



ENERGY STAR® Program Requirements Product Specification for Residential Water Heaters

Eligibility Criteria Final Draft, Version 4.0

1 Following is the Final Draft **Version 4.0** product specification for ENERGY STAR certified water heaters.
2 A product shall meet all of 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.

- 5
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; electric heat pump type units with a maximum current
13 rating of 24 amperes at an input voltage 250 volts or less, including all ancillary
14 equipment such as fans, storage tanks, pumps, or controls necessary for the device to
15 perform its function.¹
16
17 b. Instantaneous type units heat water, but contain no more than one gallon of water per
18 4,000 Btu per hour of input with an input capacity less than or equal to 200,000 Btu per
19 hour for gas-fired instantaneous.¹
20
21 c. Gas-fired storage residential-duty commercial water heaters include gas-fired storage
22 water heaters that are designed to deliver hot water at a temperature less than or equal
23 to 180°F, with an input rate greater than 75,000 Btu per hour and not exceeding 105,000
24 Btu per hour, containing more than one gallon of water per 4,000 Btu per hour of input,
25 and storage volume less than or equal to 120 gallons. For models requiring electricity, a
26 single-phase external power supply is used.²
27
28 d. Solar water heaters include a collector and storage tank, and use the sun's energy to
29 heat water using one of the five basic types of solar water heating systems:
30
31 i. forced circulation (includes both direct and indirect systems),
32 ii. integrated collector and storage,
33 iii. thermosiphon,
34 iv. self-pumped, or
35 v. photovoltaic (PV).
36
37 e. Integrated heat pump water heaters are residential water heaters where the compressor,
38 evaporator, condenser, and storage tank are integrated into the same unit.
39
40 f. Split-System heat pump water heaters are residential water heaters where the
41 compressor, evaporator, and/or condenser are separated from the storage tank.

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.

44 **Note:** The definitions above for integrated and split-system heat pump water heaters have been included
45 to recognize split-system heat pump water heaters as a distinct category, per comments received from
46 several stakeholders. One commenter also requested that add-on heat pump units be included in the
47 scope of this specification, as a way to improve the efficiency of existing electric resistance water heaters,
48 and ease the emergency replacement barrier by allowing the heat pump to be added after hot water is
49 restored. However, there is no defined test method for these products and their installation typically will
50 void the tank warranty, so EPA will continue to exclude these products from the specification at this time.

51 B. Uniform Energy Factor³: Uniform Energy Factor (UEF) is the measure of water heater overall
52 efficiency.

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54 C. Solar Uniform Energy Factor: Solar Uniform Energy Factor (SUEF) refers to the energy delivered
55 by the total system divided by the electrical or gas energy put into the system.

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57 D. First-Hour Rating³: The First-Hour Rating (FHR) is an estimate of the maximum volume of “hot”
58 water that a storage-type water heater can supply within an hour that begins with the water heater
59 fully heated (i.e., with all thermostats satisfied). It is a function of both the storage volume and the
60 recovery rate.

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62 E. Maximum GPM Rating³: Maximum GPM is the maximum gallons per minute of hot water that can
63 be supplied by an instantaneous water heater while maintaining a nominal temperature rise of 67
64 °F (37.3 °C) during steady-state operation.

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66 F. Manufacturer Limited Warranty: Manufacturer limited warranty is an assurance by the
67 manufacturer to the consumer that the water heater, including purchased system equipment and
68 components, are guaranteed to work for a defined period of time.

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70 G. Basic Model: All units of a given type of covered product (or class thereof) manufactured by one
71 manufacturer and which have the same primary energy source and, which have essentially
72 identical electrical, physical, or functional (or hydraulic) characteristics that affect energy
73 consumption, energy efficiency, water consumption or water efficiency.³ Further, all individual
74 models within a basic model have the same certified rating based on the applicable sampling
75 criteria per U.S. Department of Energy’s (DOE) regulations in Part 429⁴, and this rating must be
76 used for all manufacturer literature, the qualified product list and certification of compliance to
77 DOE standards.

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79 H. Lower Compressor Cut-off Temperature: The temperature below which a heat pump water
80 heater’s compressor will no longer operate, such that the unit will only work as a conventional
81 electric resistance water heater.

