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Concept Paper: Performance Testing Elements for FDAS-Compliant Thermostats

Purpose

This concept paper outlines the key performance elements and associated test requirements necessary to evaluate thermostat compliance with the upcoming proposed Flexible Demand Appliance Standards (FDAS). These proposed requirements will focus on ensuring thermostats used for electric space-conditioning appliances within the scope of the standard demonstrate capabilities in connectivity, memory integrity, load scheduling, user interaction, timekeeping, consumer choice, and cybersecurity.

Table 1: Overview of Proposed FDAS Thermostat Test Requirements

S.No	Requirements	Overview
1	Connectivity Requirements	Test the ability to retrieve static and dynamic datasets, integrate with third-party platforms, and execute/revert from DR events.
2	Integral Memory Requirements	Verify storage and retention of static and dynamic data, with persistence after power or connectivity loss.
3	Load Flexibility Scheduling Requirements	Confirm creation and execution of daily schedules based on GHG or pricing data, including pre-conditioning and load shedding.
4	User Interface Requirements	Ensure clear display of operational status, DR events, and environmental data, with support for overrides and Over-the-Air (OTA) updates.
5	Timekeeping Requirements	Validate accurate real-time clock operation and retention of settings for at least 72 hours during power outages. Also validate post-recovery operations.
6	Consumer Choice and Opt-Out	Confirm users can override or opt out of automated actions, with preferences persisting across sessions.
7	Cybersecurity Compliance	Verify adherence to California Code of Regulations, Title 20, Section 1692(c) General Cybersecurity Requirements, including secure data handling, authentication, and consent.
8	Functional Test Procedure Compliance	Test end-to-end functionality across all connectivity options and user selection modes

Table 2: A Comparison of the Proposed FDAS framework with the ETCC Smart Thermostat Functionality Test

S.No	FDAS Requirements	Relevant ETCC functionality (fct.) test procedures
1	Connectivity Requirements	10.1 Initial connection to Wifi Network 10.2 Initial creation of OEM online account by customer (fails if it is not a simple method.) 10.3 Initial download of OEM mobile app by customer
2	Integral Memory Requirements	11.5 Complete preliminary performance test (confirm fct. like after outage) 11.7 Router test (confirm fct. after a loss of communication - Wifi signal)
3	Load Flexibility Scheduling Requirements	11.4 Set thermostat schedule - is about scheduling
4	User Interface Requirements	12.1 number of test procedures to validate DR functions.
5	Timekeeping Requirements	11.4 Set thermostat schedule 11.5 Complete preliminary performance test (confirm fct. like after an outage) 11.6 Thermostat re-boot (confirm fct. after a reboot) 11.7 Router reset (confirm fct. after a loss of communication - Wifi signal) 11.8 Rejoin after power outage on thermostat (confirm proper functionality after reinitializing)
6	Consumer Choice and Opt-Out	12.2 Test thermostat temperature offset 12.4 Opt out function - about opt-out. 12.5 Manual override.
7	Cybersecurity Compliance	None
8	Functional Test Procedure Compliance	11.1 Thermostat temperature accuracy and precision validation

1. Connectivity Requirements

Performance Element:

Thermostat must demonstrate both static and dynamic connected capability.

Test Objectives:

