



ENERGY STAR® Program Requirements Product Specification for Residential Water Heaters

Eligibility Criteria Draft 1, Version 4.0

1 Following is the Draft 1 **Version 4.0** product specification for ENERGY STAR certified water heaters. A
2 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.

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

8
9 a. Storage type units designed to heat and store water at a thermostatically-controlled
10 temperature, including: gas-fired storage (gas storage-type) water heaters with a
11 nameplate input of 75,000 Btu per hour or less, containing more than one gallon of water
12 per 4,000 Btu per hour of input; 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).

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

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

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¹ Adapted from 10 CFR Part 430, Subpart A §430.2 *Definitions*

² Adapted from 10 CFR Part 431, Subpart G §431.102 *Definitions*

³ 10 CFR Part 430, Subpart B, Appendix E

- 43 C. Solar Uniform Energy Factor: Solar Uniform Energy Factor (SUEF) refers to the energy delivered
44 by the total system divided by the electrical or gas energy put into the system.
45
- 46 D. First-Hour Rating³: The First-Hour Rating (FHR) is an estimate of the maximum volume of “hot”
47 water that a storage-type water heater can supply within an hour that begins with the water heater
48 fully heated (i.e., with all thermostats satisfied). It is a function of both the storage volume and the
49 recovery rate.
50
- 51 E. Maximum GPM Rating³: Maximum GPM is the maximum gallons per minute of hot water that can
52 be supplied by an instantaneous water heater while maintaining a nominal temperature rise of 67
53 °F (37.3 °C) during steady-state operation.
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55 **Note:** As the Federal minimum efficiency standards are now in terms of UEF, EPA has moved the
56 definitions aligned with the UEF test procedure from Appendix A to the main body of the specification.
57 Definitions aligned with the EF test method have been moved from the main body of the specification to
58 Appendix A.
59

60 EPA has also made updated reference to Solar Uniform Energy Factor (SUEF) per the proposal to
61 update the ICC 900/SRCC 300 standard recently released by the Solar Rating and Certification
62 Corporation.

- 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.³ 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 429⁴, and this rating must be
74 used for all manufacturer literature, the qualified product list and certification of compliance to
75 DOE standards.
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- 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 **Note:** EPA has moved the definitions relevant to the optional connected criteria from this section
88 (previously definitions J – Y) to Section 4) Connected Product Criteria – Optional:. EPA has standardized
89 this location for definitions relevant only to connected, with the understanding that a different engineering
90 group is typically responsible for these capabilities.

⁴ 10 CFR Part 429, Subpart B

91 **2) Scope:**

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

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96 B. Excluded Products:

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98 a. Electric resistance water heaters,
99 b. Add-on heat pump units,
100 c. Products intended only for commercial applications,
101 d. Combination space-heating and water-heating appliances.
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104 **3) Certification Criteria:**

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

109 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	≤ 55 gallons	UEF ≥ 3.30
	> 55 gallons	UEF ≥ 2.70
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

111 **Note:** EPA is proposing more stringent criteria for Electric Water Heaters as noted above in order to
112 recognize the performance increases that have been made by the vast majority of models on the market
113 today. More than 90% of heat pump water heater models currently certified meet the proposed criteria
114 and increasing the minimum performance will allow EPA and utility partners to fully account for the energy
115 savings these models achieve. The proposed criteria will increase the annual energy savings that EPA
116 and utility partners can claim to 2,544 kWh (\$315) per year for electric water heaters under 55 gallons,
117 and to 466 kWh (\$58) per year for electric water heaters 55 gallons or greater. These are substantially
118 improved over version 3.2. The national electric savings potential will increase to 87 TWh, or \$10.8 billion.
119 EPA welcomes comments on the proposed criteria. Savings are based on a comparison of the ENERGY
120 STAR requirements to the federal minimum standard for typical tank sizes of 50 and 80 gallons,
121 respectively.

