



# ENERGY STAR® Program Requirements Product Specification for Residential Water Heaters

## Eligibility Criteria Version 3.3 Draft 2

1 Following is the **Version 3.3** product specification for ENERGY STAR certified water heaters. A product  
2 shall meet all of the identified criteria if it is to earn the ENERGY STAR.

3  
4 **Note:** Some products may have been certified using the Energy Factor (EF) criteria, but all new products  
5 shall be certified with Uniform Energy Factor (UEF), and products to be sold in the U.S. must also provide  
6 a Uniform Energy Factor (UEF) rating. Definitions, criteria, and testing requirements that are specific to  
7 EF for electric and gas-fired water heaters are outlined in Appendix A of this document.

8  
9 **1) Definitions:** Below are the definitions of the relevant terms in this document. See Appendix A,  
10 Section 1 for definitions relevant to EF.

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12 A. Residential Water Heater (Consumer Water Heater): A product that utilizes gas, electricity, or  
13 solar thermal energy to heat potable water for use outside the heater upon demand, including:

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15 a. Storage type units designed to heat and store water at a thermostatically-controlled  
16 temperature, including: gas-fired storage (gas storage-type) water heaters with a  
17 nameplate input of 75,000 Btu per hour or less, containing more than one gallon of water  
18 per 4,000 Btu per hour of input; electric heat pump type units with a maximum current  
19 rating of 24 amperes at an input voltage 250 volts or less.<sup>1</sup>  
20  
21 b. Instantaneous type units heat water, but contain no more than one gallon of water per  
22 4,000 Btu per hour of input with an input capacity less than or equal to 200,000 Btu per  
23 hour for gas-fired instantaneous.<sup>1</sup>  
24  
25 c. Gas-fired storage residential-duty commercial water heaters include gas-fired storage  
26 water heaters that are designed to deliver hot water at a temperature less than or equal  
27 to 180°F, with an input rate greater than 75,000 Btu per hour and not exceeding 105,000  
28 Btu per hour, containing more than one gallon of water per 4,000 Btu per hour of input,  
29 and storage volume less than or equal to 120 gallons. For models requiring electricity, a  
30 single-phase external power supply is used.<sup>2</sup>  
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32 d. Solar water heaters include a collector and storage tank, and use the sun's energy to  
33 heat water using one of the five basic types of solar water heating systems:  
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35 i. forced circulation (includes both direct and indirect systems),  
36 ii. integrated collector and storage,  
37 iii. thermosiphon,  
38 iv. self-pumped, or  
39 v. photovoltaic (PV).  
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41 e. Add-on Heat Pump Units are air to water heat pumps designed for use with a storage-  
42 type water heater or a storage tank that is not specified or supplied by the manufacturer.  
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<sup>1</sup> Adapted from 10 CFR Part 430, Subpart A §430.2 *Definitions*

<sup>2</sup> Adapted from 10 CFR Part 431, Subpart G §431.102 *Definitions*

- 44 B. Uniform Energy Factor<sup>3</sup>: Uniform Energy Factor (UEF) is the measure of water heater overall  
45 efficiency.  
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- 47 C. Solar Energy Factor: Solar Energy Factor (SEF) refers to the energy delivered by the total system  
48 divided by the electrical or gas energy put into the system.  
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- 50 D. First-Hour Rating<sup>3</sup>: The First-Hour Rating (FHR) is an estimate of the maximum volume of “hot”  
51 water that a storage-type water heater can supply within an hour that begins with the water heater  
52 fully heated (i.e., with all thermostats satisfied). It is a function of both the storage volume and the  
53 recovery rate.  
54
- 55 E. Maximum GPM Rating<sup>3</sup>: Maximum GPM is the maximum gallons per minute of hot water that can  
56 be supplied by an instantaneous water heater while maintaining a nominal temperature rise of 67  
57 °F (37.3 °C) during steady-state operation.  
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59 **Note:** As the Federal minimum efficiency standards are now in terms of UEF, EPA has moved the  
60 definitions aligned with the UEF test procedure from Appendix A to the main body of the specification.  
61 Definitions aligned with the EF test method have been moved from the main body of the specification to  
62 Appendix A.

- 63
- 64 F. Manufacturer Limited Warranty: Manufacturer limited warranty is an assurance by the  
65 manufacturer to the consumer that the water heater, including purchased system equipment and  
66 components, are guaranteed to work for a defined period of time.  
67
- 68 G. Basic Model: All units of a given type of covered product (or class thereof) manufactured by one  
69 manufacturer and which have the same primary energy source and, which have essentially  
70 identical electrical, physical, or functional (or hydraulic) characteristics that affect energy  
71 consumption, energy efficiency, water consumption or water efficiency.<sup>3</sup> Further, all individual  
72 models within a basic model have the same certified rating based on the applicable sampling  
73 criteria per U.S. Department of Energy’s (DOE) regulations in Part 429<sup>4</sup>, and this rating must be  
74 used for all manufacturer literature, the qualified product list and certification of compliance to  
75 DOE standards.  
76
- 77 H. Lower Compressor Cut-off Temperature: The temperature below 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.  
80
- 81 I. Combination Space-Heating and Water-Heating Appliance: Appliance that provides both space  
82 conditioning (boiler) and hot water heating with one appliance or energy source. The combination  
83 appliance circulates hot water from the water heater through a heat exchanger in the air handler.  
84 A blower will move the heated air through a standard duct system. In the summer, an air  
85 conditioner is connected to the exchanger and the system functions similarly, with cool air being  
86 pushed through the ductwork.  
87
- 88 J. Communication Link: As shown in Figure 1, the mechanism for bi-directional data transfers  
89 between the Connected Water Heater Product and one or more external applications, devices or  
90 systems.  
91
- 92 K. Connected Water Heater Product (CWHP): As shown in Figure 1, includes the ENERGY STAR  
93 certified water heater, integrated or separate communications hardware, and additional hardware  
94 and software required to enable connected functionality.  
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<sup>3</sup> 10 CFR Part 430, Subpart B, Appendix E

