

# New Section 135

## Requirements for Electrical Distribution Systems

*2013 California Building Energy Efficiency Standards*

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## OVERVIEW

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<b>Description</b>	The proposed measure is to require provisions in a building's electrical distribution system that will ensure relatively easy implementation of advanced metering and control, including demand response and the "smart grid"
<b>Type of Change</b>	<p>Mandatory Measure</p> <p>This change would add mandatory measures.</p> <p>(a) Requires the addition of modest total energy readouts to the metering of services. The requirements are progressive, with simple metering provisions up to 250kVA services and some logging capabilities for larger services. Most of these are already provided by utility meters and will easily be part of a smart meter.</p> <p>(b) Requires disaggregating the load types in an electrical system such that major load types can be easily measured at a single point. The actual measuring equipment is not required.</p> <p>(c) Requires feeders to have no greater than 2% voltage drop, and branch circuits to have not more than 3% voltage drop, as recommended by the California Electrical Code 2010.</p> <p>(d) Requires providing automatic shut off of about ½ of all receptacles in offices and related spaces to save energy.</p> <p>(e) Requires all buildings to be enabled to receive and act upon demand response signals.</p> <p>(f) Permits building automation systems to provide required control functions of several sections.</p> <p>This change would slightly increase the scope or direction of the current Standards. This change would not require implementation of systems or equipment that are not already readily available on the market and for use in the proposed applications. These systems are already regulated and included in the current Standards.</p> <p>The Standards and Manuals would be modified in order to include the new requirements. The change would require a new Section 135.</p>

<b>Energy Benefits</b>	<p>Parts (a), (b), (e) and (f) of this measure are not directly energy saving.</p> <p>Part (c) of the measure saves energy by ensuring that electrical feeders and circuit wiring are designed to minimize voltage drop. Voltage drop is wasted energy.</p> <p>Part (d) of the measure saves energy by shutting off receptacle circuits when a space is unoccupied.</p>
<b>Non-Energy Benefits</b>	<p>Parts (a), (b), (e) and (f) of this measure require basic construction that will enable the addition of control and measurement technologies as the their cost effectiveness improves and as the need for control and measurement becomes important due to demand response, time of use rates and other functions of the future “smart grid”.</p>
<b>Environmental Impact</b>	<p>There are no significant environmental impacts other than energy savings.</p>

<p><b>Technology Measures</b></p>	<p><b>Measure Availability and Cost:</b></p> <p>(a) Should not result in any measurable cost impact. The cost will be borne by the utility companies, and the new meters being installed will meet these requirements at no additional cost to the owner.</p> <p>(b) Should not result in any measurable cost impact. The code requirement would dictate specific wiring choices that are already made on a day-to-day basis.</p> <p>(c) Should not result in any measurable cost impact. Per Articles 210 and 215 of the California Electrical Code, these values are recommended and responsible engineers observe them. With inflation and escalating costs, this code requirement will prevent cost cutting that causes unacceptable amounts of wasted energy.</p> <p>(d) Will result in additional cost. Using conventional, off-the-shelf technology, it will add about 50 cents per square foot to electrical construction costs.</p> <p>(e) Will add a very small amount of cost to projects. It will save considerable cost later when the full brunt of DR and the smart grid becomes reality.</p> <p>(f) Should not result in any measurable cost impact. Its purpose is to overtly state that many of the controls requirements of Section 131 and other sections can be met with an energy management system (EMS) and for which basic requirements are added by this measure.</p> <p><b>Useful Life, Persistence and Maintenance:</b></p> <p>The proposed provisions of new Section 135 are obvious next steps needed to lay the foundation for energy flow and measurement. All of the parts and work required are conventional electrical construction with long life and predictable performance.</p>
<p><b>Performance Verification</b></p>	<p>The proposed update would require some additional commissioning during initial installation of the system by an electrician. Commissioning of this technology is already standard practice and is well understood by contractors.</p>
<p><b>Cost Effectiveness</b></p>	<p>Since most of the provisions of this measure have no significant cost impact and no direct energy savings, cost effectiveness is moot. The cost effectiveness of plug load controls cannot be exactly determined due to lack of data, but examples show considerable cost effectiveness in many applications.</p>

<b>Analysis Tools</b>	No further analysis has been performed.
<b>Relationship to Other Measures</b>	The principal relationship of this measure to other measures is that plug load control can easily be tied to automatic lighting shutoff, in essence making one control signal affect two circuits.

