ENERGY STAR®
Water Heaters Version 3.3 Connected Criteria

ENERGY STAR Products Partner Meeting (ESPPM) Discussion

Stakeholder Meeting

September 10, 2019

Webinar Audio Access

USE YOUR TELEPHONE:

Call-in Number: (877) 423-6338

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Agenda

- Welcome, Introductions
- 2019 Activity Recap
- V3.3 Draft 1 Specification Revisit
- DOE Water Heaters Demand Response Test Procedure

Introductions

Abigail Daken

U.S. Environmental Protection Agency

Catherine Rivest

U.S. Department of Energy

Navigant / ICF Staff

Meeting Attendees

Large Loads Connected Drivers (Recap)

Type	Driver of market adoption	Energy Implication and/or Opportunity	Examples
Large loads, load flexibility doesn't impact consumer	Grid services	Enable cleaner grid	Pool pumps, water heaters
Large loads, load flexibility can impact consumer somewhat	Grid services	Enable cleaner grid; protect consumer interest	EVSE, HVAC
Convenience and quality of maintenance	Consumer and brand owner interest	Better maintenance saves energy	White goods, HVAC
Safety and security	Consumer interest	Added load; may provide occupancy info	Door locks, window sensors
Additional functionality	Consumer interest	Added load	Color changing lights, VADAs

Recent Activity, Version 3.3 Water Heaters (Connected Criteria)

Water Heaters V3.3 Draft 1, on April 16, 2019

- Connected definitions, connected section with criteria, reference DR test to be developed
- Water Heaters Demand Response Test Procedure
  - Kickoff Meeting [6/6/2019]; Check-in 1 [8/15/2019]

Large Loads Discussion Guide Document, on February 14, 2019

- Comment Response Letter, Example Architectures [6/30/2019]

Demand Response in Water Heaters

- CA Title 24 Joint Appendix (JA) 13
  - Qualification Requirements for Heat Pump Water Heater Demand Management Systems (Docket)
- Demand Response Open Standards
  - CTA 2045-A Standard
  - Open ADR 2.0b Standard
- AHRI 1380 (HVAC Equipment Demand Response)
  - Framework: provides flexible DR implementation with quantifiable targets
- Washington state law requires CTA-2045 compatibility, or equivalent, in all new electric storage water heaters manufactured on or after Jan 1, 2021

ENERGY STAR Version 3.3 Specification

- Skip if attendees already familiar.

Connected and Demand Response Criteria

- Optional
  - Products meeting requirements designated ‘connected’

- Connected criteria = user functionality + grid services
  - Heat Pump Water Heater: Full DR Requirements
  - Gas Storage Water Heaters: Limited DR Requirements
  - Instantaneous Gas Water Heaters: Exempt from DR

User Amenity (Not DR)

- Remote Management
  - Product responds to remote consumer requests
  - Temporary remote change to higher energy mode: within 72 hours, revert to previous state

- User Alerts
  - At least 2 alerts relevant to energy consumption (e.g. faults, settings)

- Energy Reporting
  - Measured or estimated instantaneous power
  - May be met via DR functionality

Demand Response Connection and Override

- CTA 2045-A and/or Open ADR 2.0
  - CTA 2045-A: On premises, physical connection. Multiple connectivity options (e.g. Cellular)
  - Open ADR 2.0: Cloud based; can add on to existing cloud functionality. Easily reconfigurable.

