Appendix D - Demand Responsive Controls

This appendix to the nonresidential compliance manual addresses the demand responsive (DR) control requirements in the 2019 Building Energy Efficiency Standards (Energy Standards).

Demand response is becoming increasingly important as it permits the temporary reduction of electric load on the grid when extreme weather or supply constraints cause electricity demand to come close to the grid’s maximum supply capabilities. It is also seen as a means to allow building operators to control electricity costs, as future prices are expected to change constantly as a function of overall system demand.

The following definitions from §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:

a. Changes in the price of electricity; or
b. Participation in programs or services designed to modify electricity use.
   i. In response to wholesale market prices.
   ii. 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 ready (i.e., capable of responding to a DR signal). The decision to employ demand response is up to the building owner or manager, the utility company, and/or a governing authority. A building that is capable of responding to a request to reduce load when grid reliability is threatened (for instance with black outs) is sufficient to meet the requirements of the Energy Standards. Building that comply with the DR controls requirements in the Energy Standards are capable of participating in DR events, but the building owner/occupant needs to take additional steps to enable the DR controls and enroll in a DR program. These three terms are 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 programmed/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**: A building’s DR 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).

Table D-1 summarizes when DR controls are required in nonresidential buildings.

The requirements for DR controls only apply if the controls are used to comply with the building standards (i.e., DR Thermostats or a heat pump water heater). If DR control 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.
Table D-1: Summary of DR Control Requirements for Newly Constructed Nonresidential Buildings

<table>
<thead>
<tr>
<th>Application</th>
<th>Required DR Controls</th>
<th>Response Tested for Title 24 Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVAC</td>
<td>Must have DR Controls that are compliant with Sections 110.12(a) and (b)</td>
<td>• During DR Period, in non-critical zones:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>○ When cooling, increase the operating cooling temperature 4°F or more</td>
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<tr>
<td></td>
<td></td>
<td>○ When heating, decrease the operating heating temperature 4°F or more</td>
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<td></td>
<td></td>
<td>• Upon conclusion of the DR Period, reset the temperature set points to their original settings.</td>
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<tr>
<td></td>
<td></td>
<td>• Provide an adjustable rate of change for the temperature.</td>
</tr>
<tr>
<td>HVAC</td>
<td>Must have thermostatic controls that are compliant with Joint Appendix 5.</td>
<td></td>
</tr>
<tr>
<td>HVAC</td>
<td>Defined in Joint Appendix 5.</td>
<td></td>
</tr>
<tr>
<td>Lighting</td>
<td>Must have DR controls that are compliant with Sections 110.12(a) and (c)</td>
<td>Reduce lighting power by a minimum of 15 percent below the design full output level for the duration of the Demand Response Period.</td>
</tr>
<tr>
<td>Lighting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lighting</td>
<td>Electronic Message Centers (EMCs) having a new connected lighting power load greater than 15 kW</td>
<td>Reduce lighting power by a minimum of 30 percent for the duration of the Demand Response Period.</td>
</tr>
<tr>
<td>Sign Lighting</td>
<td>Must have DR controls that are compliant with Sections 110.12(a) and (d)</td>
<td></td>
</tr>
<tr>
<td>Electrical Power System</td>
<td>Must have DR controls that are compliant with Sections 110.12(a)</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

1. Systems serving exempt process loads that must have constant temperatures to prevent degradation of materials, a process, plants, or animals are exempt.
2. Package terminal air conditioners, package terminal heat pumps, room air conditioners, and room air-conditioner heat pumps are except.
3. Spaces with a lighting power density of 0.5 watts per square foot or less and in spaces in which lighting power or illuminance is not permitted to be reduced in accordance with health or life safety statues, ordinances, or regulations: 1) are not required to be capable of automatically reducing lighting power when a DR Signal is received; and 2) shall not be included in calculations of the design full output level or the reduced lighting power level.
4. Lighting for EMCs where lighting power or illuminance is not permitted to be reduced by 30 percent in accordance with a health or life safety statute, ordinance, or regulation is exempt.
5. Circuit-level controls installed to control HVAC, lighting, or sign lighting equipment must comply with the requirements for that application.
1. Communications Requirements for DR Controls

§110.12(a)1-3

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

1. The control must, at minimum, be able to understand a signal sent using OpenADR; and
2. The control must, at a minimum, be able to receive signals over one of the specified paths.

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

1.1 Communication with Entity that Initiates DR Signal

§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 Alliance, the primary open-standard protocol used in the California market, utilizes an OASIS Energy Interoperation taxonomy 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.¹

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

**Option A: Install an OpenADR 2.0a or 2.0b certified VEN within the building as part of the DR control system (§110.12(a)1A)**

If complying using Option A (§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 or 2.0b specification.² 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 to 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 (§110.12(a)1B)**

If complying using Option B (§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: http://www.energy.ca.gov/title24/equipment_cert/. If using Option B, the manufacturer of a

¹ The OpenADR Alliance’s Frequently Asked Questions webpage is a helpful resource: http://www.openadr.org/faq.
² The OpenADR 2.0a and 2.0b specifications are available on the OpenADR Alliance’s website: http://www.openadr.org/specification.
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.

