California Title 24 – Building Energy Efficiency Standards

A Regulatory Approach to Deploying Distributed Energy Resources

Recent California regulations mandate the installation of solar panels and battery storage in many new non-residential buildings as well as hotels and motels. The following sections summarize the requirements along with their potential benefits and challenges.

Background Information

Increasing the sustainability of energy-consuming activities requires reducing emissions to the atmosphere. Reducing energy consumption is one way to do so. Deploying zero-carbon energy sources is another. California’s 2022 Building Energy Efficiency Standards – Title 24 has adopted provisions that promote zero-carbon energy sources. California’s goal is to use 100% carbon-free electricity by 2045.

The current edition of the regulations now offers two compliance options. The first allows the use of prescriptive requirements that are already known to produce efficient energy use. The second is a performance-based option that allows greater design freedoms, provided the results meet or exceed the building efficiency metrics used in the prescriptive model. The following sections summarize the prescriptive provisions of the code.

Relevant Provisions

The 2022 edition of the code requires photovoltaic panels and storage batteries for most new commercial structures and some residential applications. Here is a summary of the key requirements for solar panels and battery storage.

Requirements for Solar Panels

With certain exceptions, Section 140.10(a) of the code requires:

- That all new buildings of the types identified in the standard …
- Use a photovoltaic system that meets specific requirements …
- With a minimum output equaling the smaller of either a provided equation or the usable roof area multiplied by 14 Watts per square foot.
Here is what the code says:

*All newly constructed building types specified in Table 140.10-A ... shall have a newly installed photovoltaic (PV) system ... The PV size in kWdc shall be not less than the smaller of the PV system size determined by Equation 140.10-A, or the total of all available Solar Access Roof Areas multiplied by 14 W/ft².*

The referenced equation is:

\[
kW_{P_{dc}} = \frac{(CFA \times A)}{1000}
\]

Where:

- \(kW_{P_{dc}}\) = Size of the Photovoltaic System in kilowatts
- \(CFA\) = Conditioned floor area in square feet
- \(A\) = Photovoltaic capacity factor in Watts per square foot

The photovoltaic capacity factor (A) is derived from the following table of building types, with specific values for California’s 15 climate zones:

<table>
<thead>
<tr>
<th>Table 140.10-A - PV Capacity Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate Zone</td>
</tr>
<tr>
<td>Grocery</td>
</tr>
<tr>
<td>High-Rise Multifamily</td>
</tr>
<tr>
<td>Office, Financial Institutions, Unleased Tenant Space</td>
</tr>
<tr>
<td>Retail</td>
</tr>
<tr>
<td>School</td>
</tr>
<tr>
<td>Warehouse</td>
</tr>
<tr>
<td>Auditorium, Convention Center, Hotel/Motel, Library, Medical Office Building/Clinic, Restaurant, Theater</td>
</tr>
</tbody>
</table>

Using the equation and table information to calculate the minimum amount of solar power for a 20,000-square-foot office building in Climate Zone 6 produces the following value:

\[
kW_{P_{dc}} = \frac{(CFA \times A)}{1000}
\]

\[
kW_{P_{dc}} = \frac{(20,000 \text{ ft}^2 \times 3.13 \text{ Watts/ft}^2)}{1000} = 62.6 \text{ kilowatts}
\]

To comply with the Title 24 requirements, our hypothetical building would require a solar panel system with a minimum output of more than 62 kilowatts. For comparison, a warehouse of that size in the same location would require ~9 kilowatts:

\[
kW_{P_{dc}} = \frac{(20,000 \text{ ft}^2 \times 0.44 \text{ Watts/ft}^2)}{1000} = 8.8 \text{ kilowatts}
\]

**Requirements for Battery Storage Systems**

Section 140.10(b) of the code requires that most new buildings with photovoltaic systems install a battery storage system:
All buildings that are required by Section 140.10(a) to have a PV system shall also have a  battery storage system ... The rated energy capacity and the rated power capacity shall be not less than the values determined by Equation 140.10-B and Equation 140.10-C.

The minimum energy and power capacities of the battery system are determined using the two following equations:

\[
\text{Eq. 140.10-B} \quad \text{Battery Rated Energy Capacity} \\
\text{kWh}_{\text{batt}} = k\text{W}_{\text{PVdc}} \times B/D^{0.5}
\]

Where:
- \( k\text{W}_{\text{batt}} \) = Rated useable energy capacity of the battery storage system in kilowatt-hours
- \( k\text{W}_{\text{PVdc}} \) = Capacity of the photovoltaic system in kilowatts, calculated above
- \( B \) = Battery energy capacity factor specified by Table 140.10-B for the building type
- \( D \) = Rated single charge-discharge cycle AC to AC (round-trip) efficiency of the battery storage system

