# Risk management: Commissioning electrical systems

**Commissioning electrical systems has become a study of economics and risk. Factors such as capital expenditure, age, safety, reliability, efficiency, and energy costs must be weighed in conjunction with replacement costs and liability risk to formulate and prioritize recommissioning and retro-commissioning plans.**

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### Learning objectives

- Demonstrate the importance of commissioning electrical systems as a critical part of a facility's risk management strategy.
- Discover the benefits of commissioning electrical systems, such as an increase in energy efficiency.
- Explain the relevance of codes and standards to commissioning.

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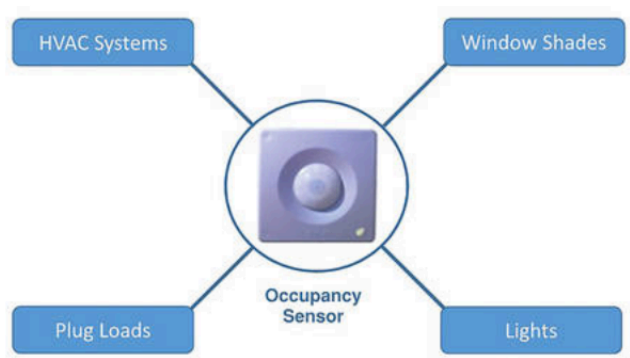
Electric power accounts for approximately 40% of the total energy used in the United States, according to the U.S. Energy Information Administration. For most buildings, electricity is the primary energy source and is the means by which interior lighting, HVAC systems, and information technology (IT) networks are able to function. The components and equipment used to distribute, monitor, and control electric power within buildings can be vast and complex, requiring interaction with many other systems. A proper commissioning strategy is essential to help ensure that electrical systems are installed correctly and are set up to operate efficiently and reliably. When performed correctly, electrical system commissioning can be a useful tool for building operators to help control utility costs, evaluate equipment replacements or upgrades, maintain continuous building operations, and ensure the health and safety of the occupants.




As building commissioning has become more prevalent, it is now widely viewed as a critical part of a facility's overall risk management strategy. The costs and risks associated with commissioning usually are minor as compared with the typical paybacks returned. Direct energy-cost savings perhaps are the most obvious examples of such paybacks. Many studies, including the most recognized report from Lawrence Berkeley National Laboratories (LBNL), show a 16% median whole-building energy savings can be realized from retro-commissioning (retro-Cx) existing buildings —commissioning performed in a building where none was previously performed. At an average cost of 30 cents/sq ft, the LBNL report found the average payback for retro-Cx to be 1.1 years. Naturally, the precise energy savings and paybacks to be expected for a building depend on a number of factors, but generally, the larger, older, or more complex facilities will experience the greatest rewards. Because electricity accounts for more than 70% of a typical building's energy consumption, commissioning of the electrical systems plays a large part in realizing these savings. To help offset the total costs associated with commissioning, most major utilities offer incentives and rebates for certain commissioning activities.

