EMP
ENERGY MANAGEMENT
PROFESSIONAL

EMA Energy Management Guideline

A Comprehensive Process for Energy Management & Enhanced Building Performance

ENERGY MANAGEMENT ASSOCIATION

EMA ENERGY MANAGEMENT GUIDELINE

A Comprehensive Process for Energy Management and Enhanced Building Performance

Revised April 2014

A ACKNOWLEDGEMENTS

The *Energy Management Guideline* would not have been possible without the dedication, hard work, and expertise of many individuals. The Energy Management Committee, chaired by Andy Heitman, worked tirelessly over three years to craft a new and innovative process to address energy management in a context similar to building commissioning.

The first edition of this guideline was published by the AABC Commissioning Group (ACG) in 2012. In 2014, the Energy Management Association (EMA) was founded as a subsidiary nonprofit organization, and will administer the EMP designation to individuals with energy-related experience.

EMA would also like to thank the team at Sieben Energy Associates (SEA), based in Chicago, Illinois, for their considerable efforts in support of writing, editing and designing the final document. The SEA team was led by Dan Bailey, Director of Strategic Services, under the guidance of Craig Sieben, President of the company.

Energy Management Committee

Andy Heitman
Jim Magee
Dan Acri
Santanu Nath
Steve Leight
Phil Pickett
Bill Thomas
Bill Schlageter
Brian Green
Mark Leafstedt

Sieben Energy Associates

Craig Sieben
Dan Bailey
Liz Brady
Mike Kuk
Phil Keuhn
Chris Bibby
Jerry Burin
Brooke Ousterhout
Chris Philbrick
Syed Suhail

Executive Staff

Ken Sufka, AABC Executive Director
Ray Bert, ACG Executive Director

ENERGY MANAGEMENT ASSOCIATION

1518 K Street, N.W., Suite 503
Washington, DC 20005
(202) 737-1334
energymanagementassociation.org

T TABLE OF CONTENTS

I INTRODUCTION

According to the U.S. Department of Energy, residential and commercial buildings in this country account for approximately 40% of primary energy use and 70% of electricity use. Buildings use more energy than any other major sector, including the industrial or transportation sectors. Therefore, expanding and improving energy efficiency in existing buildings represents one of the most cost-effective ways to reduce energy use in the United States.

Effective energy management involves identifying and understanding where and why energy is used in a facility and using that information to measure, manage, and minimize energy consumption while meeting performance standards. The *EMA Energy Management Guideline* details the process by which an energy management professional (EMP) works closely with a client and other members of the project team to develop strategies to achieve energy-related goals, improve energy efficiency, and optimize building performance.

The EMA Energy Management Program is unique within the industry. The program applies energy management skills and knowledge to the commissioning methodology. The commissioning-based process follows a data-driven approach, provides all-inclusive service, and leverages the independence of the EMP to improve energy efficiency while optimizing performance.

The scope of the EMA Energy Management Process, and the EMP's expertise, extends far beyond a single energy audit or energy efficiency exercise. The process incorporates multiple disciplines that together create a holistic approach to each individual project. This level of detail and attention enables the EMP to address and achieve each client's specific goals and building performance requirements.

The EMA Energy Management Process combines commissioning, energy management, and testing, adjusting, and balancing (TAB). In general, commissioning and TAB services provide the site-based data that supports detailed analysis and project planning.

EMA Energy Management Program

The EMA Energy Management Program consists of three components:

1. *EMA Energy Management Guideline*
2. Training and Education
3. Certification

The *Guideline* describes a systematic process for achieving maximum efficiency while ensuring optimal building performance. It is intended for use by building owners and managers, design professionals, commissioning authorities, and energy management practitioners.

EMP certification is available to individuals with three years of energy-related experience. Candidates are expected to review the *Guideline* in advance of taking the certification exam. EMA will provide educational opportunities for prospective and current EMPs that reinforce and expand on the EMA Energy Management Process described in the *Guideline*.