## 1. METHODOLOGY

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This section summarizes how this CASE report was developed.

### 1.1 Basic Concepts

Since its origin, Title 24 Part 6 has avoided topics related to electrical systems and loads that were not directly tied to the structure and building envelope. However, in its pilot study<sup>1</sup>, the Office of the Future project determined plug load exceeded lighting load in California office buildings. Moreover, the study called attention to the ability to easily disaggregate lighting power from plug load and other building energy uses if properly planned. It was decided that a relatively simple section could require electrical wiring that produces logical points for measurement of energy use.

### 1.2 Structure

This measure has following separate groups of proposed standards.

1. Standards related to the metering/measurement of electrical systems. These were determined to be mostly logical separations of loads by design. Progressive requirements relaxed the burden on smaller projects.
2. Standards related to controlling plug loads in offices and related spaces. In essence, an additional relay control from local lighting on/off control could be inexpensively adopted for about ½ of the receptacles in commercial buildings.
3. Standards related to designing electrical systems. Voltage drop in electrical systems is energy waste and meeting the California Electrical Code recommendations.
4. Standards related to demand response and building automation. These steps were added with the widest possible range of acceptance, in order to encourage implementation.

### 1.3 Other Standards

The metering provisions were interpreted from ASHRAE/IES 189.1. The voltage drop calculations were taken directly from the California Electrical Code sections 210 and 215 and are consistent with existing requirements in IECC 2009 and 90.1-2010. The demand response language was developed from evolving standards of California's IOUs.

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<sup>1</sup> Southern California Edison, oPod (The Office of the Future Phase 1) Report, Doug Avery et al, April 2007

## 1.4 Cost-Effectiveness

As stated above, most of this measure is to make smart provisions in buildings for the future “smart grid” including DR and has little or no cost impact to a building. Cost effectiveness was at least partly demonstrated in other CASE reports<sup>2</sup> and is not repeated here.

We take the position that no cost is involved with requirements to designing electrical systems to meet voltage drop recommendations of the California Electrical Code as it is already considered good practice. Plug load control adds cost. Cost effectiveness was demonstrated in another CASE report<sup>3</sup>. In addition, limited data<sup>4</sup> can be used to further justify cost effectiveness, using a practical model that demonstrates cost effectiveness well. It is presented in part 2.

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<sup>2</sup> [http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/2011-04-27\\_workshop/review/AutoDR\\_for\\_HVAC\\_template.pdf](http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/2011-04-27_workshop/review/AutoDR_for_HVAC_template.pdf) and [http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/2011-04-04\\_workshop/review/Nonres\\_DR\\_lighting.pdf](http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/2011-04-04_workshop/review/Nonres_DR_lighting.pdf)

<sup>3</sup> [http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/2011-04-04\\_workshop/review/Office\\_Task\\_Lighting\\_Plug\\_Load\\_Circuit\\_Control.pdf](http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/2011-04-04_workshop/review/Office_Task_Lighting_Plug_Load_Circuit_Control.pdf)

<sup>4</sup> Southern California Edison, Office of the Future Phase II Report, New Buildings Institute, January 12 2008

## 2. ANALYSIS AND RESULTS

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### 2.1 Another Look at Receptacle Switching

This proposal requires approximately ½ of all receptacles to be automatically switched off in a manner similar to the current automatic shutoff requirements for lighting. The intent is to reduce energy waste by disabling power to receptacles that serve loads that only require energizing when the space is occupied. A CASE report by HMG demonstrates cost effectiveness<sup>5</sup>. This report re-examines this proposal on a practical level.

