

Designing electrical systems for future-proof, energy-efficient green buildings

by Mathew Losey

Executive summary

This paper offers electrical design engineers a guide to the most relevant, up-to-date standards and technology to help specify and design future-proof electrical systems that deliver optimal energy efficiency throughout the entire building life cycle. Green, energy-efficient building design and operation is becoming common worldwide. This is being driven by international agreements to combat climate change, evolving country-based standards and regulations, and increasing demand by building owners. Designers need to be prepared to deliver electrical system designs that comply with the newest building codes, help achieve green building certifications, and support 'active' energy management programs compliant with global best practices.

Introduction

Dodge Data & Analytics reports that “Green building activity continues to grow across the globe, with dramatic increases expected in 20 countries across five continents between now and 2021.” In fact, 47% of study respondents said that by 2021 more than 60% of their projects will be green buildings (Figure 1).¹

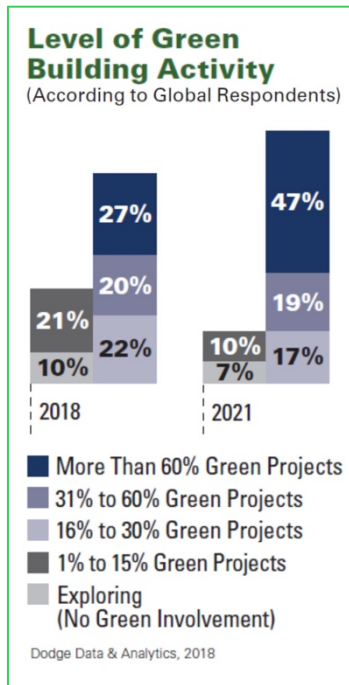


Figure 1

Green buildings are no longer a niche market, they are becoming the norm. Energy-efficient building design is quickly becoming a prevailing method for architects and engineers. ‘Active’ energy management is becoming commonplace, continuous activity for building operations and maintenance teams. There are many influences driving this evolution:

- Global directives.** The Paris Agreement aims to limit global warming to 1.5% above pre-industrial levels, through greenhouse gas (GHG) reduction, increased use of renewables, and increased energy efficiency. As per the subsequent COP21 conference, each country is expected to define and deliver on nationally determined contributions (NDCs).
- Government actions.** Some countries are taking aggressive action to meet their NDCs. For example, while the EU has committed to reducing CO₂ emissions by 80 percent by 2050, the Netherlands is targeting a 95 percent cut.² The impetus to go green is also trickling down to cities. In New York, starting in 2024, landlords of buildings over 25,000 square feet will be required to make retrofits that will help cut GHG emissions by 40 percent by 2030.³ For new building projects, governments are encouraging efficient design through incentives and guidelines, as well as updating local building codes, regulations, and permitting.
- The ROI of energy efficiency.** Whether or not a facility is required to meet new environmental regulations, building green is simply a good investment. Energy costs are reduced, while achieving a green building certification can increase real estate valuation. An efficient design will optimize heating, cooling, ventilation, and lighting, which helps improve occupant comfort, health, and productivity. A greener image can help attract talent and impact consumer preference. These benefits are leading many companies to implement and promote aggressive sustainability goals.

Figure 2

Green building practices are being driven by global, national, and business goals. New designs, such as this [LEED Gold-certified Schneider Electric office in South Africa](#), can help limit global warming while cutting energy costs and improving occupant health, comfort, and productivity.



¹ [“Smart Market Report: World Green Building Trends 2018”, Dodge Data & Analytics, 2018](#)

² [“Nederland zet zelf stok achter de deur ...”, de Volkskrant, 2018](#)

³ [“New York City Passes Sweeping Climate Legislation”, CityLab, 2019](#)

Definition: active energy management

Throughout this paper are references to 'active energy management' and 'active energy efficiency.' These relate to the steps facility teams use to *actively* improve energy efficiency on a continuous basis.

The use of the word 'active' in this context should not be confused with the electrical term that relates to the 'true or real' power consumed by the resistive components of loads.

The combination of regulatory pressures, financial returns, greater asset value, and health benefits is helping push green building to become a mainstream initiative.

Be prepared for a greener future

Electrical design firms and engineers need to be ready to support the growing demand for green buildings. As building sustainability is a life cycle consideration, the designer must ensure an electrical system supports energy efficiency across the entire life cycle by:

- Complying with newest green building codes and practices
- Helping meet the requirements for energy management and green building certifications, including the specification of green-certified components
- Supporting environmental regulatory compliance reporting
- Supporting active energy management standards and best practices during a building's operation and maintenance phase over the long term, to minimize energy consumption and OPEX

Important updates to global and local efficiency standards are continuing to emerge, including the release of:

- [ISO 50001-2018 Energy management systems](#)⁴
- [IEC 60364-8-1:2019 Low-voltage electrical installations - Energy efficiency](#)⁵

This paper offers electrical designers an introduction to the evolution of green building and some of the most important standards, guidelines, and regulations. It also provides a brief introduction to some of the relevant energy management technology that will help meet green building requirements as well as support the sustainability goals of clients.

Putting policy into action

"Buildings ... are responsible for 40% of total direct and indirect CO₂ emissions. Energy demand ... continues to rise, driven by ... rapid growth in ... floor area, at nearly 3% per year."

[International Energy Agency](#)

The following are a few examples of the ways governments, industry-based organizations, and local electric utility companies are regulating or encouraging green building practices in major markets worldwide.

Regional and national motivators

The European Commission Energy Efficiency Directive set an energy efficiency goal of 32.5% improvement by 2030.⁶ By the end of 2018, member states were required to draw up plans for how they would achieve the targets. The EU also passed an update to the *Energy Performance of Buildings Directive*,⁷ proposing several provisions including, but not limited to:

- Going beyond the building envelope to include energy performance of *all relevant elements and technical systems*: heating, cooling, lighting, and ventilation.
- Improved transparency of energy performance certificates, with *all necessary parameters for calculations* applied consistently.
- *Innovation and new technology* also make it possible for buildings to support the overall decarbonization of the economy.

⁴ [ISO 50001-2018, International Standards Organization](#)

⁵ ["IEC 60364-8-1:2019", IEC Webstore](#)

⁶ ["2030 climate & energy framework", European Commission](#)

⁷ ["Energy performance of buildings", European Commission](#)

“Nearly a fifth (17%) of Fortune Global 500 companies have now committed to set science-based emissions reduction targets.”

Science Based Targets

EU countries must enact the new elements of the Directive into national law within 20 months of the Directive updates in June of 2018.

