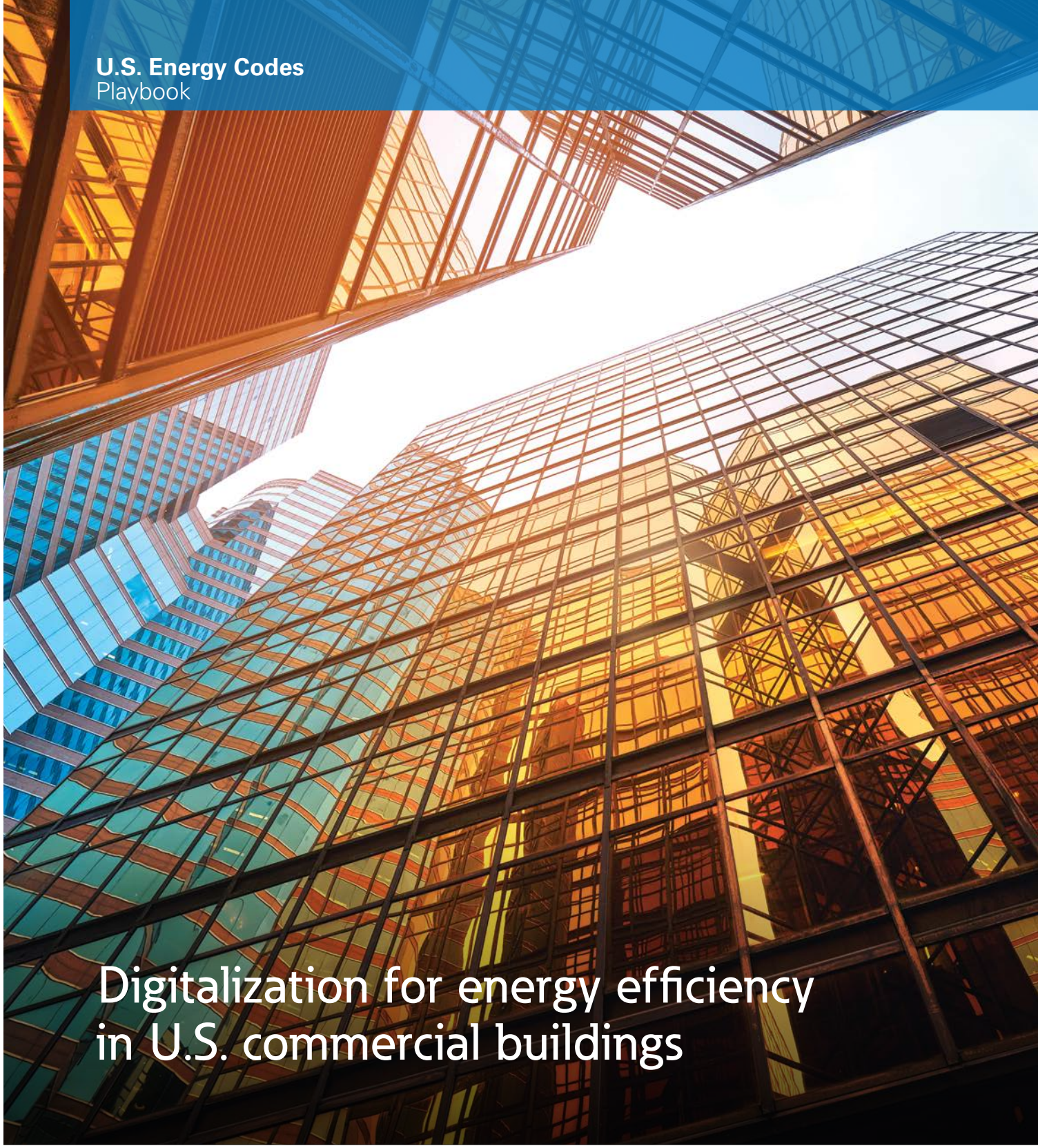
U.S. Energy Codes
Playbook



Digitalization for energy efficiency in U.S. commercial buildings

EATON
Powering Business Worldwide

Meeting the code

ASHRAE 90.1, CEC Title 24, NYC Local 97

What are the energy codes?