In the Office of the Future phase 1 field study<sup>6</sup>, the single largest type of connected load by power density was portable space heaters. The second largest load type was computers and related peripherals, followed by lighting. Over 75% of the load in these three groups was connected to receptacles. (This study avoided unusual and uncommon loads such as server rooms.) Moreover, the balance of the common office plug loads, such as kitchen appliances, office appliances, water coolers, personal electronics, etc. are all served from receptacles as well.

It is understood that a number of devices must have constant power. For instance, a computer screen could be turned off when a worker is not present, but shutting off power to the computer could cause a loss of data. (The IT industry has been improving the energy efficiency of equipment for many years including the ability for computers to sleep without data loss). A refrigerator requires constant power as well to preserve food. But the vast majority other loads could tolerate either a temporary power loss such as might be caused by DR, or an occupancy responsive shut off. A good example is the portable space heater.

### 2.2 Cost Analysis

The primary way this measure will be implemented will be in conjunction with a lighting motion sensor. In commercial applications, lighting sensors are either ceiling mounted to “look down” onto the area being controlled, or wall mounted to “look out” into the space being controlled. Line voltage sensors contain the switching circuitry within and are the least expensive type. Low voltage sensors have separate detection heads and remote power packs (transformer relays) that switch the power. In smaller buildings, the lighting is operated at 120 volts, and the sensor could switch both lighting and receptacles with essentially no added cost other than wiring from the sensor. In larger buildings with 277 volt lighting, an auxiliary relay must be added to switch the 120 volts. Power packs cost about \$25.00<sup>7</sup> and auxiliary relays about \$20

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<sup>5</sup> Op. cit.

<sup>6</sup> oPod Phase I report, op. cit.

<sup>7</sup> [www.shop.montereycorp.com](http://www.shop.montereycorp.com), an Internet retail store, for a Sensor switch single circuit 120/277 volt 20A power pack

each. In general, installed cost will be about twice this, so we assume the added relay is about \$50 for each space.

## 2.3 Energy Savings Analysis

Mentioned above, there is no reliable data to predict the amount and type of load on building circuits for testing the cost effectiveness of this measure. Instead, we have constructed a model based on the Office of the Future Phase 1 findings and typical wiring practices, as follows:

- Portable space heaters, 1.25 w/sf, 33% duty cycle<sup>8</sup>, energy use 3.7 kWh/sf/yr
- Personal computer peripherals, 1.0 w/sf, 10% duty cycle, 0.9 kWh/sf/yr
- Miscellaneous personal loads, 0.1 w/sf, 100% duty cycle, 0.9 kWh/sf/yr

TOTAL PRE-CONTROL ANNUAL ENERGY USE: 5.5 kWh/sf/yr

The simplicity of this analysis does not warrant a complete economic analysis, and data does not exist to support it. Instead the following foreshortened analysis is offered.

Average Energy Use	5.5 kWh/sf/yr
Average Control Zone	150 SF
Average Electric Rate	\$.126/kWh <sup>9</sup>
Energy Use and Cost Per Zone	825 kWh, \$103.95

Because the database is very small and there is not really a robust database for predicting energy use, we can easily estimate that the average occupancy will be about 25% of the year (42 hours per week) or less. Thus, if this measure were to save 75% of the energy presently used by these loads, the payback period would be about 9 months. Conversely, even if the estimates are significantly wrong and the measure saved only 82.5 kWh/yr (0.084 w/sf turned off 75% of the time), the payback period would be less than 5 years, well within the statutory requirements.

One of the two exemptions permits motion sensor plug strips under certain conditions. The wholesale cost of a Wattstopper Isole control station is about \$65<sup>10</sup>, which requires no installation labor cost, making it fairly consistent with this analysis.