EMP certification recognizes those consultants who possess the technical, management, and interpersonal skills to effectively facilitate the EMA Energy Management Program. Certified EMPs will have demonstrated these skills through both experience and education. EMPs possess a comprehensive knowledge base and the professionalism to guide a client and project team towards efficient building operations and related performance and sustainability goals.

The components of the EMA Energy Management Program are tied together by four core principles:

- **Commissioning-Based Process**
  The program is unique within the industry because of its emphasis on energy management within a commissioning framework. Elements of both existing building commissioning (EBCx) and testing, adjusting, and balancing (TAB) are referenced within virtually all steps of the EMA Energy Management Process. The EMP will be involved to some extent in all of these areas during the course of a project.

- **Data-Driven Approach**
  The program specifies a commitment to raw data collection and focuses on field testing and detailed analysis rather than theoretical assumptions or general suggestions. When opportunities for building improvement are discovered, all options are considered. The EMP will only recommend those options that will help achieve the client's stated efficiency and performance goals.

- **Optimum Performance + Efficiency**
  The program addresses building energy efficiency and operations comprehensively. Most traditional approaches tend to rely on limited solutions that do not address overall building performance. The scope of the EMA Energy Management Process is broader than energy audit programs and protocols and incorporates the implementation and validation of energy efficiency and performance improvement measures. The EMP will provide services that satisfy all levels of energy audit requirements.

- **Independence**
  The program requires independence with respect to manufacturers, vendors, contractors, and other parties that could create potential conflicts of interest. The objective is to serve in the client's best interest by delivering energy savings while advancing overall system performance. The EMP will not be compensated according to performance contracting models that link service fees to energy savings, and will not sell equipment, installation, or maintenance.

In short, building owners can have confidence that an energy management project led by a certified EMP will deliver positive results. The EMA Energy Management Process is client-driven and focused on producing energy-efficient, high-performance buildings.

EMA Energy Management Process

The *EMA Energy Management Guideline* describes a series of phases that comprise the EMA Energy Management Process. During this process, the EMP works closely with the client and other members of the project team to develop strategies to achieve energy-related goals, improve energy efficiency, and optimize building performance. On behalf of the client, the EMP is responsible for continually moving the project forward from one phase to the next.

The EMA Energy Management Process includes the following seven phases, each of which is explored in detail in this *Guideline*:

Assess

The **Project Assessment Phase** involves client consultation, preliminary site assessment, and benchmarking. During this phase, the EMP develops the client's goals and gauges a building's potential for reducing energy use and improving performance. The entire team must understand the direction of the project.

Explore

During the **Energy Use Exploration Phase**, the EMP uses building energy data to perform detailed analyses of current and historical usage and cost patterns. These analyses are vital to determining the energy savings and cost reduction potential of potential measures.

Investigate

Field inspection as part of the **Site Investigation Phase** provides the EMP with detailed operational data regarding specific building systems. Preliminary TAB and functional testing provide the EMP with valuable insight to further refine measures and facilitate EBCx activities.

Analyze

The **ECM/FIM and EBCx Analysis Phase** tasks the EMP with producing detailed analyses of potential measures and EBCx activities. The EMP quantifies energy savings estimates and anticipated performance improvements in support of project goals.

Implement

During the **Implementation Phase**, the EMP develops detailed plans for implementing measures and EBCx. Measures are then installed and EBCx is completed. The EMP will also be involved with commissioning new systems and installing measurement and verification (M&V) equipment.

Accept

The **Final Acceptance Phase** begins with functional testing to confirm that newly-installed systems operate as designed, followed by M&V. The EMP will also compile a variety of documents related to commissioning, operations and maintenance (O&M), and building staff training. These resources will collectively help maintain a high level of building performance.