- Loss of Connectivity
  - Revert to normal operation. If default schedule loaded, revert to schedule

- Consumer Override
  - Revert to normal operation. Temporary- 72 hours. Long term allowed.
  - Grid emergency (Off Mode) events do not have to be over-rideable

Demand Response Messaging

- **Required Messaging:**
  - Device Type (e.g. HPWH)
  - Operational State (Product activity, for example, running and in load up state)
    - Includes fault condition state and opt in / out
  - Current Available Energy Storage Capacity
    (Energy difference: current state and user set point)
  - Power / Demand (Instantaneous)

- **Optional Messaging:**
  - Energy Use (kWh)
  - Current Total Energy Storage Capacity
    (Energy difference: current state and max allowed energy storage)

Demand Response Requests and Responses

- **Required Responses:**
  - General Curtailment: Minor reduction in power with no consumer impact
  - Emergency Curtailment: Moderate reduction in power with some consumer impact
  - Grid Emergency: Extremely rare event, max power reduction. Does not have to be overrideable.
  - Load Up: Store more energy in tank now if possible

- **Optional Responses:**
  - Set Point: Adjust tank set point to this temperature
  - Price Response: Automatically operate based on energy costs

ENERGY STAR Version 3.3 Specification Discussion Topics

Water Heater Comment Summary – DR protocol

- NEEA
- PG&E
- NWEC
- EPRI
- CEE
- AHRI & all members
- NEEP
- NRDC
- CA IOUs
- TVA
- ASAP
- Bradford White

CTA port (or equivalent)

On premise

CTA or OpenADR, cloud allowed

Any open standard

No limit on how DR achieved

- Manufacturer/service provider
- Utility/CEE
- Efficiency Advocate

DR Messaging Comments

- Comments Received:
  - Status info should be very recent, within 5 seconds of poll request.
  - Loss of connectivity, should provide time delay (e.g. 30 min) before reverting to normal state.

[Discussion]

- Agree / Disagree?
- Time limits:
  - Within X seconds of poll
  - Within Y minutes of loss of connectivity

Demand Response Scope

- Comments Received
  - Gas storage; limited / uncommon use case. Recommend strike from scope.
  - Gas Instantaneous (Connected only requirements). Recommend strike from scope.
  - Solar Thermal; may have different DR needs vs typical HPWH.

[Discussion]

- Thoughts?

Advanced Load Up, Joint Appendix (JA) 13

- Advanced Load Up Command:
  - JA13 defines a load up command that is allowed to exceed user set point.
  - Command disabled by default, manual user opt-in required (for safety).
  - Defined as providing additional load shift capability when paired with light shed:
    (1.0 kWh per event vs 0.5 kWh for standard load up + shed).
  - Absorbs 0.5 kWh or greater when used alone.

[Discussion]

- Incorporate this signal type as optional DR response?
- Definition: kWh load shifted / absorbed or ‘may exceed user set point’?

Demand Response Metrics

- Comment Received:
  - Value to DR users (e.g. utilities) for defining results / impact of DR events
    - Example: curtailment [light shed] + load up. Shifts >= 0.5 kWh per event
    - Or, load up absorbs 0.5 kWh per event. Etc.

- Testable measurements and metrics floated for discussion (DOE Presentation- more on this topic):
  - Tank Temperature: during DR events
  - kWh: load shifted / absorbed (load up) / not used (curtailment)
  - Efficiency: e.g. UEF during DR cycle

- [Discussion]; value vs testing level of effort. (DOE presentation)

Electric Resistance (ER) Use in Demand Response

- Comments Received:
  - Can not restrict ER use in Demand Response, as tank state and consumer draws can result in scenarios where ER must be used to maintain consumer comfort / needs.

[Discussion]

- Would ER be used under ‘normal operating conditions’ in DR?
- Can we define ‘normal operating conditions’ ?
- More discussion later in DR test procedures

ENERGY STAR Water Heater Demand Response Test Procedure

DR Test Procedure

- Potential Pathways
  - Option 1: Only verify qualitative requirements
    - Signal and CWHP response verification, do all responses need to be verified?
  - Option 2: Option 1 + Evaluate Load Shift Capacity
  - Option 3: Implement Option 1 while DR metrics are under development.

- Test Procedure Topics for Discussion
  - Load Up test: Basic Load Up and Advanced Load Up
  - Curtailment Test(s): 1 Recovery or a Long Period?
    - Include Load Shift?
    - Verify ER isn't used during curtailment?