Singapore has targeted 80% of buildings be green by 2030. Based on the Green Mark scheme, a masterplan serves as a framework for guiding energy-efficient construction and renovation of buildings, and a benchmark for evaluating environmental sustainability. Two initiatives directly related to the electrical infrastructure are:

- Annual mandatory submission of building information and *energy consumption data*
- Mandatory periodic *energy audit of the efficiency of building cooling systems* and compliance with minimum standards

Green ratings are rewarding buildings and owners

Achieving a rating or certification for sustainable building design has become a popular trend in recent years, with a variety of standards and systems becoming mature and highly recognized. Meeting the requirements, and being recognized, for a green building rating or certification offers a range of benefits to a building owner and operator. As quoted by the U.S. Green Building Council (USGBC) regarding LEED,⁸ benefits include:

- Instant recognition for your building, enhances your brand and establishes you as a leader in green building
- Faster lease up rates, higher resale value
- *Lower use of energy*, water and other resources
- Healthier indoor space, better for building occupants, the community and the environment

Incentives are easing investment in green buildings

Though the long-term payback of a new green build or renovation project can far outweigh the incremental costs of green design and construction, many building owners may find the initial investment to be a burden. Fortunately, as green practices have spread, costs are continuing to drop, making it more accessible.

In addition, a range of incentives can be found emerging in many countries that are either encouraged or sponsored by various levels of government – federal, state, and municipal – or by local power utilities. Incentives can come in a variety of forms. As proposed by the USGBC,⁹ government-sponsored incentives might include:

- Tax credits tied to the *improvements implemented, measured reduction in energy consumption, or energy savings achieved*
- Grants (e.g., from the city) or low interest loans
- Expedited review or permitting processes, reduction or waiver of permitting fee
- Density and height bonuses
- Free assistance (e.g., planning or certification training, marketing)

Many categories of incentives require the building owner to document improvements in building performance by *accurately measuring and reporting on energy*

⁸ [“Green building leadership is LEED”, USGBC](#)

⁹ [“Encouraging building energy improvements through tax incentives”, USGBC](#)

Case study 1: World’s first ISO 50001 certification

In 2001, the corporate headquarters of Schneider Electric, in Rueil-Malmaison, France was the world’s first building to be certified to the ISO 50001 energy management standard. It has also gained certification to ISO 14001, and green building certifications HQE Exploitation and BREAAAM In-Use (“exceptional” 6 stars).

What does this mean in terms of real performance? By using Schneider Electric solutions and integrating all building systems into a single platform, 30% energy savings have been achieved, at a low consumption rate of 80 kWh/m²/year. Other features include onsite renewable energy and controls for pumps, fans, lighting, HVAC, and sun blinds.

consumption and costs during operation. In the case of retrofits, performance improvement must be compared against an accurately measured consumption baseline that is set prior to upgrades being made.

Green guidelines and building codes are being adopted and localized

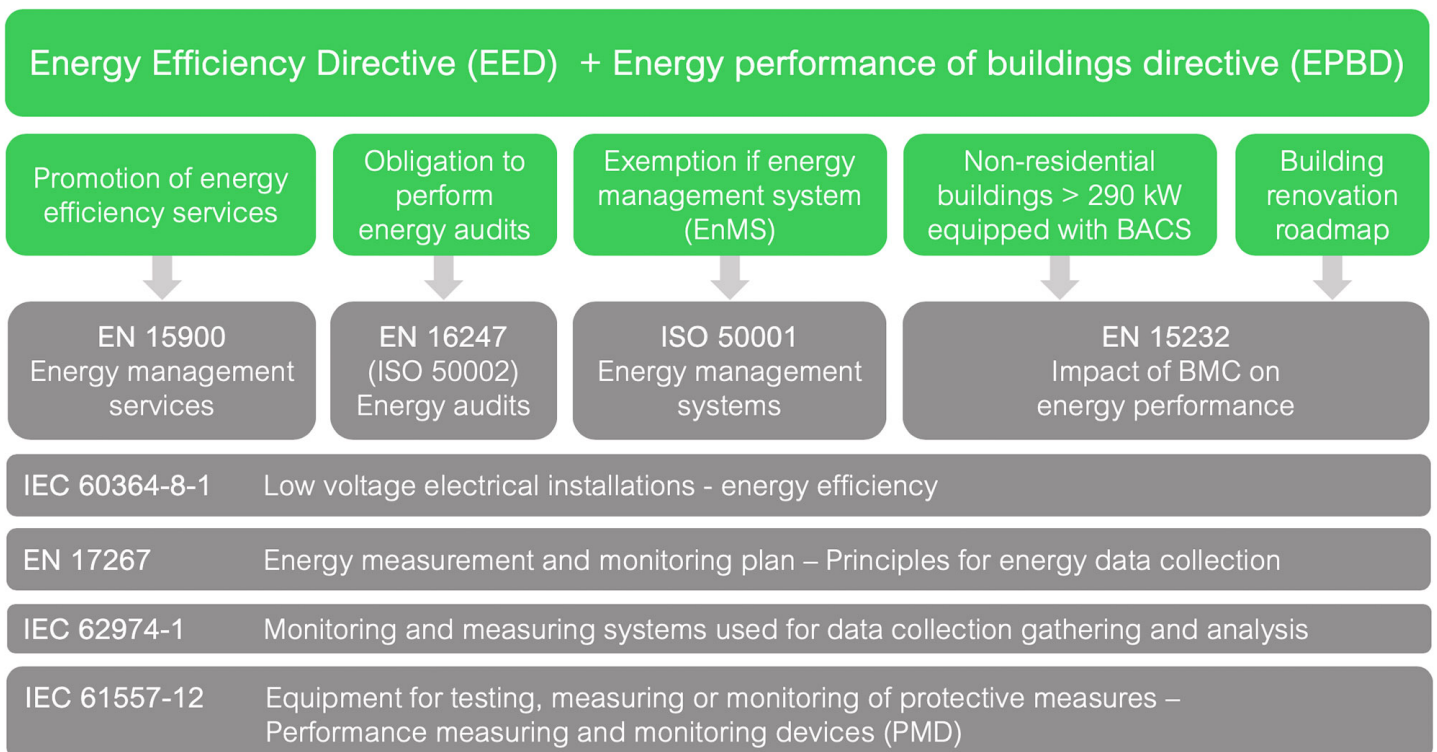
As governments commit to energy and environmental sustainability goals, the world's major standards organizations continue to either update or introduce supporting guidelines and standards covering every aspect of green "high performance" buildings. This includes site planning, building design, infrastructure, materials and products, operation, and maintenance.

International standards or codes are often tailored by individual country governments and/or industry organizations to adapt to local needs. There can also be a direct relationship between regional or national policies and associated guidelines and standards. An energy-efficient electrical code may require specific elements of the electrical infrastructure designed to support operational best practices and green building certification. The following are examples of these interrelationships:

- Europe.** The IEC 60364-8-1 standard is growing in adoption across many EU countries as a standard for energy-efficient electrical system design. As detailed later in this paper, the standard can help achieve credits for green building certifications and compliance with energy management guidelines. In terms of building operation, the EU *Energy Efficiency Directive* requires any company with more than 250 employees to either regularly perform an energy audit or put in place a permanently installed energy management system (EnMS). In addition, the *Energy Performance of Buildings Directive* requires a 'building renovation roadmap' for energy efficiency upgrades. To take action on these requirements, facility teams are encouraged to follow associated ISO guidelines and EN standards (Figure 3). These are detailed later in this paper.

