ENERGY STAR®
Water Heaters
Draft 2 Version 3.3

Stakeholder Meeting

December 9, 2019

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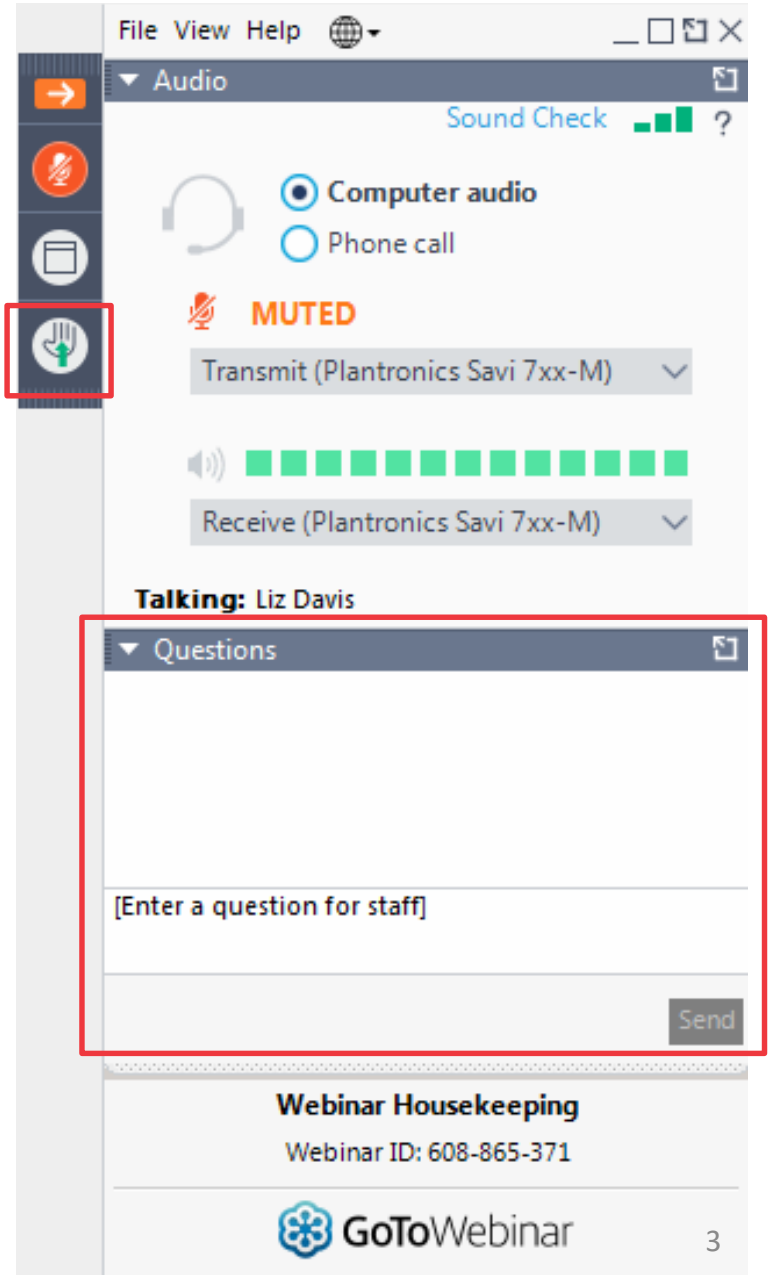
Written comments can be provided to waterheaters@energystar.gov by **January 6, 2020**



Meeting Agenda

1. Introductions
2. Draft 1 and Feedback
3. Connected Criteria
4. Test Method
5. UEF as Main Criteria
6. Next Steps
7. Questions

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1. **Introductions**
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Introductions

Abigail Daken
U.S. Environmental Protection Agency

Catherine Rivest
U.S. Department of Energy

Julia Hegarty
ICF

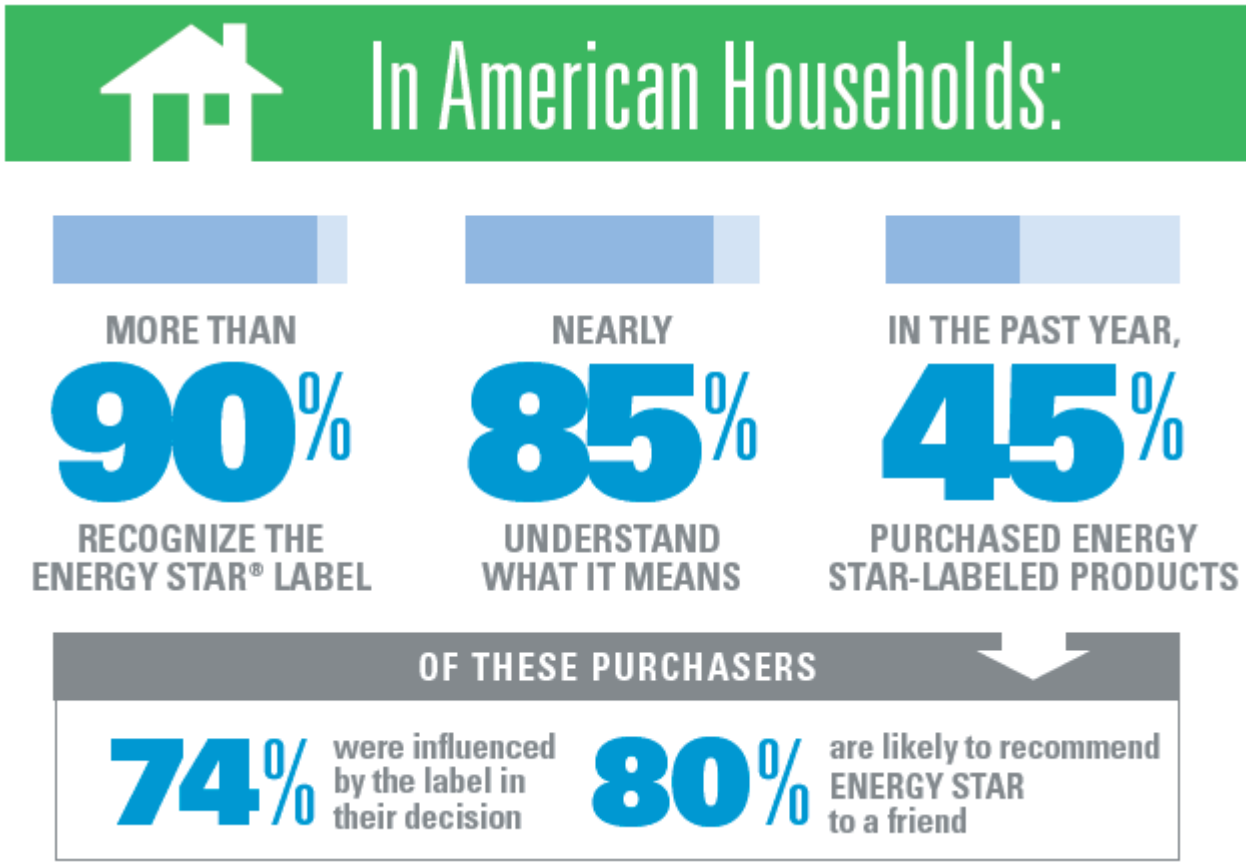
James Phillips
Navigant – A Guidehouse Company