<sup>4</sup> 10 CFR Part 429, Subpart B

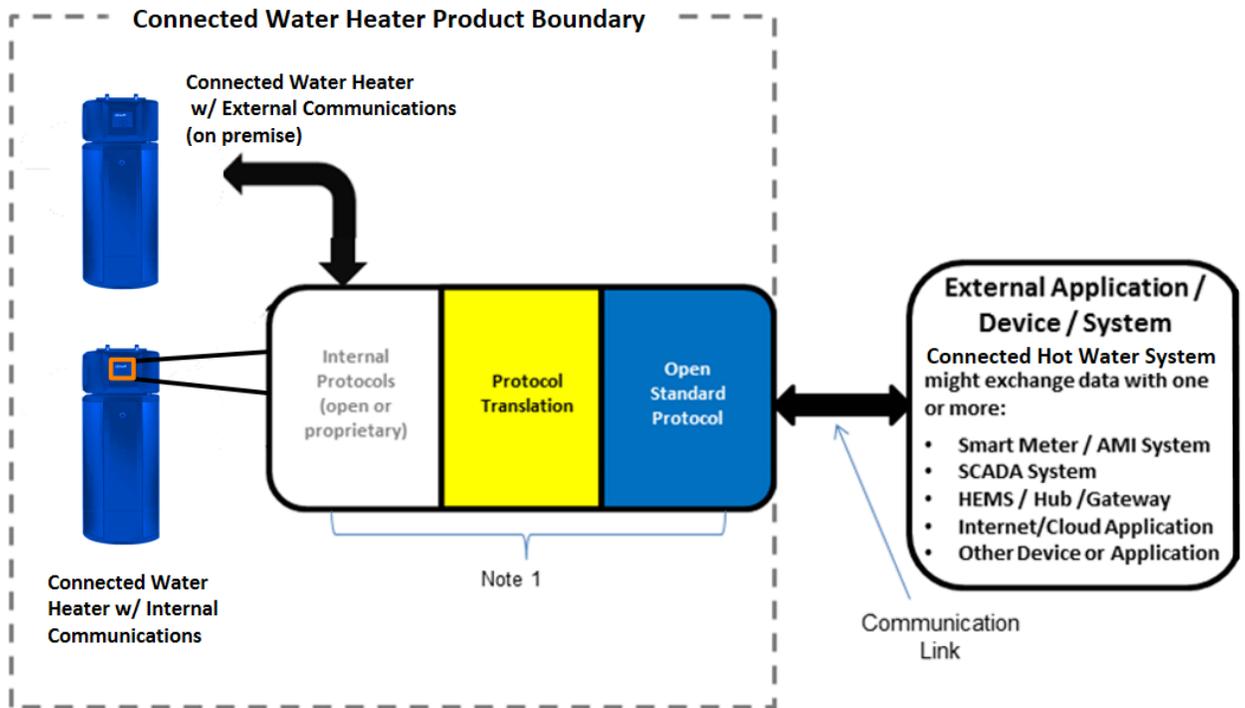


Figure 1: Connected Water Heater Product (CWHP)

**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.

- L. 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.*
- M. 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 jeopardized<sup>5</sup>.
- N. 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.
- O. 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.

<sup>5</sup> Modified to apply to gas as well, based on Federal Energy Regulatory Commission, <https://www.ferc.gov/industries/electric/industry-act/demand-response/dr-potential.asp>

- 124 P. Load Management Entity: Consumer authorized DRMS, home energy management system, or  
 125 the like.  
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- 127 Q. Open Standards: Communication with entities outside the CWHP that use, for all communication  
 128 layers, standards:  
 129
- 130 • included in the Smart Grid Interoperability Panel (SGIP) Catalog of Standards,<sup>6</sup> and/or
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  - 132 • included in the NIST Smart Grid Framework Tables 4.1 and 4.2, and/or
  - 133
  - 134 • adopted by the American National Standards Institute (ANSI) or another well-established  
 135 international standards organization such as the International Organization for Standardization  
 136 (ISO), International Electrotechnical Commission (IEC), International Telecommunication Union  
 137 (ITU), Institute of Electrical and Electronics Engineers (IEEE) or Internet Engineering Task Force  
 138 (IETF).<sup>6</sup>  
 139
- 140 R. On-Premises: Refers to a function that relies only on equipment present at the physical installed  
 141 location of the ENERGY STAR certified device/equipment.  
 142
- 143 S. Load Shift: A load shift operation moves energy that would have been used by a device within a  
 144 time interval under normal operating conditions, to occur outside that time interval. Load shifting  
 145 can be performed by a combination of load up and curtailment requests.