## Benefits of commissioning

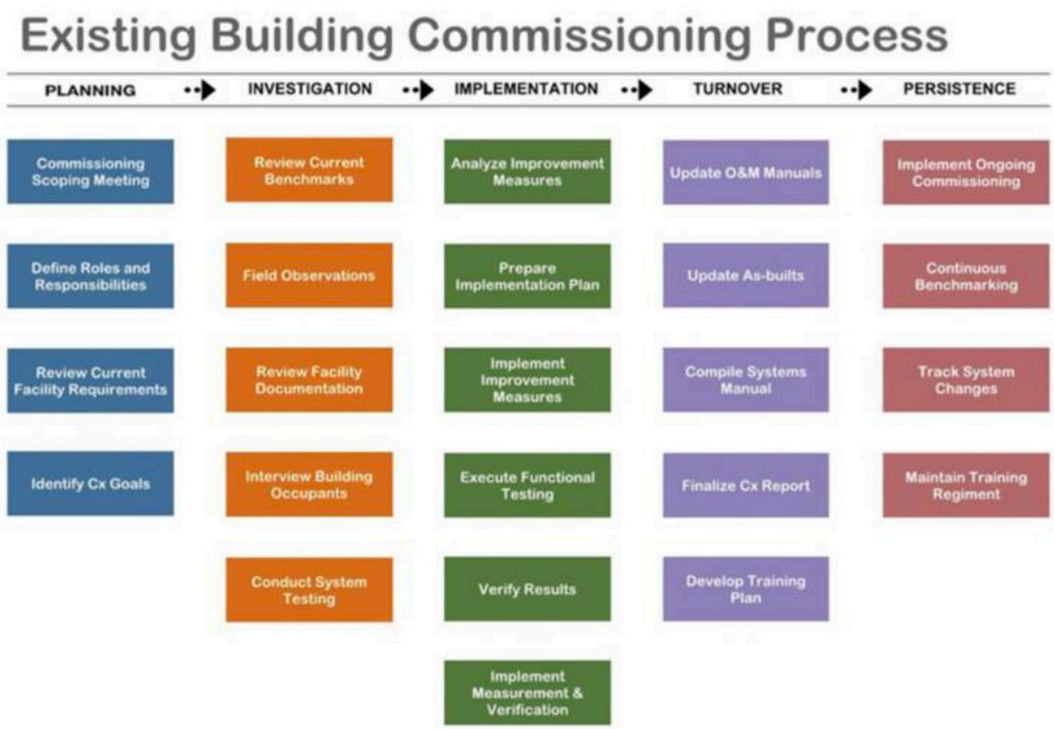


Aside from the financial benefits, there are many other reasons for commissioning electrical systems. Facilities seeking U.S. Green Building Council LEED certification must commission lighting and daylighting controls as well as any renewable energy systems as part of the certification process. In addition, the majority of energy codes and standards currently adopted by jurisdictions, such as those based on ASHRAE 90.1-2016: Energy Standard for Buildings Except Low-Rise Residential Buildings or the International Energy Conservation Code (IECC) now include similar commissioning and functional testing requirements.

While occupancy-control systems are becoming smarter—and are being designed for plug-and-play installation and setup—there still are a number of programming and adjustments necessary to fine-tune the system to ensure coordination with other devices. For example, placement of sensors for daylight harvesting and adjustment of the setpoints requires a certain amount of field coordination. Target illumination levels must be understood and the space and light levels must be measured during the initial programming to ensure the proper response. The timing also is important. Commissioning of daylight-harvesting systems should only occur after all the finishes have been installed and the furniture is placed in the room, because these components affect the light levels within the space. For these reasons, there are many well-intended energy-conservation control systems installed that may not be reaching their full potential.

Electrical commissioning offers a means to help alleviate the risks that facility managers and building owners face in dealing with complicated building systems. Commissioning is not solely a means to ensure that building systems are installed correctly and operating efficiently. It also is a systematic process to identify goals, manage testing and verification, maintain proper documentation, and ensure that the operators of the building systems are properly trained. Commissioning often is viewed as an additional set of eyes for building owners and can reduce construction changes and callbacks while providing additional quality control. Even building insurance carriers are starting to realize that buildings that have been subjected to system commissioning are safer to insure.





### Commissioning process

For best results, the process for commissioning electrical systems should begin even before a project is started. It is important for the facility to identify the goals to be achieved from commissioning. Perhaps there is a targeted risk that the facility would want to mitigate or simply an overall improvement in system efficiency and reliability. These goals must be clearly stated and defined in a document, which is often referred to as the owner's project requirements (OPR) for new construction projects or sometimes as the current facility requirements (CFR) when commissioning existing facilities. Organizations, such as ASHRAE, the AABC Commissioning Group, and the Building Commissioning Association provide guidelines and best practices outlining the framework for the commissioning process (see Figure 2).

A thorough commissioning plan must be created that includes roles and responsibilities, a description of the commissioning process activities and schedule, a list of the systems to be commissioned. The plan also identifies the necessary documentation including system verification/startup checklists (for new or replaced equipment), functional performance test reports, operation and maintenance (O&M) manuals, training materials, and so on. For larger and more complex facilities, the parties involved in the commissioning process may include more than just the obvious members, from the building owner and contractor to the electrical system designers. Because the electrical system affects nearly all other building systems, representatives from other trades, vendors, and departments may be required in the commissioning effort. Technicians for building automation controls, fire alarms, security, IT systems, elevators, generators, and paralleling gear are just some of the examples of the parties that may play a role in electrical systems commissioning.

When commissioning for certain energy-conservation goals, it is important to obtain current building system benchmarks. The further this data is broken down, the more useful it will be in identifying areas or systems to be targeted and in tracking how effective energy-conservation measures and commissioning activities are performing. Because one of the fundamental goals of commissioning is to help ensure that systems remain optimized after initial implementation, setting up energy alarms through building automation systems or electrical power monitoring systems can help facility managers actively identify problems. An example of such an alarm could be one that is set up to monitor electrical usage by building or by system against a trended maximum value. Alarms also can be established for something more specific, such as an alarm to identify locations where systems controlled by vacancy sensors are operating continuously, indicating a potential problem with an occupancy sensor or control component. Because buildings never remain in status quo, retro-Cx and recommissioning activities offer an opportunity to re-evaluate whether metering and monitoring points should be adjusted or added.

### Codes and standards

Paybacks for electrical commissioning are not always in the form of lower utility bills, but also in other sometimes unrecognized ways, such as operational reliability and risk mitigation. Because nearly everything in society is ruled by the availability of reliable power, commissioning of electrical systems is essential to ensuring a steady and reliable flow of electricity. In some cases, lives depend on it. The NFPA recognized this issue with the introduction of the Critical Operations Power Systems (COPS) chapter to the 2008 edition of NFPA 70: National Electric Code (NEC), which requires commissioning for power systems to facilities deemed essential to national security or public health and safety. Other guidelines and standards have similarly followed suit, and commissioning of emergency power systems is now required by the 2014 edition of the Facilities Guidelines Institute (FGI) Guidelines for Design and Construction of Hospital and Outpatient Facilities, to which many states already have or are in the process of adopting into building codes. In these cases, the value in commissioning is not to achieve certain energy goals, but to ensure that complicated electrical and control systems are operating appropriately.

