

# **ACHIEVING A HIGH PERFORMANCE FACILITY: THE IMPACT OF THE ENERGY MANAGER IN NEW CONSTRUCTION**

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## **ABSTRACT**

We typically see the role of energy manager as operating existing buildings for efficiency and monitoring energy usage. However, they have a critical part to play in new construction projects as well. In fact, the energy manager's responsibilities begin prior to the design phase, long before any construction actually takes place.

Pre-construction activities include selection of A&E firms and development and application of design criteria. Initially, energy managers should ensure that firms acquainted with the latest energy codes and energy-saving techniques and technologies are selected. Design guidelines must be in place for choosing the proper building envelope materials and mechanical and electrical systems equipment. Windows, insulation, lighting, HVAC, and controls can all greatly impact a building's energy efficiency. An often overlooked but key item is the early selection of a professional, reputable test and balance consultant for mechanical systems. Energy managers should also arrange to attend plan and specification reviews to provide input and to assess the documents' compliance with the Owner's standards.

After plans and specifications are complete and construction begins, the energy manager's duties do not end. They should monitor job site activities regularly, personally or via a representative. Working along with the Engineer, the energy manager is the Owner's eyes and ears regarding energy and indoor air quality, and to some extent maintainability and serviceability. All of these facets must be seen as they relate to each other. Energy managers must also understand the impact of late-night, last minute decisions on project costs, constructability, and schedule. Toward the end of construction, they should be involved in building commissioning to ensure that components and equipment are installed and operating properly.

To have a successful role in building construction, the energy manager must possess certain qualities and skills. They need to be team players and good communicators. Both oral and written communication is essential to achieving a quality end product that follows the original design intent. By being actively involved from building concept to occupancy, the energy manager can make a great contribution to ensure a successful construction project.

## **EXISTING FACILITIES**

### **The Energy Manager**

The familiar functions of the energy manager generally relate to economic operation of existing buildings. On the whole, their responsibilities typically include energy management plans, energy usage tracking and analysis, and energy procurement. Compiling historical data and promoting energy conservation and awareness comprise much of their time.

The energy manager should possess at least some technical expertise to make informed decisions regarding energy options, be a good communicator, and have a willingness to be a team player with colleagues, architects, engineers, manufacturers, and suppliers. Non-abrasive, enthusiastic, and energetic are desirable personality traits in an energy manager. Specific experience and qualifications often listed in the job description of an energy manager are a degree in engineering or business, familiarity with building systems, and knowledge of budget development. As an energy manager interacts with various groups of people on a regular basis, the ability to communicate well is essential. For example, in a school district an energy manager may need to relate the district's energy policy to teachers, attend meetings with administrators, and make presentations to the school board. During construction they will interface with architects, engineers, and contractors.

An energy manager should be familiar with building codes and standards, especially the ones that apply to and have an impact on energy efficiency. The most common of these are the *International Energy Conservation Code (IECC)* and *ASHRAE 90.1 (Energy Standard for Buildings Except Low-Rise Residential Buildings)*. These references give requirements for envelope design, mechanical systems, lighting systems to promote energy conservation and efficiency. Seeing the impact of building and energy codes first hand, energy managers can provide meaningful feedback in the code development process. In fact, some have become advocates for changing code requirements that result in excessive construction or operating costs.

### **Related Issues**

Energy management in facilities is not a stand-alone matter. It affects and is affected by other building issues. As examples, improperly sized, installed, or maintained air conditioning equipment can adversely impact indoor air quality (IAQ) as well as energy efficiency. For instance, units that are too large do not adequately remove moisture from the air, leaving the indoor environment uncomfortably humid. These oversized units also use more energy than a properly sized unit. Also, air conditioning systems with improperly sized or missing filters or leaky ductwork can contribute to poor indoor air quality and inefficient operation.

Carrollton-Farmers Branch ISD near Dallas, Texas has implemented a program called TEAMS – Tools for Schools (an indoor air quality program produced by the Environmental Protection Agency), Energy, Asbestos, Moisture Management, and Safety. This concept recognizes the interrelation of all of these issues. For instance, an exterior door left propped open contributes to poor indoor air quality, energy inefficiency, increased moisture, potential pest infestation, and compromised building safety. A group, with members responsible for each of the TEAMS areas, meets periodically to discuss relevant issues. Meetings are typically held at a different District facility each time to acquaint everyone with the program.