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83 I. Combination Space-Heating and Water-Heating Appliance: Appliance that provides both space
84 conditioning (boiler) and hot water heating with one appliance or energy source. The combination
85 appliance circulates hot water from the water heater through a heat exchanger in the air handler.
86 A blower will move the heated air through a standard duct system. In the summer, an air
87 conditioner is connected to the exchanger and the system functions similarly, with cool air being
88 pushed through the ductwork.

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³ 10 CFR Part 430, Subpart B, Appendix E

⁴ 10 CFR Part 429, Subpart B

90 **2) Scope:**

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

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95 B. Excluded Products:

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97 a. Electric resistance water heaters,
98 b. Add-on heat pump units,
99 c. Products intended only for commercial applications,
100 d. Combination space-heating and water-heating appliances.

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103 **3) Certification Criteria:**

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105 **Note:** All products to be sold in the U.S. are expected be certified with a UEF rating, as Federally
106 required. Definitions, criteria, and testing requirements that are specific to EF for electric and gas-fired
107 water heaters are outlined in Appendix A of this document, for use of models sold only in Canada.

108 A. Product Performance Requirements for Electric Water Heaters:

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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

110 **Note:** Several commenters advocated raising the UEF for electric storage water heaters over 55 gallons
111 to 3.30, in alignment with the proposed level for products 55 gallons and under. Through conversations
112 with stakeholders, EPA confirmed that most products below the 3.30 UEF level would be leaving the
113 market by the effective date of this specification or would be recognized under a different category in this
114 draft. EPA is proposing a single level for 220/240 Volt integrated heat pump water heaters of all sizes at
115 3.30 UEF. This level better reflects actual savings for electric storage water heaters over 55 gallons.

116 Commenters also indicated that 120 Volt heat pump water heaters will enter the market in 2021. These
 117 products allow for easier and less costly replacement of gas water heaters with heat pump water heaters,
 118 as they would not require adding a 240-volt electrical service. As these products will be the first
 119 generation of their kind and may be subject to size constraints in some cases, EPA is creating a distinct
 120 category for those products. The proposed UEF of 2.20 is in line with the current specification
 121 requirement for heat pump water heaters over 55 gallons, and EPA believes this is appropriate for these
 122 new products coming to market. Some commenters did propose creating a distinct category for low-usage
 123 draw pattern units or lowering the first hour rating (FHR) requirement for this category. EPA believes that
 124 the current FHR requirement protects homeowners by ensuring a unit is appropriate for whole home
 125 installation. As contractors and homeowners become more familiar with sizing by FHR rather than storage
 126 volume, and as demand for heat pump water heaters for small apartments and homes grows, EPA may
 127 reconsider coverage of this product type.

128 EPA is also introducing a category for split-system heat pump water heaters and proposes a UEF of 2.20
 129 for this category. Stakeholders requested a distinct category for these products, as many would not be
 130 able to meet the levels proposed in the Draft 1 for two reasons. First, they are a less developed option
 131 and designs have not been refined as much. Second, either the hot water or the refrigerant travel some
 132 distance between the components of the system, and some energy will be lost there. As these products
 133 are appropriate for installation in cold climates as well as space constrained environments, they may be
 134 important to increasing the adoption of heat pump water heaters, and EPA agrees there is value in
 135 ensuring that these products remain certified.

136 EPA proposes to allow the use of either UL 1995 or UL 60335-2-40 to demonstrate compliance with the
 137 safety requirements for electric water heaters. Some commenters indicated that they plan to comply with
 138 the new standard before it is required in 2024, and EPA would accept this certification.

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

140 a. Gas-Fired Storage Water Heaters:

142 **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 ≥ 51 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 \geq 0.87
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

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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 \geq 0.80
Warranty	Warranty \geq 6 years on system
Safety	ANSI Z21.10.3/CSA 4.3

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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 \geq 3.00 for electric backup SUEF \geq 1.80 for gas backup
Warranty	Warranty \geq 10 years on collector, \geq 6 years sealed system, \geq 2 years on controls, \geq 1 year on parts