As discussed in Section 1.3 below, 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. It should also be noted that if using Option B, the DR control system is capable of communicating with an OpenADR 2.0b certified VEN, but that does not mean that DR programs have to used OpenADR 2.0b in their programs.

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.

### 1.2 Communication Pathways

§110.12(a)2

DR controls must be capable of using one or more of the following to communicate (i.e., send and receive signals):

- Wi-Fi: for more information see the Wi-Fi Alliance website: [https://www.wi-fi.org/](https://www.wi-fi.org/).
- ZigBee: for more information see the ZigBee Alliance website: [http://www.zigbee.org/](http://www.zigbee.org/).
- Ethernet; or
- Hard-wiring.

As described in Section 1.3 below, DR control systems can also support additional communication protocols.

### 1.3 Additional Communication

§110.12(a)3

Section 110.12(a)3 explicitly states that DR controls are allowed to use communications protocols in addition to the ones required above. This means that the control can communicate with entities that initiate DR signals using different protocols, including but not limited to proprietary protocols and other non-proprietary protocols like the American National Standards Association / Consumer Technology Association Standard for Modular Communications Interface for Energy Management (ANSI/CTA-2035-A), provided that it complies with one of the options for OpenADR compatibility. Similarly, the DR control system is allowed to use other physical means of communication provided at least one of the specified methods is supported.

The DR control may use any of its available communication features to participate in DR programs.

### 2. Other Requirements for DR Controls

#### 2.1 Perform Regular Functions When Not Responding to DR Events

§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.

### 2.2 Certification Requirements for DR Thermostats

§110.12(a)5

DR thermostats 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 for instructions to manufacturers that wish to certify products: [http://www.energy.ca.gov/title24/equipment_cert/](http://www.energy.ca.gov/title24/equipment_cert/).

### 3. DR Controls for HVAC Systems

#### 3.1 HVAC Systems with DDC to the Zone Level

§110.12(b)

As specified in §120.2(j), the Energy Standards require certain buildings to have Direct Digital Control (DDC) to the zone level (See Chapter 4 Section 4.5.1.9 of the nonresidential compliance manual). When the building has DDC to the zone level, either to comply with the Energy Standards or if DDC was installed voluntarily, the HVAC system must also have a DR control system that complies with the requirements in §110.12(a) and (b).

At the time of inspection, the DR control system must be programmed so it automatically initiates the test control strategy described below. Note that 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 Standards is simply a basic, generic strategy that is useful 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 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:

1. Increase the operating cooling temperature set points by 4°F or more in all non-critical zones and maintain the set points throughout the DR Period.
2. Decrease the operating heating temperature set points by 4°F or more in all non-critical zones and maintain the set points throughout the DR Period.
3. Maintain the temperature and ventilation set points 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 set points in non-critical 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 revisions adjustments to temperature setpoints in non-critical zones while maintaining setpoints in critical zones. The Energy Standards define 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." Non-critical zones are defined as "a zone that is not a critical zone."

(Note that 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.

3.2 HVAC Systems without DDC to the Zone Level

§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:

1. Systems serving zones that must have constant temperatures to protect a process or product (e.g., a laser laboratory or a museum).

2. The following HVAC systems:
   a. Gravity gas wall heaters
   b. Gravity floor heaters
   c. Gravity room heaters
   d. Non-central electric heaters
   e. Fireplaces or decorative gas appliance
   f. Wood stoves
   g. Room air conditioners
   h. Room heat pumps
   i. Packaged terminal air conditioners
   j. Packaged terminal heat pumps

When OCSTs are required, they must comply with the technical specifications described in Joint Appendix 5 (JA5). According 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/.
4. DR Controls for Lighting Systems

§110.12(c)

Buildings larger than 10,000 square feet (ft²) must be equipped with DR controls for indoor lighting systems that comply with §110.12(a) and (c). There are two exceptions that impact the calculation of the 10,000 ft² threshold and impact where DR controls can 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 10,000 ft² threshold:

1. Spaces with a lighting power density of 0.5W/ft² or less; and
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. Note that 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 Standards is simply a basic, generic strategy that is useful 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 tester manually simulates the condition where the lighting control system receives a DR signal, the lighting system must automatically reduce lighting power so that the lighting power of the non-excluded spaces is reduced by a minimum of 15 percent below the total installed lighting power. Lighting 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 Standards).

(Note that 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 7.6.3 and Chapter 13 of this compliance manual for more information on the acceptance test 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.

5. **DR Controls for Electronic Message Centers**

§110.12(d)

Electronic Message Centers (EMCs) that have a lighting load greater than 15kW 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 §110.12(a) (as explained in Section 1 above) and be capable of reducing the lighting power by a minimum of 30 percent during a DR Period.

6. **DR Controls for Power Distribution Systems**

§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 §110.12(a) (as explained in Section 1 above).

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.


Required thermostatic and lighting control functions (including DR control functions) can be incorporated into and performed by an Energy Management Control System. 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.

While the term “Home Automation System” is not used within the Standards, a Home Automation Systems 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.