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APPENDIX D:
Demand-Responsive Controls

This appendix to the nonresidential compliance manual addresses the demand-responsive (DR) control requirements in the 2025 Energy Code.

Demand response is an increasingly important function of buildings as distributed energy resources become more common and customers have access to time of use electricity rates and incentive programs designed to encourage demand side optimization. Demand response occurs on a range of timescales, from seconds to seasons, and represents any demand change in response to grid or economic needs. In addition to current time of use electricity rates, utilities in the future will likely connect electricity costs to high frequency fluctuations in both the supply and demand for electricity. Appropriate demand responsive controls allow building operators to maintain the quality of services a building provides and reduce the total cost of energy by automating a building's response to changes in electricity rates.

The following definitions from Section 100.1 are relevant to the DR control requirements:

- **Demand response** is short-term changes in electricity usage by end-use customers, from their normal consumption patterns. Demand response may be in response to:
    - Changes in the price of electricity; or
    - Participation in programs or services designed to modify electricity use.
        - In response to wholesale market prices.
        - When system reliability is jeopardized.
- **Demand response period** is a period of time during which electricity loads are modified in response to a demand response signal.
- **Demand response signal** is a signal that indicates a price or a request to modify electricity consumption for a limited time period.
- **Demand responsive control** is an automatic control that is capable of receiving and automatically responding to a demand response signal.

The DR control requirements ensure that the building is DR capable (i.e., capable of responding to a DR signal). The decision to employ demand response is up to the building owner or manager, in coordination with their utility company and/or a governing authority. A building that is capable of receiving and responding to a demand response signal is sufficient to meet the requirements of the Energy Code. DR-capable is described as follows:

- **DR-capable:** A building is capable of DR when the building has loads that can be curtailed, DR controls are installed, and the controls have been programed/configured so the test control strategy that is defined in the building code can be deployed (note: the DR controls can be programmed with additional control strategies).

- **DR-enabled:** The DR of a building is enabled when the connection between the entity that sends the DR signal and the DR control in the building has been tested and communications have been allowed or "enabled."
- **DR-enrolled:** A building is enrolled when the building owner/occupant has enrolled in a DR program (note: this may include updating the settings or programming of the DR controls to better match the terms of the program).

The requirements for DR controls apply only if the controls are used to comply with the building standards (i.e., DR thermostats or a heat pump water heater). If DR controls are installed voluntarily and do not contribute to compliance with minimum code requirements, they do not need to adhere to requirements in Title 24, Part 6.

For residential dwellings, DR controls are only required as a part of specific Exceptions to HVAC and Solar Ready requirements identified in Section 110.10 of the Energy Code.

Communications Requirements for DR Controls

Reference: Section 110.12(a)1-5

There are two main communication requirements that apply to all DR controls:

- The control must, at minimum, be able to understand a signal sent using OpenADR.
- The control must, at a minimum, be able to communicate with the virtual end node using a wired or wireless bidirectional communication pathway.

These are minimum requirements, meaning that the control can have (and use) additional communication features provided that the required features are included.

Communication With Entity That Initiates DR Signal

Reference: Section 110.12(a)1

DR controls must have the capability of communicating with the entity that initiates a DR signal by way of an OpenADR certified virtual end node (VEN).

The OpenADR is the primary open-standard protocol used in the California market. It implements a profile within the Organization of Structured Information Standards (OASIS) Energy Interoperation information and communication model that defines two types of communications entities – virtual top nodes (VTNs) and virtual end nodes (VENs). VTNs are information exchange servers typically operated by utilities or third-party providers and can dispatch events. VENs are the recipients of DR payloads and are typically the gateway or end-use devices installed at customer facilities throughout a dispatcher's territory. See OpenADR Alliance's website (http://www.openadr.org/) for more information about OpenADR certified VENs.

There are two ways to comply with the OpenADR certified VEN requirement:

Option A: Install an OpenADR 2.0a, 2.0b Certified VEN, or a Certified Baseline Profile OpenADR 3.0 VEN Within the Building as Part of the DR Control System (Section 110.12(a)1A)

If complying using Option A (Section 110.12(a)1A), the designer of the DR control system(s) must select a VEN that the OpenADR Alliance has certified as being compliant with the OpenADR 2.0a, 2.0b specification or Baseline Profile OpenADR 3.0. The OpenADR Alliance maintains a list of certified VENs (https://products.openadr.org/). If using Option A, the certified VEN must be installed inside the building at the time of inspection. The building can comply if the DR control system has a certified VEN that is incorporated into a networked system of devices such that the single VEN communicates control strategy information to multiple devices in the network (e.g., a gateway system), or if each device (e.g., thermostat) in the building is itself a certified VEN.