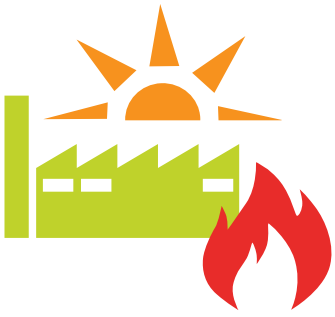
Increasing the energy efficiency of building systems is one of the most effective ways to reduce energy costs and greenhouse gas emissions. Energy codes address this challenge and they impact electrical systems supporting lighting, plug loads, heating, ventilation and air conditioning (HVAC), which account for a significant portion of building energy consumption.

The U.S. does not have a national energy code. Instead, it's up to the states and municipalities to adopt codes. Guidelines are based on national model codes, a modified version of the model code, or states develop their own code.

ASHRAE 90.1 is a model energy code that's designed to provide state and local jurisdictions with a framework for enforceable regulations, like Title 24 and Local Law 97.

ASHRAE 90.1—A proven benchmark

For more than 35 years, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1 has guided the energy-efficient design of buildings. This code is a parallel standard to the International Energy Conservation Code (IECC). These codes are updated on staggered three-year cycles.

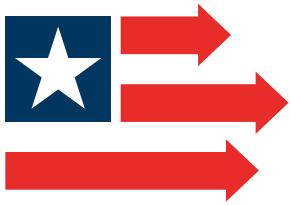


CEC Title 24—Raising the bar for a more sustainable future

First developed in 1976, the California Energy Commission (CEC) Title 24 building standards code is a broad set of requirements for "energy conservation, green design, construction and maintenance, fire and life safety, and accessibility."

Local Law 97—Creates carbon emissions limits on commercial buildings

New York City is addressing emissions from existing commercial buildings with Local Law 97, passed in 2019. Affecting most buildings over 25,000 square feet, this law aims to reduce building-based emissions by 40 percent by 2030 (from a 2005 baseline) and impacts over 57,000 buildings across the city.



What states are leading the charge?

Energy codes are adopted by states. According to the U.S. Department of Energy, Title 24 in California, along with six states and the District of Columbia, follow a version of ASHRAE 90.1 that requires metering for commercial and multi-tenant buildings.

What's the upside of energy codes?

According to the DOE, adopting the latest energy codes through 2040 can help U.S. homes and business owners save an estimated:

- **$126 billion** in energy costs
- **841 million metric tons** of carbon emissions

A common theme: You can't manage what you can't monitor

The latest versions of ASHRAE 90.1 require metering by load category, while Title 24 does not. In any case, the intent is to track building energy usage down to various load types in aggregate—so intelligent decisions and targeted improvements can be made to optimize energy efficiency.

The fundamentals of reducing building emissions and energy costs

While there are a variety of design approaches to meet energy codes, all will depend on the following building blocks:

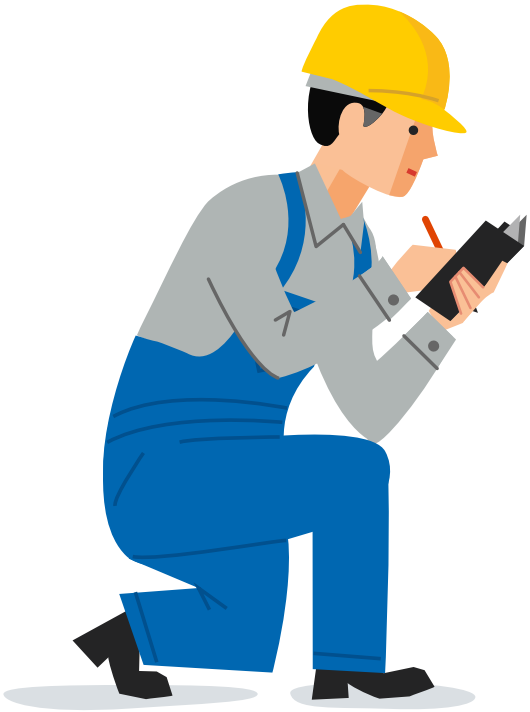
1. **Digitalization and interoperability,** so building infrastructure can be activated
2. **Cybersecurity,** which is essential in a connected world
3. **Energy monitoring,** as you cannot manage what you don't know
4. **Visualization software** that makes it easy to see energy habits that can be modified
5. **Intelligent control** for automatic adjustments, creating big savings

Section II

How are energy codes implemented in the real world?