ENERGY STAR is the simple choice for energy efficiency.

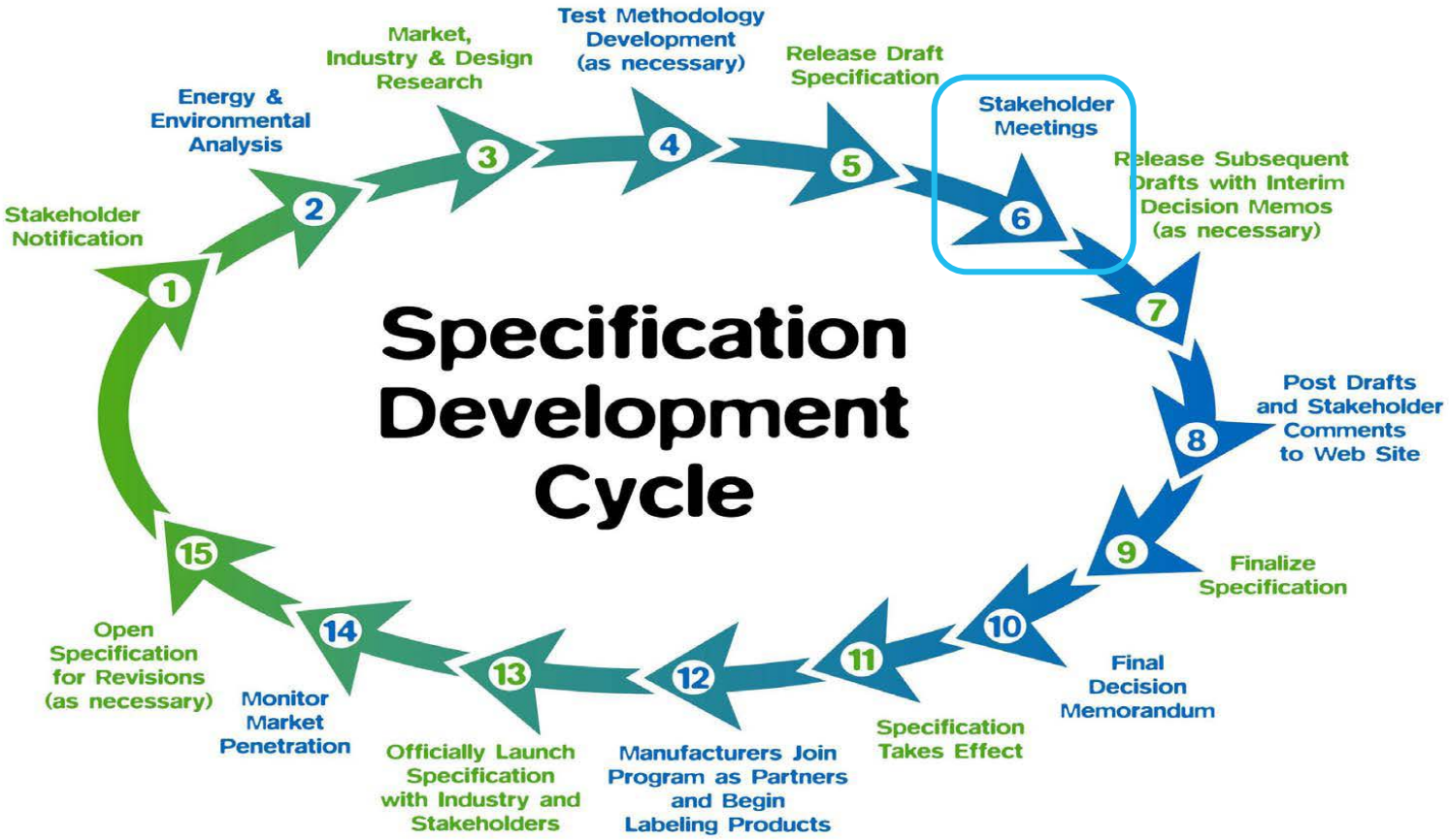
EPA's ENERGY STAR identifies the most energy-efficient products, buildings, plants, and new homes – all based on the latest government-backed standards.

Today, every ENERGY STAR label is verified by a rigorous third-party certification process.