146 **Note:** EPA is proposing the above definition for Load Shift and welcomes feedback on it.

147 **2) Scope:**

- 148 A. Included Products: Only products that meet the definition of a Residential Water Heater, as  
 149 specified herein, are eligible for ENERGY STAR certification with exception of those products  
 150 listed in Section 2B.  
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- 152 B. Excluded Products:
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  - 154 a. Electric resistance water heaters,
  - 155 b. Add-on heat pump units,
  - 156 c. Products intended only for commercial applications,
  - 157 d. Combination space-heating and water-heating appliances.  
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160 **3) Certification Criteria:**  
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162 **Note:** Some products may have been certified using the EF criteria, but all new products shall be  
 163 certified with UEF, and products to be sold in the U.S. must also provide a UEF rating. Definitions,  
 164 criteria, and testing requirements that are specific to EF for electric and gas-fired water heaters are  
 165 outlined in Appendix A of this document.  
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- 167 A. Significant Digits and Rounding:
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  - 169 a. All calculations shall be carried out with actual measured (unrounded) values. Only the final  
 170 result of a calculation shall be rounded.  
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  - 172 b. Unless otherwise noted in this section, compliance with specification limits shall be evaluated  
 173 using exact values without any benefit from rounding.

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<sup>6</sup> [http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/PMO#Catalog\\_of\\_Standards\\_Processes](http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/PMO#Catalog_of_Standards_Processes)

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 175 c. Reporting on the ENERGY STAR website shall be performed using calculation results or  
 176 measured values that are rounded to the nearest unit in the last right-hand digit as specified  
 177 in the corresponding specification requirement below.  
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179 B. Product Performance Requirements for Electric Water Heaters:

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

Criteria		ENERGY STAR Requirements
Uniform Energy Factor	≤ 55 gallons	UEF ≥ 2.00
	> 55 gallons	UEF ≥ 2.20
First-Hour Rating		FHR ≥ 45 gallons per hour
Warranty		Warranty ≥ 6 years on sealed system
Safety		UL 174 and UL 1995
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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 182 C. Product Performance Requirements for Gas-Fired Water Heaters:

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 184 a. Gas-Fired Storage Water Heaters:

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

Criteria		ENERGY STAR Requirements
Uniform Energy Factor	≤ 55 gallons	Medium Draw Pattern UEF ≥ 0.64 High Draw Pattern UEF ≥ 0.68
	> 55 gallons	Medium Draw Pattern UEF ≥ 0.78 High Draw Pattern UEF ≥ 0.80
First-Hour Rating		FHR ≥ 67 gallons per hour
Warranty		Warranty ≥ 6 years on system (including parts)
Safety		ANSI Z21.10.1/CSA 4.1

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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 ≥ 0.87
Maximum Gallons Per Minute	Max GPM ≥ 2.9 over a 67°F rise
Warranty	Warranty ≥ 6 years on heat exchanger and ≥ 5 years on parts
Safety	ANSI Z21.10.3/CSA 4.3

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

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

Criteria	ENERGY STAR Requirements
Uniform Energy Factor	UEF ≥ 0.80
Warranty	Warranty ≥ 6 years on system
Safety	ANSI Z21.10.3/CSA 4.3

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D. Product Performance Requirements for Solar Water Heaters:

**Table 5: Criteria for Certified Solar Water Heaters**

Criteria	ENERGY STAR Requirements
Solar Energy Factor	SEF ≥ 1.8 for electric backup SEF ≥ 1.2 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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**Note:** These criteria remain unchanged but have been moved from Appendix A to the main body of the specification to reflect the move toward UEF as the primary certification pathway. The certification criteria in terms of EF have been move to Appendix A.

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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

207 will be identified on the ENERGY STAR website as having 'Connected' functionality. As for all ENERGY  
208 STAR products, these criteria define products which provide a combination of additional user functionality  
209 and grid services, as appropriate for the product type.

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211 A. Communications

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- 213 a. The CWHP Communication Link, in Figure 1, shall use Open Standards for all  
214 communication layers to enable functions listed in Sections 4B) and 4C).  
215 b. An Interface Control Document (ICD), Application Programming Interface (API), or other  
216 documentation shall be made available to interested parties that, at minimum, allows  
217 access to the functions listed in Sections 4B) and 4C).

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219 B. Remote Management and Consumer Feedback

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221 The CWHP shall provide the following functionality:

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223 a. **Remote Management:**

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

- 228 i. Higher energy mode settings shall be temporary: If a remote management signal  
229 puts the CWHP into a mode that uses more energy than the mode selected  
230 locally, the product shall revert to the locally set mode within 72 hours if no  
231 additional user input is received.

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233 b. **User Alerts:**

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

- 236 i. On the product (e.g. water heater and/or controller), and/or  
237 ii. Transmitted to consumers and consumer authorized third parties via a  
238 communication link. This link can include open standards protocols used for  
239 Demand Response or could use a secondary communication link.

