Optimizing Sustainability Throughout a Building's Life Cycle

By Mary Acciani, P.E., CEM

Newly constructed buildings are designed to be extremely energy efficient to meet current building and energy codes, but meeting these code requirements does not optimize the building's energy sustainability. Sustainability goals and especially energy efficiencies designed into a project can be unrealized due to changes during construction, buildings not operated as designed, occupants' behavior countering sustainability goals, and equipment/systems aging. The purpose of this article is to provide facility managers with tools to help optimize the energy efficiency of buildings over each phase of the entire life cycle: **predesign**, **design**, **construction**, **initial occupancy,** and **post-occupancy**.

OPTIMIZING SUSTAINABILITY IN EACH PHASE OF A BUILDING'S LIFE CYCLE

Predesign

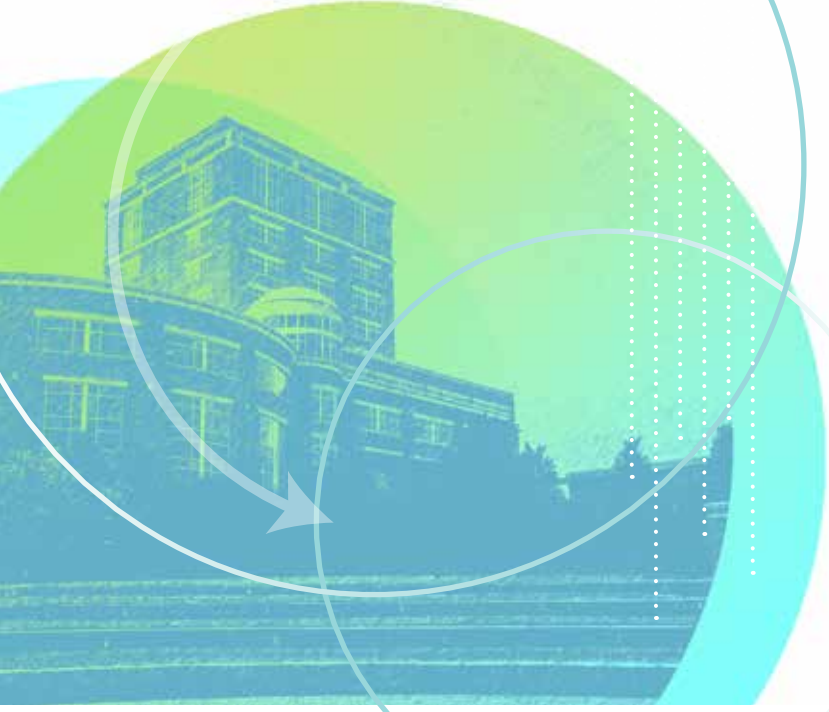
In higher education, the **predesign** phase usually starts with a need identified in an academic or strategic master plan. If the institution has one, a sustainability master plan will provide guidance on sustainability goals the building project should target. During this phase, a design team is hired comprising architects; civil, geotechnical, structural, HVAC, plumbing, fire protection, and electrical engineers; IT/AV/security specialists; and commissioning agents and energy modeling specialists. An institution's goal of making a new project sustainable can be unrealized when project execution fails to focus on what's necessary to assure that the goal is met. Below are recommendations for steps to take during the predesign phase to achieve optimal sustainability.

Create a sustainability master plan prior to beginning a new building project. If such a plan doesn't exist, having one can help guide the process toward optimization.

Set criteria for site selection. Often an institution's facility master plan will identify sites for future building construction.

Identify attributes of proposed sites to maximize sustainable options. Are sites near public transportation? Is the proposed site a greenfield site or a previously developed site? Is the proposed site large enough and oriented in such a way as to allow building orientation to be optimized? Can renewable energy, solar, or wind energy be located there or at another location on campus?

Set Goals. It's important to identify the desired level of sustainability for the project. Will it be Net Zero? Will it be LEED-certified (Leadership in Energy and Environmental Design) and if so, at what level? Will it be WELL-Building or Living-Building certified? What are the important attributes desired by the institution? If energy optimization is desired, it is critical to define measurable performance goals. Along with identifying desired certification levels, setting measurable performance goals at the beginning of the project makes it easier to evaluate options and make decisions. It's also important to identify the extent of the institution's commitment to fund sustainable options in the project. Many buildings end up less sustainable/energy efficient when the allocated budget is insufficient to cover the additional investment for desired sustainable options.



Select an experienced, sustainability-focused design team. Choose a team whose members have worked together successfully on several *sustainable* projects. Choose one in which the different disciplines respect one another and are all invested in collaboration and cooperation to achieve the optimum sustainability solution for the institution.