### **NEW CONSTRUCTION**

In addition to their customary tasks associated with energy conservation, energy managers also have an important part to play during construction of new facilities. In order to realize the goal of an energy-efficient facility, a designated representative must champion the cause. The energy manager is the plausible one to fill this role.

#### **Pre-design**

The energy manager's role in new construction starts before actual project design. During this pre-design phase, decisions made based on input from the energy manager can have lasting consequences. If they are not already

established, the energy manager should develop or assist in developing guidelines for a variety of construction related issues, including: architect/engineer team selection, equipment specifications, commissioning, and other design guidelines and criteria.

To achieve an energy efficient facility, energy efficiency must be established as a project goal. To this end, an appropriate architect and engineering team must be selected. Firms with experience in energy-efficient design and construction methods are needed. They should, for instance, understand the use and potential impact of building configuration and orientation, daylighting, natural ventilation, high-efficiency mechanical equipment and lighting installations, and renewable/alternative energy sources (e.g. wind, solar, fuel cells). Qualified architects and engineers are essential for a successful energy-efficient project. If there is not sufficient in-house experience, hiring an energy consultant to aid in the selection process should be considered.

As previously noted the IECC and ASHRAE Standard 90.1 set a certain level of energy efficiency for buildings. However, facilities can potentially be made more efficient by going above and beyond these standards. Options for architectural building materials (e.g. windows and insulation), mechanical equipment (e.g. chillers, condensing units, pumps), and lighting (lamps, ballasts) should be evaluated. Specifications must then be developed for these items. Guidelines for efficiency, standardization, operation, and maintenance will be needed.

Materials and equipment that are energy efficient often have higher first costs. Since most construction projects must fall within budget constraints, some highly desirable options are often not included in the final product. Therefore, to prepare for the proverbial budget ax, alternatives should be prioritized. Ideally, prioritization should be based on life cycle costs (the total of first costs and lifetime operating costs); however, this is often not the reality. Routinely, cuts are made based on initial costs only. Prioritizing available options will improve the chances that preferred alternatives are included in the finished product.

An HVAC test and balance (T&B) contractor should be chosen during this phase. Choosing a reputable, experienced firm is important, as proper tuning of mechanical systems leads to better and more efficient operation. While often made later, in the course of the bid process, their early selection carries decided benefits. First, the T&B contractor can be more carefully chosen. A firm used because of their low bid or selection by the mechanical contractor may not necessarily be the best choice or provide the best services. Second, by choosing a contractor before design, their input can be sought

throughout the project. The Engineer along with the energy manager should meet with the T&B contractor soon after their selection to discuss and coordinate requirements and expectations. A representative from the Engineer will conduct progress meetings with the T&B contractor periodically throughout the project.

**Design**



During the design phase, the energy manager must work to ensure that the standards, guidelines, and criteria previously developed are actually included in the building design. They may accomplish this in several ways. First, they can attend design coordination meetings. These sessions usually involve representatives from various departments within the (Owner’s) organization. The purpose of such meetings is to exchange ideas and make sure everyone is “on the same page”. Second, the energy manager should work closely with representatives from the architectural and engineering firms, ensuring that they are aware of and are incorporating the Owner’s requirements in their design. Finally, the energy manager should review plan drawings and specifications before they go out for bids to verify that all applicable materials, equipment, and design elements have been included. Changes are much easier and less costly to implement at this stage than after equipment has been bid, ordered, or even worse, installed. In other words, the opportunities to achieve a high performance (meeting energy and environmental performance criteria, among other characteristics) facility decrease as time passes. This concept becomes more notable when shown graphically as in Figure 1.

During this time sequences of operation for mechanical systems should also be developed. Experience reveals that this is a much more successful approach than waiting until the last minute or just allowing the contractor on the job to do it.

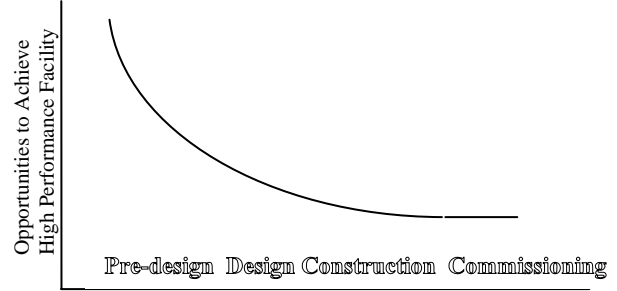


FIGURE 1.