Manage

The project comes to a close with the **Continuous Energy Management Phase.** The EMP helps the building enact an Ongoing Commissioning Plan with the express goal of maintaining and prolonging the energy savings from installed measures and EBCx. The EMP will work with the client to develop strategies for ongoing energy management activities, including enhanced O&M practices, regular benchmarking, and additional training opportunities.

A qualified EMP may perform any or all of the functions described above during an energy management project. If the EMP is not qualified to perform a particular function, or prefers to rely on a trusted partner for aspects of the project, a colleague or contractor who can perform these services should be included as a member of the project team. For example, an EMP may be a CxA but not have design experience, in which case a project that calls for design experience will require a design professional to join the team.

EMA Energy Management Guideline

Each of the seven phases of the *EMA Energy Management Guideline* is divided into major sections, many of which are further divided into subsections. The Table of Contents lists these sections and subsections.

Each phase follows the same basic structure:

- Brief summary of the phase
- Bulleted list describing the mission of the phase
- Bulleted list describing EMP skills and knowledge featured in the phase
- Detailed outline that lists major sections and subsections
- Single-paragraph introduction to the phase
- Narrative content, including text and graphics
- Short summary within a red box

As a means of providing real-world examples of energy management in action, case studies appear throughout all seven phases of the document. These case studies feature real building projects. Some projects are featured in a single case study within one phase of the document, while others are presented in multiple case studies across several phases of the document. Appendices and a glossary follow the phases.

1 PROJECT ASSESSMENT

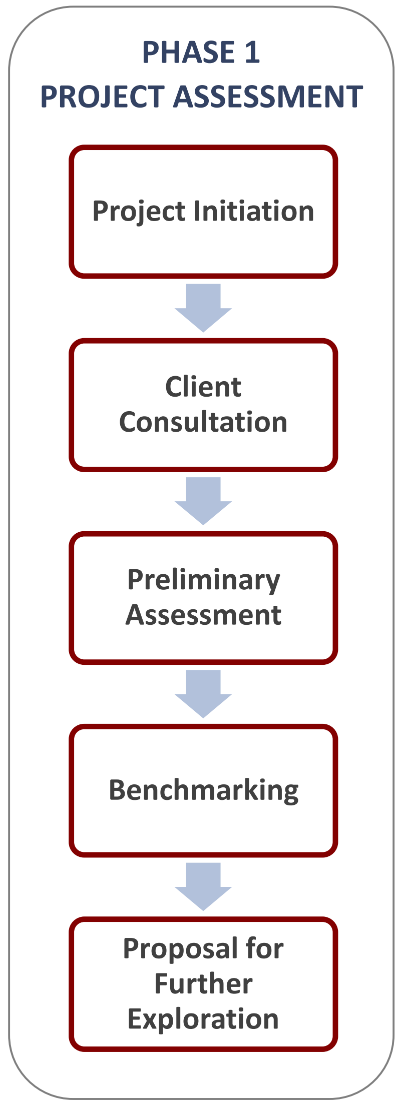
The first phase of an energy management project is Project Assessment. During this phase, the Energy Management Professional (EMP) gains an understanding of the client's goals, gathers basic information about building systems and operations, and begins to analyze energy performance relative to that of similar facilities.

The mission of the Project Assessment phase is:

- Launch the energy management project for a building or set of buildings.
- Hold productive meetings with the client and other team members to outline goals and instill confidence in the project.
- Conduct an initial site visit and capture preliminary data.
- Benchmark building energy performance.

This chapter should provide the EMP with:

- Information about various kinds of client goals and motivations.
- Guidance regarding how to prepare for a client consultation.
- Details about important features of an initial site walk-through.
- Steps for developing an introductory perspective on the project building's energy use.



PROJECT ASSESSMENT OUTLINE

This phase is divided into five major subsections:

During **Phase 1: Project Assessment**, the EMP will begin a number of tasks and conversations that contribute to a successful energy management project. The EMP will collect preliminary information about the building and confirm the client's objectives. This information will form the basis for more detailed analysis and investigation as the project develops.