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

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124 a. Gas-Fired Storage Water Heaters:

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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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Note: EPA is revising the minimum FHR requirement to align with the minimum FHR for the Medium-Usage draw pattern, per Table I in 10 CFR Part 430, Subpart B, Appendix E, Section 5.4.1. This will allow all Medium-Usage units that meet the UEF requirements to certify. EPA proposes to maintain the UEF criteria from Version 3.2; EPA considered setting more stringent requirements but was unable to find higher levels with compelling savings potential or consumer payback.

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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 ≥ 2.8 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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Note: EPA is revising the Maximum GPM requirement to 2.8 over a 67°F rise, to align with the Medium-Usage draw pattern, per Table II in 10 CFR Part 430, Subpart B, Appendix E, Section 5.4.1.

EPA proposed to maintain the Version 3.2 requirements for Gas-Fired Instantaneous Water Heaters. EPA considered proposing more stringent criteria but was unable to identify higher levels with compelling savings or consumer payback.

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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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C. Product Performance Requirements for Solar Water Heaters:

Table 5: Criteria for Certified Solar Water Heaters

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

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Note: EPA is revising the metric and test method for ENERGY STAR solar water heaters. The new metric, SUEF, references Appendix A to the ICC 900/SRCC 300 Solar Thermal Standard which more closely resembles the test method to determine the UEF metric. The Appendix A, which was recently released as a [draft for public comment](#) by the Solar Rating & Certification Corporation, incorporates the specific draw patterns which are used to determine UEF.

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In the process of developing the proposed SUEF criteria above, EPA received preliminary modeled SUEF ratings for a number of ENERGY STAR certified solar water heaters. The proposed SUEF levels were selected to reflect approximately the same savings and recognize the same subset of products as the current SEF criteria. EPA will continue to work with industry partners to ensure the test reflects the installed performance of the solar water heater and welcomes feedback on the use of this revised test method and on the proposed levels above.

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4) Connected Product Criteria – Optional:

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

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Note: EPA has been working with stakeholders on adding connected criteria and has reviewed comments received to the [Version 3.3 Draft 2 specification](#) and the [Draft 1 Test Method to Validate Demand Response](#). EPA has incorporated changes to the connected criteria in this draft, and has released the [Draft 2 Test Method to Validate Demand Response](#) and comment responses.