Figure 3

Consistency between European regulations (in green) and standards (in grey)



- **India.** The Energy Conservation Building Code (ECBC) was first launched by the central government of India in 2007, and is applicable to non-residential buildings. The Code was revised in 2017 to include requirements for envelope, mechanical, electrical, and plumbing systems. The ECBC for Residential Sector was subsequently developed and launched in December 2018, which currently covers only passive design measures, including envelope, ventilation, and daylighting requirements. Requirements for mechanical, electrical, and plumbing systems will be developed and added in the years to come. In general, building code implementation falls under the purview of local urban bodies and their respective state governments, so implementation and enforcement of the ECBC is scattered and sporadic¹⁰. Of the 29 states and 7 union territories in India, only 15 states have issued notifications mandating compliance with ECBC¹¹ (a key first step to implementation and adoption), and just a handful of cities have started enforcing it at present. The Bureau of Indian Standards has adopted the IEC 60364-8-1 standard and, by and large, ISO 50001 and its associated standards. Adoption of these standards by industry has, so far, been voluntarily.

The high-performance building of the future

Case study 2: Carbon neutral by 2020

The East Asia and Japan regional headquarters of Schneider Electric in Kallang, Singapore, will be the first of its kind to achieve the goal of being carbon neutral by 2020.

Housing 1,400 employees, the combined office building and innovation hub uses smart building technologies – with 3000 connected IoT devices – and operates on 100% solar energy during daytime hours.

The retrofitted office building is also the first to qualify for a BCA Green Mark Platinum Award.

There are many aspects of a building's design that contribute to its overall energy efficiency during the operational phase. Optimizing the energy performance of a building requires addressing many *passive* and *active* factors.

Elements of passive energy efficiency

Passive energy efficiency refers to the natural processes that contribute to the comfort and efficiency of a building – typically related to water, air, vapor, and thermal effects. Some passive elements affecting overall energy efficiency are:

- Building site and orientation with respect to natural light
- Building envelope, including the materials used (e.g., insulation, windows)
- Natural ventilation (e.g., free cooling)

With passive systems, optimizing capital costs is important to bear in mind, as these types of systems are typically fixed. This means that they are commonly a one-time-only investment, with limited upgrade potential beyond building envelope renovation, and require low relative maintenance cost.

Elements of active energy efficiency

Active energy efficiency refers to the adaptive systems that contribute to energy usage and cost to drive occupant comfort, processes, and other operations. Such systems include:

- Heating, ventilation, and air conditioning (HVAC) systems
- Lighting systems
- Building and energy control systems, including building management systems (BMS), and power and energy management systems
- Renewable energy systems, including microgrid control systems, and distributed energy resources

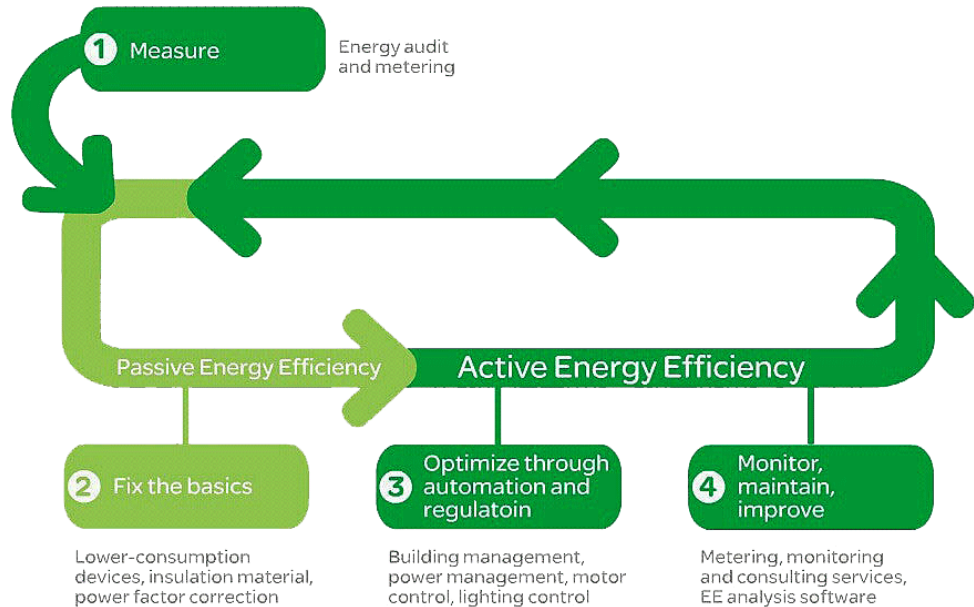
¹⁰ [“Roadmap to fast track adoption and implementation of Energy Conservation Building Code \(ECBC\) at the urban and local level”, NITI Aayog / BEE / AEEE, 2017](#)

¹¹ [“Handbook: ECBC Compliance in Indian Cities”, ICLEI South Asia and Shakti Sustainable Energy Foundation, 2018](#)

Active energy efficiency systems contribute to the operational performance of the facility by enabling the facility operations team to perform real-time monitoring, advanced analytics (using performance metrics and key performance indicators), control, and maintenance (Figure 4).

Figure 4

Active energy efficiency continuously optimizes building energy use on an ongoing basis.



This has become recognized as a highly effective best practice to minimize energy costs over the life cycle of a building, and why these measures comply with international energy management standards, such as ISO 50001.

“Initial costs of facilities represent only 15% of a building’s total cost ... [ignoring this fact when developing a building] ... wastes an opportunity to minimize the other 85%” for the client.”

National Research Council

However, these systems can be complex. They often include new and emerging technologies (e.g., IoT-based metering systems), while requiring integration of various systems (e.g., building management and lighting control). For this reason, active systems are often value engineered from capital projects, with little regard for the end client’s use cases during the operational phase of the facility. This value engineering can often result in additional costs during the operational life cycle.

As retrofitting facilities after construction can be much costlier, it is extremely important for builders and designers to consider specifying and optimizing active systems as part of the initial design and commissioning of the facility.

The important role of the electrical designer

Balancing the capital costs related to the design of passive and active energy efficiency systems in a building involves many stakeholders. But it is the role of the electrical designer to implement energy efficient and cost-optimized electrical systems design.

Electrical systems design is at the core of energy efficient buildings. To highlight this fact, two of the prerequisites and up to 28 of the 69 total credit points (over 40

percent) toward a LEED green building certification are affected by the electrical design.¹² Examples of the breadth of inputs possible are provided later in this paper.