1.A Project Initiation

At the start of an energy management project, the EMP should gather information about the client and project site. Additionally, the EMP must understand clearly and completely the client's motivations for pursuing the project.

In order to gain the client's confidence, the EMP should understand thoroughly the particular energy management objectives. The client may not fully comprehend the purpose of the project or may have concerns about whether one goal or another is realistic. Moreover, the client's representative with whom the EMP is in contact may not have a firm grasp of the project, but may have simply been assigned the job by somebody else.

In general, the EMP should not assume that the client is 100% certain about project direction. The EMP should gauge how much direct knowledge the client's representative has about the project. The EMP may need to review the basics—typical project steps and characteristics—before starting a discussion about motivations. This is often the case with clients who have numerous job responsibilities and for whom energy management is far down on the list.

1.A.1 Characterizing the Client

The EMP may be engaged by several types of clients interested in pursuing energy management projects, including:

- **Building Owners**

  Owners may wish to review the performance of their facility or explore energy management as a means to boost asset value, cut energy costs, achieve corporate energy goals, compete with similar buildings, or some other reason. Owners often aim to minimize project expenses without negatively impacting building performance and tenant satisfaction.

- **Property Management Firms**

  Many commercial building owners hire property management firms to handle day-to-day building operations. Property managers are often focused on reducing energy costs and operating as efficiently as possible, but they may not have the authority to make significant energy management decisions without the owner's approval. The owner may task the property manager with administering an energy management project. Occupant comfort and rent rolls are priorities for the property manager.

- **Utility Program Administrators or Energy Service Companies**

  A utility or ***energy service company (ESCO)*** *that has secured a contract for a building project may select an EMP. They may hire the EMP as an independent third-party, relying on the EMP to review energy management recommendations and assure building stakeholders that the final plan is thorough and accurate.*

Energy Service Company (ESCO)

A business that develops, installs, and arranges financing for projects focused on improving energy efficiency.

- **Building Occupants**

  Occupants may have agreed to pay additional rent to the property manager on their behalf in order to engage an EMP. Their motivations usually include improving their environment while reducing their energy usage. If energy costs are included in rent, the energy management project may eventually result in an agreement with the landlord to reduce rental payments. This scenario is most likely in either multi-family residential or commercial office buildings.

- **Public Entities**

  Government, education, and other public sector groups recognize the value of high-level energy management. Efficient operations are a growing priority for such institutions. As the public demonstrates greater awareness of sustainability, these groups are increasingly electing to allocate funding for related projects, regardless of whether energy prices rise, fall, or remain flat. In some cities or states, these initiatives may be mandated by law.

Regardless of the type of client that is initiating the project, the EMP has a responsibility to be an advocate for the owner. The needs and interests of building ownership must be considered throughout the project. If the EMP is hired by an intermediary, he or she should maintain solid communication with building ownership and management. The structure of this relationship will depend largely on the type of facility. For example, a commercial office building may be investor-owned and managed by a professional property management company, but an industrial facility may be owned and managed directly by the corporation that occupies it.

In addition to building and maintaining client relationships, the EMP may need to work with other parties throughout the project. For example, design review and energy analysis often lead to relationships with architects, engineering firms, and general contractors. The EMP is expected to excel at managing these professional relationships. Any of these parties may generate requests for future energy management services through the EMP.

Energy Conservation Measures (ECMs)

Building operational improvements, equipment installations, or other upgrades that provide energy payback, regardless of initial cost. Reduced energy consumption leads to savings on monthly bills.

1.A.2 Motivations for Energy Management

Clients pursue energy management projects for many different reasons. The EMP must pay careful attention to understanding the unique motivations for each project, because these will serve as the basis for affirmation of quantitative goals, development of project scope, and evaluation of progress. The motivations will have substantial impact on the first few phases of the EMA Energy Management Process. These objectives will influence the scope of energy management activities. During the project, the EMP may identify both energy conservation and facility improvement measures.