Brand Preference and Loyalty



Specification Revision Process



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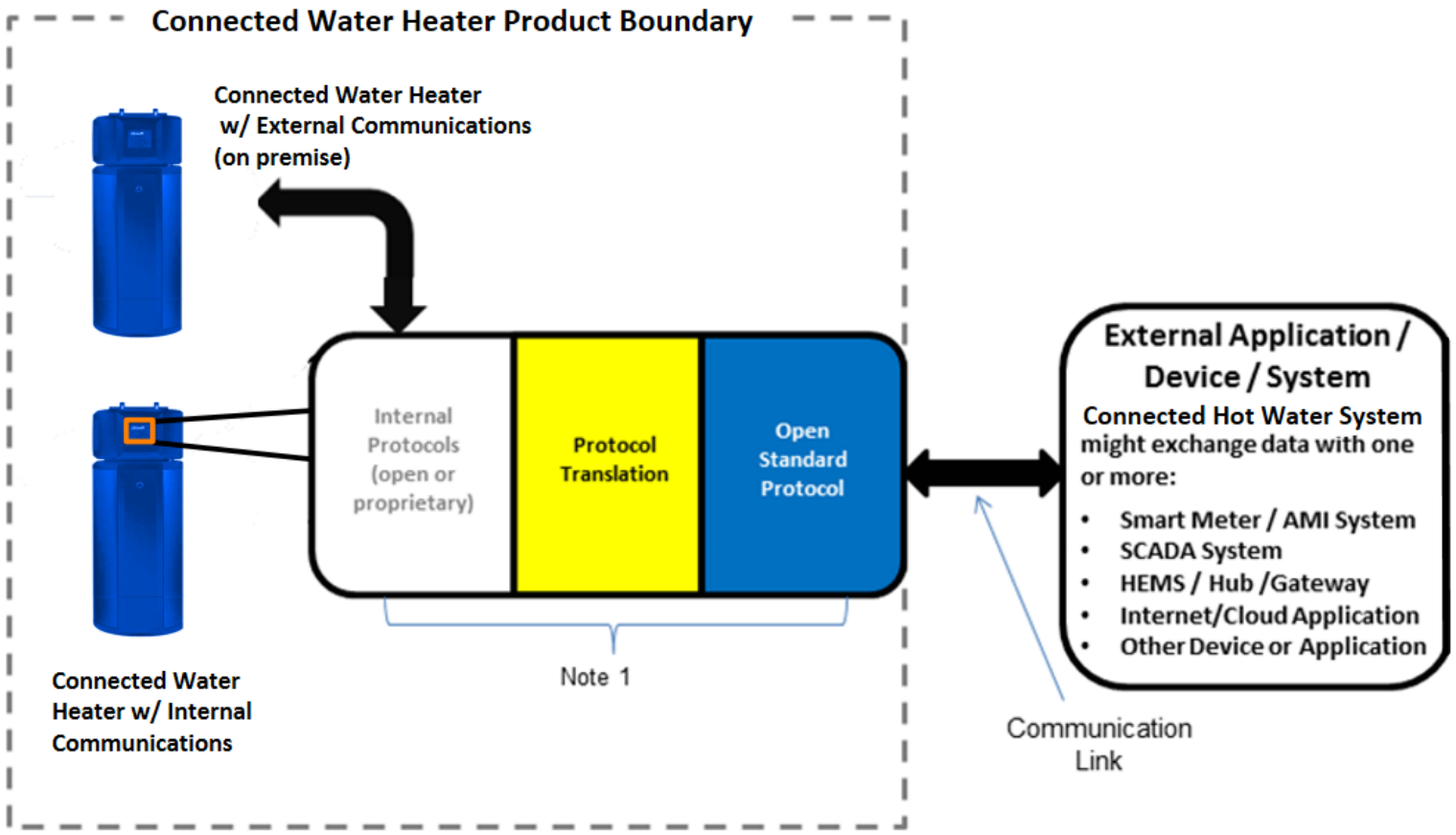
Connected Criteria

- **Meeting connected criteria is OPTIONAL**
  - Identify models that meet as "Connected" on the Qualified Products List (for web visitors + API access)
  - This revision will not affect ENERGY STAR certification

- **Connected criteria = user functionality + grid services** (as appropriate for product type)
  - Electric Heat Pump Water Heaters: Full DR requirements
  - Gas Storage Water Heaters: Limited DR requirements, as per current gas curtailment programs
  - Instantaneous Gas Water Heaters: Exempt from DR, connected if meets non-DR requirements

Connected Water Heater Product (CWHP)



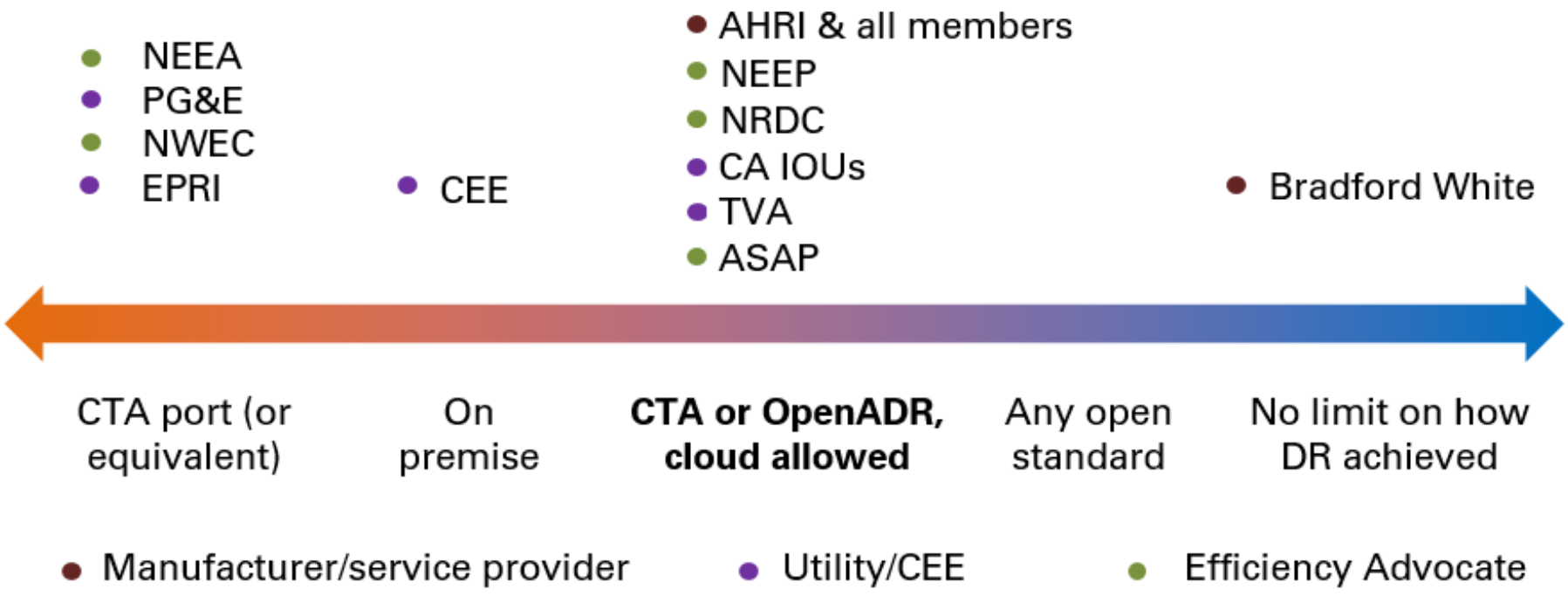
How are Connected Criteria organized in the Spec?