Load Up Test: Verification

- Load up: stored thermal energy must increase within safety parameters as determined by the manufacturer.
- Basic Load Up:
  - Starts with the tank at a depleted or partially depleted state, but not in recovery.
  - Upon basic load up signal, tank must recover to a mean tank temperature (MTT) similar to that under normal operation.
  - If tank energy consumption increases after basic load up command, increased stored thermal energy is verified (since no thermal energy exiting tank through hot water draw, energy consumed is assumed to be stored in tank)
- Advanced Load Up
  - Starts with tank fully recovered under normal operation or basic load up.
  - Upon advanced load up signal, tank should cut-in to begin recovery increasing the MTT and stored energy beyond that in normal operation and basic load up.
  - If tank energy consumption increases after advanced load up command, increased stored thermal energy is verified.
- Should both basic and advanced load up be tested? If not, which is more important?

Updated Load Up Test

1. Start after a cut-out has occurred under normal operation at the user setpoint. Record MTT.
2. Draw 10 gallons of hot water. If the water heater cuts in before or immediately after the draw, restart the test and draw off 1 gallon less than the volume of water at which cut-in occurred.
3. Send Basic Load Up signal.
4. Allow CWHP to fully recover and cut out
   - CHWP should be at or near MTT in step 1
   - End test if not testing to Advanced Load Up
5. Send Advanced Load Up signal.
6. Allow CWHP to fully recover and cut out.
   - CWHP mean tank temperature should be higher than in step 1