**Construction**

The energy manager’s role does not end when construction begins. Their task during this phase is to ensure that the materials and equipment installed and the techniques used, which relate to and/or effect energy efficiency, meet the intent of the drawings and specifications issued. To do this the energy manager may review applicable vendor submittals. Walking through the new facilities, conducting visual assessments of the work completed, is a means to verify that the equipment approved via submittals is actually installed. Items potentially affecting the new building’s energy efficiency and related issues such as IAQ, maintainability, and serviceability should be the scope of the energy manager’s inspections. Periodically attending construction meetings is another way the Energy Manager can remain involved during this period. At these sessions they can ask questions about concerns observed during walk-throughs. Construction meetings also present an opportunity to learn about other issues which may be of concern. Where it is impractical for an energy manager to visit the site personally, they may delegate this responsibility by providing checklists to a representative within the organization or utilizing the engineering firm.



At times hasty decisions are made by the Owner or Construction Manager in an attempt to meet construction deadlines or budget targets. Energy-efficient systems, methods, or components may be sacrificed to one of these ends. The energy manager must understand the impact of these often last-minute or late-night decisions. He or she

should point out the potential consequences of such choices, noting that dollars saved in first costs may mean increased operating or maintenance expenditures, decreased serviceability, or poor indoor environmental conditions later.

### **Post-construction**

The post-construction phase, after the work is largely complete, begins the balance of the commissioning work. The energy manager may want to witness some of the functional testing to verify that specified procedures are followed. Observing testing also allows the energy manager to become aware of any deficiencies or problems early on, instead of having to wait for the formal reports. Again, this responsibility may be delegated where it is impractical for the energy manager to visit the site in person.

### **Post-acceptance**

Even after acceptance of the work and building occupancy, systems should be monitored for proper performance. The Energy Manager should compare actual energy expenses with estimates. Significant differences between these figures may sometimes be attributed to defective equipment or incorrectly installed or adjusted systems. Incorrectly operated equipment is also a potential cause of higher than expected costs. Investigations by the energy manager, sometimes aided by manufacturer's representatives, outside consultants, and in-house maintenance personnel can usually reveal the causes of excessive costs.

## **AFTER THE BUILDING IS COMPLETE: APPLYING THE PSYCHOLOGY OF ENERGY MANAGEMENT**

The opening of a new facility or the remodeling of an existing one may be a good time to implement changes in energy management strategies. However, these kinds of changes may involve some form of behavior modification. Choosing the proper approach and appropriate amount of change can lead to more likelihood of success.

Several levels of behavioral approaches are available to implement increasing amounts of change within a district's organization. In brief, these approaches, in order of increasing complexity, are:

- "Head in the Sand" – Doing nothing, keeping things basically as they are
- "Casper" – Acting directly, often without people's knowledge, without requiring a change in their thinking or behavior (e.g. replacing all lighting with more energy efficient lamps during summer break)
- Soft Shoe" – Implementing changes that require more personnel involvement and modification of attitudes and practices (e.g. moving all after

school activities to only one or two evenings a week)

- "Brain Surgery" – Transforming a group's entire culture and promoting individual responsibility for energy waste and management

Remember that the energy manager cannot motivate others to join the effort, nor can others motivate the energy manager. Motivation comes from within an individual. One doesn't have the power to motivate others, but may have a great deal of influence to help them motivate themselves. People need role models. Make wise choices, honor commitments, and focus on hardware, people, and procurement.

## **COMMISSIONING**

Although often thought of only in terms of functional testing, commissioning encompasses a broader scope. It is essentially a systematic process of documenting that all systems perform according to the design intent and the Owner's operational needs. While startup, testing, balancing, and calibration are the core elements of commissioning, other activities such as design review, documentation, and training are crucial supporting elements. (These latter facets are discussed in greater detail elsewhere in this paper.) The point of commissioning is to enhance quality assurance and improve the likelihood that newly installed building systems will perform as desired. Typically, fire alarm, communications, mechanical, and plumbing systems are included in the commissioning process. Of the several types of systems that may be incorporated in the commissioning process, mechanical systems would be of the most concern to the Energy manager.