The challenge for electrical designers is to balance multiple client needs:

- Ensuring the electrical system is designed according to existing, stringent electrical codes and standards
- Considering how the building will be designed and built to achieve green building accreditations
- Including the necessary technologies that building operators will need to use to achieve compliance to energy management standards (e.g., ISO 50001 or U.S. DOE Superior Energy Performance), whether pursued on a voluntary basis, or to comply with mandated government directives (e.g., EU Energy Efficiency Directive), or to comply with the requirements of tax incentives
- Optimizing project cost

Fortunately, the newest energy-efficient building standards and guidelines offer the electrical designer the opportunity to meet building codes while innovating with new technologies. This will help maintain a competitive edge in a marketplace moving quickly toward green standards. The cost of energy-efficient design should also be defensible based on the many recognized benefits, as noted in the introduction.

Green building is a massive opportunity, and that includes energy-efficient renovations, due to the large existing building stock in all countries. The newest codes and standards will help firms keep up with demand by integrating energy efficiency into master specifications for electrical systems. This can help limited staff better manage design project capacity.

The following sections provide an introduction to some of the most established, highly adopted energy-efficient building standards and guidelines relevant to the electrical designer. Gaining familiarity with these can help designers deliver high-performance, future-proof solutions to their clients.

There are many energy-efficient building standards, guidelines, and rating systems in use around the world, developed by standards organizations, governments, industry organizations, or a collaboration between entities. As mentioned previously, some standards have been developed or tailored for local application (e.g., country, state, or municipal). This section of the paper focuses primarily on international standards that are finding wide adoption in multiple countries.

While most standards apply exclusively to the design or operation phase of a building, some standards or rating systems may encompass elements of both. As the design of an electrical system affects both the passive and active efficiency of a building, many of the relevant design and operation standards are closely related.

Figure 5 offers a simplified view of the standards and guidelines described in this section of the paper, showing relationships and contributions between them. The figure is organized to represent the chronology of a building, from design through operation. The following sections offer an introduction to each standard, while the Resources section provides hyperlinks to complete information on each.

Case study 3: \$1.8 M savings through SEP/ISO rollout

Schneider Electric has successfully achieved certification to the U.S. DOE Superior Energy Performance (SEP) program for 20 of its manufacturing plants, which also includes a certified ISO 50001 energy management system.

The company used a novel, 3-phased approach, each with progressive greater savings in implementation costs. With the support of its Energy and Sustainability Services (ESS) group, an enterprise-wide strategy leveraged best practices and support across all plants.

Across multiple sites in the U.S., Canada, and Mexico, an annual savings of \$1.8 M has been achieved, 80% in electricity, and 20% in natural gas.

Standards and guidelines for green buildings

¹² [“Sustainable Design for Electrical Engineers”, EC&M, 2006](#)

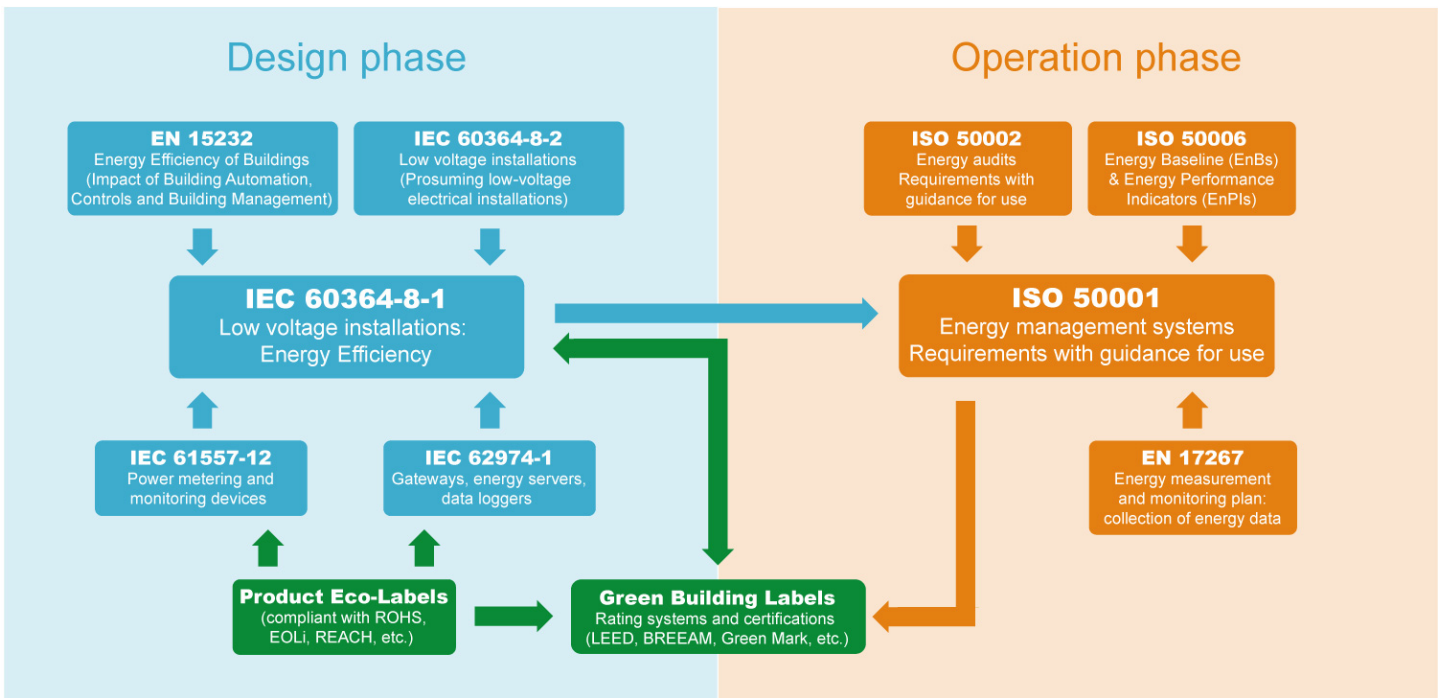


Figure 5
Relationship of selected standards and guidelines for building design and operation phases.