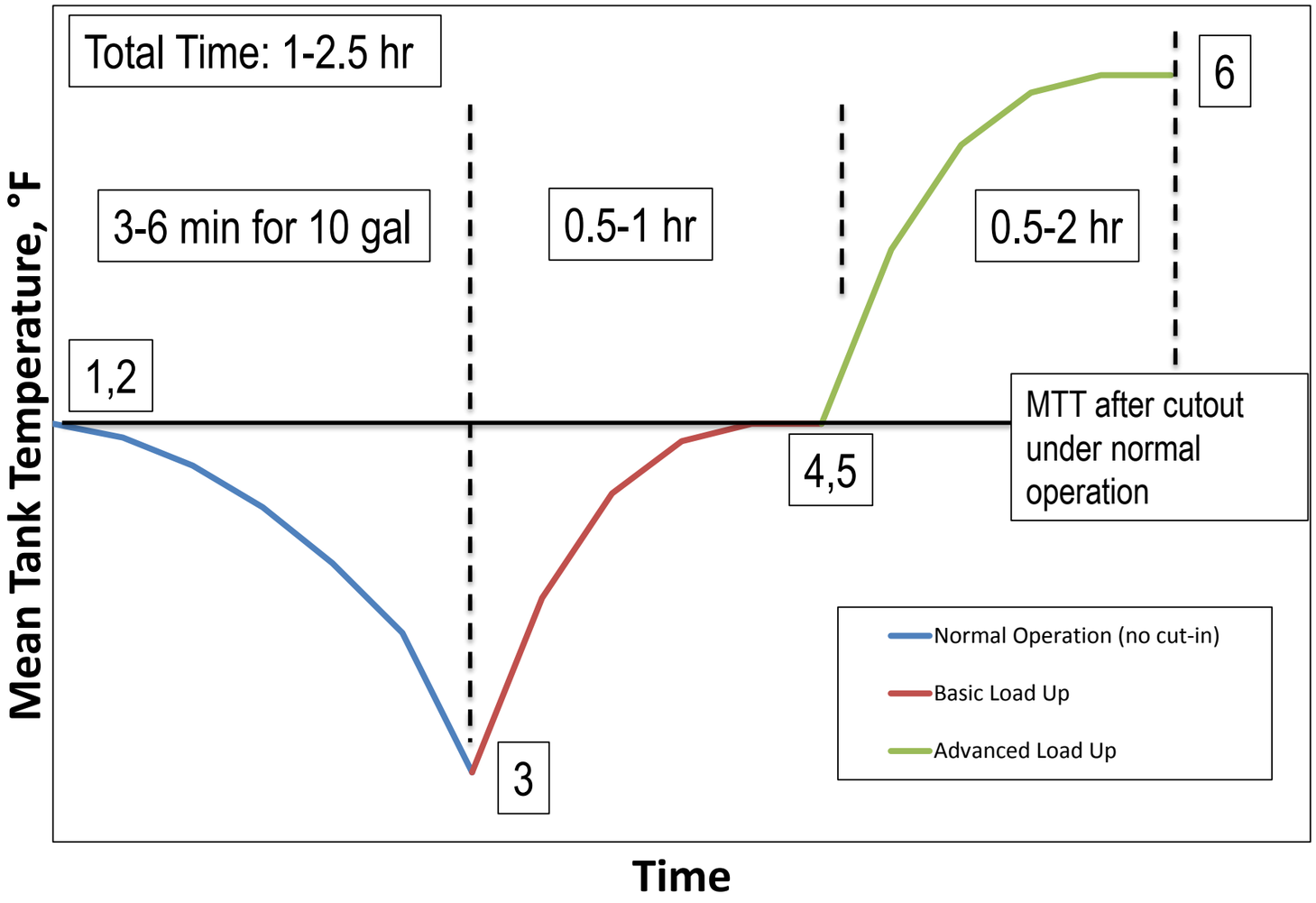
Updated Load Up Test

- Draw flow rate depends draw pattern bin:

Capacity Bin	Flow Rate (GPM)
Low/Medium	1.7
High	3.0

- Measure energy consumption and MTT values
- Example:

Load Up Type	MTT (°F)
Basic	125
Advanced	140



Curtailment Tests – Verification

- General Curtailment: Energy consumed must be reduced moderately.
- Emergency Curtailment: Energy consumed must be reduced to a very low level, less than that for general curtailment.
- Grid Emergency: CWHP must immediately stop using energy for water heating when safe to do so.
- Changes in stored thermal energy are assumed to be directly correlated to energy consumed during recoveries
  - Energy consumed in each mode should be as follows: Normal Operation > General Curtailment > Emergency Curtailment > Grid Emergency
  - If energy consumed follows the relationship above then stored thermal energy in each curtailment mode is verified.