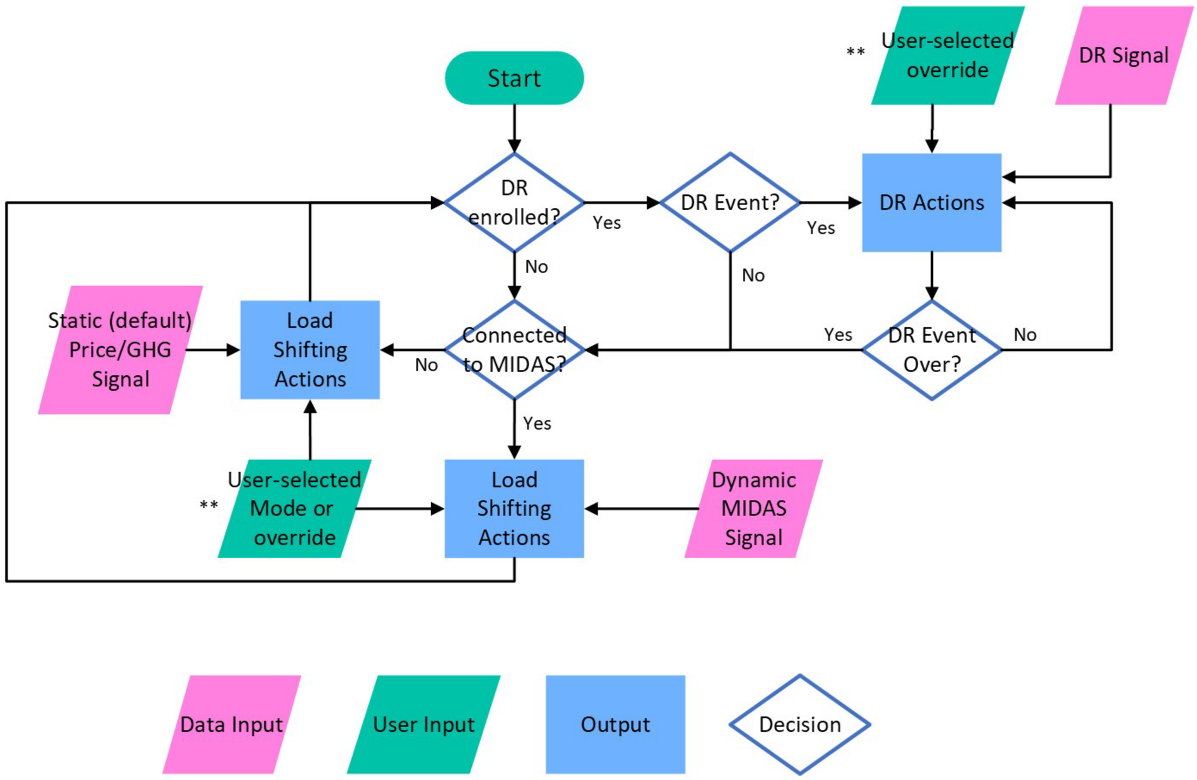
- Confirm retrieval of static datasets (GHG and electricity pricing) from pre-loaded memory.
- Validate the ability to download static datasets Over-the-Air (OTA) from a secure source (MIDAS). For testing, the static data is required to be downloaded from MIDAS and stored (uploaded) in the local memory of the thermostat under test. (Note: An alternative is for the static data to be downloaded from a cloud platform that connects to MIDAS and stored in the local memory of the thermostat under test. This alternative is currently under CEC's consideration.) In production, once the FDAS is effective, OEMs would ship thermostats with the static signal (Price/GHG) stored in local memory. These thermostats will have the ability to receive OTA updates of the static signal when made available by the CEC.
- Verify the thermostat retrieves dynamic datasets daily from MIDAS when connected.
- Verify that the thermostat uses open-source connectivity and record its behavior during demand response (DR) events.
- Validate the ability of the thermostat to respond to Event-based DR signals from a Virtual Power Plant (VPP)/Aggregator, to execute DR commands, and to revert to pre-event mode post-event.

Test Scenarios:

- Test OTA update process using thermostat user interface for static datasets.
- Simulate daily Application Programming Interface (API) and Over the Air updates and validate automatic retrieval for dynamic datasets.
- Assess integration with 3rd-party platforms (e.g., Automation Service Providers).
- Simulate a DR event called by a VPP/Aggregator; verify that the thermostat executes received DR commands (e.g., setpoint adjustment, HVAC cycling).

- After the DR event ends, confirm the thermostat returns to the pre-event operating mode – responding to static or dynamic data sets per Section 3. Figure 1 is a simplified representation of a proposed control logic associated with the 3 data input modes – Static ("Default Price/GHG Signal"), Dynamic ("MIDAS Signal"), and event-based DR ("DR Signal").

Figure 1: Proposed Control Logic associated with 3 different Data Inputs



Source: California Energy Commission

** **User-Selected Override:** Allows users to override the thermostat's load shifting settings resulting from Static or Dynamic data inputs, or DR actions settings resulting from the DR Signal. This override can be activated at any time during operation.

User-Selected Mode: Enables users to choose their preferred operational mode, such as Price-Based, GHG-Based, or Custom, either during the initial setup or at a later time if preferences change.

2. Integral Memory Requirements

Performance Element:

Thermostat must retain data for offline operation.

Test Objectives:

- Verify the ability to store annual hourly entries (8,760 hours for a common year, 8,784 hours for a leap year) for a full year of static data.
- Confirm retention of 48 hours of dynamic data during connectivity loss.
- Ensure data persistence after power loss and automatic recovery.

Test Scenarios:

- Power-cycle the thermostat and confirm data availability.
- Validate memory write/read for full dataset size.
- Simulate network loss and record fallback behavior.

3. Load Flexibility Scheduling Requirements

Performance Element:

After retrieving static or dynamic data sets per Section 1, Thermostat must process these data sets and execute load shifting schedules.

Test Objectives:

- Confirm creation of daily schedules based on static/dynamic inputs.
- Validate performance of pre-conditioning (+/- 2°F) and shedding actions.
- Demonstrate schedule execution based on GHG or billing optimization.

Test Scenarios:

- Provide sample GHG or pricing datasets and verify generated schedules.
- Record Thermostat schedule output to confirm real-time implementation.
- Validate user-selected objective (GHG vs. cost savings).

4. User Interface Requirements

Performance Element:

Thermostat must present operational and environmental data to the user. The thermostat shall include a fully functional user interface, incorporating remote web-based control and remote interface-based control.