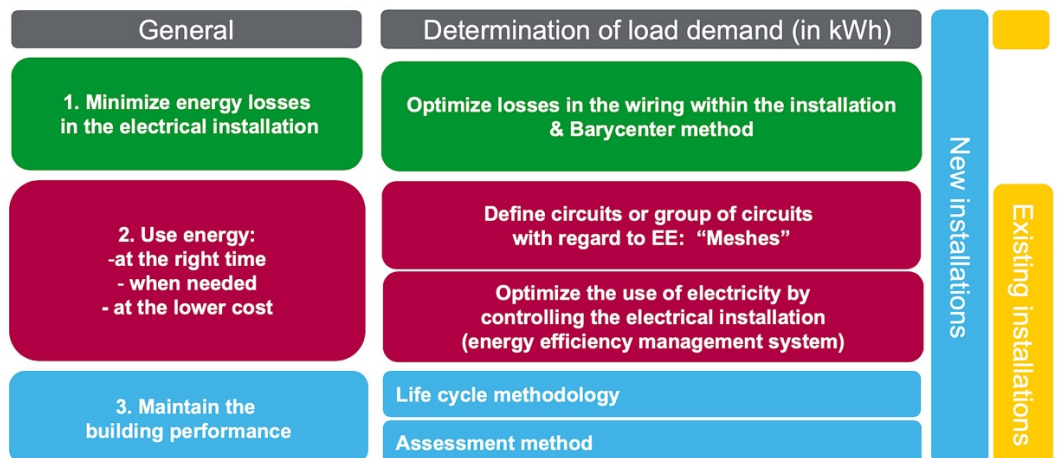
DESIGN PHASE STANDARDS

IEC 60364-8-1: Low voltage electrical installations – Energy efficiency

This standard refers to residential buildings, commercial buildings, industrial buildings, and infrastructures. It provides a framework, with requirements and recommendations, to help design and assess an efficient low voltage electrical distribution for new and existing structures. While delivering the same level of service and safety, the goal of the standard is to enable permanent reduction of power losses, better use of the electrical energy during operation, and reduced energy bills.

The standard uses a system approach to energy efficiency, guided by three main principles, each provided with technical guidance (see Figure 6).

Figure 6
Summary of principles and technical guidance for the IEC 60364-8-1 standard, illustrating the three guiding principles.



Engineering tools supporting green design

There are many software applications that help engineers with the design of electrical distribution systems. Some leading vendors are updating their design software offers to provide native support for the IEC 60364 standard. An example is [EcoStruxure Power Design - Ecodial software](#) from Schneider Electric. This solution enables engineers to more easily integrate energy efficient design into their workflow, in compliance with the standard.

Examples of various aspects of technical guidance include:

- Reduction of the wiring losses, by increasing the cross-section area of cables and by implementation of power factor correction and harmonic mitigation
- Optimal location of the HV/LV substation and switchboard by using the Bary-center method
- Determination of *meshes* or *zones* with equipment having similar energy requirements, with installation of power monitoring, communications, and energy usage analysis equipment. See also the IEC 61557-12 standard below.
- Controlling use of electricity using an energy efficiency and load management system (e.g., energy management, building automation and control). See also the EN 15232 standard below.

The standard also describes a life cycle methodology, representing a formal efficiency program of continuous-improvement (e.g., active energy management) to ensure new buildings maintain their performance and can help bring existing facilities up to present-day standards over time.

Finally, the standard provides a *point-system* method to assess the energy efficiency of an electrical installation based on the level of implementation of the measures covered in the standard (e.g., the initial installation, energy management, performance maintenance, power monitoring, etc.). This results in an overall efficiency ranking (Figure 7), helping the designer assess their own design and promote a competitive 'best-in-class' solution to clients. In turn, clients can more easily prescribe the level of design efficiency they require.

Figure 7

Point-based electrical design efficiency rankings for the IEC 60364-8-1 standard.



IEC 60364-8-1 is the only electrical distribution design standard that defines the need for tools to visualize energy usage and identify conservation measures. These capabilities offer clients multiple benefits:

- Can provide many points towards green building certifications.
- Helps determine the measurements and planning to support an energy management system compliant to the ISO 50001 standard.
- Contributes to the power and energy data requirements for Building Information Management (BIM), Building Energy Management (BEM), and building energy simulation (SIM) systems, helping further optimize building design, construction, and operations.

The extensive value of this standard has encouraged some countries to adopt it as part of their national electrical codes, with Germany being one of the first. Many more are planning adoption of the standard over the next few years.

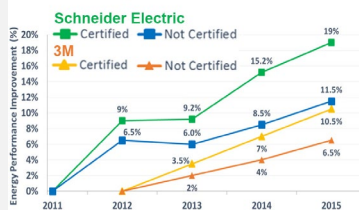
Case study 4: 3M and Schneider Electric achieve up to 65% greater energy performance

In the course of certifying a number of manufacturing facilities to the ISO 50001 standard and the Superior Energy Performance program, 3M and Schneider Electric have both proven “energy performance improvements at the certified facilities were significantly greater compared to the non-certified facilities.”

With 23 plants certified to ISO 50001, seven certified to DOE SEP, and one certified to Korean SEP, 3M “certified plants have realized savings that, on average, are 62% greater than their peer facilities.”

After certifying 20 of their North America plants, Schneider Electric has reported they have “experienced a 65% savings improvement compared to the non-certified sites over the last 4 years.”

ISO 50001 and SEP Certified Plants Outperform Peers



[U.S. Office of Energy Efficiency & Renewable Energy](#)

IEC 61557-12: Power metering and monitoring devices (PMDs)

This standard is referred to by the IEC 60364-8-1 standard. It will help the designer select the right device for any electricity cost-management application, whether the metering and monitoring functionality is in a stand-alone device or embedded in equipment such as a smart circuit breaker.

The standard covers energy measurements (e.g., active, reactive, apparent), as well as other critical electrical characteristics (e.g., power, voltage, current, power factor, frequency), and power quality measurements (e.g., harmonics, voltage dip, etc.). It also defines rated ranges of operation, and allowable measurement techniques. This broad scope differentiates it from other electricity metering standards.

Three performance classes define how well a PMD operates, in terms of accuracy, measuring range, environmental and electromagnetic conditions, and ability to provide continuous (gap free) measurement.

IEC 62974-1: Gateways, energy servers, data loggers

The standard specifies requirements for “monitoring and measuring systems used for data collection, gathering and analysis.” Specifically, energy servers, energy data loggers, data gateways and I/O data concentrators are used to transfer energy, power, temperature or other information for energy efficiency purposes.

These can be either embedded type or connected to a software application that consolidates and analyzes the data to support energy management (as per ISO 50001), energy audits (as per ISO 50002), monitoring (as per IEC 60364-8-1), or certification (e.g., LEED, BREEAM).

Similar to PMDs, this class of devices needs to be chosen based on the required level of robustness for use in sometimes harsh commercial and industrial environments. PMDs and all other communicating devices must also be cybersecurity, complying with all relevant standards (e.g., IEC 62443) for communication and system integration.

EN 15232: Impact of Building Automation, Controls, and Building Management

This standard is designed to support the EU Energy Performance of Buildings Directive (EPBD),¹³ and therefore contains relevant guidance for the design of energy efficient electrical systems.

The standard recognizes the significant impact that building automation and control systems (BACS) can have on buildings and occupants. It provides a list of all automation functions that affect energy performance, procedures for quantifying impacts, and a method to define the minimum requirements for building management systems for different types of buildings.

There are specific recommendations for performing a building energy audit, calculating BACS efficiency, and assessing financial aspects of projects using the simple payback or detailed life cycle analysis methods.