- **Communications**: Open standard(s) and API or interface docs
- **Functionality:**
  - User Amenity: Similar to other specs, services for homeowners and for home energy management integration
  - Demand Response: Specific choices of communication protocols, responses to specific messages and requests
    - Let manufacturer protect user experience; avoid prescriptive requirements (e.g. reduce tank temp by X ºF)
    - Let manufacturers compete on optimal logic/control strategies to provide grid services
- **Testing:** Refer to test requirements section
- **Appendix**, details on how a given open standard implementation would look (e.g. OpenADR 2.0 / CTA 2045-A).

Draft 1 Feedback

- EPA generally received support for the Draft 1 proposal
- Requests for clarification on several messaging items and the test method
- Stakeholder meetings indicated Load Shift is most useful to utilities, and there was a need to define explicit quantities for Basic and Advanced Load Shift

Communications Protocol Comments



Changes for Draft 2

- Mostly Clarifying changes –
  - Scope of connected criteria
  - Loss of connectivity
  - DR messages and responses
- Three more significant changes:
  - Add Minimum Load Shift
  - Advanced Load Up
  - UEF and EF rearrangement – no requirement changes

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Scope of Connected Criteria

- Solar Water Heaters (consisting of PV panels and electric resistance tanks)
  - Allowed to certify as Connected for now, but should only respond to DR when the device is operating on grid power
- Gas-fired water heaters
  - EPA received comments that there may be gas utilities interested in pilot programs
- Electric Resistance water heaters
  - Several commenters proposed a label for grid connected products that would recognize ERWHs. EPA does not intend to recognize this product category

DR Capabilities

- Override – When an event is overridden CWHP shall return to normal operation as set by the consumer
- Loss of connectivity – If 5 consecutive polling events are not responded to:
  - If processing a DR event with a set duration or end-time, complete event and then resume normal operation
  - If processing a DR event without a set duration, resume normal operation as set by the consumer within 30 minutes

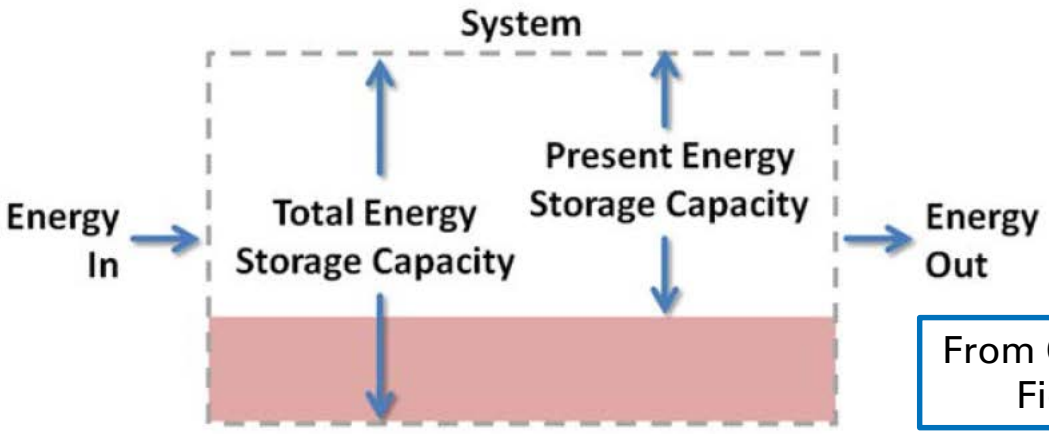
DR Capabilities

- Minimum Load Shift –
  - Basic: 0.5 kWh via combination of Basic Load Up and General Curtailment
  - Advanced : 1.0 kWh via a combination of Advanced Load Up and General Curtailment

- How will this tested load shift compare to load shift in the field?

DR Messaging

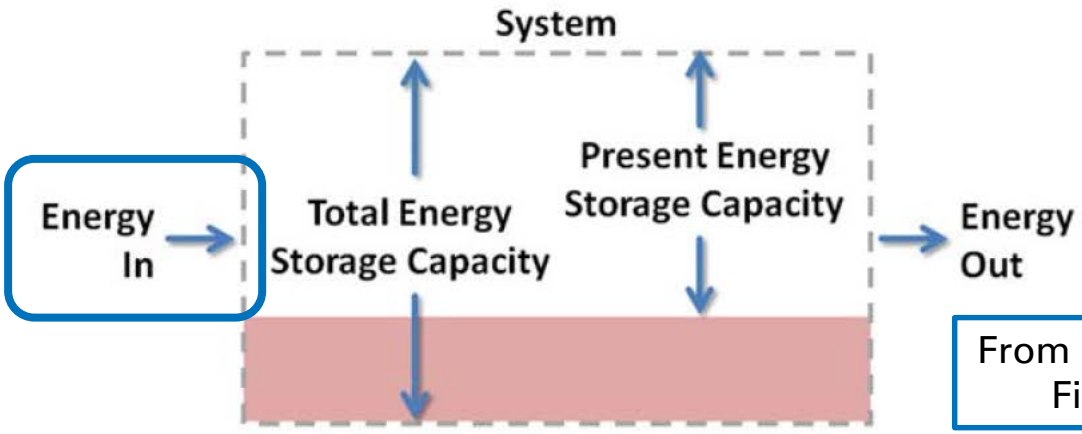
- **Current Available Energy Storage Capacity** – The amount of estimated grid energy that the end device can take now.
- **Current Total Energy Storage Capacity** – The total amount of estimated grid energy that the end device represents.