How are these codes applied?

How do you design an electrical system that meets the energy codes of your region? No doubt there will be more than one design approach and many solutions—including lighting control, plug-load control and metering—will be essential to support compliance. With today's growing levels of digitalization and communications, cybersecurity will also apply to nearly every design.



Complying with energy codes requires a system design approach that involves:

- **Lighting control**
- **Plug-load control**
- **Metering**

Digitalization, communications and interconnectivity are foundational to comply with energy codes. Electrical devices will need to communicate data and values through industry standard communications protocols and connect to an energy dashboard or building automation system (BAS).

With all that connectivity, cybersecurity needs to be a primary consideration—just like safety and quality. Cybersecurity measures that are effective today may not be effective tomorrow because the vulnerabilities keep evolving. This means strict procedures and cybersecurity protocols need to be integrated at every phase of product development that involves people, processes and technologies.

Eaton manages cybersecurity risks in its products through a Secure Development Lifecycle (SDL) with protocols in place for threat modeling, requirements analysis, implementation, verification and ongoing maintenance to manage risks throughout the entire product lifecycle. Looking for manufacturers that utilize an SDL approach that has been validated by a third party is critical to creating trusted environments. It's the third-party certification that provides confidence, much like safety certifications and standards in the National Electrical Code®.

And the more connected devices flourish, the more cybersecurity matters. You may be at risk if your product manufacturers aren't adhering to SDL processes. It is also critical that you establish a robust cybersecurity program that includes periodic assessment of their IT/OT network to ensure they stay on top of vulnerabilities on the network. If they do not have this expertise in-house, then they can leverage third-party cybersecurity service offerings from trusted suppliers.

Eaton manages cybersecurity risks in products through a Secure Development Lifecycle (SDL) with protocols in place

Lighting control impacts code compliance and reduces energy costs

Lighting control systems are common and critical to complying with U.S. energy codes and help reduce energy consumption. For example, ASHRAE 90.1 identifies interior and exterior lighting and special applications (like hotel rooms) that can be controlled to reduce energy consumption.

In both residential and commercial applications, lighting control can be designed as a standalone system or integrated into a building management system (BMS). Additionally, circuit breaker controlled lighting can be used for interior and exterior applications for larger commercial and industrial facilities, whereas residential lighting systems can be used in high-rise apartment buildings and even some commercial buildings.

Add plug-load control to comply with energy codes

There is an opportunity to expand a focus on energy efficiency to plug loads, and energy codes recognize this. ASHRAE 90.1, for example, indicates that half of all 125 V, 15 A and 20 A receptacles are automatically controlled for private offices, conference rooms and individual workstations.

When plug-load controls are paired with occupancy sensors and other inputs like timers, plug loads can be automatically turned off or cycled. Furthermore, dimming components or circuitry enable substantial reductions in energy consumption.

Integrating these systems requires connectivity via various protocols that are dependent on site requirements. For example, Modbus® RTU and Modbus TCP are typically used in hardwired solutions, while BACnet protocols are used to connect to BMS systems. On the other hand, for residential or some commercial applications, Z-Wave or WiFi components enable easy integration with smart home or office building systems.

Metering is important. Meters are optional.

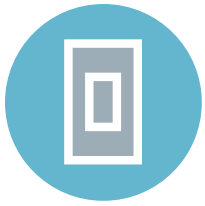
Energy codes, including ASHRAE, require that energy data is read and recorded for a period of time. However, energy codes do not require how you get that data. The key for ASHRAE is that the load is split into five categories:

Total energy usage

HVAC system

Interior lighting

Exterior lighting



Receptacle unit

What's the best design concept to deploy?

There is more than one design approach and many technologies that can help support this level of metering requirements, and each option has its advantages and challenges. Let's take a look at possible design techniques.