¹³ [“Overview of EN 15232...”, Build Up](#)

IEC 60364-8-2: Prosumer's low-voltage electrical installations

This standard relates to IEC 60364-8-1, focusing specifically on local production and/or storage of energy. Referred to as *prosumer's electrical installations* (PEIs), the standard provides requirements for sustainable, efficient, and safe operations when integrated into smart grids. The standard applies to new builds or retrofit applications.

OPERATIONS PHASE STANDARDS

ISO 50001: Energy management systems

Driven by the United Nations Industrial Development Organization (UNIDO), and developed in collaboration with the International Standards Organization, member countries, and the World Energy Council (WEC), the ISO 50001 standard was introduced in 2011. It is a systematic approach designed to help organizations “improve energy-related performance and energy efficiency continuously and to identify energy reduction opportunities.” As such, it provides guidelines for a comprehensive process including management buy-in, energy efficiency program reviews, improvements, verification, and further actions. It also encompasses management of all utilities, including water, air, natural gas, electricity, and steam.

Though a voluntary standard, the ISO 50001 framework has been widely adopted by many countries as a basis for policies and regulations. It has also become popular with organizations as a standard for efficient building operations, with certifications to the standard totaling approximately 22,000 in 2017.¹⁴ Most of these are within the EU. The U.S. DOE offers additional recognition for third-party verification of performance improvements, through its Superior Energy Performance 50001 program.

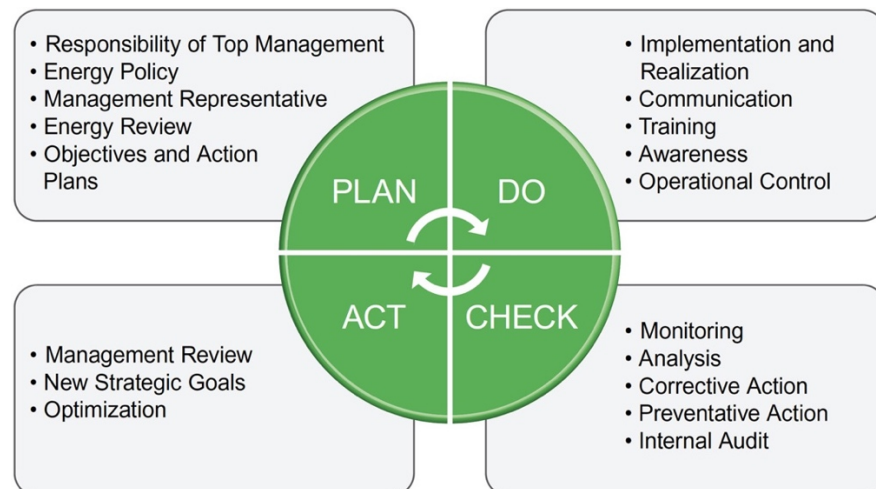


Figure 8

ISO 50001 four-step strategic framework.

ISO 50001 is similar in some ways to green building standards such as LEED, as it provides a holistic view from energy-efficient design to operations and maintenance of facilities. However, while many green building systems only set a passive requirement for an energy management system to be in place, the ISO 50001 standard defines a process of continual improvement through a Plan-Do-Check-Act framework (Figure 8).

¹⁴ [“ISO Survey”, International Standards Organization](#)

The 2018 Edition 2 revision to the standard includes the requirement for high-level leadership to be engaged, risks to be identified up front, a data collection plan to be specified earlier, and the right data to be collected, among other improvements.

Execution of an energy management system requires the appropriate metering, monitoring, and energy management technologies referred to earlier. Further useful information about measurement plans can be found in the EN 17267 standard, discussed in a later section of this paper.

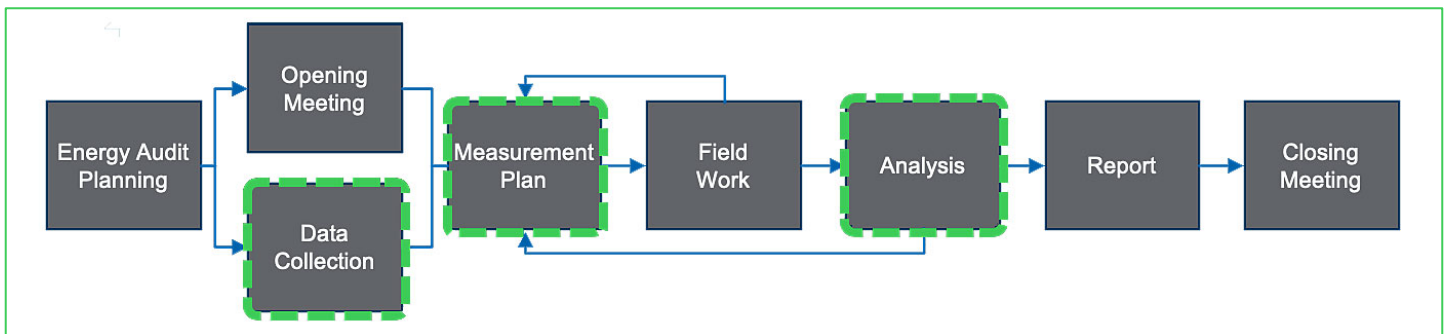
ISO 50002: Energy audits

This standard defines “the minimum set of requirements leading to the identification of opportunities for the improvement of energy performance.” Though the standard is not a requirement of the ISO 50001 standard, it describes a consistent method for energy audits that can be used as an input to the ISO 50001 ‘energy review.’

Figure 9

Energy auditing method described by the ISO 50002 standard, highlighting steps for which energy metering and analysis are required.

The method provides a detailed analysis of facility energy use, efficiency, and consumption to help identify and prioritize opportunities to reduce waste and improve energy and financial performance (Figure 9). This requires the support of an accurate energy metering and data analysis system. Consistent use of the method can support accurate benchmarking across different sites.



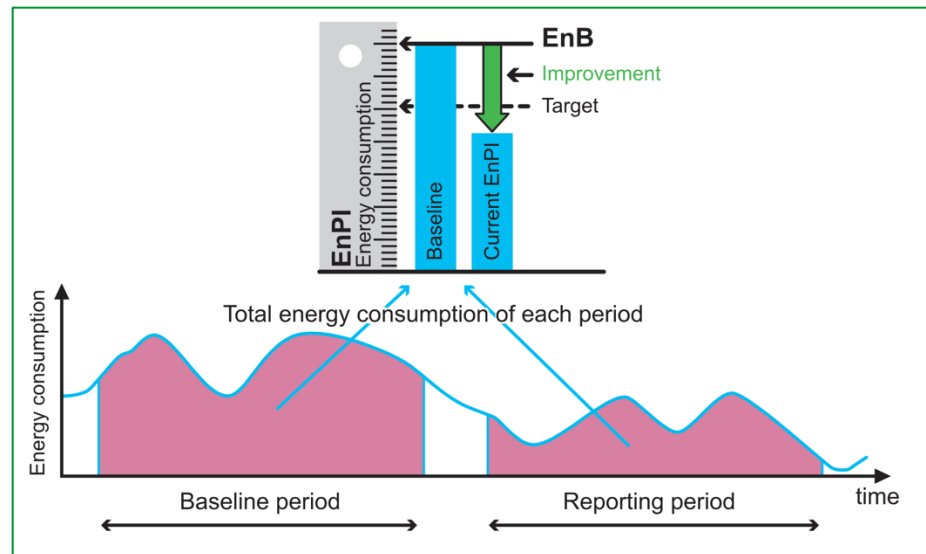
ISO 50006: Measuring energy performance using energy baselines (EnB) and energy performance indicators (EnPI)