Curtailment Tests

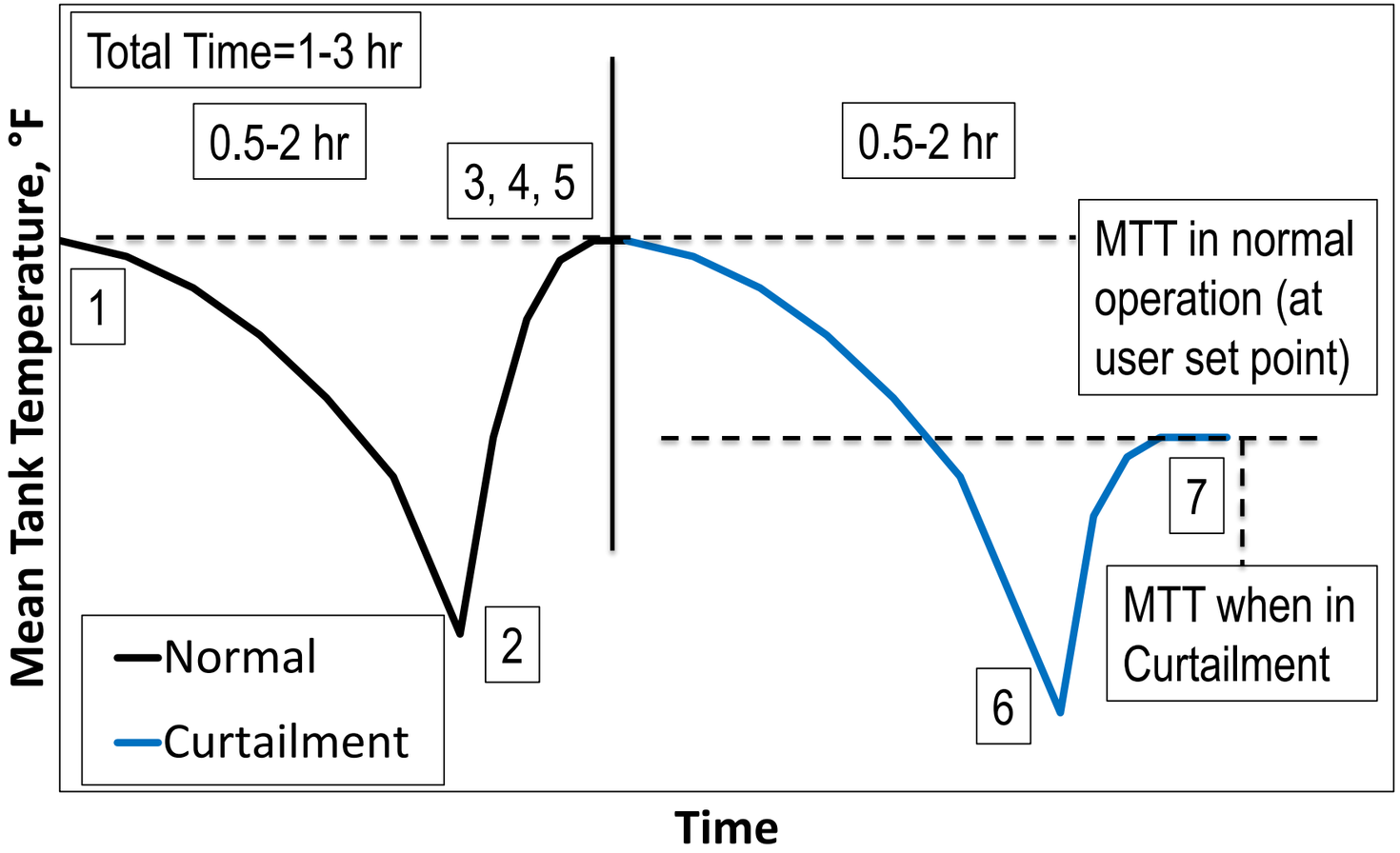
- Option 1: Curtailment Test – 1 (Presented in Check-In 1)
  - 1 recovery doesn't capture how a CWHP would work in the field over a longer curtailment period that includes some active and some standby period
  - During UEF test, heat pump recoveries take up to 2.5 hours depending on how much water has been removed
- Option 2: Curtailment Test – Longer Recovery Period
  - 4 hour curtailment has been suggested.
- Is it necessary to test every curtailment outlined in the draft specification?
- Should the TP verify that ER does not operate in a curtailment? If so, should these provisions be imbedded within the curtailment test or be an additional test?

Check-in 1 Procedure: Curtailment Tests – 1 Recovery

- Draw water until cut-in for general and emergency curtailment. Flow rate based on draw pattern bin:

Capacity Bin	Flow Rate (GPM)
Low/Medium	1.7
High	3.0

- Measure energy consumption and MTT
- For Grid Emergency, no recovery expected so draw until outlet temp ≤ 60 °F. Total test time is mostly dependent on the normal operation time, so 0.5-2 hr.