First, a few notes:

- Metering is essential because you cannot manage what you don't know. The design techniques will address energy data requirements.
- Embedded metering functionality in various products today, such as circuit breakers, allows reduction of components, while still providing that all-important metering data.
- Beyond metering, there are many technologies that can help manage and reduce energy consumption and we will look at applicable solutions in the next section.

Branch-level metering

What does the solution look like?

With a branch-level metering approach, here's what's involved:

1. Service-entrance meter
2. Branch circuit monitoring (BCM) system

What's the good and the bad?

Upsides: With a branch-level metering approach, the system is reliable and the number of downstream panels is minimized.

Challenges: The system is complex and requires field programming, the panels themselves are labor intensive, and the branch metering control board takes up valuable space in the panels.

Design approach and recommendations

This design concept involves a service-level meter, branch circuit monitoring downstream, communications and data collection. Here's how this plays out:

- The **service-entrance meter** will provide the total energy usage data. This meter can and usually is factory installed into electrical equipment, but it can also be provided in its own enclosure for the contractor to install near the electrical equipment being metered.
- **Branch circuit monitoring** needs to be placed on downstream 277/480 V and 120/208 V panels that contain the other four load categories. The loads are mixed together in the panel, and metering software will separate and total the loads as the meters and current transformers (CTs) are programmed with a given load type during commissioning. These meters are typically factory installed into the electrical equipment, but the branch circuit meters can also be provided in their own enclosure for a contractor to install near the electrical equipment being metered, while the CTs are factory installed inside the panel.

Equipment list for branch-level metering

Service-entrance meter:
Power Xpert® Meter 3000 (PXM 3000)

Branch circuit monitoring:
Eaton Multi-Point Meters for switchboards and distribution panels, **Eaton Branch Circuit Monitor** for smaller downstream panels

Dashboard:
Eaton Power Xpert Dashboard Lite; alternatively, data can be fed into the BAS via the dashboard or a gateway

Panel-level metering

What does the solution look like?

Panel-level metering involves:

1. Service-entrance meter
2. Panelboards or switchboards with metering for each of the four load types (one load type per panel)
3. Communications so that data can be incorporated into a dashboard or BAS

What's the good and the bad?

Upsides: Using panel-level metering is less complex and the panel builds are less labor intensive than the branch-level approach, and the solution is reliable.

Challenges: Additional panels are required to split into specific load types and meters take up some space inside the panels, but not as much as the branch-level metering design.

Design approach and recommendations

This design concept involves a service-level meter and panelboards or switchboards for each load type. Here's how this design works:

- The **service-entrance meter** will provide the total energy usage data or it can be tallied by downstream meters. This meter can and usually is factory installed into electrical equipment, but it can also be provided in its own enclosure for the contractor to install near the electrical equipment being metered.
- With this design, each of the four load types are divided into their own panelboards, with one load type per breaker or incoming lugs. This applies to both 277/480 V and 120/208 V panelboards. These meters are typically factory installed into electrical equipment, but can also be provided in their own enclosure for a contractor to install near the electrical equipment being metered.

Equipment list for panel-level metering by load type

Service-entrance meter:
Power Xpert Meter 3000 (PXM 3000)

Panelboard metering for each load type:
Eaton Power Xpert Meter 350

Dashboard:
Eaton Power Xpert Dashboard Lite; alternatively, data can be fed into the BAS via the dashboard or a gateway

Building-level metering

What does the solution look like?

This approach uses molded case circuit breaker trip units to obtain energy data and make it available to the BAS or dashboard (rather than meters); each of the four load types are divided into their own panelboards or switchboards. Here's what's involved:

1. Service-entrance meter
2. Panelboards or switchboards for each of the four load types (one load type per panel) and circuit breaker trip units (rather than meters) are used to obtain energy data
3. Communications so that data can be incorporated into a dashboard or BAS

What's the good and the bad?

Upsides: Using this modified panel-level metering involves less equipment (no meters at the panelboards or switchboards), takes up less space than alternative approaches, provides new capabilities for system "health" monitoring, provides power quality functions at the panel level, and is less involved and less labor intensive than the other design options.