From CTA-2045-A, Figure 9-1

DR Messaging

- **Current Available Energy Storage Capacity** – The amount of **estimated grid energy** that the end device can take now.
- **Current Total Energy Storage Capacity** – The total amount of **estimated grid energy** that the end device represents.
  - EPA notes that the grid energy accepted is **not** equal to the energy stored within the water heater, this will vary with the efficiency of the product.



From CTA-2045-A, Figure 9-1

DR Requests and Responses

Operational Mode Request	Response
General Curtailment	Added: For Heat Pump Water Heaters with resistive elements, on recovery, elements should not be used to return the stored thermal energy to its normal operating level
Emergency Curtailment	Added: For Heat Pump Water Heaters with resistive elements, this request would result in heat pump only operation during the request period
Grid Emergency	Immediately, stop using energy for water heating when safe to do so.

DR Requests and Responses

Operational Mode Request	Response
Load Up: Basic or Advanced	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. 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
Return to Normal Operation	In the event an ongoing event is canceled for any reason, the product shall return to normal operation.

DR Requests and Responses – Optional

Operational Mode Request	Response
Set Point Adjustment	Adjusts product thermostat set point up or down if safe to do so.
Relative Price Signal(s)	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.

Appendix B

- This Appendix has been provided to ensure that DR requests and responses are mapped to the same responses in OpenADR and CTA-2045
- Not every response is required, but any response implemented in the product must match these commands in the appropriate implementation

This is to ensure that all products using the same protocol will respond to a DRMS request in the same way

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Test Setup

- Unless otherwise specified, all test setup and condition requirements are identical to sections 2, 3, and 4 of 10 CFR 430, Appendix E to Subpart B, as of January 1, 2019 (DOE Test Procedure)
  - Section 2: Test Conditions
  - Section 3: Instrumentation
  - Section 4: Installation

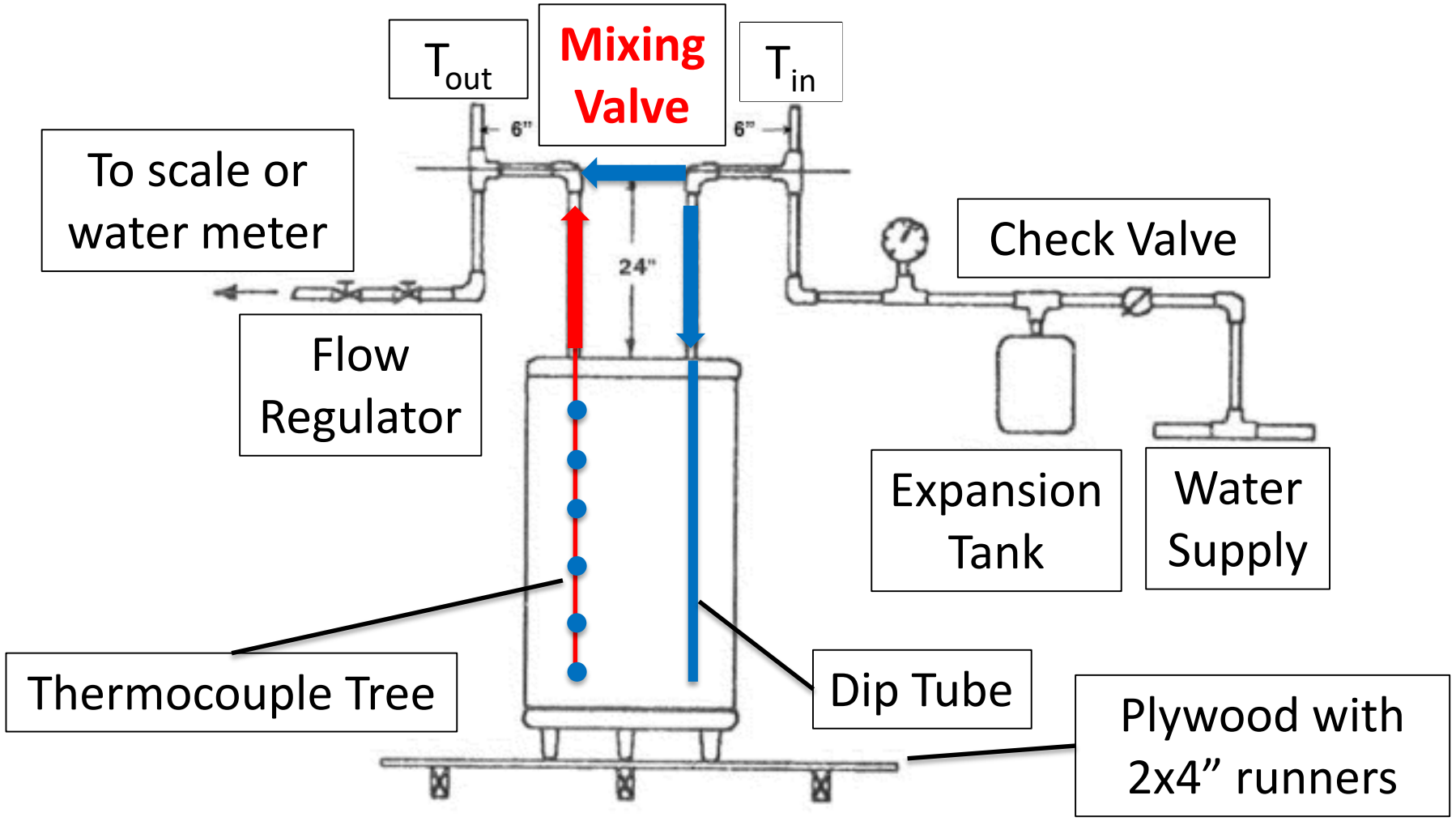
- Additional setup requirements
  - Appliance Communication Module (ACM) and Utility Equivalent Communication Device (UECD) are set up in accordance with manufacturer instructions
  - Connection between ACM and UECD can be wired or wireless
    - Use wireless if both are available
  - ACM must be able to both send and receive messages from the UECD