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

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245 c. **Energy Reporting**

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

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252 C. Demand Response (DR)

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

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**Note:** A stakeholder commented that solar water heaters consisting of PV panels and electric resistance tanks are currently certified. In recognition of this, EPA proposes several changes to address this case. EPA suggests that solar water heaters only process (i.e. respond to) DR requests when the device is operating under grid power. Note that when the specification is revised to Version 4, EPA will consider whether including these units in scope continues to make sense.

EPA also received stakeholder feedback that gas-fired storage water heaters are a future DR candidate in several major utility programs, therefore the Agency should maintain DR criteria where suitable for gas technology.

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a. **DR Communications Protocols**

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

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**Note:** EPA proposes to retain the requirement of either CTA-2045-A and/or OpenADR 2.0b compliance as proposed in Draft 1 of the specification. Stakeholder feedback on this requirement varied: some requested EPA allow proprietary cloud architectures, whereas others requested EPA only allow CTA-2045-A, and everything in between. While there was significant support for CTA2045-A only, there was more support for EPA's Draft 1 proposal. EPA also notes that while Washington state will require demand response communications via CTA-2045-A on all new water heaters starting January 1, 2021, California is adopting OpenADR 2.0b as a standard DR protocol. EPA is maintaining the flexibility from Draft 1 proposal.

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- b. **Override:** The product shall provide an easily accessible means for consumers to override demand response events during the event or ahead of time for a scheduled event, except for Grid Emergency/Off Mode events. When the event is overridden, the CPWH shall return to normal operation as set by the customer.
- c. **Loss of connectivity:** A 'loss of connectivity' event is defined as 5 consecutive polling events from the DRMS not responded to by the CWHP, or vice versa. **Note:** DR program implementation may set the polling time interval, so the elapsed time for a 'loss of connectivity' event may vary.
- i. If a 'loss of connectivity' event occurs while processing a DR event with a set duration or end time, product may complete DR event as planned, returning to normal operation as set by the customer afterwards, or if over-ridden.
  - ii. If a 'loss of connectivity' event occurs while processing a DR event without a set duration or end time, product will resume normal operation within 30 minutes.
- d. **Minimum Load Shift:** CWHP shall be capable of load shifting either:
- i. Basic Load Shift: 0.5 kWh or more via a combination of Basic Load Up and General Curtailment responses defined in 4)C.f, under the conditions defined in the ENERGY STAR Test Procedure for Water Heater Demand Response, or
  - ii. Advanced Load Shift: 1.0 kWh or more via a combination of Advanced Load Up and General Curtailment responses defined in section 4)C.f. under the conditions as defined in the ENERGY STAR Test Procedure for Water Heater Demand Response.

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

302 **Note:** EPA thanks stakeholders for robust participation in improving criteria for loss of connectivity. EPA  
303 proposes defining loss of connectivity in terms of missed polling events, providing clarity for design and  
304 testing. In addition, EPA proposes that when disconnected, water heaters may complete DR events that  
305 have planned ending times and allows them to delay stopping events without end times. Discussion with  
306 stakeholders indicated this would have the best balance of grid service and consumer protection. EPA  
307 has attempted to clarify that after the end of the event, or if it is overridden, the water heater will resume  
308 its “normal” operating state. This is intended to encompass user settings such as “eco mode” as well as  
309 any stored schedule. EPA requests further feedback on this wording.

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311 EPA proposes to require a minimum load shift under specific conditions. In talking to grid operators, load  
312 shift appears to be the most uniquely useful DR function of water heaters and has emerged as a key  
313 criterion in at least one other specification (California’s Building Energy Efficiency Standards, Draft Joint  
314 Appendix 13 on Water Heater Demand Management, or JA13). However, how much load a water heater  
315 can shift will depend on the circumstances of its installation and use. Thus, EPA’s requirement refers to  
316 specific laboratory conditions. EPA and DOE look forward to refining the amount of load shifting and the  
317 conditions to reflect real world potential. The criterion was written to mirror criteria in JA13, and to allow  
318 testing of only one shift event.

319 EPA requests stakeholder feedback on these proposals.

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321 **e. DR Information and Messaging**  
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323 The CWHP shall support the following upstream messaging from the device when  
324 available and may support the additional (optional) messaging capabilities. Support for  
325 these messaging signals is implemented via the open standards protocol used in the  
326 product. The required mapping for these events is described in *Appendix B*. While the  
327 required or optional functionality may vary based on product type and either protocol may  
328 be used, the messaging must be communicated via the specified protocol command  
329 within this appendix.

330 Data provided by below messaging functions shall be calculated from product state no  
331 older than 60 seconds from request.

