	

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¹² CTA-2045-A, Appendix A & Appendix B

¹³ Electric Power Research Institute, Communication Protocol Mapping Guide 1.0, OpenADR 2.0 to ANSI/CTA-2045-A, Table 2-3 Measurement and Reporting Mapping Requirements

518 **Appendix B (Informational) – Demand Response Use cases**

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a. Peak Load Reduction: Curtailment and Emergency Curtailment

- i. Includes protocols for both advance notice and scheduled peak shed (reduction), and emergency curtailment programs.
- ii. Utility implementation may vary regionally but would be accessed via the open standards application layer specification for **General Curtailment**, **Emergency Curtailment**, and **Off Mode** in the relevant standard. See *Informational Appendix B* **Error! Not a valid bookmark self-reference.** for messaging examples in common protocols.
- iii. Implementation could include downward adjustment of set points via application layer **Set Point Adjustment**. No requirements set on this parameter.

b. Spinning Reserves: Short Term Curtailment and (Simple) Load Up

- iv. Includes protocols for short term curtailment and load up. Utility implementation may vary regionally but would be accessed via the open standards application layer specification for **General Curtailment** and **Load Up** in the relevant standard. See *Informational* **Error! Not a valid bookmark self-reference.** for messaging examples in common protocols.
- v. Implementation could include application layer **Set Point Adjustment** downward. No requirements set on this parameter.

c. Thermal Storage

- vi. Includes routines which can incorporate tank stratification strategies and set point adjustment up to on-site maximum allowed tank temperature during load up (ramp) event. This storage is then used to reduce energy usage during a targeted future time period.
- vii. Utility implementation may vary regionally but would be accessed via the open standards application layer specification for **Set Point Adjustment** and **Load Up** in the relevant standard. See *Informational* **Error! Not a valid bookmark self-reference.** for messaging examples in common protocols.
- viii. Manufacturer strategies may include analysis of **Utility Peak Load Price Signal** and **Excess (DER) Capacity** signals to assist in identifying times where Thermal Storage should be initiated by the product.

Note: Impact of thermal storage strategies varies by tank capacity and installation circumstances.

d. Fast Response: Frequency Balancing

- ix. Fast response routines, where <10 second response intervals are used to frequency balance sections of an operator’s grid, are still under active development. Additional research and more widespread adoption would be necessary prior to including this protocol in the standard DR suite for CWHP’s.
- x. Utility implementation would require communication with the CWHP, providing **Real Time System Load** signals to the application layer of the product.

Note: Fast response operational modes require relay technology capable of a large number of switching cycles, which typically require upgraded contactor terminals.