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A. Definitions

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

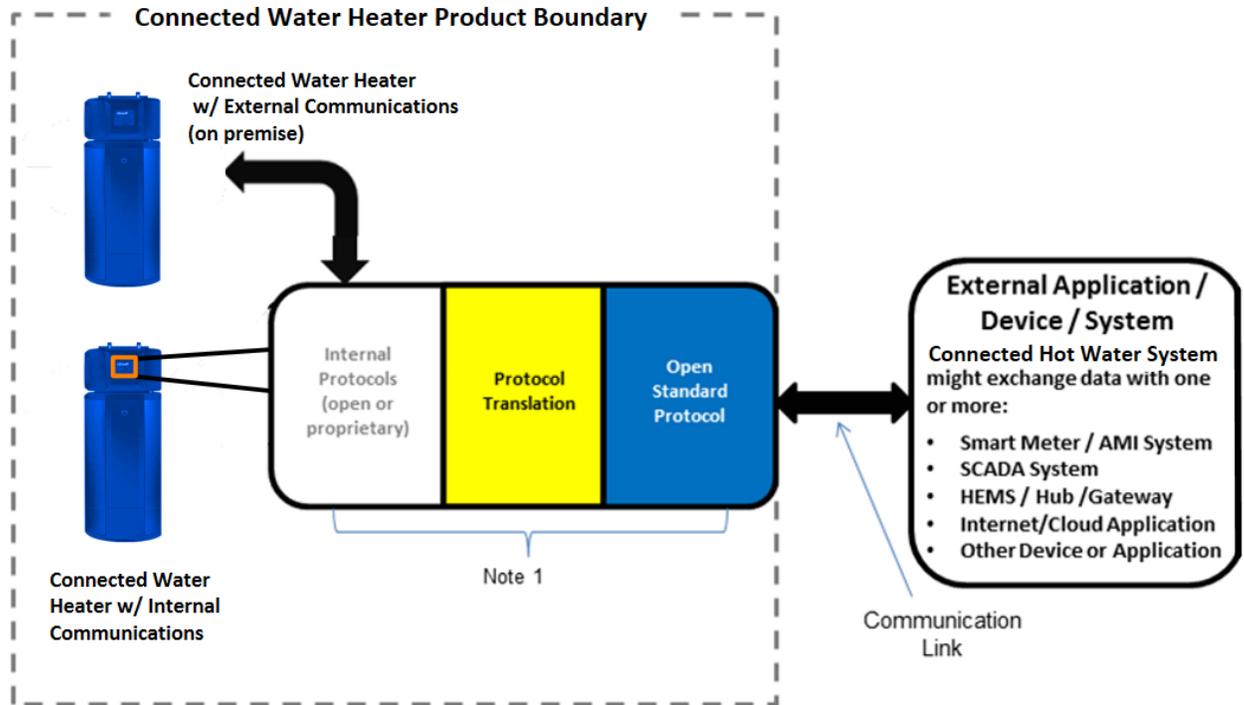


Figure 1: Connected Water Heater Product (CWHP)

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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.

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

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>

- 200 e. Demand Response Management System (DRMS): The system operated by a consumer
201 authorized program administrator, such as the utility or third party, which dispatches
202 signals with DR instructions and/or price signals to the CWHP products and receives
203 messages from the CWHP product.
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- 205 f. Interface Specification: A document or collection of documents that contains detailed
206 technical information to facilitate access to relevant data and product capabilities over a
207 communications interface.
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- 209 g. Load Management Entity: Consumer authorized DRMS, home energy management
210 system, or the like.
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- 212 h. Open Standards: Communication with entities outside the CWHP that use, for all
213 communication layers, standards:
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- 215 • included in the Smart Grid Interoperability Panel (SGIP) Catalog of Standards,⁶ and/or
 - 216 • included in the NIST Smart Grid Framework Tables 4.1 and 4.2, and/or
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 - 219 • adopted by the American National Standards Institute (ANSI) or another well-
 - 220 established international standards organization such as the International Organization
 - 221 for Standardization (ISO), International Electrotechnical Commission (IEC), International
 - 222 Telecommunication Union (ITU), Institute of Electrical and Electronics Engineers (IEEE)
 - 223 or Internet Engineering Task Force (IETF).⁶
224
- 225 i. On-Premises: Refers to a function that relies only on equipment present at the physical
226 installed location of the ENERGY STAR certified device/equipment.
227
- 228 j. Load Shift: A load shift operation moves energy that would have been used by a device
229 within a time interval under normal operating conditions, to occur outside that time
230 interval. Load shifting can be performed by a combination of load up and curtailment
231 requests.
232

233 B. Communications

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- 235 a. The CWHP Communication Link, in Figure 1, shall use Open Standards for all
236 communication layers to enable functions listed in Sections 4B) and 4C).
237
- 238 b. An Interface Control Document (ICD), Application Programming Interface (API), or other
239 documentation shall be made available to interested parties that, at minimum, allows
240 access to the functions listed in Sections 4B) and 4C).
241

242 C. Remote Management and Consumer Feedback

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

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

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

255
256 **b. User Alerts:**

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

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

263
264 *For example, messages relevant to energy consumption for water heaters might address*
265 *a fault condition, a reminder to descale heating elements, heat pump refrigerant charge,*
266 *or a report of energy consumption that is outside the product's normal range*

267
268 **c. Energy Reporting**

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

274
275 **D. Demand Response (DR)**

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

280
281 **a. DR Communications Protocols**

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

284 **Note:** EPA received comments supporting the future inclusion of alternate DR Communications
285 Protocols. EPA will continue monitoring the development of different communications protocols, and
286 should there be an alternative to CTA-2045-A and OpenADR 2.0b that becomes established to a level
287 that is appropriate for this specification, EPA can amend the specification to include it as an additional
288 option.