Option B: Install a DR Control System that has been Certified to the Energy Commission as Being Capable of Communicating with an OpenADR 2.0b Certified VEN or a Baseline Profile OpenADR 3.0-Certified VEN (Section 110.12(a)1B)

If complying using Option B (Section 110.12(a)1B), the designer of the DR control system(s) must select a DR control system that the Energy Commission has approved for the certified list of DR control systems. The Energy Commission maintains a list of certified products and instructions on how manufacturers can certify products on their website at http://www.energy.ca.gov/title24/equipment_cert/. If using Option B, the manufacturer of a DR control system must submit documentation to the Energy Commission confirming that the DR control system is capable of communicating with an OpenADR 2.0b certified VEN or a Baseline Profile OpenADR3.0 certified VEN. Demand responsive controls must be programmed or configured so any test control strategy defined in building code can be deployed at the time of permitting.

Option B requires that the manufacturer of the DR control system certify to the Energy Commission that the control system is capable of communicating with an OpenADR 2.0b certified VEN or a Baseline Profile OpenADR3.0 certified VEN. This requirement does not mean that the DR control system must be connected to a 2.0b certified VEN or a Baseline Profile OpenADR3.0 certified VEN. When the DR control system is connected to a VEN, it can be connected to either a 2.0a or 2.0b certified VEN or a Baseline Profile OpenADR3.0 certified VEN.

The DR control system must comply with Option A or Option B, but the control system can also include features that allow the control system to use other communications protocols.

When specifying DR control systems, it is recommended that the controls designer check to see which DR programs are currently available in the area and specify controls that are both compliant with Title 24, Part 6, and eligible for the area's DR programs.

Other Requirements for DR Controls

Perform Regular Functions When Not Responding to DR Events

Reference: Section 110.12(a)4

Controls that include demand response with other control functions must perform their regular control functions, as required by other parts of the building code, when the control is not performing DR-related functions. This includes when the controls are not responding to a DR event, when the DR functions are not enabled (see description of DR-enabled in the introduction to this chapter of the compliance manual) or when the DR controls are temporarily disabled or disconnected (e.g., due to a network outage).

For example, if the building owner/operator never enables the DR controls or enrolls in a DR program, the building control system(s) must comply with all other applicable controls requirements and continue to provide those control functions. Similarly, if the building owner/operator does enable the DR controls and is enrolled in a DR program, the building control system(s) must perform as required by the applicable building code requirements whenever the building is not participating in a DR event. The DR control functionality is an additional control feature on top of all of the other required building controls.

Certification Requirements for DR Thermostats

Reference: Section 110.12(a)5

Residential DR thermostats, also called Occupant Controlled Smart Thermostats (OCSTs), must comply with the technical specifications described in Joint Appendix 5 (JA5). According to the requirement in JA5, manufacturers of DR thermostats must submit documentation to the Energy Commission to certify that the thermostat meets the code requirements. See the Energy Commission's website for a list of certified products and instructions on how manufacturers can certify products on their website at http://www.energy.ca.gov/title24/equipment_cert/.

DR Controls for HVAC Systems

HVAC Systems with DDC to the Zone Level

Reference: Section 110.12(b)

As specified in Section 120.2(j), the Energy Code requires certain buildings to have direct digital control (DDC) to the zone level. (See Chapter 4 Direct Digital Controls section of the nonresidential compliance manual.) When the building has DDC to the zone level, either to comply with the Energy Code or if DDC was installed voluntarily, the HVAC system must also have a DR control system that complies with the requirements in Section 110.12(a) and (b).

At the time of inspection, the DR control system must be programmed so that it automatically initiates the test control strategy described below. The DR control system must pass this test to comply with code, regardless of what control strategy the building operator intends to use. If a building owner/operator enables the DR controls and enrolls in a DR program (see description of these terms in the introduction to this chapter), they have the option of

deploying alternate control strategies consistent with their program. The strategy described in the Energy Code is simply a test to confirm the DR control system is installed correctly and can perform the function while being suitable for leaving in place after testing.