Test Conditions and Instrumentation

Test Condition	Value
Ambient Temperature	67.5°F ± 2.5°F
Supply Water Temperature	58°F ± 2°F
Initial Outlet/Setpoint Water Temperature	125°F ± 5°F
Relative Humidity (Heat Pump Only)	50% ± 2%

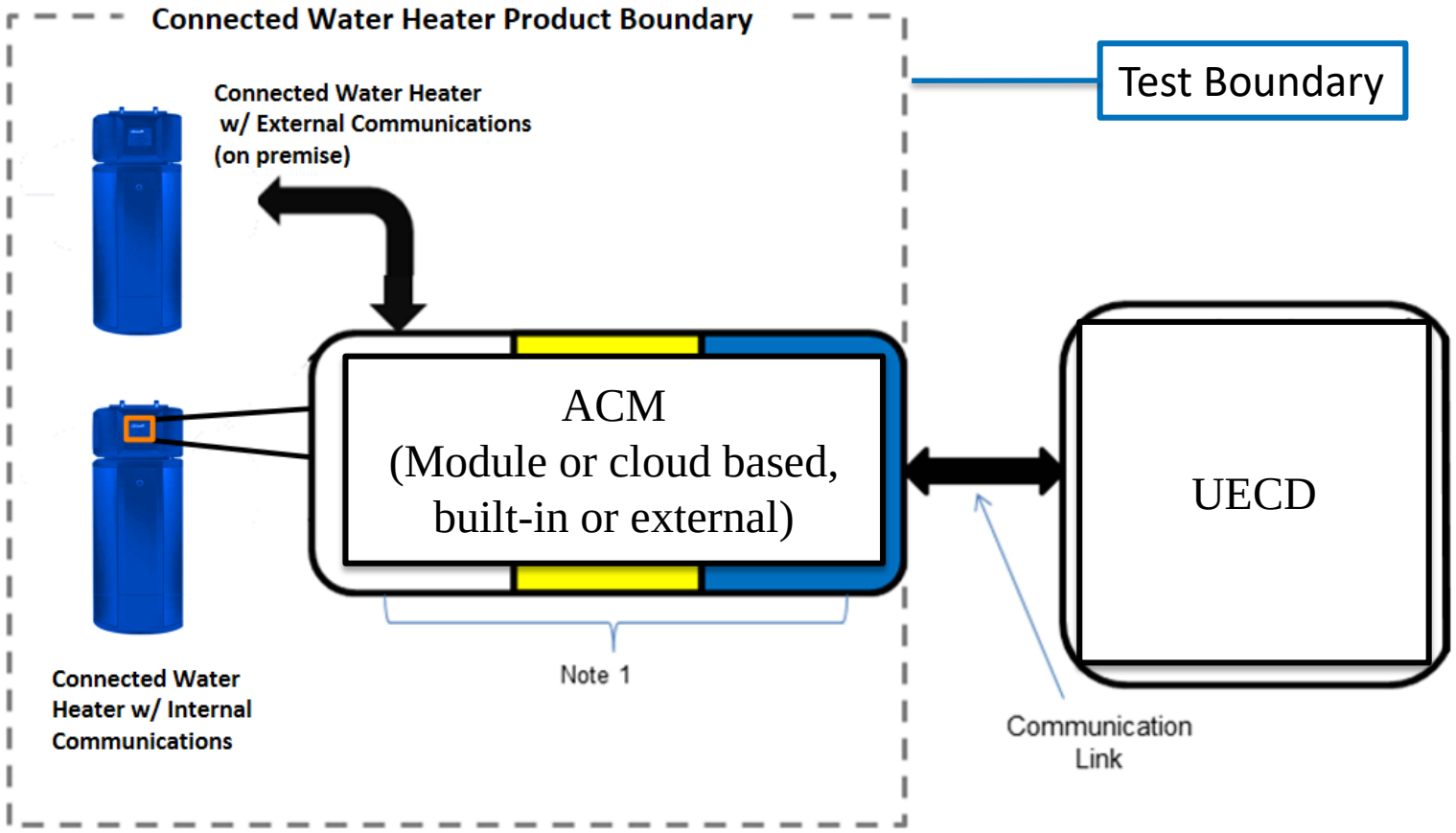
- Accuracy and precision of the instruments are specified
- No requirement for the outlet water to be between 120°F to 130°F after initial thermostat setting
- Flow rate varies based on Rated Draw Pattern

Installation



Additional Test Setup

- Setup according to manufacturer instructions



Preparation

- Perform the procedures found in section 5.2 of the DOE Test Procedure. These include:
  - Determining storage tank volume, V_{st}
  - Setting the outlet discharge temperature (120 °F – 130 °F)
  - Determining power input (gas only)
  - Soak-In Period (Rated storage volumes ≥ 2 Gallons)

Demand Response Test Procedure

- Initialization (section 6.1)
- User Interface (section 6.2)
- Consumer Override (section 6.3)
- Load Shift (section 6.5)
- Emergency Curtailment and Grid Emergency (section 6.6)

- Loss of Connectivity (section 6.4) is not being tested

Consumer Override

- Tested using the General Curtailment DR request
- Signal verification only
- Verifies that:
  1. A General Curtailment event can be stopped during an event and
  2. That a General Curtailment request will not be initiated when override is in place
- Procedure
  - Start with CWHP in normal mode of operation
  - Send a General Curtailment request
  - Verify CWHP is undergoing a General Curtailment event
  - Initiate Consumer Override
  - Verify CWHP is in an “Opted Out” state
  - Send a General Curtailment request
  - Verify CWHP remains in an “Opted Out” state
  - End test by ending Consumer Override

Load Shift – Overview

Consists of testing in: (1) Normal Mode, (2) Load Up (Basic or Advanced), and (3) General Curtailment

- Normal Mode operation determines baseline performance
  - 4 hour test period
  - First draw cluster from UEF TP simulates load
- Load Up verifies response (Either Basic or Advanced Load Up)
  - Command given between Normal and General Curtailment tests
  - Basic Load Up test starts with tank at depleted state
  - Advanced Load Up test starts after recovery in Normal Mode
- General curtailment determines performance relative to normal
  - 4 hour test period
  - Same draw pattern as in Normal Mode
- Total test time: approximately 9 hours