This design can also use the trip units to provide additional data and capabilities: event and alarm logging, the ability to set circuit breakers remotely, information on the cause of trips and waveform capture. These capabilities are embedded in the circuit breaker trip units and/or through their (free) software.

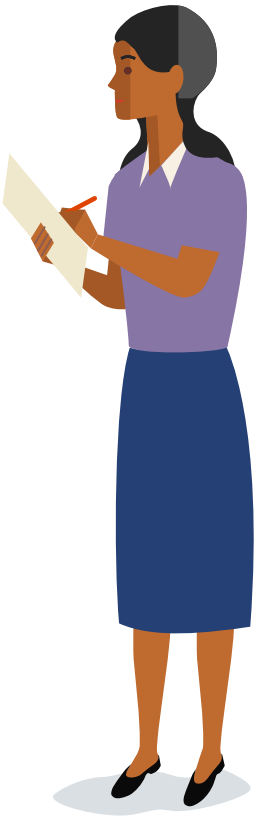
Challenges: The circuit breaker trip units require a 24 Vdc power supply.

Design approach and recommendations

This design concept involves a service-level meter, panelboards or switchboards for each load type with molded case circuit breakers and trip units. Here's how this design works:

- The **service-entrance meter** will provide the total energy usage data or it can be tallied by downstream meters. This meter can and usually is factory installed into electrical equipment, but it can also be provided in its own enclosure for the contractor to install near the electrical equipment being metered.
- With this design, each of the four load types are divided into their own panelboards. The difference with the previous approach is that this design does not use a separate meter in each panelboard; instead, molded case circuit breaker trip units obtain the energy data and make it available. These trip units would be used in the main circuit breaker of the 120/280 V panels, or in the upstream assembly that feeds that panel to monitor the load. Preferably, the trip unit in the feeder breaker is feeding the low-voltage transformers, so you're able to capture the transformer losses, which provides more accurate energy consumption data.

The trip units communicate data and values into the BAS or dashboard.