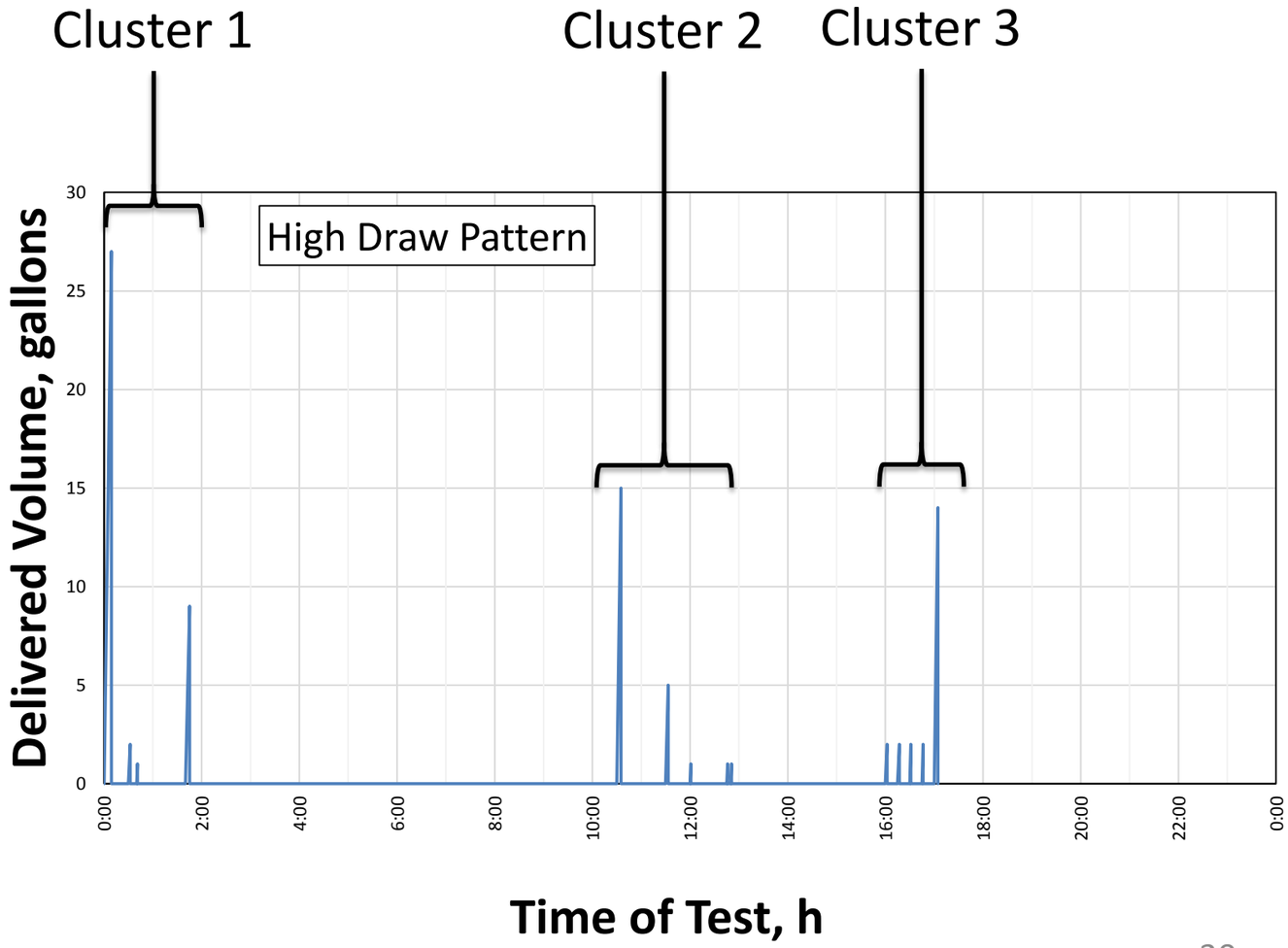


Potential Curtailment Test – Long Period: Test Steps

1. Start after a cut-out has occurred under normal operation at the user setpoint. Record MTT and energy consumption throughout the test.
2. Perform a specified draw pattern (e.g., first draw cluster for the CWHP rated draw pattern)
3. Wait for the CWHP to fully recover in normal operation mode.
4. After cut-out following recovery, send general curtailment signal.
5. Perform the specified draw pattern (same as in step 2).
6. End test once one of the following occurs:
   - At some specified duration (e.g., 3 hours), if a recovery is not occurring, or
   - If recovery is occurring at the specified duration, when maximum MTT is observed after cut-out
7. Return the water heater to normal operation and repeat steps 3-6 for emergency curtailment.
8. For grid emergency: draw water until outlet temperature is at 60°F (inlet temperature).

Potential Curtailment Test – Long Period: Example UEF TP Draw Pattern

- Draw pattern is a series of draws at specific times, flow rates, and volumes
- Different draw pattern for Very Small, Low, Medium, and High
  - 2 draw clusters in the Very Small
  - 3 draw clusters in all others
- Initial draw of cluster 1 removes the most water and usually results in a long recovery
- Which cluster(s) appropriate for running during a curtailment to assess response?



Testing for the use of ER in curtailment?

- Option 1: Embed provisions into the curtailment tests that monitor the power draw.
  - If element activates at any time during the curtailment tests, the model fails
- Option 2: Include additional test that focuses only on confirming heating elements do not come on while in curtailment mode
  - Impose large hot water draw(s) while in curtailment mode and monitor element power draw. If element activates at any time during test, the model fails

Test Steps for Option 2

1. Start with a tank at the user set point
2. Send Curtailment request
3. Draw hot water from the tank until outlet temperature stabilizes (e.g., successive readings over 15 minute period within 2 °F)