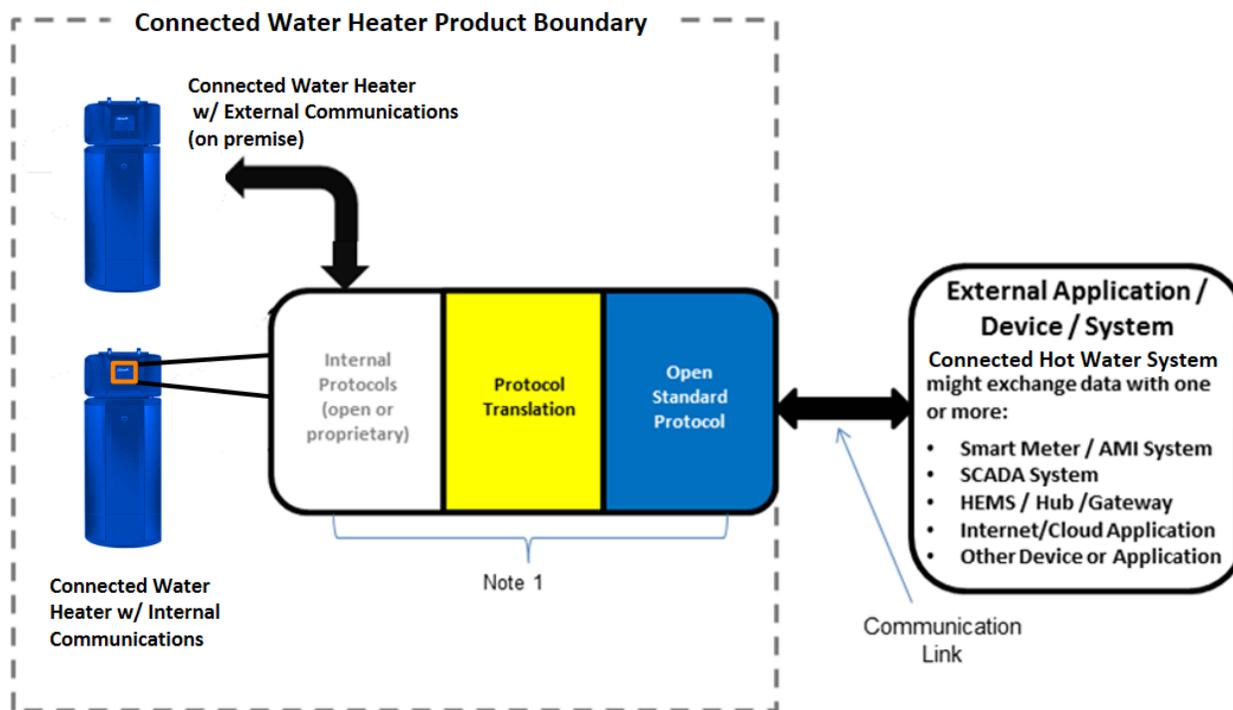
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4) Connected Product Criteria – Optional:

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

164 A. Definitions

- 165
- 166 a. Communication Link: As shown in Figure 1, the mechanism for bi-directional data
- 167 transfers between the Connected Water Heater Product and one or more external
- 168 applications, devices or systems.
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- 170 b. Connected Water Heater Product (CWHP): As shown in Figure 1, includes the ENERGY
- 171 STAR certified water heater, integrated or separate communications hardware, and
- 172 additional hardware and software required to enable connected functionality.
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174 **Figure 1:** Connected Water Heater Product (CWHP)

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177 **Note 1:** Communication device(s), link(s) and/or processing that enables Open Standards-based

178 communication between the CWHP and external application / device / system(s). These

179 elements, either individually or together, could be within the water heater/controller, and/or an

180 external communication module, a hub/gateway, or in the Internet/cloud.

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- 182 c. Consumer Authorized Third Party: Any entity for which the consumer has provided
- 183 explicit permission to access the CWHP connected functionality, in whole or in part, via a
- 184 Communication Link. *Example: A consumer may allow a Home Energy Management*
- 185 *System (HEMS) or a Demand Response Management System (DRMS) access to the*
- 186 *CWHP connected functionality.*
- 187
- 188 d. Demand Response (DR): Changes in electric or gas usage by end-use customers from
- 189 their normal consumption patterns in response to changes in the price of electricity or gas
- 190 over time, or to incentive payments designed to induce lower electricity or gas use at
- 191 times of high wholesale market prices or when system reliability is jeopardized⁵.
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⁵ 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>