Test Control Strategy

When the person performing the acceptance test manually simulates the condition where the HVAC control system receives a DR signal and a DR Period is beginning, the HVAC system must initiate the following response:

- When in cooling mode, increase the operating cooling temperature setpoints by 4°F or more in all noncritical zones and maintain the setpoints throughout the DR period.
- When in heating mode, decrease the operating heating temperature setpoints by 4°F or more in all noncritical zones and maintain the setpoints throughout the DR period.
- Maintain the temperature and ventilation setpoints in all critical zones throughout the DR period.

When the person performing the acceptance test manually simulates a condition where the DR period has concluded, the control system must restore the temperature setpoints in noncritical zones to the settings that were in place before the DR period began.

In addition, the controls must be able to provide an adjustable rate of temperature change when the temperature is adjusted at the beginning and the end of the DR period.

The control strategy calls for adjustments to temperature setpoints in noncritical zones while maintaining setpoints in critical zones. The Energy Code defines a critical zone as "a zone serving a process where reset of the zone temperature setpoint during a demand shed event might disrupt the process, including but not limited to computer rooms, data centers, telecom and private branch exchange (PBX) rooms, and laboratories." Noncritical zones are defined as "a zone that is not a critical zone."

(The connection between the entity that initiates the DR signal and the control system within the building is not evaluated as part of the test.)

In addition to demonstrating compliance with the test condition, the DR controls for HVAC systems with DDC to the zone level must allow an authorized facilities operator to 1) disable the DR controls, and 2) manually adjust heating and cooling setpoints from a centralized location on either the HVAC control system or the building's energy management control system.

An acceptance test is necessary to ensure that the system was programmed as required. See Nonresidential Appendix 7.5.10 and Chapter 13 of this compliance manual for more information on the acceptance test requirements.

HVAC Systems Without DDC to the Zone Level

Reference: Section 120.2(b)4

In buildings that do not have DDC to the zone level, thermostatic controls for single zone air conditioners and heat pumps must be DR thermostats, also called occupant-controlled smart thermostats (OCSTs). There are two exceptions to this requirement:

- Systems serving zones that must have constant temperatures to protect a process or product (e.g., a laser laboratory or a museum).
- The following HVAC systems:
    - Gravity gas wall heaters
    - Gravity floor heaters
    - Gravity room heaters
    - Non-central electric heaters
    - Fireplaces or decorative gas appliance
    - Wood stoves
    - Room air conditioners
    - Room heat pumps
    - Packaged terminal air conditioners
    - Packaged terminal heat pumps

When OCSTs are required, they must comply with the technical specifications described in Joint Appendix 5 (JA5). According to the requirement in JA5, manufacturers of OCSTs must submit documentation to the Energy Commission to certify that the thermostat meets the code requirements. See the Energy Commission's website for a list of certified products and for instructions to manufacturers that wish to certify products, http://www.energy.ca.gov/title24/equipment_cert/.

DR Controls for Lighting Systems

Reference: Section 110.12(c)

Nonresidential indoor lighting systems subject to Section 130.1(b) with an installed lighting power of 4,000 watts or greater must be equipped with DR controls that comply with Section 110.12(a) and (c). There are two exceptions that impact the calculation of the 4,000 watt threshold and impact where DR controls must be installed. Specifically, spaces that fall into these two categories do not need to have DR lighting controls and do not need to be included in the calculation of the 4,000 watt threshold:

1. Lighting systems not subject to Section 130.1(b)
2. Spaces where health or life safety statute, ordinance, or regulation does not permit lighting to be reduced.

At the time of inspection, the DR control system must be programmed to automatically initiate the test control strategy described below. The DR control must pass this test to comply with code regardless of what control strategy the building operator intends to use. If a building owner/operator enables the DR controls and enrolls in a DR program (see description of these terms in the introduction to this chapter), they have the option of deploying alternate control strategies consistent with their program. There is no acceptance test to verify such alternate control strategies. The strategy described in the Energy Code is simply a test for confirming the DR control system is installed correctly and can perform its function, while also being suitable for leaving in place after testing.

Test Control Strategy

When the acceptance test technician manually simulates the condition where the lighting control system receives a DR signal, the lighting system must automatically reduce lighting power so that the total installed lighting power of building or space, excluding lighting where health and safety statute, ordinance or regulation do not permit lighting to be reduced, is reduced by a minimum of 15 percent below the total installed lighting power. This means that lighting power for general lighting systems subject to Section 130.1(b) must be reduced by more than 15 percent to account for no reduction in the additional lighting systems, or a combination of reduction in the power of general lighting systems subject to Section 130.1(b) and additional lighting systems must be reduced to achieve at least a 15 percent reduction in total lighting power across these lighting systems. Lighting subject to Section 130.1(b) shall be reduced in a manner consistent with uniform level of illumination requirements in Table 5-1 in Chapter 5 of this compliance manual (Table 130.1-A of the Energy Code).