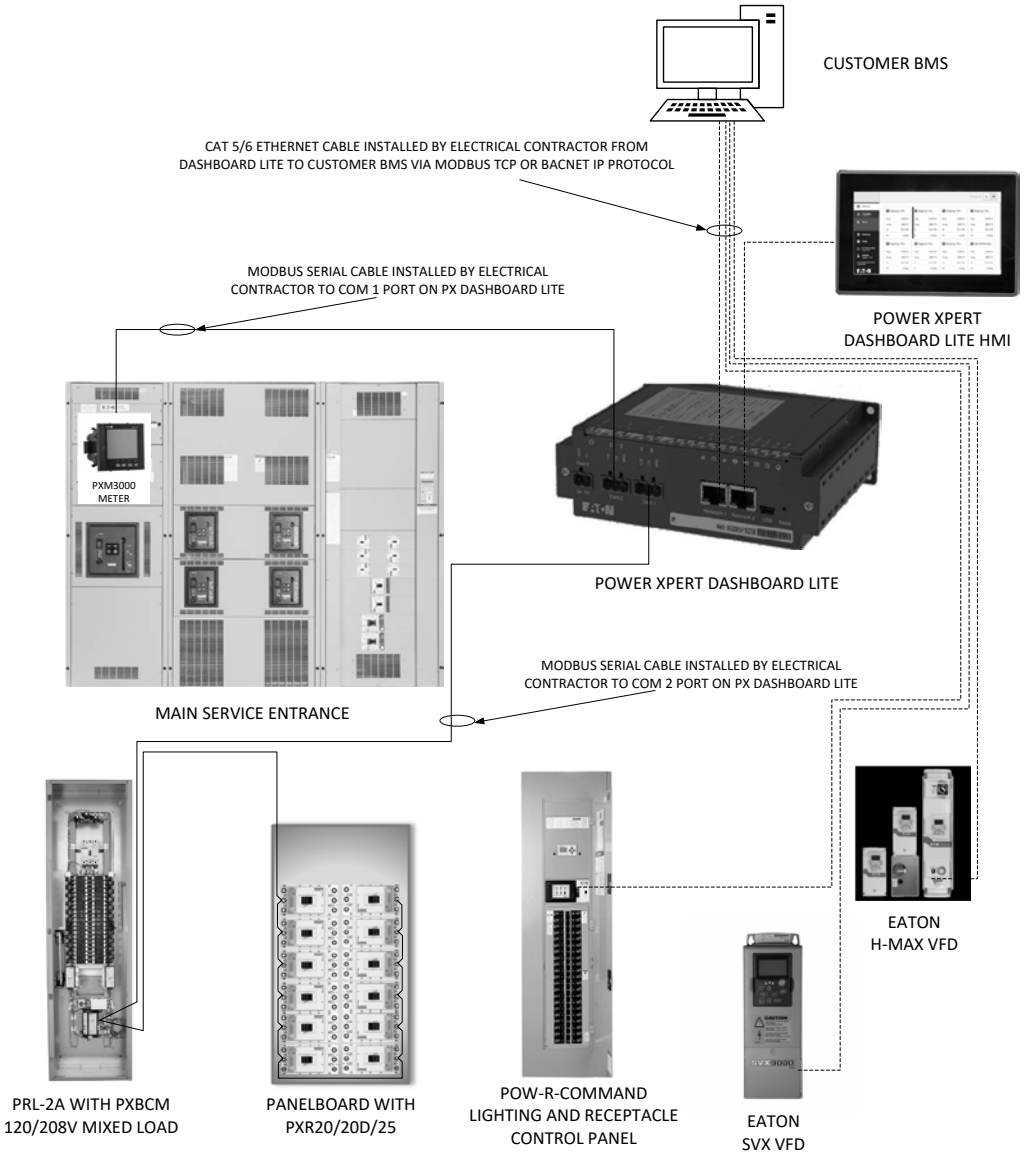


Equipment list for panel-level metering by load type

Service-entrance meter:
Power Xpert Meter 3000 (PXM 3000)

Panelboards with **Power Defense™ circuit breakers** and **Power Xpert Release 25 trip units**

Dashboard:
Eaton Power Xpert Dashboard Lite; alternatively, data can be fed into the BAS via the dashboard or a gateway



Designing communications

Power monitoring designs and strategies sometimes combine these concepts, so you don't have to select just one. You can deploy the different design techniques wherever it makes the most sense within a system.

With all of these approaches, meter, trip unit and data collection software will reside on the same communications network. The most common communication protocol for energy data is Modbus RTU and/or TCP. That said, some meters come with BACnet native.

If needed, protocols can be converted by the use of gateways or protocol converters. However, these devices add complexity and a potential point of failure in the system.

Dashboard perspective applies across design options

Each of the design options involves a dashboard. To meet energy codes, the dashboard needs to provide a means to see and record energy usage (not control equipment).

Eaton's Power Xpert Dashboard Lite is a plug-and-play software that automatically recognizes and imports data from Eaton meters, trip units and other communications devices. The dashboard can be located on a HMI screen and placed in the building lobby to meet energy codes.

Power monitoring design and strategies sometimes combine these concepts, so you don't have to select just one. You can deploy the different design techniques where they make sense within a system. Dashboard Lite can combine the data no matter the design concept used.

The meters and data collection software will reside on the same communication network. The most common communication protocols are Modbus RTU and/or TCP and BACnet.

Section III

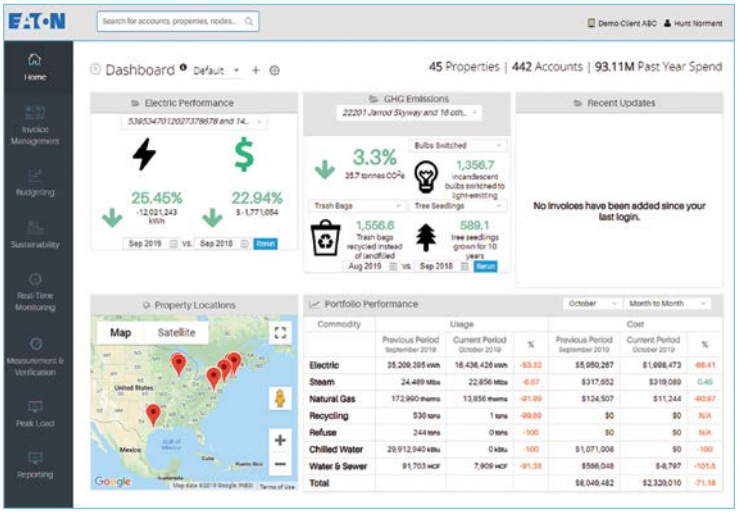
Industry solutions to adhere to and maximize benefits of energy code compliance

Solutions and benefits

A critical component of energy codes is collecting the data needed to make effective and prescient operational decisions that are based on current energy habits and tailored to actual energy needs.