- 193 e. Demand Response Management System (DRMS): The system operated by a consumer
194 authorized program administrator, such as the utility or third party, which dispatches
195 signals with DR instructions and/or price signals to the CWHP products and receives
196 messages from the CWHP product.
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- 198 f. Interface Specification: A document or collection of documents that contains detailed
199 technical information to facilitate access to relevant data and product capabilities over a
200 communications interface.
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- 202 g. Load Management Entity: Consumer authorized DRMS, home energy management
203 system, or the like.
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- 205 h. Open Standards: Communication with entities outside the CWHP that use, for all
206 communication layers, standards:
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- included in the Smart Grid Interoperability Panel (SGIP) Catalog of Standards,⁶ and/or
 - included in the NIST Smart Grid Framework Tables 4.1 and 4.2, and/or
 - adopted by the American National Standards Institute (ANSI) or another well-
212 established international standards organization such as the International Organization
213 for Standardization (ISO), International Electrotechnical Commission (IEC), International
214 Telecommunication Union (ITU), Institute of Electrical and Electronics Engineers (IEEE)
215 or Internet Engineering Task Force (IETF).⁶
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- 217
- 218 i. On-Premises: Refers to a function that relies only on equipment present at the physical
219 installed location of the ENERGY STAR certified device/equipment.
220
- 221 j. Load Shift: A load shift operation moves energy that would have been used by a device
222 within a time interval under normal operating conditions, to occur outside that time
223 interval. Load shifting can be performed by a combination of load up and curtailment
224 requests.
225

226 B. Communications

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- 228 a. The CWHP Communication Link, in Figure 1, shall use Open Standards for all
229 communication layers to enable functions listed in Sections 4B) and 4C).
230
- 231 b. An Interface Control Document (ICD), Application Programming Interface (API), or other
232 documentation shall be made available to interested parties that, at minimum, allows
233 access to the functions listed in Sections 4B) and 4C).
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235 C. Remote Management and Consumer Feedback

236 The CWHP shall provide the following functionality:
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- 239 a. **Remote Management:**
240 The product shall be capable of receiving and responding to consumer authorized remote
241 requests (not including third-party remote management which may be made available
242 solely at the discretion of the manufacturer), via a communication link, similar to
243 consumer controllable functions on the product.
244 i. Higher energy mode settings shall be temporary: If a remote management signal
245 puts the CWHP into a mode that uses more energy than the mode selected

⁶ http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/PMO#Catalog_of_Standards_Processes

246 locally, the product shall revert to the locally set mode within 72 hours if no
247 additional user input is received.

248
249 **b. User Alerts:**

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

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

256
257 *For example, messages relevant to energy consumption for water heaters might address*
258 *a fault condition, a reminder to descale heating elements, heat pump refrigerant charge,*
259 *or a report of energy consumption that is outside the product's normal range*

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261 **c. Energy Reporting**

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

267
268 **D. Demand Response (DR)**

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

273
274 **a. DR Communications Protocols**

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

277 **Note:** Stakeholders pointed out in their comments the publication of CTA-2045-B. EPA understands that
278 current programs and state requirements are written explicitly including CTA-2045-A, and so will allow
279 products that can meet this specification using either version of this protocol to be recognized as
280 connected. EPA understands that CTA-2045-B is backwards compatible and does not believe any
281 adjustments need to be made to the specification to incorporate this version but appreciates any
282 feedback or concerns about its inclusion.

283 EPA also received a comment supporting the inclusion of OpenADR 2.0a in order to allow compatibility
284 with existing programs that use OpenADR 2.0a virtual top nodes, which cannot control OpenADR 2.0b
285 virtual end nodes. However, OpenADR 2.0a does not have two-way communication capability and
286 therefore cannot provide all the functions required in these criteria. Thus, EPA will not allow OpenADR
287 2.0a implementation as an option.

- 288 **b. Override:** The product shall provide an easily accessible means for consumers to
289 override demand response events during the event or ahead of time for a scheduled
290 event, except for Grid Emergency/Off Mode events. When the event is overridden, the
291 CPWH shall return to normal operation as set by the customer. Temporary overrides
292 shall be limited to a duration up to 72 hours without additional user input; after this time,
293 the CPWH will return to its previous operating mode.

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Note: One stakeholder recommended the inclusion of a maximum duration for temporary overrides. EPA is including a maximum temporary override duration of 72 hours. This is in line with the requirements in section 4.C.a Remote Management and is in line with other ENERGY STAR connected products.