289 EPA also received comments recommending requiring a CTA-2045 port for all CWHPs. EPA is retaining
290 the flexibility of the previous drafts and allowing those units that only use an OpenADR to be recognized
291 as connected, but notes that market forces appear to be driving the adoption of CTA-2045 anyway.

- 292
293 **b. Override:** The product shall provide an easily accessible means for consumers to
294 override demand response events during the event or ahead of time for a scheduled
295 event, except for Grid Emergency/Off Mode events. When the event is overridden, the
296 CPWH shall return to normal operation as set by the customer.

- 297
298 **c. Loss of connectivity:** A 'loss of connectivity' event is defined as 5 consecutive polling
299 events from the DRMS not responded to by the CWHP, or vice versa. **Note:** DR program
300 implementation may set the polling time interval, so the elapsed time for a 'loss of
301 connectivity' event may vary.

- 302 i. If a 'loss of connectivity' event occurs while processing a DR event with a set
303 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.

- 304 ii. If a 'loss of connectivity' event occurs while processing a DR event without a set
305 duration or end time, product will resume normal operation within 30 minutes.
306 iii. If the CWHP is capable of storing and operating with a time of use schedule, the
307 unit may continue operating on that schedule during a 'loss of connectivity' event.
308
309 d. **Minimum Load Shift:** CWHP shall be capable of load shifting either:
310 i. Basic Load Shift: 0.5 kWh or more via a combination of Basic Load Up and
311 General Curtailment responses defined in 4)D.f. under the conditions defined in
312 the ENERGY STAR Test Procedure for Water Heater Demand Response, or
313 ii. Advanced Load Shift: 1.0 kWh or more via a combination of Advanced Load Up
314 and General Curtailment responses defined in section 4)D.f. under the conditions
315 as defined in the ENERGY STAR Test Procedure for Water Heater Demand
316 Response.

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

318
319 e. **DR Information and Messaging**

320
321 The CWHP shall support the following upstream messaging from the device when
322 available and may support the additional (optional) messaging capabilities. Support for
323 these messaging signals is implemented via the open standards protocol used in the
324 product. The required mapping for these events is described in *Appendix B*. While the
325 required or optional functionality may vary based on product type and either protocol may
326 be used, the messaging must be communicated via the specified protocol command
327 within this appendix.

328
329 Data provided by below messaging functions shall be calculated from product state no
330 older than 60 seconds from request.

331 **Note:** EPA received comments regarding the data freshness requirement above. EPA clarifies that this
332 only requires that when a utility requests energy use information, the data reported by the unit must be
333 less than 60 seconds old. This is not a requirement that this information should be transmitted every 60
334 seconds or stored for every 60 second interval. If there is a loss of connectivity, the unit is not expected to
335 keep recorded data, only communicate recent data if it receives a request once it is back online. EPA
336 notes that the more frequent these requests are, the more energy the messaging will use, and so would
337 encourage utilities to account for this when they consider how frequently to request information.

338 Required Messaging I/O

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

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

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372 Optional Messaging I/O:

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

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

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

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

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

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

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

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

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392 Required Operational Mode Functionality:

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

⁷ CTA-2045-A

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

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

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Note: Per stakeholder comments, EPA has revised the General Curtailment language to allow for use of electric resistance elements when user needs cannot be met, in alignment with California’s Building Energy Efficiency Standards, Draft Joint Appendix 13 on Water Heater Demand Management, or JA13.