Since 2013, ASHRAE 90.1 has incorporated a variety of submetering requirements for all buildings or building additions over 25,000 square feet. Typical metering provides utility measurements for the whole building or facility each month. Submetering is the application of metering technology below the level necessary for utility metering.

Eaton's **Power Xpert Energy Visualization Analysis** is a cloud-based submetering solution that provides users with simple access to metering data, so energy billing and real-time and predictive operational decisions can be activated to drive more energy-efficient operations.



Lighting control

Lighting control is essential to comply with energy codes and reduce energy consumption and emissions.

Meet energy codes and cut energy bills: circuit breakers can control lighting with dimming and monitoring

Eaton's Pow-R-Command intelligent lighting control panelboards support ASHRAE and Title 24 energy-efficiency codes. This technology has been used for decades and is updated regularly. The technology meets U.S. federal government-grade cybersecurity standards and provides mobile device management and additional BMS protocols. It also easily integrates with BMS systems based on BACnet/IP, Modbus TCP and Modbus RTU.

Smart receptacles meet energy codes

Eaton's Z-Wave and WiFi wiring device solutions provide flexible options regardless of the hotel's or facility's existing system. Combining smart wiring devices and occupancy/vacancy sensors, the full portfolio of wiring devices supports both energy codes and reduction of energy usage through on/off control and dimming capabilities.

Eaton's 0–10 V dimmer sensors (OS10D7 image) allow customers to satisfy commercial energy codes, simplify installation and save on energy consumption by combining the functionality of a sensor, a switch pack and a 0–10 V dimmer in one device.

Reduce energy consumption, simplify code compliance and increase comfort with Eaton's commercial lighting control solutions designed to help commercial and institutional customers. The universal slide dimmer (SUT7W image), universal phase selectable slide dimmer (SUF7W image) and 0–10 V dimmer sensor (OS10D7 image) feature a modern, industrial design that is consistent across Eaton's entire line of commercial wiring devices and available in five standard colors for integration with existing schemes.

Simplify energy code requirements for controlled receptacles

Eaton's controlled receptacles make it easy to see which outlets are controllable by having a permanent, NEMA-approved and NEC-compliant "controlled" marking on the face of the receptacle. Eaton has the devices for nearly every application in commercial buildings and facilities.

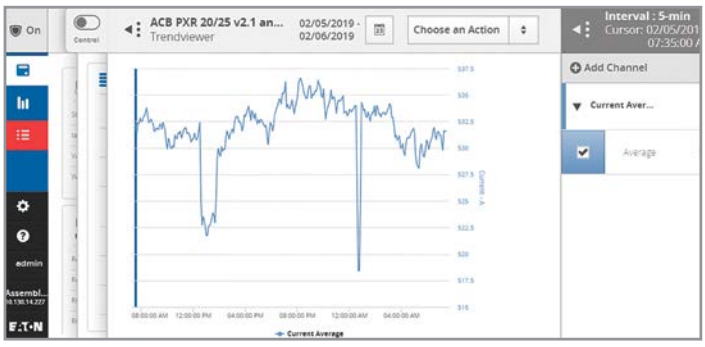
Metering

Branch circuit monitoring made easy

Eaton's Pow-R-Line Branch Circuit Monitoring (PXBCM) panelboard helps meet the measurement and verification information that are required as part of energy codes. The PXBCM provides a means to monitor 84 branch circuits and 16 main and auxiliary main and auxiliary panel connections.

Metering is required

Eaton's metering solutions provide critical energy metering data that's required for energy codes. For example, Eaton's Power Xpert Energy Visualization & Analytics (PXEVA) software provides real-time monitoring of power usage, helping you meet your sustainability goals by reducing energy costs and optimizing the operations of your building or facility.