Commissioning of electrical systems is beyond just electrical acceptance testing. While testing of electrical components in accordance with standards, such as those produced by the InterNational Electrical Testing Association, is the first step to ensuring the proper operation of electrical equipment, the intent of commissioning is to verify that all of the related electrical systems and subsystems meet the facility's objectives, intended use, and system-performance goals. It is not merely enough to know whether a circuit breaker has been verified through injection testing to operate in accordance with the manufacturer's published trip times (time-current curves), but also that the settings for the electronic trip unit are adjusted according to the approved overcurrent protective device (OCPD) coordination study (see Figure 3). This ensures that an electrical distribution system designed to be selectively coordinated is actually installed as such. For emergency power systems and feeders supplying elevators, this selective coordination of the OCPDs is essential, and required by the NEC, to ensure that an overload or fault is isolated to the first upstream protective device limiting the power interruption to other parts of the facility.



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Because some components must be disconnected to be acceptance tested, such as instrument transformers in switchgear, a thorough functional performance test of the entire system after the component has been tested and reinstalled ensures that the reconnection was done correctly. Using low-cost test switches is a simple way to electrically isolate instrument current and voltage transformers to allow for easier access to test connections and is something that could be identified from a commissioning review of the equipment shop drawings. Similarly, when new programming or firmware updates are made to programmable logic controller (PLC)-controlled equipment, a complete functional performance test should be immediately performed to verify the updates have not detrimentally affected the operation of the equipment.

Functional performance testing for electrical systems can range from the painfully simple, such as receptacle testing, to the much more elaborate, such as what is required of multiple generator paralleling systems. NFPA 110-2016: Standard for Emergency and Standby Power Systems provides the minimum requirements for the testing of emergency and standby power systems and is a good starting point. However, mission critical generator systems often are specified with redundant support systems and complicated failure sequences that must be proven. The functional performance test must account for all potential scenarios. In many cases, this will require manual intervention to simulate the failure condition. For example, power to the active pump in a redundant fuel transfer system should be turned off to ensure that the redundant pump starts automatically and maintains required fuel flow. Fuses supplying the primary PLC (or controller) in paralleling gear should be pulled to ensure automatic response of the backup controls. In addition, generators should be manually shut off to ensure proper load-shed functionality occurs to avoid bus overloads (see Figure 4).

**Existing buildings and recommissioning**

Rarely is there a building that is not renovated or modified within its lifespan. As such, even the best efforts in the initial commissioning of a system can be diminished over time as systems are modified or expanded. Recommissioning is a process for reverifying that a system is still operating as intended. In most cases, the requirements, plans, and strategies employed during the initial system commissioning can be used for the reverification process. A strategic plan for periodic recommissioning should be established, which takes into account factors including the age of equipment, how often modifications occur, and the impact to areas and processes affected by the equipment.

Commissioning of electrical systems in existing buildings present a different set of challenges. In many cases, the testing scripts for confirming a specific sequence of operation may require interruption of power. For most commercial facilities, these kinds of tests can be strategically scheduled or conducted after normal operating hours. For facilities that operate 24 hours a day, such as hospitals or data centers, these tests require much more advanced planning.

One of the most effective means for verifying the proper operation of emergency power systems is to initiate a full outage of the normal service, often referred to as a “blackout” or “drop” test. While testing individual components of a system is prudent and necessary, only by replicating the exact conditions of a utility outage can the simultaneous response of all the interrelated components and systems be observed. Conducting such a test within an occupied facility can be a daunting task. However, if properly planned, it can provide greater assurance that the systems will respond as anticipated when required. The risk in conducting such a planned test must be weighed against the risks of disruption. However, when faced with the possibilities of unknown failures that may occur during a true unplanned outage, the risk-benefit analysis should be fairly self-evident (see figure 5).

Planned outages allow building owners to make occupants aware of the event and have additional staff and support vendors onsite to address issues immediately as they occur. Spare parts can be on hand and contingency equipment, such as battery lanterns, mobile generators, and other equipment, can be made readily available. Command centers can be established with hotline phone numbers for occupants to immediately notify facility operations and testing personnel of problems or to abort the test. The scheduled outage also can help verify or improve training of responding personnel and building occupants to better prepare for a real and unplanned event.

Recommissioning and retro-Cx can not only be used to optimize the performance of building systems, but also to provide the opportunity to re-evaluate and update maintenance procedures and documentation. The process of retesting and verifying existing equipment means that old O&M manuals and installation documents must be gathered, creating the perfect opportunity to organize often neglected record storage areas or replace the documents with digitized versions. In some cases, it may even be possible to replace old O&M information that has been lost or damaged. However, to truly use commissioning as a risk management strategy, it must not be thought of as a one-time event. Ongoing electrical systems commissioning plans should be incorporated into regular preventive maintenance schedules and integrated with a buildingwide building commissioning program.

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