This is another supporting standard to ISO 50001, offering much greater detail regarding establishing, using, and maintaining energy performance baselines (EnB) and indicators (EnPI). It explains how energy performance fits within the ISO 50001 Plan-Do-Check-Act cycle, defining the four types of EnPIs, and puts EnPI and EnB in context of quantifying energy performance.

The standard helps an organization define targets for energy performance as part of the energy planning process in their energy management systems. It also explains how to use normalization, calculate energy performance improvements (see Figure 10) and communicate changes, and maintain EnPIs and baselines if changes occur or adjustments are required.

Figure 10

Concept of baseline and reporting periods for quantifying results related to energy efficiency.



EN 17267: Energy measurement and monitoring plan – collection of energy data

This standard is another that is complementary to ISO 50001, helping plan for data collection. Organizations wishing to follow the ISO 50001, 50002, or 50006 guidelines often need more help regarding:

- What to measure
- How many measurement devices, what kinds, and where to install them
- How to ensure long term accuracy and repeatability
- How often to upload data
- How to budget for a measurement system

The EN 17267 standard helps answer these questions using a concrete six-stage process. It includes a pragmatic approach, allowing three levels of compliance (e.g., base, medium, high).

GREEN BUILDING AND PRODUCT LABELS

Green building labels

Green building rating systems are voluntary programs that may emerge and find success in different ways. Promotion by governments can help. As noted above, the Green Mark scheme has been adopted and strongly promoted by the Singapore government, and is now spreading throughout Asia, with approximately 71 cities in 15 countries adopting the scheme so far.

In contrast, the LEED green building rating system (the world's most widely used) emerged in the U.S. within the private sector yet has grown quickly beyond those borders. Its originator, the non-profit USGBC, reported that by the end of 2018 the LEED system had "96,275 registered and certified projects in more than 167

Examples of green building rating systems

- BEAM (Hong Kong)
- BREEAM (international)
- CASBEE (Japan)
- DGNB, Passivhaus (Germany)
- EDGE (emerging markets)
- Energy Star (US, Canada)
- Green Mark (Asia)
- Green Star (S.Africa, Australia)
- Green Globes (US, Canada)
- HQE, E+C- (France)
- LEED (international)
- Pearl (UAE)

(from WBDG.org and other sources)



countries and territories.”¹⁵ Another private sector program, the BREEAM sustainability assessment system was launched by research and advisory firm BRE Group, and now has over 2.2 million buildings registered and 565,000 certificates issued in 83 countries.¹⁶

Programs may differ between countries, with overlap in some cases, but all provide a framework that encompasses requirements for many aspects of design and construction, including guidelines and checklists. Ratings and certification levels are typically based on a point system, with credits being awarded for specific characteristics and functionality, often including *technology capable of measuring and managing all aspects of energy consumption*. Table 1 offers a comparison between the LEED and BREEAM rating systems, listing credits that the electrical design of a building will encompass.

Though a building design rating or certification process may include considerations for a building’s operation phase, not all require validation of actual performance. Rating systems such as NABERS (Australia) help measure if green design delivers expected results over the life cycle of the facility. In addition, an accurate energy measurement system will be required to provide documentation of ongoing energy consumption if required to maintain (i.e., recertify) a green building rating.

Table 1

Comparison of electrical design related credits for LEED and BREEAM green building rating

Credit	LEED	BREEAM
Zones*	X	
Usages*	X	X
DR	X	
Meshes	X	
Measurement by usages	X	X
Detection of occupancy	X	
Implementation EMS	X	X
HVAC control	X	X
Lighting control	X	X
Implementation of life cycle methodology*	X	X
Frequency of the performance verification procedure	X	X
Data management	X	X
Presence of continuous monitoring for large energy using systems	X	X
Renewable energy source	X	X
Electrical energy storage	X	X

* Encompasses all technical systems of a building, not just electrical

Product eco-labels

As described by the Whole Building Design Guide, “Green product certifications are intended to outline and confirm that a product meets a particular standard and offers an environmental benefit. Many product labels and certification programs certify products based on life-cycle parameters, making them multi-attribute programs. These parameters include energy use, recycled content, and air and water

¹⁵ [“USGBC Announces Top 10 Countries and Regions for LEED Green Building”, USGBC, 2019](#)

¹⁶ [BREEAM, USA](#)



Standards-compliant technology

emissions from manufacturing, disposal, and use. Others focus on a single attribute, such as water, energy, or chemical emissions that directly impact IEQ [indoor environmental quality].”¹⁷

As many building rating systems such as LEED and Green Globes recognize green products, and as demand for green products increase, certifications are on the rise. One of the most well-known eco-labels in North America is Energy Star, managed by the U.S. DOE, and focusing exclusively on energy efficiency. An example of a full life cycle, multi-attribute eco-label is **Green Premium**, a Type II ISO 14021 standard by Schneider Electric,¹⁸ that includes:

- Certification of minimal use of hazardous substances in, and beyond, compliance with regulations (RoHS, REACH)
- Product Environmental Profiles (PEPs) for easy carbon footprint calculation
- End-of-life instructions for reduced cost and optimized recycling

As energy efficiency standards and guidelines have emerged and evolved, leading technology providers are enhancing their solutions to comply with these requirements. Power and energy metering, monitoring, analysis, and control capabilities can be provided as separate or integrated solutions. However, each component should be chosen to comply with the relevant standards or guidelines to ensure the client can achieve their energy performance and certification goals.

Energy metering and power monitoring

The electrical designer should specify energy meters, power monitoring devices, and network devices that comply with the latest standards. This will help ensure the appropriate measurements, accuracy, and security. For example:

- Energy metering and power monitoring devices (PMD), should be compliant with the IEC 61557-12 standard, and include all measurements needed to support a facility complying with the ISO 50001 standard.
- Gateways and energy servers should be compliant with the IEC 62974-1 standard.
- For critical power facilities, including advanced power quality (PQ) monitoring and analysis capabilities should be considered. The designer should refer to the IEC 61000-4-30 and IEC 62586 standards for guidance.
- The designer should choose IoT-enabled metering, monitoring, logging, and communication devices from a manufacturer that demonstrates cybersecurity best practices during product development. Products should also provide functionality that aligns with the requirements of international cybersecurity standards such IEC 62443-4-2.