Load Shift – Normal Mode Procedure

1. Start after a max mean tank temperature is observed after cut-out **(tank at the user setpoint)**
2. Perform the draw pattern
   a. First draw cluster based on the UEF test procedure and the rated draw pattern
3. Wait until 4 hours after start of step 2
4. End Normal Mode portion after a max mean tank temperature is observed after a cut-out
   a. If recovery is occurring at hour 4, allow to finish
   b. If no recovery is occurring at hour 4, draw off water until a cut-in occurs, then wait for cut-out

Load Shift – Basic Load Up Procedure

Requires depleted tank (Basic Load Up cannot exceed consumer setpoint)

1. Start immediately after the end of the Normal Mode portion
2. Draw off water until a cut-in occurs and wait until a max mean tank temperature is observed after cut-out
    a. This step may be skipped if a cut-in occurred during the first draw of the Normal Mode Procedure. Use the volume drawn at cut-in in the next step.
3. Draw off water and stop drawing when 1 gallon less than the drawn volume in step 2 is drawn.
4. Send a Basic Load Up request
5. Wait until a max mean tank temperature is observed after cut-out

Load Shift – Advanced Load Up Procedure

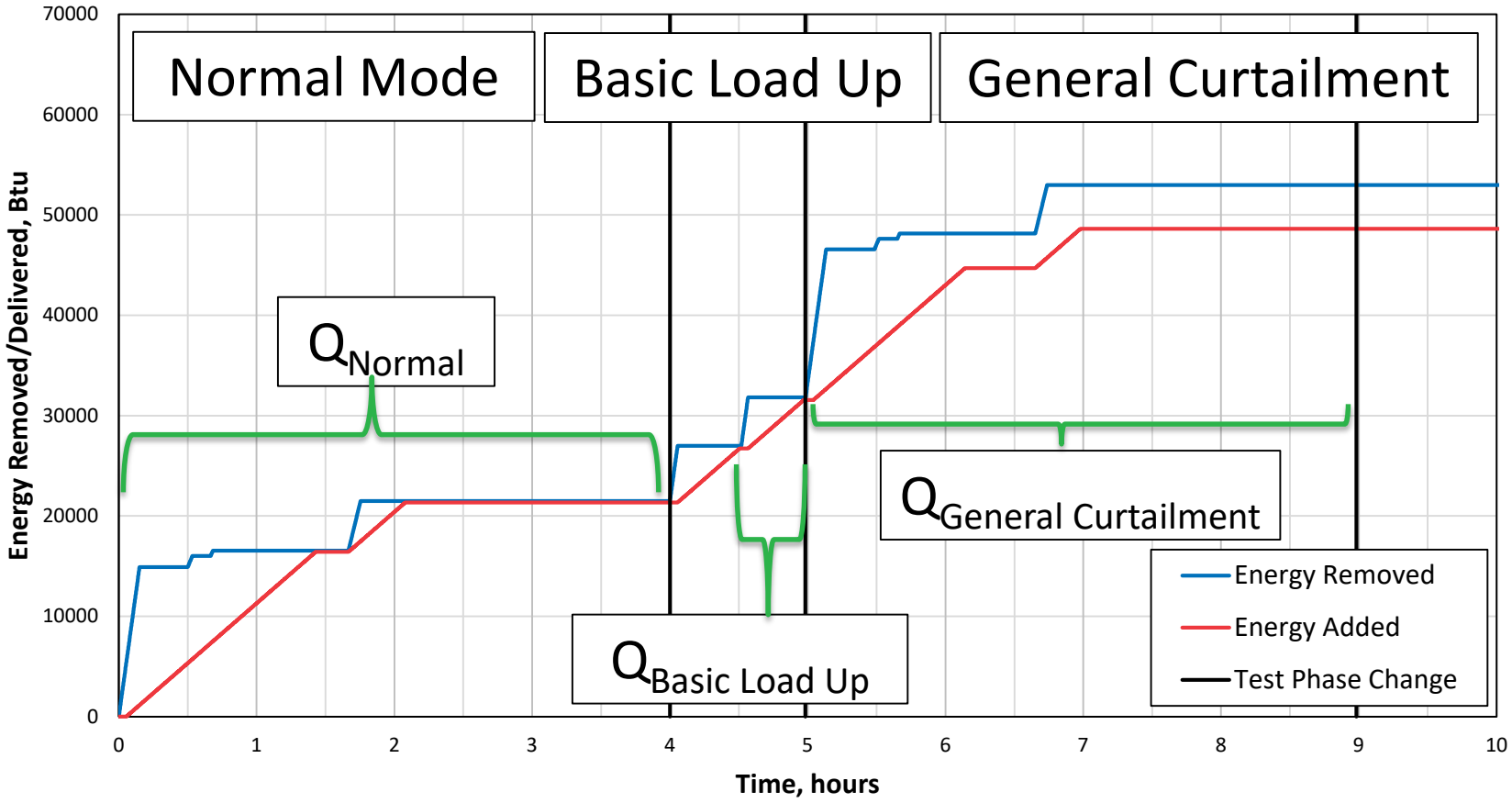
Requires CWHP at setpoint (Advanced Load Up requires heating CWHP past the user setpoint)

1. Start immediately after the end of the Normal Mode portion
2. Send an Advanced Load Up request
3. Wait until a max mean tank temperature is observed after cut-out