Design

In the **design** phase of a project, the architect and design team work with the client to develop a building that meets the institution's needs, fits into the campus, and can be built with the available budget. The design team creates a set of bidding and construction documents that define what the building looks like, how to build it and all of its systems, and what materials are to be used. During this phase, the sustainable aspects of the building project are identified and documented in the bidding and construction documents.

The design phase of a project starts optimistically, but over the course of the design process, the project can become less sustainable because of competing interests. The design phase is typically broken into subphases, which generally include programming/schematic (SD), design development (DD), 50 percent construction documents (CDs), and 100 percent CDs.

During the SD phase, the building is defined. How big is it? How many floors? What shape does it take? What does the building exterior look like? How much window area versus opaque wall area is there? What kind of HVAC systems will be used? Some suggestions for optimizing sustainability in the SD phase are offered below.

Verify concepts early on. During the early design phase, the sustainable potential of the project is identified by the design team. All projects involve a series of compromises, and it is no different with the sustainable aspects. For example, future occupants may desire more window area than what is optimal for maximizing daylighting while minimizing energy use. Or, the most energy-efficient HVAC system may cost more than the budget can handle. Early energy modeling should be used to vet the various options and provide insight and analysis to inform design choices and compromises, in order to verify that performance goals are being achieved. Life-cycle cost analysis of the various design choices should also be performed. It's essential that these choices and compromises be clearly identified and accepted by the whole team—the design team as well as the client team.

Investigate grants and rebates. It pays to investigate grants and rebates for energy-efficient systems and equipment early in the programming phase so they can be included in life-cycle cost analysis and decision making.

Choose enhanced and monitoring-based commissioning (EMBC) as well as envelope commissioning. Fundamental commissioning is necessary to make sure systems work as designed, but it is limited. A commissioning agent who is involved from the beginning of design can provide valuable insight and resources to optimize energy efficiency. In EMBC, the commissioning agent provides another set of experienced eyes reviewing the design prior to 50 percent CDs. The commissioning agent also assists with the requirements for measuring and metering, since providing adequate means to meter and monitor all energy consuming systems is one of the most valuable ways to enable optimization of the energy sustainability of a building.

When the design phase moves into the DD and CD subphases, changes can occur that reduce the overall sustainability of the project. During these subphases, the design team's focus shifts to documenting the ways and means of constructing the building—and sometimes energy efficiency takes a backseat. Strategies for continuing to optimize sustainability are given below.

Monitor goals, budgets, and value engineering. Projects typically review construction estimates after each subphase of design. Changes to the design are often made to keep the construction budget on track, and these changes can reduce project sustainability. For example, although there may be an acceptable payback for the initial investment in an energy-efficient HVAC system, sometimes there is simply not enough funding in the budget, and more expensive energy-efficient options are "value engineered" out of the project.

In order to verify that desired performance goals will be achieved, require an energy model after each subphase of design and for any value-engineering recommendations. Include a review of value-engineering options by the EMBC commissioning agent. Staying informed throughout the project allows the opportunity to make decisions to optimize sustainable aspects. Instead of value engineering to a cheaper HVAC system, an institution may prefer less-expensive finishes. Once a project reaches the final subphase of design, it

is often too late to reverse earlier value-engineering decisions without incurring additional design fees and extending the project schedule.

Review specifications. Make sure that the specifications are written to limit substitution of material and equipment, and that they require the contractor to provide thorough proof that substitutions are equal in every way, including all sustainable/energy-efficiency aspects.

All photos provided by AKF.

Assemble a team with experience working together and who share the desire to achieve optimum solutions.

Construction

After the construction documents are completed, the project is put out to bid and awarded to a contractor or construction manager. During the **construction** phase, there are many times when the sustainable aspects of the project become endangered. If the bids are overbudget, the project often undergoes value engineering, and sustainable aspects are at risk. Contractors often attempt to substitute less-sustainable items for those specified in the construction documents. During construction, installation of systems may not be as designed, which can negatively impact energy efficiency. Below are some strategies to help assure the finished building is as sustainable as it was designed.

Monitor budgets, substitution requests, and value engineering during bidding. Even if bids come in at or under budget, contractors sometimes suggest value-engineering alternates or request substitutions of specified items. To assure that the desired performance goals are achieved, it's important to stay involved and proactively require bidders to provide the energy impact of all suggested value-engineering/substitution recommendations. In the bid documents, require bidders to engage and pay for the design-team energy modeler to prepare new energy models reflective of any value-engineering/substitution suggestions.