The second equation is:

\[
\text{Eq. 140.10-B} \quad \text{Battery Rated Power Capacity} \\
k\text{W}_{\text{batt}} = k\text{W}_{\text{PVdc}} \times C
\]

Where:
- \( k\text{W}_{\text{batt}} \) = Power capacity of the battery storage system in kilowatts of direct current
- \( k\text{W}_{\text{PVdc}} \) = Capacity of the photovoltaic system in kilowatts, calculated above
- \( C \) = Battery power capacity factor specified in Table 140.10-B for the building type

The following table provides Energy Capacity and Power Capacity values for variables in the equations:

<table>
<thead>
<tr>
<th>Table 140.10-B - Battery Capacity Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factor B - Energy Capacity</strong></td>
</tr>
<tr>
<td><strong>Storage-to-PV Ratio</strong></td>
</tr>
<tr>
<td>Grocery</td>
</tr>
<tr>
<td>High-Rise Multifamily</td>
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</tbody>
</table>

Using the equations and table information to calculate the minimum energy and power capacities for our 20,000-square-foot office building produces the following values, assuming a charge-discharge cycle efficiency of 80 percent:
The calculations show that our 20,000 ft² office building must be equipped with a battery system capable of (1) storing at least 117.6 kilowatt-hours of energy and (2) delivering at least 26.3 kilowatts at any moment.

\[ \text{Eq. 140.10-B} \quad \text{Battery Rated Energy Capacity} \]
\[ \text{kWh}_{\text{batt}} = \text{kW}_{\text{PVdc}} \times \frac{B}{D^{0.5}} \]
\[ \text{kWh}_{\text{batt}} = 62.6 \text{ kilowatts} \times (1.68/0.8^{0.5}) = 117.6 \text{ kilowatt-hours} \]

and

\[ \text{Eq. 140.10-B} \quad \text{Battery Rated Power Capacity} \]
\[ \text{kW}_{\text{batt}} = \text{kW}_{\text{PVdc}} \times C \]
\[ \text{kW}_{\text{batt}} = 62.6 \text{ kilowatts} \times 0.42 = 26.3 \text{ kilowatts} \]

Considerations for Facility Power Systems

In legacy backup power systems, generators run at all times when backup power is needed. Most often, the actual load is far less than the maximum possible load for which a generator is sized. As a result, generators are started for every qualifying outage and often run inefficiently at levels below their optimal output.

California’s new solar panel requirement promotes the deployment of zero-carbon solar energy sources. Its new battery storage requirement will enable more efficient use of those solar sources and provide several hours of reserve power when outages occur. For facilities that require backup power with a longer or indefinite runtime, the new requirements will not provide a complete solution. To meet their objectives, these facilities will still require a generator and one or more automatic transfer switches to provide power continuity for utility outages that outlast battery capacity. Nevertheless, the deployment of solar panels and battery storage will improve the sustainability of facility operations in the following ways.

The deployment of these new measures would reduce overall genset runtime due to utility outages, resulting in a more sustainable overall operation. Shorter outages could be handled by the battery systems without starting an engine-generator, and longer outages will require less generator operation because solar-supplied battery reserve will be consumed first. When its use is necessary, generator operation would be optimized by running it at the most efficient output near its full nameplate capacity until the battery system is charged and battery use can resume. The generator would only be restarted when a utility outage continues to outlast battery reserves.
Using battery storage changes when and how generators are operated. When outages occur, batteries provide alternate power until they discharge to a minimum level. If the outage resolves before stored energy is depleted, the facility is returned to grid power without starting any generator and the battery system can be recharged by the solar panels. This means that the power used to sustain operations can be essentially emission-free. As noted, generators are started once battery reserves are depleted and are then run at levels of optimal output near their maximum capacity rating. This strategy minimizes overall generator runtime. It also optimizes generator efficiency to decrease emissions, promote sustainability, and increase cost-effectiveness.

Exceptions

The examples provided demonstrate the most basic elements of California’s recent solar panel and battery storage requirements. The code does set forth important exceptions that have not been included in this summary. These include adjustments for multiple-use buildings, various exemptions where small installations make implementation less practicable, exemptions from solar panel requirements for specific roof designs, and more. Healthcare facilities may also be exempt from some or all of these provisions.

Additional Information

More about California’s Title 24 requirements for providing solar power and battery storage can be found in Section 140 of the code. The code can be downloaded from the California Energy Commission website here. A summary of the updates in the latest edition may be found here.

For additional information about integrating distributed energy resources and battery storage systems into buildings and their power distribution systems, consult a qualified electrical design professional or contact an authorized ASCO Power Technologies representative.

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2 Ibid. Section 140.10(a), p. 294.

3 Ibid.

4 Ibid. Section 140.10(b), p. 295.

5 Ibid.

6 Ibid. p. 296.