Load Shift – General Curtailment Procedure

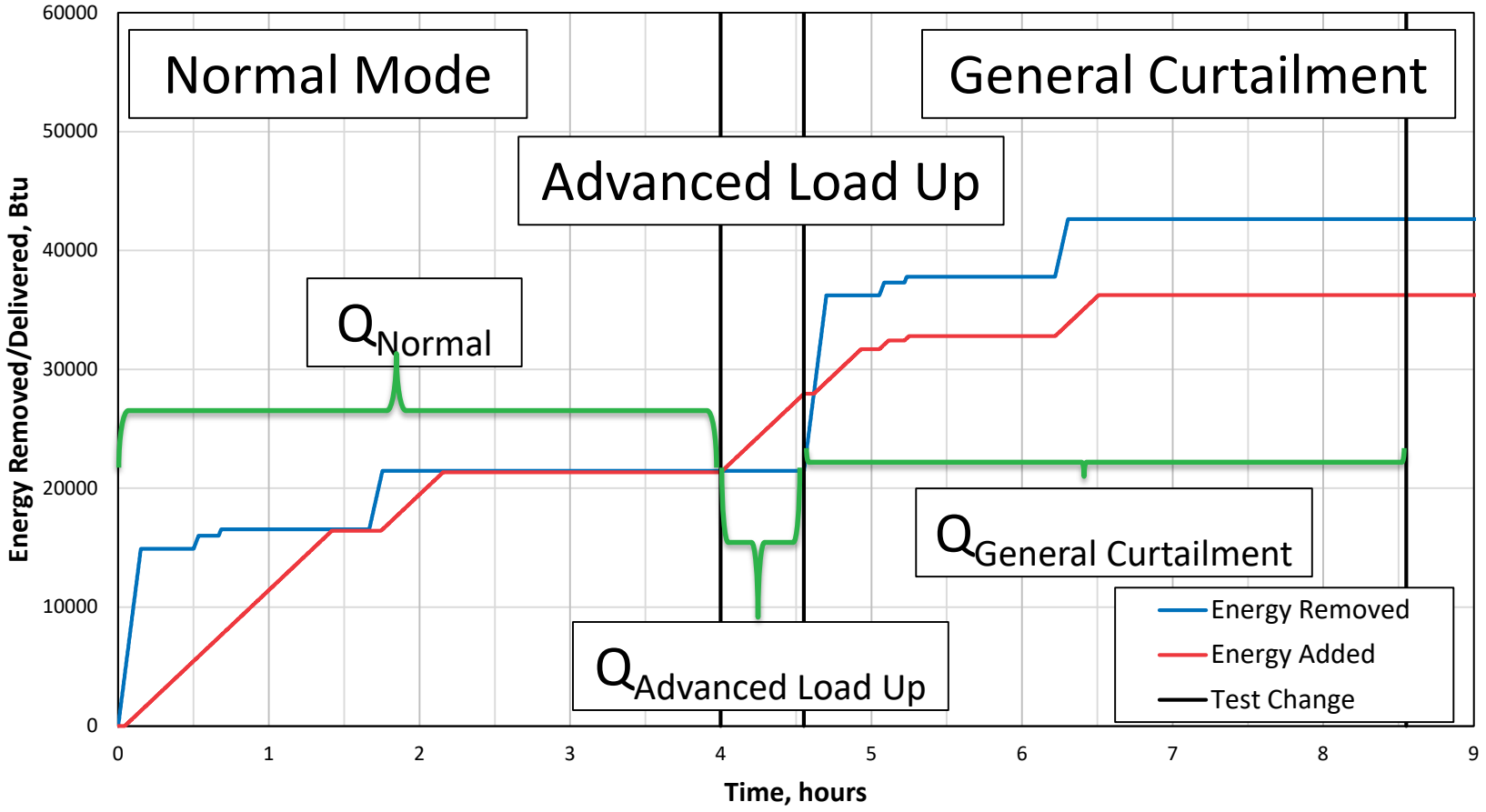
1. Start immediately after Load Up test
2. Send a General Curtailment request
3. Perform the same draw pattern as in Normal Mode
4. Wait until 4 hours after start of previous step
5. End General Curtailment portion
    a. If a recovery is occurring at hour 4, wait until a max mean tank temperature is observed after cut-out

Load Shift Example – Basic Load Up Verified



$$Q_{Basic\ Load\ Up} + (Q_{Normal} - Q_{General\ Curtailment}) \geq \text{Basic Load Shift} = 0.5\ kW$$

Load Shift – Advanced Load Up Verified



$$Q_{Advanced\ Load\ Up} + (Q_{Normal} - Q_{General\ Curtailment}) \geq \text{Advanced Load Shift} = 1.0\ kW$$

Emergency Curtailment and Grid Emergency

- Emergency Curtailment
  - For HPWH with ER elements, if elements are used, the unit fails.
  - For ER only units, if any element but the top is used, the unit fails.
- Grid Emergency
  - If any energy is used to heat water, the unit fail.

- Procedure
  1. Start with a CWHP in standby (not recovering)
  2. Send Emergency Curtailment request
  3. Draw off water at prescribed flow rate for the rated draw pattern
  4. When the delivery (outlet) temperature reaches 80°F, send a Grid Emergency request
  5. Stop drawing water when the delivery temperature reaches 60°F

Accuracy of Current Available Energy Storage Capacity

During the Load Shift test the Current Available Energy Storage Capacity (AE) is requested and recorded several times.

1. Calculate the energy content of the CWHP at each recording ($\bar{T}_{Step}$ is the mean tank temperature at each recording)

$$E_{Step} = V_{st}\rho C_p \bar{T}_{Step}$$

2. Calculate $\bar{E}_{Setpoint}$

3. Calculate AE for each E_{Step} not used to determine $\bar{E}_{Setpoint}$

$$AE_{C,Step} = \bar{E}_{Setpoint} - E_{Step}$$

4. Calculate the root-mean-square difference (RMSD)

$$RMSD_{AE} = \sqrt{\frac{\sum(AE_{C,Step} - AE_{R,Step})^2}{N}}$$

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UEF as Main Criteria

- As the Federal minimum efficiencies are now in terms of UEF, EPA has moved the water heaters UEF criteria from Appendix A to the main body of the specification.
- Legacy criteria in terms of EF will remain in the specification for reference but have been moved to Appendix A
- Definitions, criteria, and test method have been updated to reflect this.
- Products currently certified against EF criteria will remain certified. However, Partners with products currently listed with only EF criteria will be contacted to provide UEF ratings.

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Next Steps

Nov. 26, 2019

Draft 2 and Test Method Published

Dec. 9, 2019

Stakeholder Webinar

Q1 2020

DOE Product testing

Q2 2020

Final Draft and Test Method

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Questions

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Stakeholders are encouraged to provide written comments for consideration to waterheaters@energystar.com by Jan 6, 2020.