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333 Required Messaging I/O  
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- 336 • **Device Type** – Electric Resistance / Gas-fired Storage / Heat Pump.
- 337 • **Operational State** – Information on product running state, DR conditions  
338 operating on product, opt in/out state, and fault conditions. The following states  
339 will be able to be reported, as applicable to the chosen DR protocol:
  - 340 ○ **Idle Normal** – Water heater is not heating but is in a normal mode of  
341 operation.
  - 342 ○ **Running Normal** – Water heater is in a Normal Operating Mode and the  
343 water heater is presently heating (heat pump compressor or any heating  
344 elements are energized).
  - 345 ○ **Running Curtailed Grid** – Water heater is running in a grid service  
346 mode of operation and the water heater is presently heating (heat pump  
347 compressor or any heating elements are energized).
  - 348 ○ **Running Heightened Grid** – Water heater is processing a load up  
349 request and water is being heated.
  - 350 ○ **Idle Grid** – Water heater is in a grid service operational mode and the  
351 water heater is not heating water.
  - 352 ○ **Water Heater Error** – Device is malfunctioning. Recommended use:  
353 Failure of heat pump or element.
  - 354 ○ **Idle Heightened** – Water heater is processing a Load Up request and

- 355 water is not being heated.
- 356 ○ **Idle Opted Out** – Water heater is overridden has no/insignificant energy
- 357 consumption.
- 358 ○ **Running, Opted Out** – Water heater is overridden and is consuming
- 359 significant energy.
- 360 ● **Current Available Energy Storage Capacity** – The amount of grid energy that
- 361 the end device can take now. It is recognized that under some extraordinary
- 362 circumstances, the Current Available Energy Storage could exceed the Total. For
- 363 example, if a water heater temperature has fallen well below the normal minimum
- 364 regulation range.<sup>7</sup>
- 365 ● **Power/Demand (Instantaneous)** – Measured or estimated power consumption
- 366 in current conditions (kW or Btu/hr).

367 Optional Messaging I/O:

- 370 ● **Energy Use** – Measured or estimated cumulative energy use of product (kWh or
- 371 Btu).
- 372 ● **Current Total Energy Storage Capacity** – The total amount of grid energy
- 373 storage that the end device represents. For example, the energy capacity of a
- 374 water heater would be the total amount of energy (kWh) supplied to move the
- 375 tank from its minimum operating temperature (e.g. what it would allow itself to
- 376 drop to during a curtailment event) to its maximum operating temperature (e.g.
- 377 what it could run up to when asked to “Load Up” before shutting off).<sup>7</sup> **Error!**
- 378 **Bookmark not defined.**

379 **Note:** EPA proposes to require a minimum data freshness requirement of 60 seconds for messaging  
 380 requests. EPA notes that this duration was provided by stakeholders conducting field trials at scale of  
 381 connected water heaters, and is not aware of any configuration of the allowed DR protocols that would  
 382 prevent a response within this interval.

383 EPA has aligned the definitions of Current Available Energy Storage Capacity and Current Total Energy  
 384 Capacity with those from the CTA-2045-A, with small modifications clarifying that the values reported  
 385 should represent the estimated grid energy accepted. EPA notes that for a heat pump water heater, the  
 386 energy stored within the water heater will be higher than the amount of grid energy consumed.  
 387 Stakeholder feedback on this interpretation and if there are difficulties for manufacturers in estimating grid  
 388 energy capacity from tank storage capacity.

389 **f. DR Requests and Responses**

390 The CWHP shall also support the required DR operational modes listed below and may  
 391 support additional open standard defined DR signals. Support for these requests is  
 392 implemented via the open standards protocol used in the product. The required mapping  
 393 for these events is described in *Appendix B*. While the required or optional functionality  
 394 may vary based on product type and either protocol may be used, the messaging must  
 395 be communicated via the specified protocol command within this appendix.

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<sup>7</sup> CTA-2045-A

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Required Operational Mode Functionality:

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, on recovery, elements should not be used to return the stored thermal energy to its normal operating level. <sup>1</sup>
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. <sup>1</sup>
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. <sup>1</sup>
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. <sup>2</sup> 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. <sup>1</sup>
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. <sup>1</sup>

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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.

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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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**Note:** EPA proposes multiple modifications to the previous DR request definitions. Curtailment modes and load up modes are redefined in terms of their impact on expected energy use under normal operating conditions, to better align with the manufacturer strategies which can be used to achieve these desired results. Critical curtailment was adjusted to heat pump only operation for HPWH. EPA notes that this would not impact consumer experience as the HPWH may exit the DR request if consumer needs require a faster recovery.

EPA also proposes the addition of the Advanced Load Up request defined similarly to CA Title 24 Joint Appendix 13 by allowing a load up command to exceed user set points at manufacturer discretion. EPA notes that a given water heater is expected to respond to a load up request with either a basic load up or an advanced load up, depending on its installation and control setup. The advanced load up response is intended to be used with a mixing valve and an additional point of user opt in, to ensure consumer safety. EPA requests stakeholder feedback on these proposals.

429 D. Additional Information for Consumers

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

441  
442 **5) Test Requirements:**

443 **Note:** See Appendix A, Section 3 for Test Methods for water heaters certifying using UEF.

- 444
- 445 A. One of the following sampling plans shall be used to test energy performance for qualification to
- 446 ENERGY STAR:
- 447 a. A single unit is selected, obtained, and tested. The measured performance of this unit and of
- 448 each subsequent unit manufactured must be equal to or better than the ENERGY STAR
- 449 specification requirements. Results of the tested unit may be used to certify additional

450 individual model variations within a basic model as long as the definition for basic model  
 451 provided in Section 1, above, is met; or  
 452  
 453 b. Units are selected for testing and results are calculated according to the sampling  
 454 requirements defined in 10 CFR Part 429, Subpart B §429.17. The certified rating must be  
 455 equal to or better than the ENERGY STAR specification requirements. Results of the tested  
 456 unit may be used to certify additional variations within a basic model as long as the definition  
 457 for basic model provided in Section 1, above, is met. Further, all individual models within a  
 458 basic model must have the same certified rating based on the applicable sampling criteria.  
 459 This rating must be used for all manufacturer literature, the qualified products list, and  
 460 certification of compliance to DOE standards.