Some of the steps in the commissioning process, sorted by project phase, are as follows:

- Pre-design phase

- Develop design goals and concepts
- Design phase
  - Incorporate design concepts into construction documents
- Construction phase
  - Review submittals
  - Conduct site visits
  - Oversee startup and functional testing
- Post-construction phase
  - Observe and verify proper functioning of equipment, systems, and controls
  - Staff training
- Post-acceptance phase
  - Continue to ensure proper functioning of systems
  -

The Contractor may offer some rudimentary testing in their bid. Engineer's standard specifications will generally include at least some commissioning activities. However, requirements for further functional testing, if required, should be forwarded to the Engineer for inclusion in the bid specifications.



The benefits of commissioning are manifold. Frequently mentioned and of greatest interest to the Energy manager, is its energy-related aspect. Commissioning can help ensure that energy savings expected from the design intent will be realized. Other advantages include efficient and proper equipment operation, improved IAQ, and reduced operation and maintenance costs. Some consequences of not commissioning include improper system operation, increased post-occupancy corrections, unacceptable indoor environment, and decreased energy efficiency.

The results of a study from a 1994 study by the Lawrence Berkeley National Laboratory of newly constructed commercial buildings found that:

- 50% had control problems
- 40% had malfunctioning HVAC
- 33% had sensors not operating properly
- 15% had equipment shown on the plans missing
- 25% had EMCS, economizers, or variable speed drives not running properly

There is no guarantee that building systems will operate as designed or planned 100% of the time. However, a well planned and implemented commissioning process can greatly improve the probability that the design intent will be met, and that newly completed facilities will function properly.

Commissioning confirms that building systems are properly functioning at the time the commissioning process occurs. To maintain a high level of performance, recommissioning is often recommended every few years. The age, usage, types, and complexities of systems will determine the actual interval.

Staff training, as previously mentioned, is another important element of commissioning. This process generally begins as construction is completed. Training is comprised of two areas: operating and maintenance. Employees who will be using or running various systems should be given instructions on how to do this properly. They should understand the energy-saving features that are installed and how to use them correctly. Similarly, those who are expected to maintain and repair equipment need to know correct procedures for doing so. Equipment that is properly maintained lasts longer, is more reliable, and tends to operate more efficiently. Training should be provided by qualified manufacturer's representatives. The bid specifications should spell out the requirements. Ideally, training should be an ongoing process, not just during building commissioning.

## **SURVEY**

### **Results**

Estes, McClure & Associates, Inc., Engineering and Consulting, conducted a survey by sending a short questionnaire to approximately 56 energy managers in Texas school districts, colleges, and universities. Twenty-two surveys were completed and returned. The questions dealt mainly with how energy managers believed that they could influence energy efficiency and related issues during the building construction process.

In one question respondents were asked to rate the importance of the following actions (on a scale from 1-5, with 5 indicating high importance) to an energy manager as they relate to new construction:

<u>Actions</u>	<u>Mean of Responses</u>
Selection of architectural firm	3.5
Selection of engineering firm	4.0
Development of design criteria for energy efficiency	4.7
Standardization of controls and equipment	4.7
Attendance at design meetings	4.3
Review of drawings	4.3
Review of specifications	4.3
Observations during construction	4.3
Participation in commissioning	4.3
Selection of energy provider	4.1
Selection of contractors/subcontractors	3.4

In another question, participants were asked to rank 10 potential measures (1-10, with 1 being most important) used for selection of energy saving equipment and materials:

<u>Measures</u>	<u>Aggregate Ranking</u>
Performance	1
Future energy savings	2
Life cycle cost	3
Maintenance cost	4
Standardization	5
Payback period	6
Initial cost	7
Rebates/incentives	8
Low environmental impact	9
LEED certification	10*

\*While LEED (Leadership in Energy & Environmental Design) does not certify materials or equipment, points toward LEED certification are earned for the use of certain energy conserving and environmentally friendly measures.

Another question dealt with energy efficiency during the design phase. Specifically, respondents were asked to rank four components of energy efficient design (1-4, with 1 being most important).

<u>Components</u>	<u>Aggregate Ranking</u>
Building envelope	1
Controls (EMCS, etc.)	2
HVAC alternatives	3
Energy efficient lighting	4

### Lessons Learned

Energy managers surveyed were also asked to comment, based on their past experience, on various aspects of the construction process. Some of the questions with the most common responses received:

What top 3 criteria do you consider important in the selection of an Architectural and Engineering firm?