Dashboard views make monitoring easy

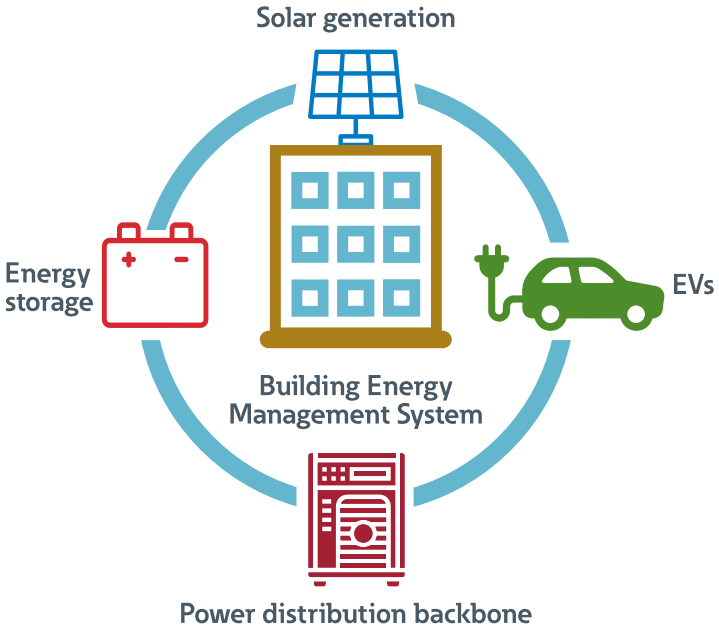
Eaton's Power Xpert Dashboard enables users to monitor, diagnose and control devices and track energy data. This equipment is essential to meet energy code requirements. Dashboards provide users with a portal to Eaton's switchboards, panelboards, motor control centers and switchgear.

Pow-R-Line Xpert™ (PRLX) is the latest panelboard and switchboard series from Eaton
PRLX offers Eaton's state-of-the-art Power Defense circuit breakers with advanced features such as embedded communications, breaker health diagnostics and standardized Arcflash Reduction Maintenance System™ functionality. Integrated metering capabilities simplify installation with no need for external meter modules.

Keep a close eye on HVAC energy usage and variable frequency drives
Variable frequency drives (VFDs) can be used to meet the building standards in many HVAC and pumping applications.

Gateway to energy data
Eaton's Power Xpert Gateways come equipped with a powerful, yet simplified, user interface, providing a remote, efficient, information-rich window into a BAS.

On-site renewables are also part of energy codes



Everything as a grid advances energy transition
Eaton has a host of technologies and services to support the integration of renewables and energy storage. Ultimately, energy codes are about reducing emissions and energy requirements in buildings, and power sourced from renewables advances these goals.

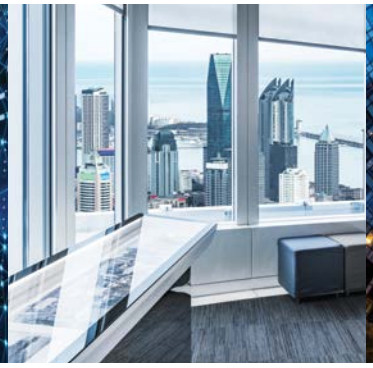
Additional solutions that can help meet energy codes

Meet modern energy-efficiency requirements for dry-type transformers
Eaton's line of dry-type transformers enable reduced inrush current and reduction of load losses. These features reduce overall energy usage in a facility.

We make what matters work.*

* At Eaton, we believe that power is a fundamental part of just about everything people do. Technology, transportation, energy and infrastructure—these are things the world relies on every day. That's why Eaton is dedicated to helping our customers find new ways to manage electrical, hydraulic and mechanical power more efficiently, safely and sustainably. To improve people's lives, the communities where we live and work, and the planet our future generations depend upon. Because that's what really matters. And we're here to make sure it works.

See more at Eaton.com/electrical



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Eaton
1000 Eaton Boulevard
Cleveland, OH 44122
United States
Eaton.com

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