(The connection between the entity that initiates the DR signal and the control system within the building is not evaluated as part of the test.)

An acceptance test is necessary to ensure that the system is installed correctly and includes a basic, functional level of programming. See Nonresidential Appendix NA7.6.3 and Chapter 14 of this compliance manual for more information on the acceptance testing requirements.

Example 4-1 Compliance Method 1 – Using Centralized Powerline Dimming Control

This method requires the use of luminaires with dimmable ballasts or LED drivers, compatible with powerline controls, and the use of a lighting control panel downstream of the breaker panel. The lighting circuit relays are replaced by circuit controllers, which can send the dimming signal via line voltage wires. The panel could have several dry contact inputs that provide dedicated levels of load shed depending upon the DR signal received. Different channels can be assigned to have different levels of dimming as part of the demand response. Local controls can be provided by either line-voltage or low-voltage controls.

Example 4-2 Compliance Method 2 – Using Addressable Lighting System

The addressable lighting system is similar in design to that of a centralized control panel, but with additional granularity of control. With an addressable system, each fixture can be addressed individually, whereas a centralized control panel is limited to an entire channel, or circuit, being controlled in unison. The cost of enabling DR on a system with a centralized

control panel is less dependent on building size or number of rooms than an addressable zone based system.

Enabling DR for the addressable lighting system entails making a dry contact input available to receive an electronic signal. This is a feature that is included in the base model of most lighting control panels. Some smaller scale addressable lighting systems may have a limited number of inputs dedicated for alternative uses, such as a time clock. If this is the case, an I/O input device can be added to the network to provide an additional closed contact input.

Example 4-3 Compliance Method 3 – Demand Response for Select Zones

Enabling demand response for a zoned system would entail adding a network adapter to each room to be controlled for purposes of demand response. The network adapter allows for each room to be monitored and controlled by an energy management control system (EMCS). These types of systems are commonly used for HVAC systems, and to respond to demand response signals. The assumption is that if the building is installing an EMCS, the preference would be to add the lighting network to that existing demand response system. There is additional functionality that results from adding the lighting system to an EMCS. In addition to being able to control the lighting for demand response, the status of the lighting system can then be monitored by the EMCS. For example, occupancy sensors would be able to be used as triggers for the HVAC system, turning A/C on and off when people entered and leave the room. Therefore, the potential for savings from this type of system is higher than the value of the lighting load shed for demand response.

DR Controls for Electronic Message Centers

Reference: Section 110.12(d)

An electronic message center (EMC) is a pixilated image producing electronically controlled sign formed by any light source. EMCs that have a lighting load greater than 15 kW must have demand responsive controls unless a health or life safety statute, ordinance, or regulation does not permit EMC lighting to be reduced. The DR controls must meet the requirements in Section 110.12(a) and be capable of reducing the lighting power by a minimum of 30 percent during a DR period.

DR Controls for Controlled Receptacles

Reference: Section 110.12(e)

Controlled receptacles are required by Section 130.5(d) in nonresidential buildings and hotel/motel buildings. Spaces required to have controlled receptacles include office areas, lobbies, conference rooms, kitchen areas in office spaces, copy rooms.

If DR lighting controls are required in the building or space per Section 130.1(e), DR controls are also required for controlled receptacles. The DR control must be capable of automatically turning off all loads connected to the receptacle in response to a demand response signal.

DR Controls for Power Distribution Systems

Reference: Section 130.5(e)

If DR controls are installed as part of the power distribution system (e.g., circuit-level controls), the controls must meet the requirements in Section 110.12(a).

DR controls for HVAC, lighting, or sign lighting equipment may be installed at the circuit level; in this case, the DR controls must meet the complete requirements for that application.

Energy Management Control Systems and Home Automation Systems

Required thermostatic and lighting control functions (including DR control functions) can be incorporated into and performed by an energy management control system (EMCS). Using an EMCS to perform these control functions complies with Title 24, provided that all of the criteria that would apply to the control are met by the EMCS.

A home automation system that manages energy loads (such as HVAC and lighting systems) is considered a type of energy management control system and, as such, can similarly incorporate the ability to provide required control functions.