¹⁷ [“Green Building Standards and Certification Systems”, WBDG](#)

¹⁸ [“Green Premium: One label, many advantages”, Schneider Electric](#)

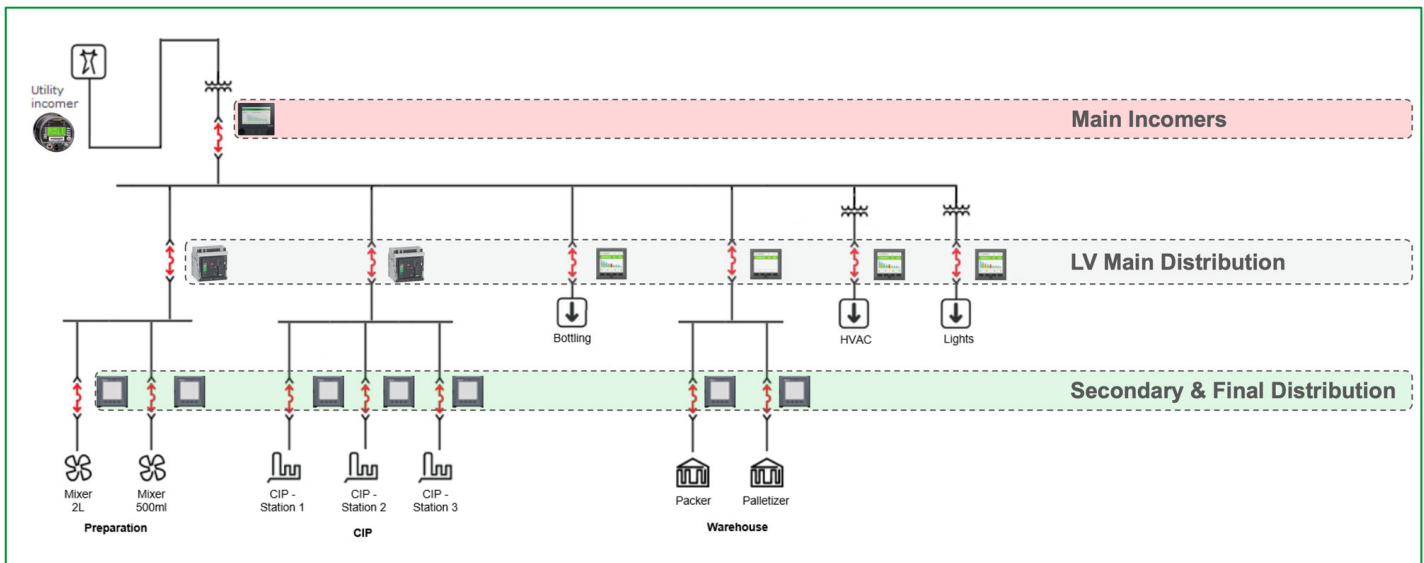


Figure 11

Examples of IEC 61557-12 compliant digital energy metering and power monitoring devices.

Software applications

To support ISO energy management guidelines and the operational requirements of green building rating systems, some manufacturers offer software applications that include all relevant energy parameters and key performance indicators. For example:

- Energy Management Systems (EnMS) should be chosen based on the ability to provide functionality and characteristics in accordance with the ISO 50001, ISO 50002, ISO 50006, EN 17267, and IEC 60364-8-1 standards. Some vendors offer applications that have been verified by certified auditors.
- Building Automation and Control Systems (BACS) – alternately referred to as Building Management Systems (BMS) or Home and Building Electronic Systems (HBES) – should be chosen based on compliance with EN 15232.

Beyond compliance with standards and rating systems, a number of considerations will determine the most appropriate choice of solution. For example:

- **Cloud-based versus locally-hosted applications.** Depending on the size of a building and the availability of in-house facility management and engineering resources, it may be more appropriate to propose cloud-hosted applications and expert services over facility-based software.
- **Fast alarming and power quality analytics.** For most large or critical power facilities, it will be important for alarm functionality to have the highest speed and reliability, and that a complete range of power, power quality, and power availability analytic capabilities be provided.
- **Microgrid control.** If the facility will include onsite energy (e.g., renewables, energy storage), a complete microgrid management system should be considered, compliant with IEC 60364-8-2.
- **Application integration.** EnMS, BACS, microgrid control, and all other building, power, and energy management systems should be as tightly integrated as possible to optimize facility-wide safety, reliability, and energy efficiency.
- **Cybersecurity compliance.** All system and component level parts of an energy management solution must be cybersecurity. Software should comply with IEC 62443-4-1 and IEC 62443-4-2 component security level 1.

Figure 12

Example of ISO 50001 compliant EnMS application software, showing energy KPI reporting.



Conclusion

As the number of buildings and their associated emissions grow worldwide, governments and industry groups continue to rally into action by introducing standards and guidelines that are driving the design and operation of green buildings. This represents a massive opportunity for design firms and engineers that are prepared to respond to clients' requests for energy-efficient electrical systems in new and retrofit applications.

To deliver the most efficient, future-proof electrical systems, the designer needs to become familiar with the most current, relevant standards and guidelines within their region, and their relationships to each other. Doing so will help a building achieve best-in-class energy efficiency and green building certification.

Integrating the necessary metering, monitoring, and analytic technology at the design stage will also support best practices in active energy management during a building's operational phase. This will help the client comply with the newest standards and environmental regulations while continuously optimizing energy efficiency, maintenance, power quality, and uptime over the entire life cycle of the building.



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Resources

Standards

-  [IEC 60364-8-2: 2018 Low-voltage electrical installations - Prosumer's low-voltage electrical installations](#)
-  [IEC 61557-12:2018 Electrical safety in low voltage distribution systems - Power metering and monitoring devices \(PMD\)](#)
-  [IEC 62974-1:2017 Monitoring and measuring systems used for data collection, gathering and analysis](#)
-  [EN 15232 Energy performance of buildings - Impact of Building Automation, Controls and Building Management](#)
-  [IEC 60364-8-2:2018 Low-voltage electrical installations - Prosumer's low-voltage electrical installations](#)
-  [ISO 50001:2018 – Energy Management System](#)
-  [ISO 50002:2014 Energy Audits](#)
-  [ISO 50006:2014 Measuring Energy Performance Using Energy Baselines \(Enb\) And Energy Performance Indicators \(Enpi\)](#)
-  [EN 17267 Energy measurement and monitoring plan for organisations - Design and implementation](#)

White papers

-  [Implementing an Energy Management System: Your Guide to ISO50001 Compliance](#)
-  [ISO 50001: Recommendations for compliance](#)
-  [Guide to using IEC 61557-12 standard to simplify the setup of an energy measurement plan](#)
-  [The Impact of Power Management on Building Performance and Energy Costs](#)