461 B. When testing residential water heaters, the following test methods shall be used to determine  
 462 ENERGY STAR certification:  
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 464

**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 431, Subpart G
Whole-home solar units	Solar Energy Factor	SRCC – OG-300: Operating Guidelines and Minimum Standards for Certifying Solar Water Heating Systems
Connected Products	Demand Response	Test Method to Validate Demand Response (in development)

465 \* Includes any applicable guidance that DOE has issued regarding the testing of these products (See  
 466 <http://www1.eere.energy.gov/guidance/default.aspx?pid=2&spid=1>).  
 467

468 \*\*Refer to the 10 CFR parts 200 to 499 edition revised as of January 1, 2014. An abbreviated version  
 469 of this reference, titled "*Historical Water Heaters Test Method*" can be found on the ENERGY STAR  
 470 Water Heaters for [Partners webpage](#).  
 471

472 **Note:** This table has been moved from Appendix A to reflect the U.S. Federal minimum standard change  
 473 to UEF. The Test Methods for certification with EF criteria have been moved to Appendix A.

474 C. Compliance with Connected Criteria  
 475  
 476 a. Aside from demand response functionality, compliance with connected criteria, as  
 477 specified in Section 0, shall be through examination of product and/or product  
 478 documentation.  
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**Note:** The U.S. Department of Energy has released the Draft 1 Test Method to Validate Demand Response. Stakeholders are asked to follow the progress of this test method on the [Water Heaters Version 3 Specification Development webpage](#).

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**6) Effective Date:**

The ENERGY STAR Residential Water Heaters specification shall take effect on **April 16, 2015**. 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.

**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. EPA is planning to further investigate the following topics in future revisions:

- A. Several factors will lead to significant change to the mix of products available on the market in the next few years. First, the impact of the newest federal standards was delayed by confusion around test method and metric. Second, the new test method allows different types of products to move into the market. Third, all products have UEF test data available, and consumers can use this measure to more easily compare different types of water heaters. Taking these factors into consideration, EPA expects the market will be in a position to begin a revision in late 2020 or in 2021.
- B. For some time, DOE has had minimum efficiency standard equations that rely largely on some measure of capacity while EPA has had single levels. This continues to be true now. EPA has not examined this practice for this version but will reconsider it for future revisions.
- C. The service delivered by gas-fired storage and gas-fired instantaneous water heaters is similar enough that consumers, particularly those working with new construction, actively consider which type of water heater to purchase. Therefore, it may be appropriate for EPA to set a single level for all gas-fired water heaters. EPA has not done so in the past because market dynamics and test method peculiarities have prevented this course of action. EPA will re-examine this possibility for the next revision.

514 **Appendix A – Eligibility Requirements in terms of Energy Factor**

515 Appendix A contains the definitions, product performance criteria, and test requirements applicable to  
516 water heaters certifying using EF, which, by appearing in Appendix A, supersede those in the rest of the  
517 specification. Aside from those appearing in Appendix A, all definitions, criteria, and test requirements in  
518 the specification above apply to water heaters certified via EF.

519 **Note:** As the DOE minimum efficiency regulations now require water heaters in the United States to  
520 comply with the UEF minimum standards and test methods, EPA has replaced the EF criteria with the  
521 UEF criteria in the body of this specification. Water heaters sold in the U.S. may still certify by meeting the  
522 EF criteria outlined below, but must report the UEF rating as well.

523 **1) Definitions:** Below are the definitions relevant to the EF test method.

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A. Residential Water Heater (Consumer Water Heater): A product that utilizes gas, electricity, or solar thermal energy to heat potable water for use outside the heater upon demand, including:

527 a. Storage type units designed to heat and store water at a thermostatically-controlled  
528 temperature of less than 180 °F, including: gas storage-type water heaters with a nominal  
529 input of 75,000 British thermal units (Btu) per hour or less and having a rated storage  
530 capacity of not less than 20 gallons nor more than 100 gallons; electric heat pump type  
531 units with a maximum current rating of 24 amperes at an input voltage 250 volts or less,  
532 and, if the tank is supplied, having a manufacturer's rated storage capacity of 120 gallons  
533 or less.<sup>8</sup>

534

535 b. Instantaneous (or "tankless") type units which initiate heating based on sensing water  
536 flow and deliver water at a controlled temperature of less than 180 °F, heat water, but  
537 contain no more than one gallon of water per 4,000 Btu per hour of input with an input  
538 capacity greater than 50,000 Btu per hour but less than 200,000 Btu per hour.<sup>8,9</sup>

539

540 c. Solar water heaters include a collector and storage tank, and use the sun's energy to  
541 heat water using one of the five basic types of solar water heating systems:

542

- 543 i. forced circulation (includes both direct and indirect systems),
- 544 ii. integrated collector and storage,
- 545 iii. thermosiphon,
- 546 iv. self-pumped, or
- 547 v. photovoltaic (PV).