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<sup>8</sup> The estimated “on” time of the load due to use and/or temperature controls. The “off” power is assumed negligible.

<sup>9</sup> [www.eia.gov](http://www.eia.gov)

## 2.4 Metering Provisions

These requirements are represented as having no significant cost impact. That is because the break points in the standards were determined on the basis of panelboard sizes feeding branch circuits. For example, the first major break point in the requirements is 25kVA for receptacles (plug loads). This was chosen because 25kVA of load corresponds roughly to the fully loaded capacity of a 100-amp panelboard, a practical standard size that would typically be used to serve an area of 10,000 sf designed for up to 2.5 w/sf. The metering point is the feeder to that panelboard, which with minimal provisions could easily be equipped in the future.

Smaller systems, such as for a tenant retail store, are often served 120/208v three-phase service or 120/240v single-phase service. Even with an air conditioning system on the meter, the service size is likely to be about 10 VA/sf. At this load, a space of up to 5,000 sf could be served and only have the lowest level of requirements. Office occupancies without server farms or other excessive loads are more likely to have a service of about 5 to 6 VA/sf, corresponding to a space of 10,000 sf. In the event that separate 277-volt lighting and 120-volt plug load circuits are used and a central HVAC system is separately fed, the practical area for separately metered tenants could be as large as 12,000 to 15,000 sf with the lowest level of requirements. This is about as large an area as would be served from a single panel due to voltage drop and other practical limits.

The next break point for services is 50kVA, corresponding to about 150 amps at 120/208 volts three phase and 200 amps at 120/240 volts single phase. This will require separate subpanels for lighting and receptacles as well as separate feeders for HVAC and bigger loads. For a 20,000 sf grocery store, for example, the service size might be 100 kVA, and it would have connected lighting loads of about 30,000 watts, plug and miscellaneous loads of about 10,000 watts, HVAC loads of about 30,000 watts, and refrigeration and equipment loads of about 30,000 watts. Each group (except plug loads) would be at least 100 amps at 120/208 or 120/240 volts. These are practical sizes for panels and feeders.

Larger buildings naturally break riser systems down into 100 or 200 amp groups. This provision requires a specific organization and in some cases may add some cost, but it will be negligible.

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<sup>10</sup> Actual cost of components, Office of the Future project at LA Federal Building, spring 2011.

### 3. PROPOSED CODE LANGUAGE CHANGE

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This section describes the specific recommended language.

#### 3.1 Summary of Proposed Changes

We propose six specific sections.

(a) Require the addition of modest total energy readouts to the metering of services. The requirements are progressive, with simple metering provisions up to 250kVA services and some logging capabilities for larger services. Most of these are already provided by utility meters and will easily be part of a smart meter.

*This will allow building owners and managers to easily make simple readings of how much energy they are using. For larger systems, it will allow electric energy use to be monitored on an hourly, daily, or monthly basis.*

(b) Require disaggregating the load types in an electrical system such that major load types can be easily measured at a single point. The actual measuring equipment is not required.

*This will allow future metering of systems to be installed at the lowest possible cost and with the most ease.*

(c) Require feeders to have no greater than 2% voltage drop, and branch circuits to have not more than 3% voltage drop, as recommended by the California Electrical Code 2010.

*While this is considered to be good practice and currently occurs in most buildings, this code requirement will ensure that future projects are not made less efficient due to cost cutting in electrical distribution.*

(d) Require providing automatic shut off of some receptacles to save energy.

*The low cost of motion sensing devices makes this a relatively inexpensive and easy measure. Whether sharing a sensor with lighting using a separate auxiliary relay, or providing a motion sensor for the area's receptacles alone, this measure should not add more than about 50 cents per square foot to the cost of an office building or similar uses, and less to schools, retail and other uses with less plug load and plug use.*

(e) Requires all buildings to be enabled to receive and act upon demand response signals.