Test Objectives:

- Confirm display of connectivity status (static/dynamic), demand response status, pricing or GHG levels, and current Indoor temperature.
- Verify interface supports OTA update option and setpoint overrides.
- Verify that the appliance can be easily connected and set up through a simple process, including remote setup via an internet website or mobile application.

Test Scenarios:

- Conduct UI walkthrough with all statuses simulated. (Note: It was suggested that the CEC consider allowing an app-based route to satisfy some of the interface requirements. However, the thermostat's display screen should still provide basic information such as the HVAC system's operating conditions and environmental conditions, including the current indoor temperature, see "performance elements" of this section.)
- Confirm user-initiated updates and overrides work without delay.
- Test DR status during mock event.

5. Timekeeping Requirements

Performance Element:

Thermostat must retain time and settings during power disruptions.

Test Objectives:

- Verify every twenty-four hours that the real-time clock (RTC) operates accurately when pulling day-ahead data.
- Confirm settings and schedules are retained for 72 hours without power.

Test Scenarios:

- Simulate long-term power outage.

- Record RTC drift over a 72-hour period.
- Validate post-recovery operations.

6. Consumer Choice and Opt-Out

Performance Element:

User must be able to override or opt-out of system-generated schedules.

Test Objectives:

- Confirm manual setpoint overrides are respected and persistent.
- Validate opt-out settings persist and are enforceable across sessions.

Test Scenarios:

- Trigger flex-schedule event and override with user setpoint.
- Test opt-out and re-enablement workflow.

7. Cybersecurity Compliance

Performance Element:

Thermostat must comply with cybersecurity and data protection standards.

Test Objectives:

- Verify compliance with California Code of Regulations, Title 20, Section 1692(c) (General Cybersecurity Requirements).
- Confirm consumer consent is required before transmitting data.
- Verify secure authentication and encrypted data handling.

Test Scenarios:

- Penetration test against device network interfaces.
- Review authentication logs and certificate management.
- Validate secure storage and access controls for sensitive data.

8. Functional Test Procedure Compliance

Performance Element:

Thermostats must pass all functional testing as per FDAS regulations.

Test Objectives:

- Confirm all connectivity options (static and dynamic) and user selection modes (GHG, Price, Hybrid, and User override setpoint) are functional.
- Validate accurate response to control signals and environmental inputs.

Test Scenarios:

- End-to-end compliance test using standardized testing protocol (to be defined).
- Regression testing under load and environmental variance.

Conclusion

This concept paper serves as a foundation to define the initial FDAS thermostat compliance test framework. These tests will ensure that compliant thermostats provide grid-flexibility functionality, consumer control, reliable performance, and data security as required by the California Energy Commission.

Glossary

This glossary includes basic definitions of some of the terms used in this concept paper.

Application Programming Interface (API): A set of rules and protocols that allows different software systems to communicate with each other. In energy systems, APIs are commonly used to exchange data, such as electricity prices, emissions signals, or device performance, between platforms, applications, or devices in a secure and standardized way.

Dynamic connected capability: A thermostat's ability to retrieve and use day-ahead hourly projections of GHG emissions and electricity prices from external sources when internet connectivity is enabled by the consumer or consumer's authorized third party (such as an Automation Service Provider). A thermostat with dynamic connected capability is able to automatically retrieve these data sets from the CEC's MIDAS platform (Note: It was commented that the CEC consider allowing a thermostat to receive these data sets from a cloud platform that connects to MIDAS. This may be considered as an alternative, see Section 1, Connectivity Requirements.) The data are updated daily based on day-ahead wholesale electricity prices and self-generation incentive program (SGIP) forecasts of future GHG emissions from electricity generation. These current updated projections can be used in place of static data to optimize thermostat operations in alignment with current grid conditions.

Event-Based Demand Response (DR): A type of demand response program where participating devices or customers are signaled to reduce or shift electricity usage during specific periods, typically when the grid is under stress or prices are high. These events are triggered by utilities or grid operators and usually last for a defined duration.

Over-the-Air (OTA) Update: A method of remotely delivering software or firmware updates to a device via a network connection, without requiring physical access. In the context of thermostats or connected appliances, OTA updates enable manufacturers or service providers to fix bugs, enhance features, or ensure compliance with updated standards automatically.

Static connected capability: A thermostat's ability to operate using pre-loaded, time-varying GHG emissions and electricity price data without requiring continuous connectivity. A thermostat with static connected capability is able to retrieve hourly GHG and pricing data from its integral memory for use in automated responses. OEMs shall upload pre-saved data sets, downloaded from a secure CEC site or via API, into the thermostat's internal memory prior to shipment.

Virtual Power Plant (VPP): A network of distributed energy resources, such as solar panels, battery storage systems, electric vehicles, and flexible appliances, that are coordinated through a central software platform to function like a single power plant. VPPs optimize the generation, storage, and consumption of electricity to support grid reliability, reduce peak demand, and provide energy and ancillary services.