4. End test

Test Burden Estimates

Test	Description	Duration (hrs)
Load Up	Basic + Advanced	1-2.5
Curtailment Test (1 recovery)	General Curtailment	1-3
	Emergency Curtailment	1-3
	Grid Emergency	0.5-2
	Total	3.5-10.5
Curtailment Test (Long Period)	Normal Operation	3 or 4
	General Curtailment	3 or 4
	Emergency Curtailment	3 or 4
	Grid Emergency	0.5
	Total	9.5-12.5

Load Shift: As defined by JA13

- At the default set point as shipped from the manufacturer, the System shall be able to shift:
  - A min of 0.5 kWh of user electrical energy per (Basic Load Up + Light Shed) event,
  - A min of 1 kWh of user electrical energy per (Advanced Load Up + Light Shed) event, including at least 0.5 kWh on Advanced Load Up

Load Shift: Verification

- Basic Load Shift:
  - Normal energy consumed – General Curtailment energy consumed
  - For CA: should be ≥ 0.5 kWh
- Advanced Load Shift:
  - Energy consumed in the Load Up test during the Advanced Load Up portion of test + Basic Load Shift
    - For CA: should be ≥ 1 kWh
  - Energy consumed in the Advanced Load Up portion of Load Up test
    - For CA: should be ≥ 0.5 kWh
- Necessary to include this in test procedure? Alternatively, could report energy consumed during each Load Up and Curtailment and utilities decide how to use this information for evaluating load shift capability

Next Steps

- Specification and Test Procedure (DOE) developed concurrently
- Mid November: Test Procedure Check-In 2 (If necessary)
- Anticipated Q4-2019: Specification Draft 2 and Test Method Draft 1
- Anticipated Q1-2020: Specification and Test Method Draft Final; not necessarily at exactly the same time, then Specification Final
- Anticipated Q2-2020: Test Method Final

Questions

For Specification Questions:

Abigail Daken

Daken.Abigail@epa.gov

202-343-9375

For Test Method Questions:

Catherine Rivest

Catherine.Rivest@ee.doe.gov

202-586-7335

For Connected Criteria Questions:

Dan Baldewicz

Dan.Baldewicz@icf.com

518-452-6426

James Phillips

James.Phillips@Navigant.com

202-481-7347