Energy conservation measures (ECMs) are recommended improvements that are intended to reduce building energy consumption and provide energy payback. The cost associated with an ECM is irrelevant in terms of its classification as an ECM. Some ECMs require little or no expense and have shorter payback, while others are capital-intensive and have longer payback. All ECMs have some energy benefit to the extent that they produce energy savings.

Facility Improvement Measures (FIMs)

Actions or installations that improve building performance but provide no energy payback. Most benefits are not related to energy. Many, but not all, FIMs have a positive impact on operations.

Facility improvement measures (FIMs) are recommended improvements that are often, but not always, related to operational performance. They provide benefits that cannot be measured in the form of energy payback. An improvement that provides primarily non-energy benefits, as well as some relatively small energy benefit that does not produce a quantifiable energy payback, should typically be classified as a FIM. As with ECMs, the cost of FIMs can vary widely. In applying the FIM label, improvement of the facility without energy payback is the deciding factor, even if the nature of the improvement does not impact operations. For example, installation of a fire suppression system, while certainly improving the facility and bearing some cost, has no energy or operational impact, but would still be classified as a FIM.

Existing Building Commissioning (EBCx)

A process that implements improvements to existing building controls and other systems. EBCx also involves testing and balancing.

In addition to ECMs/FIMs, the development of a plan for **existing building commissioning (EBCx)** will also be informed by the project goals. The EBCx process ensures that systems that are expected to remain in the building following project completion are operating as efficiently as possible and in accordance with the building's needs. EBCx is a critical, non-optional part of the EMA Energy Management Process.

Alternative terms for commissioning services for existing buildings include re-commissioning, retro-commissioning, continuous commissioning, monitoring-based commissioning, and similar terms. EBCx can lead to the implementation of improvements that solve complex or persistent problems. The EMP combines ECMs/FIMs and EBCx to improve building performance more comprehensively than either one could alone.

For all projects, regardless of which kinds of planning documents are developed, the EMP must be aware of the typical reasons for pursuing energy management. Nevertheless, the EMP may encounter client motives that he or she has not heard previously. The EMP should be prepared for a client to offer new, different, or unexpected rationale for a particular project.

Common catalysts for pursuing energy management include:

- **Signs of Inefficiency and Poor Performance**

  The client may communicate that utility bills seem too high, occupants complain about poor indoor air quality, or the building incurs high equipment repair costs. Energy management in this case is pursued as a means to resolve problems and improve the building.

- **Legal Requirements**

  Whole building concerns or regulations regarding a specific system or piece of equipment may warrant a review of mechanical and electrical components. Code violations, for example, are a key driver of retrofits.

- **Long-term Facility Planning**

  The development of plans for the replacement of existing building systems or other large-scale building renovations may require the services of an EMP.

- **Organizational Planning**

  The client may wish to integrate the project building's energy management process into an energy plan or sustainability plan that is being administered by the larger organization.

- **Third-Party Analysis Needs**

  A client that is not the building owner may require the independent services of the EMP or additional expertise for a certain type of building or building system. This is a frequent occurrence when utilities or energy service companies are clients.

Strategic Energy Plan

A living document prepared for a client that establishes long-term energy consumption goals as well as financing strategies and plans for equipment replacement.

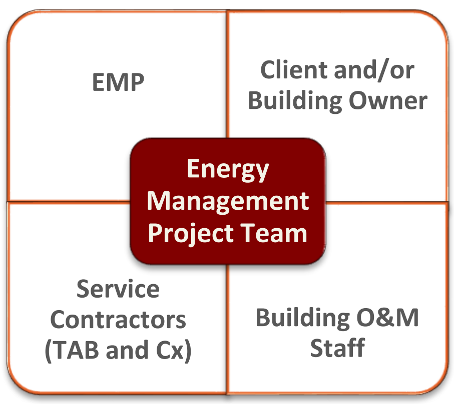
In some cases, project goals will be incorporated into a more comprehensive **Strategic Energy Plan (SEP)**, which includes detailed information regarding measures, financing strategies, and additional energy-related goals. It serves as a roadmap for the organization. The document may help guide decisions for the next three, five, or even ten years or more.