- Past working relationship
- Experience
- Level of expertise
- Reputation
- Knowledge of codes
- Familiarity with latest technologies
- Cost/fees
- Working with the Owner

What items are important for an energy manager to observe during construction?

- Installation of HVAC equipment and ductwork
- Adherence to specifications
- Building envelope
- Controls locations
- Controls sequencing
- Verification of installation with design
- Moisture control
- Commissioning
- System efficiencies
- Lighting

What one action can an energy manager take during the construction process that will have the greatest impact on the project's success?

- HVAC selection
- Emphasizing energy efficiency during design
- Participating as a team member
- Ensuring users know how to properly operate systems
- Selection of Engineer
- Visit the construction site regularly

If you could ask the General Contractor to do five things during construction for energy efficiency, what would they be?

- Adhere to specifications
- Turn off unnecessary equipment
- Do not run HVAC unnecessarily
- Properly prepare building envelope
- Have adequate supervision and inspection
- Follow building design
- Communicate with the Owner and design team
- Be proactive
- Provide reports/conduct walkthroughs

Overall, in their responses, the Energy managers responding to the survey emphasized proper installation of HVAC system equipment and components, adherence to

plans and specifications during construction, good design and construction team communications, and monitoring of construction.

### **STATE ENERGY CONSERVATION OFFICE**

The Texas State Energy Conservation Office, a division of the Comptroller of Public Accounts, administers a variety of programs aimed at maximizing energy efficiency. One of the curricula offered is the Energy Management Training Program for schools and local governments. Workshops provide technical and administrative training for energy managers, business officials, and building operators in the areas of energy saving technologies and techniques as well as utility issues.

### **CONCLUSIONS**

The Energy manager has a role to play in the construction process. From pre-design through post-construction, decisions they make and actions they take can impact a building's energy efficiency, maintainability, serviceability, and indoor air quality.

In the pre-design phase, the selection of an Architect and Engineer with experience in energy-efficient design is important. In hot and humid climates the building shell, lighting, and HVAC are typically responsible for 10-20%, 25%, and 55-65%, respectively, of a building's energy consumption. Therefore, specification of materials and equipment to enhance the energy efficiency of each of these systems is essential in the design phase.

During construction the monitoring of installation methods and contractors' practices is critical to ensure that the energy-efficient design intent is carried out. Proper testing, commissioning, and training are the last steps in achieving a high performance building.

The key is to keep the main thing the main thing. Becoming distracted by issues not related to energy efficiency along the way is sometimes easy. However, the energy manager must remain focused on their role in the construction process. With their experience, knowledge, effective communication, influence, and expertise in energy-efficient design and operation, energy managers can play a valuable role in each of the steps involved in new construction.

### **BIOGRAPHIES**

James D. McClure, P.E., President of Estes, McClure & Associates, Inc., has extensive experience that includes energy efficiency, master planning, and sustainability. Estes, McClure & Associates, Inc. was selected as Engineering Firm of the Year in 1999 by PM Engineer after national competition. The 30 year-old engineering firm with 43 employees has provided energy efficient services including energy efficient designs for more than

575 Texas ISDs, 47 colleges and universities, and other facilities. McClure served on the U.S. Department of Energy's Energy Smart Schools Round Table in 2000. In addition, he has served on Texas A&M University's planning committee to the Symposium on Improving Building Systems in Hot and Humid Climates for 19 years and is serving on the Texas Engineers Task Force for Homeland Security and the University of Texas at Tyler College of Engineering Executive Advisory Board. McClure has been a co-presenter for numerous workshops including Energy Efficiency for Public Facilities as sponsored by the Texas State Energy Conservation Office with funding from the Department of Energy. Estes, McClure & Associates, Inc. provided mechanical, electrical, and plumbing engineering services, energy consulting, rainwater collection systems, and sustainability for four sustainable elementary schools in McKinney ISD.

David Fisher, P.E. holds a B.S.E.E. from Southern Methodist University. He has held various positions in the electric utility industry and private engineering practice. At Estes, McClure & Associates., Inc., Fisher works as a research engineer and consultant. This work has been for schools and colleges. He has prepared and assisted in presenting workshops for school personnel on energy efficiency, including renewable energy. In 2003 he completed a large campus study for integrating renewable technologies such as wind, solar, fuel cells, etc.

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