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- 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.
 - iii. If the CWHP is capable of storing and operating with a time of use schedule, the unit may continue operating on that schedule during a 'loss of connectivity' event.
- 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)D.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)D.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.

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e. **DR Information and Messaging**

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

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

Required Messaging I/O

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- **Device Type** – Electric Resistance / Gas-fired Storage / Heat Pump.
- **Operational State** – Information on product running state, DR conditions operating on product, opt in/out state, and fault conditions. The following states will be able to be reported, as applicable to the chosen DR protocol:
 - **Idle Normal** – Water heater is not heating but is in a normal mode of operation.
 - **Running Normal** – Water heater is in a Normal Operating Mode and the water heater is presently heating (heat pump compressor or any heating elements are energized).
 - **Running Curtailed Grid** – Water heater is running in a grid service mode of operation and the water heater is presently heating (heat pump compressor or any heating elements are energized).
 - **Running Heightened Grid** – Water heater is processing a load up request and water is being heated.

- 348 ○ **Idle Grid** – Water heater is in a grid service operational mode and the
- 349 water heater is not heating water.
- 350 ○ **Water Heater Error** – Device is malfunctioning. Recommended use:
- 351 Failure of heat pump or element.
- 352 ○ **Idle Heightened** – Water heater is processing a Load Up request and
- 353 water is not being heated.
- 354 ○ **Idle Opted Out** – Water heater is overridden has no/insignificant energy
- 355 consumption.
- 356 ○ **Running, Opted Out** – Water heater is overridden and is consuming
- 357 energy.
- 358 ● **Current Available Energy Storage Capacity** – The amount of grid energy that
- 359 the end device can take now (kWh or therms). It is recognized that under some
- 360 extraordinary circumstances, the Current Available Energy Storage could exceed
- 361 the Total. For example, if a water heater temperature has fallen well below the
- 362 normal minimum regulation range.⁷
- 363 ● **Power/Demand (Instantaneous)** – Measured or estimated power consumption
- 364 in current conditions (kW, Btu/hr, or therms).

365 Optional Messaging I/O:

- 366 ● **Energy Use** – Measured or estimated cumulative energy use of product (kWh or
- 367 Btu, therms).
- 368 ● **Current Total Energy Storage Capacity** – The total amount of grid energy
- 369 storage that the end device represents. For example, the energy capacity of a
- 370 water heater would be the total amount of energy (kWh or therms) supplied to
- 371 move the tank from its minimum operating temperature (e.g. what it would allow
- 372 itself to drop to during a curtailment event) to its maximum operating temperature
- 373 (e.g. what it could run up to when asked to “Load Up” before shutting off).⁷
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376 **Note:** One stakeholder recommended including specific information on how to use OpenADR Operational
 377 State Codes to indicate the states required in the specification. Given that there is a precedent for such
 378 established by AHRI-1380, EPA agrees this would be both helpful and not overly restrictive. Table 8 and
 379 Table 9 in Appendix B now specify this. We welcome stakeholder comments on this approach.

380 f. **Error! Bookmark not defined.DR Requests and Responses**

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

387 Required Operational Mode Functionality:

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⁷ CTA-2045-A

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
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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392 1. For all commands both immediate events and events scheduled in advance will be supported.

393 2. **Advanced Load Up** response is anticipated to be used on installations with a mixing valve, and is
394 anticipated to require a user action to enable this request for the first time.

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Optional Operational Mode Functionality:

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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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399 E. Additional Information for Consumers

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- 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.").

410 **5) Test Requirements:**

- 411 A. One of the following sampling plans shall be used to test energy performance for qualification to
412 ENERGY STAR:

- 413 a. A single unit is selected, obtained, and tested. The measured performance of this unit and of
414 each subsequent unit manufactured must be equal to or better than the ENERGY STAR
415 specification requirements. Results of the tested unit may be used to certify additional
416 individual model variations within a basic model as long as the definition for basic model
417 provided in Section 1, above, is met; or

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- 419 b. Units are selected for testing and results are calculated according to the sampling
420 requirements defined in 10 CFR Part 429, Subpart B §429.17. The certified rating must be
421 equal to or better than the ENERGY STAR specification requirements. Results of the tested
422 unit may be used to certify additional variations within a basic model as long as the definition
423 for basic model provided in Section 1, above, is met. Further, all individual models within a
424 basic model must have the same certified rating based on the applicable sampling criteria.
425 This rating must be used for all manufacturer literature, the qualified products list, and
426 certification of compliance to DOE standards.