Monitor contractor substitutions during construction. Substitution of specified equipment and material is common in construction projects. Contractors will claim they are unable to procure the specified equipment or that they cannot get it in time to meet the schedule. Sometimes they will submit substituted equipment with the hope that it will be approved as an equal. Rarely do they provide the owner with a reduction in the contract cost even if the substituted equipment is less expensive than what was specified. The design professionals should be fully engaged to review equipment submittals to assure that what is provided is equal in all respects to what was specified. With EMBC, the commissioning agent will review contractor submittals and provide yet another set of eyes.

Commission all systems. In addition to commissioning HVAC systems, domestic water heating systems, lighting, daylighting, and renewable energy systems provide for commissioning of electrical service and distribution as well as the building envelope. All of these contribute to the overall efficiency of the building, and commissioning can verify that they perform as designed.

Verify the contractor provides thorough training for facilities operations staff. The systems in a highly sustainable building are complicated and often on the leading edge of innovation. It is important for facilities staff to understand the systems, how they operate, and how to maintain them to keep them at peak efficiency. Contractors sometimes provide only rudimentary training. With EMBC, the commissioning agent develops a systems manual and verifies that the appropriate training is provided by the contractors. Videotaping the training sessions is a good way to keep the information available so as to refresh the knowledge of current staff or train new staff.

Initial Occupancy

Once the building is completed, commissioned, and has received a certificate of occupancy from the code official, the **initial occupancy** phase begins.

The initial occupancy period of a building can be challenging. Occupants are learning to adjust to new surroundings with features they may not have encountered before. Building operators are learning to work with complicated systems with which they may not have experience. Behaviors of both occupants and building operators can have negative consequences for the building's energy efficiency. Strategies to help optimize sustainability through this phase are listed below.

Educate occupants and building operators. Consider having the project design team conduct educational workshops to present the salient green features of the building. This will help occupants and operators understand the purpose behind the various systems' design features. Also, be sure to provide a building user's guide.

Engage occupants. Consider including a dashboard system to display monitored and tracked energy consumption in order to provide feedback to occupants.

Engage building operators with enhanced and monitoring-based commissioning. With EMBC, the commissioning agent conducts a review of building operations 10 months after substantial completion. The performance of energy- and water-consuming systems are monitored to determine energy and water use profiles that can help uncover conflicts between systems and out-of-sequence operation of system components.

Analysis of monitored systems is made at least quarterly in the first year of occupancy. An action plan is developed for identifying and correcting operational errors and deficiencies to achieve performance goals identified for the project. Training is provided to prevent errors, and a plan is developed for repairs needed to maintain performance.

Post-Occupancy

Once the first year of occupancy is through, optimization of the sustainable aspects of the building depends on the systems continuing to operate at the most efficient point as they age. Strategies to achieve **post-occupancy** optimization follow.

Millersville University's completed Lombardo Welcome Center.

Provide diligent maintenance. The importance of diligent maintenance can't be overstated. Performing preventive maintenance keeps equipment and systems operating at like-new efficiencies. Neglecting preventive maintenance to save time or money can create a domino effect, reducing system efficiencies. For example, neglecting timely changing of air-handling-unit filters results in dirty filters. These dirty filters obstruct airflow, with the result that fans must use more energy to overcome the obstruction. If the filters are extremely dirty, the fans may not be able to provide enough air, potentially resulting in poor temperature control and complaining occupants. This leads to issues addressed by the next strategy.

Operate the building according to the designed sequence of operations. Building operators sometimes make changes to how buildings are operated based on their own preferences or as a result of complaining occupants. Making changes to the operating sequences will negatively affect the building's energy efficiency. If occupants are suddenly complaining and the building is past the initial occupancy phase, it's likely due to systems not behaving as designed because they need maintenance or repair.

Conduct energy audits on aging buildings. After a building has been operating for 10 years or more, its systems are no longer state-of-the-art. Conducting energy audits on these buildings can identify worthwhile energy conservation measures (ECMs) with attractive payback periods. Implementing these ECMs will improve the energy sustainability of the building.

Retrocommission aging buildings. As buildings age, components and systems can develop problems and not perform optimally. Retrocommissioning can fine-tune existing systems to make them operate more efficiently.

CONCLUSION

As the saying goes, "The devil is in the details." And so it is with building sustainability. The strategies described above will help address those devilish details and optimize sustainability throughout a building's life cycle.

Mary Acciani is a professional engineer at AKF Group Engineers, Hamilton, NJ; she can be reached at *macciani@akfgroup.com*. This is her first article for *Facilities Manager* and was adapted from her presentation at the 2018 Conference of the Association for the Advancement of Sustainability in Higher Education.