*This prepares buildings for communications to the "smart grid". The cost is very small, but it ensures that the thought was put into the design of the building such that future outfitting of a communication system and its implementation will be low cost and easy to do.*

(f) Permits building automation systems to provide required control functions of several sections.

*This clarifies that a building-automation system with certain minimum features may be used to achieve the required control of lighting and other building systems. It is added to encourage designers and owners to investigate systems that will permit higher levels of control and interoperability in anticipation of demand response, time of use pricing and the “smart grid”.*

## 3.2 Proposed Language

### SECTION 135 –ELECTRICAL POWER DISTRIBUTION SYSTEMS

- (a) **Service Metering** Each electrical service shall have permanently installed user-accessible metering of total electrical energy use per Table 135-A.

**EXCEPTION to Section 135 (a)** Buildings for which the utility company provides a meter for occupant or user use that indicates instantaneous kW demand and kWh for a user-resettable period.

- (b) **Disaggregation of Electrical Circuits.** Electrical power distribution systems shall be designed to permit the disaggregated measurement of electrical load energy uses downstream from the service meter according to Table 135-B. Additive and subtractive methods may be used to determine aggregate and disaggregated energy use. This may be accomplished by any of the following methods:

1. Separate switchboards, motor control centers, or panelboards to which are connected only the required load or group of loads; or,
2. Subpanels of the above to which are connected only the required load or group of loads and for which the subpanel load can be independently measured in aggregate; or
3. Branch circuits, taps or disconnects requiring overcurrent protection devices rated 60 amperes or greater.

**EXCEPTION to Section 135 (b)** Buildings for which a complete metering and measurement system is provided.

(c) **Voltage Drop**

1. **Feeders.** Feeder conductors shall be sized for a maximum voltage drop of two percent at design load.
2. **Branch Circuits.** Branch circuit conductors shall be sized for a maximum voltage drop of three percent at design load.

**EXCEPTION to Section 135(c):** Feeder conductors and branch circuits that are dedicated to emergency services.

- (d) **Circuit Controls for 120-Volt Receptacles.** In all buildings, both controlled and uncontrolled 120 volt receptacles shall be provide in each private office, open office area, reception lobby, conference room, kitchen, and copy room, to automatically shut off task lighting and other plug loads when the area is not occupied. Controlled receptacles shall meet the following requirements:

1. Electric circuits serving controlled receptacles shall be equipped with automatic shut-off controls complying with the requirements in section 131(c); and
2. At least one controlled receptacle shall be installed within 6 feet from each uncontrolled receptacle or a split-wired duplex receptacle with one controlled and one uncontrolled receptacle shall be installed; and
3. Controlled receptacles shall have a permanent marking to differentiate them from uncontrolled receptacles, and
4. For open office areas, controlled circuits shall be provided and marked to support installation and configuration of office furniture with receptacles that comply with section 131(a) 1, 2, and 3; and
5. Plug-in strips and other plug-in devices that incorporate an occupancy sensor shall not be used to comply with this requirement.

**EXCEPTION 1 to Section 135 (d):** In open office areas controlled circuit receptacles are not required, if at time of permit workstations are installed, and each workstation is equipped with a local motion sensor that controls a power strip that is permanently marked to differentiate controlled from uncontrolled receptacles.

**EXCEPTION 2 to Section 135 (d):** Receptacles which are only for the following specific purposes: refrigerators, water dispensers, kitchen appliances, clocks, network copiers, fax machines, A/V and data equipment other than personal computers, and receptacles on circuits rated more than 20 amperes are exempt from this sections.