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

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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

Applicable Products	ENERGY STAR Requirement	Test Method Reference
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 (in development)

* 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), 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.

6) **Effective Date:**

The ENERGY STAR Residential Water Heaters specification shall take effect on **TBD**. 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.

Note: EPA aims to finalize the Version 4.0 Water Heaters specification in the coming months, with an effective date in Q4 of 2021. The Version 4.0 specification will be available for early certification as soon as it is finalized. Products currently certified to Version 3.2 will remain certified and listed until the effective date.

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. The Federal minimum efficiency standards are based on the unit volume, reflecting the influence of design elements on efficiency. However, since ENERGY STAR levels are not, comparison between them is challenging. EPA may consider restructuring this specification to include similar metrics that are dependent on volume and categorized further by draw pattern. This may include a distinct level for low draw pattern units in the future.

472 B. EPA is also in discussion with the Northwest Energy Efficiency Alliance on their Advanced
473 Water Heating Specification and with the Advanced Water Heating Initiative on the West
474 Coast, seeking to harmonize specifications as much as possible in the future. This may
475 include adding reporting or performance requirements similar to those in the other
476 specifications.

477 C. EPA is monitoring the savings potential and consumer payback offered by ENERGY STAR
478 gas storage and gas instantaneous water heaters. If more significant energy savings at a
479 lower initial investment do not materialize, EPA will consider sunsetting those product
480 categories.

481

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

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

487
488 **Note:** Gas water heaters sold exclusively in Canada may still certify by meeting the EF criteria outlined
489 below. Gas water heaters sold in both the U.S. and Canada shall certify by meeting the UEF criteria
490 contained in the body of this specification but may optionally report EF criteria.

491
492 **1) Definitions:** Below are the definitions relevant to the EF test method.

- 493
494 A. Residential Water Heater (Consumer Water Heater): A product that utilizes gas, electricity, or
495 solar thermal energy to heat potable water for use outside the heater upon demand, including:
- 496 a. Storage type units designed to heat and store water at a thermostatically-controlled
497 temperature of less than 180 °F, including: gas storage-type water heaters with a nominal
498 input of 75,000 British thermal units (Btu) per hour or less and having a rated storage
499 capacity of not less than 20 gallons nor more than 100 gallons; electric heat pump type
500 units with a maximum current rating of 24 amperes at an input voltage 250 volts or less,
501 and, if the tank is supplied, having a manufacturer’s rated storage capacity of 120 gallons
502 or less.⁸
 - 503
504 b. Instantaneous (or “tankless”) type units which initiate heating based on sensing water
505 flow and deliver water at a controlled temperature of less than 180 °F, heat water, but
506 contain no more than one gallon of water per 4,000 Btu per hour of input with an input
507 capacity greater than 50,000 Btu per hour but less than 200,000 Btu per hour.^{8,9}
 - 508
509 c. Solar water heaters include a collector and storage tank, and use the sun's energy to
510 heat water using one of the five basic types of solar water heating systems:
511
 - 512 i. forced circulation (includes both direct and indirect systems),
 - 513 ii. integrated collector and storage,
 - 514 iii. thermosiphon,
 - 515 iv. self-pumped, or
 - 516 v. photovoltaic (PV).
 - 517
518 d. Add-on Heat Pump Units are air to water heat pumps designed for use with a storage-
519 type water heater or a storage tank that is not specified or supplied by the manufacturer.
 - 520
521 e. Light Duty EPACT covered gas water heaters heat and store water at a thermostatically-
522 controlled temperature, with an input rate >75,000 Btu per hour and ≤100,000 Btu per
523 hour, and storage volume between 20 and 100 gallons.
- 524
525 B. Energy Factor¹⁰: Energy Factor (EF), a measure of water heater overall efficiency, is the ratio of
526 useful energy output from the water heater to the total amount of energy delivered to the water
527 heater.
- 528
529 C. First-Hour Rating⁸: The First-Hour Rating (FHR) is an estimate of the maximum volume of hot
530 water in gallons that a storage water heater can supply within an hour that begins with the water
531 heater fully heated