548

549 d. Add-on Heat Pump Units are air to water heat pumps designed for use with a storage-  
550 type water heater or a storage tank that is not specified or supplied by the manufacturer.

551

552 e. Light Duty EPACT covered gas water heaters heat and store water at a thermostatically-  
553 controlled temperature, with an input rate >75,000 Btu per hour and ≤100,000 Btu per  
554 hour, and storage volume between 20 and 100 gallons.

555

556 B. Energy Factor<sup>10</sup>: Energy Factor (EF), a measure of water heater overall efficiency, is the ratio of  
557 useful energy output from the water heater to the total amount of energy delivered to the water  
558 heater.

559

<sup>8</sup> 10 CFR Part 430, Subpart B, Appendix E. Revised as of January 1, 2014.

<sup>9</sup> 10 CFR Part 430, Subpart A, § 430.2 Definitions. Revised as of January 1, 2014.

<sup>10</sup> Based on definition in 10 CFR Part 430, Subpart B, Appendix E. Revised as of January 1, 2014.

- 560 C. First-Hour Rating<sup>8</sup>: The First-Hour Rating (FHR) is an estimate of the maximum volume of hot  
 561 water in gallons that a storage water heater can supply within an hour that begins with the water  
 562 heater fully heated  
 563
- 564 D. Gallons per Minute<sup>11</sup>: Gallons per Minute (“GPM”) is the amount of gallons per minute of hot  
 565 water that can be supplied by an instantaneous water heater while maintaining a nominal  
 566 temperature rise of 77°F during steady state operation.  
 567
- 568 E. Thermal Efficiency<sup>12</sup>: Thermal efficiency (TE) is the ratio of the heat transferred to the water  
 569 flowing through the water heater to the amount of energy consumed by the water heater.  
 570
- 571 F. Standby Loss<sup>12</sup>: Standby Loss (SL) means the average hourly energy required to maintain the  
 572 stored water temperature.  
 573

574 **3) Certification Criteria:**

575 **Note:** Below are the product performance requirements for water heaters certifying using EF.  
 576

577 B. Product Performance Requirements for Electric Water Heaters:  
 578

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

Criteria		ENERGY STAR Requirements
Energy Factor	≤ 55 gallons	EF ≥ 2.00
	> 55 gallons	EF ≥ 2.20
First-Hour Rating		FHR ≥ 50 gallons per hour
Warranty		Warranty ≥ 6 years on sealed system
Safety		UL 174 and UL1995
Lower Compressor Cut-off Temperature (Reporting Requirement Only)		Report ambient temperature below which the compressor cuts off and electric resistance only operation begins

581 C. Product Performance Requirements for Gas Water Heaters:  
 582

583 d. Gas Storage-Type Water Heaters:  
 584

585 **Table 2: Criteria for Certified Gas Storage-Type Water Heaters**

Criteria		ENERGY STAR Requirements
Energy Factor	≤ 55 gallons	EF ≥ 0.67
	> 55 gallons	EF ≥ 0.77
First-Hour Rating		FHR ≥ 67 gallons per hour
Warranty		Warranty ≥ 6 years on system (including parts)
Safety		ANSI Z21.10.1/CSA 4.1

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587 <sup>11</sup> 10 CFR Part 430, Subpart B, Appendix E. Revised as of January 1, 2014.

<sup>12</sup> 10 CFR Part 431, Subpart G. Revised as of January 1, 2014.

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e. Gas Instantaneous Water Heaters:

**Table 3: Criteria for Certified Gas Instantaneous Water Heaters**

Criteria	ENERGY STAR Requirements
Energy Factor	EF ≥ 0.90
Gallons Per Minute	GPM ≥ 2.5 over a 77°F rise
Warranty	Warranty ≥ 6 years on heat exchanger and ≥ 5 years on parts
Safety	ANSI Z21.10.3/CSA 4.3

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f. Light Duty EPACT covered Gas Water Heaters:

**Table 4: Criteria for Certified Light Duty EPACT covered Gas Water Heaters**

Criteria	ENERGY STAR Requirements
Thermal Efficiency	TE ≥ 0.90
Standby Loss	Standby loss ≤ 1889 Btu/h × (TE-0.73)
Warranty	Warranty ≥ 6 years on system
Safety	ANSI Z21.10.3/CSA 4.3

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D. Product Performance Requirements for Solar Water Heaters:

**Table 5: Criteria for Certified Solar Water Heaters**

Criteria	ENERGY STAR Requirements
Solar Energy Factor	SEF ≥ 1.8 for electric backup SEF ≥ 1.2 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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**5) Test Methods:**

**Note:** Below are the test methods for water heaters certifying using EF.

- A. When testing residential water heaters, the following test methods shall be used to determine ENERGY STAR certification:

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609

**Table 6: Test Methods for ENERGY STAR Certification**

Applicable Products	ENERGY STAR Requirement	Test Method Reference
Gas and electric units; FHR only for storage units, GPM only for instantaneous units.	Energy Factor	10 CFR Part 430, Subpart B, Appendix E* Revised as of January 1, 2014**
	First-Hour Rating (FHR)	
	Gallons per minute (GPM)	
Light Duty EPACT covered gas water heaters	Thermal Efficiency	10 CFR Part 431, Subpart G Revised as of January 1, 2014**
	Standby Loss	

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\* 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>).