- (e) **Demand Response Signals.** Demand response signals shall conform to a nationally recognized open communication standard. Acceptable standards include those defined by groups such as the Organization for the Advancement of Structured Information Standards (OASIS), Energy Interoperation Technical Committee (also known as Energy InterOp and OpenADR) or the ZigBee Alliance (also known as Smart Energy profile).
- (f) **Energy Management Control System (EMCS).**
1. An EMCS which at a minimum provides the functionality of a specific lighting control device or system covered in Section 119; meets the acceptance test requirements in Section 134 for that lighting control device or system, meets the specific application requirements for that lighting control device or system in Title 24, Part 6, may be installed as that lighting control device or system for compliance with Title 24, Part 6.
  2. An EMCS which at a minimum provides the functionality of a thermostat, including two-stage, electronic, and setback thermostats covered in Sections 144 and 149; meets the acceptance test requirements in Section 134 for that thermostat, meets the specific application requirements for that thermostat in Title 24, Part 6, may be installed as that thermostat for compliance with Title 24, Part 6.

**TABLE 135-A MINIMUM REQUIREMENTS FOR METERING OF ELECTRICAL LOAD**

Meter Type	Services rated 50 kVA or less	Services rated more than 50kVA and less than 250 kVA	Services rated more than 250 kVA and less than 1000kVA	Services rated more than 1000kVA
Instantaneous (at the time) kW demand	Required	Required	Required	Required
Historical peak demand (kW)	Not required	Not required	Required	Required
Resettable kWh	Required	Required	Required	Required
kWh per rate period	Not required	Not required	Not required	Required

**TABLE 135-B MINIMUM REQUIREMENTS FOR SEPARATION OF ELECTRICAL LOAD**

<b>Load Type</b>	<b>Services rated 50 kVA or less</b>	<b>Services rated more than 50kVA and less than 250 kVA</b>	<b>Services rated more than 250 kVA and less than 1000kVA</b>	<b>Services rated more than 1000kVA</b>
Lighting including exit and egress lighting and exterior lighting	Not required	All lighting in aggregate	All lighting disaggregated by floor, type or area	All lighting disaggregated by floor, type or area
HVAC systems and components including chillers, fans, heaters, furnaces, package units, cooling towers, and circulation pumps associated with HVAC	Not required	All HVAC in aggregate	All HVAC in aggregate and each HVAC load rated at least 50 kVA	All HVAC in aggregate and each HVAC load rated at least 50kVA
Domestic and service water system pumps and related systems and components	Not required	All loads in aggregate	All loads in aggregate	All loads in aggregate
Plug load including appliances rated less than 25 kVA	Not required	All plug load in aggregate  Groups of plug loads exceeding 25 kVA connected load in an area less than 5000 sf	All plug load separated by floor, type or area  Groups of plug loads exceeding 25 kVA connected load in an area less than 5000 sf	All plug load separated by floor, type or area  All groups of plug loads exceeding 25 kVA connected load in an area less than 5000 sf
Elevators, escalators, moving walks, and transit systems	Not required	All loads in aggregate	All loads in aggregate	All loads in aggregate
Other individual non-HVAC loads or appliances rated 25kVA	Not required	All	Each	Each

or greater

Industrial and commercial load centers 25 kVA or greater including theatrical lighting installations and commercial kitchens	Not required	All	Each	Each
Renewable power source (net or total)	Each group	Each group	Each group	Each group
Loads associated with renewable power source	Not required	All loads in aggregate	All loads in aggregate	All loads in aggregate
Charging stations for electric vehicles	All loads in aggregate			

## 4. MATERIAL FOR COMPLIANCE MANUALS

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We will develop material for the compliance manuals in the final CASE report once the proposed code language has been approved by the Commission.

In this section, we will provide information that will be needed to develop the Residential and/or Nonresidential Compliance Manuals, including:

- Possible new compliance forms or changes to existing compliance forms.
- Examples of how the proposed Standards change applies to both common and outlying situations. Use the question and answer format used in the current Residential and Nonresidential Compliance Manuals.
- Any explanatory text that should be included in the Manual.
- Any data tables needed to implement the measure.

## 5. BIBLIOGRAPHY AND OTHER RESEARCH

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ASHRAE/IES 90.1-2010, Chapter 10

IECC 2009, Chapter 5

ASHRAE/IES 189.1, Chapter 7

California Electrical Code 2010, Sections 210 and 215