A complete SEP combines both tactical and strategic energy-related initiatives in one comprehensive document. Tactical plans—such as those for ECM/FIM implementation and EBCx—are developed for every energy management project. An SEP supplements these intentional measures with long-term strategic planning, as well as additional areas of consideration, such as sustainability and energy purchasing. Not every organization requires an SEP, however, and may not be inclined to allocate the time and expense necessary to have one completed.

1.A.3 Typical Client Team Members

The EMA Energy Management Process is a team-based approach. The EMP must engage building ownership and/or management, contractors, engineers, and operations and maintenance (O&M) staff in a project. This may involve managing opposing interests effectively in order to develop workable solutions to energy issues.

Leadership throughout the project distinguishes the EMP from other energy and engineering professionals who may deal with narrowly defined goals and limited scopes. The EMP must exhibit both technical competence and the interpersonal skills to manage a complex and collaborative approach. Sensitivity to the spoken and unspoken concerns of all team members is crucial to the EMP's success.



Speaking to facility staff about the goals of the project will require diplomacy if outside assessment is viewed as unwarranted criticism or a threat to their responsibilities or employment. One way to deflect antagonism and create enthusiasm around the project is to suggest that energy management promises resources and a commitment to solve problems of which the facility staff is well aware. Their contribution to a positive project outcome will ease their own work schedules, as they will no longer need to attend repeatedly to malfunctioning or underperforming equipment. The EMP will need to provide reassurance to building staff and reinforce a spirit of cooperation to help advance the project.

The EMP must also contact and work effectively with outside contractors and service providers. These may include commissioning and test, adjust, balance (TAB) professionals, energy service contractors, building automation and control companies, and/or other third-party vendors of materials or maintenance. In addition to the facility staff, these team members will be able to provide essential information about the building and its operations, and they too will have a significant impact on a project's outcome.

CASE STUDY 1.1 — CLIENT TEAM | BUILDING A

Leadership in Energy and Environmental Design (LEED)

A green building certification program that helps design teams and building operators construct and maintain facilities in an energy-efficient and sustainable manner.

The project site is a high-rise multi-tenant office building located in downtown Denver. The client hired the EMP to address energy use at Building A. Throughout the project, the EMP worked with a team consisting of building management staff, the building engineer, and consultants and contractors engaged by the building.

The management of Building A has a strong commitment to sustainability. They decided to pursue ***Leadership in Energy and Environmental Design (LEED)*** *certification through the U.S. Green Building Council. One step in the LEED process involved the assessment and optimization of building energy use. The EMP worked closely with the building engineer to gather building energy usage information, plan site visits, and obtain detailed information about building operations and operational practices as ECMs were being developed.*

The EMP was able to identify several potential ECMs for the building to consider. These included optimizing AHU startup and outdoor air intake levels, retrofitting lighting controls in common areas of multi-tenant floors, and adjusting the air-to-fuel ratio in the boiler. The EMP discussed these ECMs in detail with the project team. Nine of the ten recommended measures were implemented at the building.

Collaboration among team members played a significant role in decisions about the implementation of ECMS and facilitation of actual installation. For example, for the ECM involving optimization of AHU startup, the EMP worked closely with the project's LEED consultant to ensure that minimum outdoor air requirements for LEED were met. The EMP also worked with the building's controls contractor to ensure measures involving system start and stop cycles were scheduled properly in the building automation system (BAS).

Building management also provided insight into potential ECMs. For example, the general manager indicated that the recommendation to update common area lighting was not feasible on some floors because of tenant preferences. After careful coordination between management and a handful of tenants, however, the ECM was implemented on three tenant floors and in all public lobbies.