**Note on recovery efficiency:** Guidance includes that for thermostatically-controlled water heaters that do not initiate and complete a recovery cycle prior to the start of the second draw of the simulated-use test, the recovery efficiency shall be determined as specified in Section 11.2 of ASHRAE 118.2.

\*\*Refer to the 10 CFR parts 200 to 499 edition revised as of January 1, 2014. An abbreviated version of this reference, titled "*Historical Water Heaters Test Method*" can be found on the ENERGY STAR Water Heaters for [Partners webpage](#).

625 **Appendix B – Demand Response Message Mapping**

626

627 **Note:** The below table is provided to define the required mapping of the DR responses in each protocol,  
 628 although not every response below may be required. Refer to the body of this specification for required  
 629 responses.

630

Category	Subtype	Demand Response Messaging	Response Result	ANSI/CTA (2045-A)	OpenADR (2.0b)
Basic Signals	Curtailment	<b>General Curtailment</b>	Reduce load (moderate)	Shed <sup>13</sup>	oadrDistributeEvent: SIMPLE level 1. <sup>14</sup>
		<b>Emergency Curtailment</b>	Reduce load (major)	Critical Peak Event <sup>13</sup>	oadrDistributeEvent: SIMPLE level 2. <sup>14</sup>
		<b>Off Mode</b>	Turn off (if possible)	Grid Emergency <sup>13</sup>	oadrDistributeEvent: SIMPLE level 3. <sup>14</sup>
	Load Up	<b>Load Up</b>	Use more energy (if possible)	Load Up <sup>13</sup>	oadrDistributeEvent: NEAR / FAR flag. CHARGE STATE, LOAD_DISPATCH. <sup>14</sup>
	Run Normal	<b>Return to Normal Operation</b>	Return to defaults	End Shed / Run Normal <sup>13</sup>	oadrDistributeEvent: CANCELLED. <sup>14</sup>
Advanced Signals	Device State (in event)	<b>Set Point Adjustment</b>	Adjust water setpoint (if possible)	Get / Set SetPoint <sup>15</sup> [Section 9.1.6]	oadrDistributeEvent: LOAD_CONTROL. <sup>14</sup>
	Real Time / Device Logic	<b>Real Time System Load</b>	Use / do not use energy when appropriate (follow programming)	Request for Power Level <sup>15</sup> [Section 8.2.1]	
		<b>Utility Peak Load Price Signal</b>		Present Relative Price <sup>15</sup> , [Section 9.1.3]	oadrDistributeEvent: ELECTRICITY_PRICE <sup>14</sup>
		<b>Excess Capacity(DER)</b>		Grid Guidance <sup>13</sup>	
Opt Out	<b>Consumer Override</b>	Skip response to event within opt out	Customer Override Message, in response to Operational State Query or load reduction request <sup>13</sup>	oadrCreateOpt: device sends upstream opt message <sup>16</sup>	

<sup>13</sup> CTA-2045-A: Table 8-2

<sup>14</sup> 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

<sup>15</sup> CTA-2045-A: Table 9-2

<sup>16</sup> Section 8.5, OpenADR 2.0b EiOpt Service; Figure 17, Interaction Diagram: Create Opt

<b>Device Properties &amp; Enrollment</b>	Dev. Info	<b>Device Information</b>	Indicates all mandatory product information	Info Request <sup>15</sup> [Section 9.1.1]	Ei:eiTargetType (endDeviceAsset)
	Status	<b>State Reporting Requirements</b>	Provide state information to requestor	Operational State Query <sup>13</sup> [Section 8.2.4]	EiReport. oadrPayloadResource Status
	Hardware	<b>Hardware Requirements</b>	Design of product & comms.	DC or AC Form Factor <sup>17</sup>	
<b>Device Energy</b>	Energy	<b>Power (Instantaneous)</b>	Demand of product (W)	GetCommodity Read, code 0	oadrPayloadResource Status: energyReal
		<b>Energy (Cumulative)</b>	Energy used by product (kWh)	GetCommodity Read, code 0	oadrPayloadResource Status: energyReal
	Storage	<b>Current Energy Storage Capacity</b>	Available energy storage (Wh)	GetCommodity Read, Code 7	oadrPayloadResource Status: oadrCapacity: oadrCurrent
		<b>Total Energy Storage Capacity</b>	Energy storage under ideal conditions (Wh)	GetCommodity Read, Code 6	oadrPayloadResource Status: oadrCapacity: oadrNormal

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632 **Note:** EPA is developing the above appendix on DR messaging under common protocols to improve the  
633 specificity of DR method definitions in section 4D, and assist with the interoperability and implementation  
634 of DR strategies for connected water heaters. EPA is requesting feedback on this appendix, and  
635 encourages stakeholders to engage in a dialogue with EPA to further develop this resource. In Draft 2,  
636 EPA has clarified that ater heaters implementing optional and required responses shall do so with the  
637 specific mapping defined in this appendix.

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<sup>17</sup> CTA-2045-A, Appendix A & Appendix B

639 **Appendix C (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 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.