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

414 **5) Test Requirements:**
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- 416 A. One of the following sampling plans shall be used to test energy performance for qualification to
 417 ENERGY STAR:
- 418 a. A single unit is selected, obtained, and tested. The measured performance of this unit and of
 419 each subsequent unit manufactured must be equal to or better than the ENERGY STAR
 420 specification requirements. Results of the tested unit may be used to certify additional
 421 individual model variations within a basic model as long as the definition for basic model
 422 provided in Section 1, above, is met; or
- 423
 424 b. Units are selected for testing and results are calculated according to the sampling
 425 requirements defined in 10 CFR Part 429, Subpart B §429.17. The certified rating must be
 426 equal to or better than the ENERGY STAR specification requirements. Results of the tested
 427 unit may be used to certify additional variations within a basic model as long as the definition
 428 for basic model provided in Section 1, above, is met. Further, all individual models within a
 429 basic model must have the same certified rating based on the applicable sampling criteria.
 430 This rating must be used for all manufacturer literature, the qualified products list, and
 431 certification of compliance to DOE standards.
- 432 B. When testing residential water heaters, the following test methods shall be used to determine
 433 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
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

Applicable Products	ENERGY STAR Requirement	Test Method Reference
Connected Products	Demand Response	Test Method to Validate Demand Response (in development)

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

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

440 C. Compliance with Connected Criteria

- 441
- 442 a. Aside from demand response functionality, compliance with connected criteria, as
443 specified in Section 0, shall be through examination of product and/or product
444 documentation.

445

446 D. Significant Digits and Rounding:

- 447
- 448 a. All calculations shall be carried out with actual measured (unrounded) values. Only the
449 final result of a calculation shall be rounded.
- 450
- 451 b. Unless otherwise noted in this section, compliance with specification limits shall be
452 evaluated using exact values without any benefit from rounding.
- 453
- 454 c. Reporting on the ENERGY STAR website shall be performed using calculation results
455 or measured values that are rounded to the nearest unit in the last right-hand digit as
456 specified in the corresponding specification requirement below.

457

458 **6) Effective Date:**

459 The ENERGY STAR Residential Water Heaters specification shall take effect on **TBD**. To qualify for
460 ENERGY STAR, a product model shall meet the ENERGY STAR specification in effect on the
461 model's date of manufacture. The date of manufacture is specific to each unit and is the date on
462 which a unit is considered to be completely assembled.

463 **Note:** EPA aims to finalize the Version 4.0 Water Heaters specification by Q1 2021, with an effective date
464 in Q4 of 2021. As stakeholders are likely aware, the Version 3.3 specification adding optional Connected
465 criteria for water heaters is also currently under development. Rather than finalize that version separately,
466 EPA currently plans to include the final connected criteria in the next draft of the Version 4.0 specification
467 and release the Final Draft Demand Response Test Method at that time. Once the specification is
468 finalized, products may certify to Version 4.0 to gain connected recognition at any time.

469 **7) Future Specification Revisions:**

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

- 475 A. The Federal minimum efficiency standards are based on the unit volume, reflecting the
476 influence of design elements on efficiency. However, since ENERGY STAR levels are not,
477 comparison between them is challenging. EPA may consider restructuring this specification

478 to include similar metrics that are dependent on volume and categorized further by draw
479 pattern.

480 B. EPA is also in discussion with the Northwest Energy Efficiency Alliance on their Advanced
481 Water Heating Specification and with the Advanced Water Heating Initiative on the West
482 coast, seeking to harmonize specifications as much as possible in the future. This may
483 include adding reporting or performance requirements similar to those in the other
484 specifications.

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

489

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

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

495
496 **Note:** Gas water heaters sold exclusively in Canada may still certify by meeting the EF criteria outlined
497 below. Gas water heaters sold in both the U.S. and Canada shall certify by meeting the UEF criteria
498 contained in the body of this specification, but may optionally report EF criteria.

499 **Note:** As the DOE minimum efficiency regulations now require water heaters in the United States to
500 comply with the UEF minimum standards and test methods, EPA has replaced the EF criteria with the
501 UEF criteria in the body of this specification. In alignment with regulated efficiency standards in Canada,
502 EPA has included the note above regarding certifying to and reporting EF criteria.