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

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

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

- 532
- 533 D. Gallons per Minute¹¹: Gallons per Minute (“GPM”) is the amount of gallons per minute of hot
- 534 water that can be supplied by an instantaneous water heater while maintaining a nominal
- 535 temperature rise of 77°F during steady state operation.
- 536
- 537 E. Thermal Efficiency¹²: Thermal efficiency (TE) is the ratio of the heat transferred to the water
- 538 flowing through the water heater to the amount of energy consumed by the water heater.
- 539
- 540 F. Standby Loss¹²: Standby Loss (SL) means the average hourly energy required to maintain the
- 541 stored water temperature.
- 542

543 **3) Certification Criteria:**

544

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

546

547 B. Product Performance Requirements for Gas Water Heaters:

- 548
- 549 d. Gas Storage-Type Water Heaters:

550

551 **Table 2A: 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

- 552
- 553
- 554 e. Gas Instantaneous Water Heaters:

555

556 **Table 3A: 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

- 557
- 558 f. Light Duty EPACK covered Gas Water Heaters:
- 559

¹¹ 10 CFR Part 430, Subpart B, Appendix E. Revised as of January 1, 2014.

¹² 10 CFR Part 431, Subpart G. Revised as of January 1, 2014.

560

Table 4A: 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

561

562

563 **5) Test Methods:**

564

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

566

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

569

Table 6A: Test Methods for ENERGY STAR Certification

Applicable Products	ENERGY STAR Requirement	Test Method Reference
Gas 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	

571

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

574

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

578

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

582

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 ¹³	oadrDistributeEvent: SIMPLE level 1. ¹⁴
		Emergency Curtailment	Reduce load (major)	Critical Peak Event ¹³	oadrDistributeEvent: SIMPLE level 2. ¹⁴
		Off Mode	Turn off (if possible)	Grid Emergency ¹³	oadrDistributeEvent: SIMPLE level 3. ¹⁴
	Load Up	Load Up	Use more energy (if possible)	Load Up ¹³	oadrDistributeEvent: NEAR / FAR flag. CHARGE STATE, LOAD_DISPATCH. ¹⁴
	Run Normal	Return to Normal Operation	Return to defaults	End Shed / Run Normal ¹³	oadrDistributeEvent: CANCELLED. ¹⁴
Advanced Signals	Device State	Set Point Adjustment	Adjust water setpoint (if possible)	Get / Set SetPoint ¹⁵ [Section 9.1.6]	oadrDistributeEvent: LOAD_CONTROL. ¹⁴
	Real Time / Device Logic	Real Time System Load	Use / do not use energy when appropriate (follow programming)	Request for Power Level ¹⁵ [Section 8.2.1]	
		Utility Peak Load Price Signal		Present Relative Price ¹⁵ , [Section 9.1.3]	oadrDistributeEvent: ELECTRICITY_PRICE ¹⁴
		Excess Capacity(DER)		Grid Guidance ¹³	
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 ¹³	oadrCreateOpt: device sends upstream opt message ¹⁶
	Dev. Info	Device Information	Indicates all mandatory product information	Info Request ¹⁵ [Section 9.1.1]	Ei:eiTargetType (endDeviceAsset)
	Status	State Reporting Requirements	Provide state information to requestor	Operational State Query ¹³ [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 ¹⁷	

¹³ CTA-2045-A: Table 8-2

¹⁴ 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

¹⁵ CTA-2045-A: Table 9-2

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

¹⁷ CTA-2045-A, Appendix A & Appendix B

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

588
589

Table 9: OpenADR 2.0b Operational State Reporting¹⁸

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	

590

591 **Note:** Tables 8 and 9 have been added above to clarify how the operational states should be reported in
592 both CTA-2045 and OpenADR 2.0b. These have been adapted from the Electric Power Research
593 Institute's document titled Communication Protocol Mapping Guide 1.0, OpenADR 2.0 to ANSI/CTA-
594 2045-A, Table 2-3 Measurement and Reporting Mapping Requirements. One commenter had expressed
595 that the Test Method to Validate Demand Response would require further clarification to test products
596 using OpenADR 2.0b only. EPA believe the tables above clarify how OpenADR 2.0b communications
597 should align with the operational states as described in this specification and the DR test method.

598

¹⁸ 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

599 **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 Appendix B* 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 Appendix B* 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 Appendix B* 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.