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

- 504
505 A. **Residential Water Heater (Consumer Water Heater):** A product that utilizes gas, electricity, or
506 solar thermal energy to heat potable water for use outside the heater upon demand, including:
- 507 a. Storage type units designed to heat and store water at a thermostatically-controlled
508 temperature of less than 180 °F, including: gas storage-type water heaters with a nominal
509 input of 75,000 British thermal units (Btu) per hour or less and having a rated storage
510 capacity of not less than 20 gallons nor more than 100 gallons; electric heat pump type
511 units with a maximum current rating of 24 amperes at an input voltage 250 volts or less,
512 and, if the tank is supplied, having a manufacturer's rated storage capacity of 120 gallons
513 or less.⁸
514
 - 515 b. Instantaneous (or "tankless") type units which initiate heating based on sensing water
516 flow and deliver water at a controlled temperature of less than 180 °F, heat water, but
517 contain no more than one gallon of water per 4,000 Btu per hour of input with an input
518 capacity greater than 50,000 Btu per hour but less than 200,000 Btu per hour.^{8,9}
519
 - 520 c. Solar water heaters include a collector and storage tank, and use the sun's energy to
521 heat water using one of the five basic types of solar water heating systems:
522
 - 523 i. forced circulation (includes both direct and indirect systems),
 - 524 ii. integrated collector and storage,
 - 525 iii. thermosiphon,
 - 526 iv. self-pumped, or
 - 527 v. photovoltaic (PV).
528
 - 529 d. Add-on Heat Pump Units are air to water heat pumps designed for use with a storage-
530 type water heater or a storage tank that is not specified or supplied by the manufacturer.
531
 - 532 e. Light Duty EPACT covered gas water heaters heat and store water at a thermostatically-
533 controlled temperature, with an input rate >75,000 Btu per hour and ≤100,000 Btu per
534 hour, and storage volume between 20 and 100 gallons.
535

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.

- 536 B. Energy Factor¹⁰: Energy Factor (EF), a measure of water heater overall efficiency, is the ratio of
 537 useful energy output from the water heater to the total amount of energy delivered to the water
 538 heater.
 539
- 540 C. First-Hour Rating⁸: The First-Hour Rating (FHR) is an estimate of the maximum volume of hot
 541 water in gallons that a storage water heater can supply within an hour that begins with the water
 542 heater fully heated
 543
- 544 D. Gallons per Minute¹¹: Gallons per Minute (“GPM”) is the amount of gallons per minute of hot
 545 water that can be supplied by an instantaneous water heater while maintaining a nominal
 546 temperature rise of 77°F during steady state operation.
 547
- 548 E. Thermal Efficiency¹²: Thermal efficiency (TE) is the ratio of the heat transferred to the water
 549 flowing through the water heater to the amount of energy consumed by the water heater.
 550
- 551 F. Standby Loss¹²: Standby Loss (SL) means the average hourly energy required to maintain the
 552 stored water temperature.
 553

554 **3) Certification Criteria:**
 555

556 **Note:** Below are the product performance requirements for gas water heaters certifying using EF.
 557

558 B. Product Performance Requirements for Gas Water Heaters:
 559

560 d. Gas Storage-Type Water Heaters:
 561
 562

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

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

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.

565 e. Gas Instantaneous Water Heaters:
 566
 567

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

568
 569 f. Light Duty EPACT covered Gas Water Heaters:
 570
 571

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

572

573 **Note:** EPA has not included the EF criteria for electric storage water heaters nor the SEF criteria for solar
 574 water heaters in Appendix A, as those metrics are not needed for alignment with regulated standards in
 575 Canada.

576 **5) Test Methods:**

577
 578 **Note:** Below are the test methods for water heaters certifying using EF.

579
 580 A. When testing residential water heaters, the following test methods shall be used to determine
 581 ENERGY STAR certification:
 582

583

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	

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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](#).

Appendix B – Demand Response 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 (in event)	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	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)

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

	Status	State Reporting Requirements	Provide state information to requestor	Operational State Query ¹³ [Section 8.2.4]	EiReport. oadrPayloadResource Status
	Hardware	Hardware Requirements	Design of product & comms.	DC or AC Form Factor ¹⁷	
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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¹⁷ CTA-2045-A, Appendix A & Appendix B

600 **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.