The EMP's communication with the building engineer and management led to the development of ECMs that were in line with building's goals. Open dialogue with contractors ensured proper implementation of measures and ongoing trending to ensure effectiveness. Without feedback and cooperation regarding potential ECMs, the partial implementation of new lighting controls may not have been pursued at all.

Integrating energy management into the LEED process would not have been so smooth without ongoing collaboration with the LEED consultant. Building A accomplished its goal of LEED certification. Communication among project team members was an essential part of executing a successful energy management program at Building A.

The Energy Management Project at Building A is discussed further in Case Studies 6.1 and 7.2.

1.B CLIENT CONSULTATION

During the **client consultation**, the EMP meets with one or more representatives of the client to gather information about the project site and goals. The objectives of the consultation are to:

- Discuss the client's motivations for pursuing the project.
- Collect basic information about the site and the scope of the project.
- Determine how the success of the project will be measured.

The client's objectives and terms of evaluation will establish the direction for the next few phases of the EMA Energy Management Process.

Client Consultation

Initial discussion between a client and EMP to gather basic information about the site and establish goals for an energy management project.

1.B.1 Facility Information

The client consultation provides an opportunity for the EMP to assemble building information and ask the client to provide essential documents, including drawings, equipment schedules, and utility and operations data.

1.B.1.a Before Consultation

In advance of the on-site meeting, the EMP should ask the client to collect and be prepared to provide:

- Utility and/or energy supplier bills
- Energy supply contracts
- Spreadsheets summarizing energy consumption and costs
- Original construction plans and renovation plans
- Major equipment submittal data
- O&M manuals
- TAB reports
- Commissioning reports

A complete set of original bills is crucial. Ideally, bills should be requested and received for the most recent 36 months. All energy sources should be represented: electricity, natural gas, water, and additional sources, if applicable. Increasingly, bills may be available to the EMP in electronic format (as PDFs), but photocopies of the original paper bills are still quite common.

The bills should be complete—including all pages. The first page typically lists only current charges without additional detail that the EMP requires. Complete bills should include not only line item charges, but also consumption, demand (for electricity), meter number(s), and rate structure. Energy supplier bills, if applicable, should also be provided for the same period.

All of these documents will help the EMP understand what the building is designed to do and develop a sense of how it is and has been operating.

1.B.1.b During Consultation

During the meeting itself, the EMP should develop further knowledge of the project's direction and ask questions about information that was already received. The consultation is a two-way conversation. The EMP should also be prepared to answer questions posed by the client.

When practical, a best practice is to hold the consultation at the project site immediately prior to the preliminary site assessment. Not only does this simplify scheduling, but this enables the EMP to visit the site and meet additional members of the project team while the consultation is still fresh in his or her mind. Additionally, the EMP can also utilize the consultation to ask questions about what to expect at the site, and the client will have the opportunity to highlight specific areas for the EMP to investigate.

During the client consultation, it is important for the EMP to develop a sense of the project team, record basic site data, and address aspects of building operations that may not be visible during a walk-through. The following questions provide the EMP with a starting point for gathering this information:

Project Team

- *Who will compose the project team?*
- *What is the relationship of the client to the building owner? To building Management?*
- *How will building staff and occupants be involved in the project?*
- *Who are the EMP's primary points of contact, and how can they be reached?*

Site Information

- *Does the project address one building or multiple buildings?*
- *How old is the building? Has it undergone major or minor renovations?*
- *How large is the site?*
- *What are the various uses of the building?*
- *When is the building typically occupied?*
- *What are the building's Energy Star rating and/or Energy Use Index (EUI)?*

Building Operations

- *What services are performed by building staff and which are contracted to third parties?*
- *Have occupants complained about discomfort?*
- *Has O&M staff indicated a need for frequent repairs of any particular equipment?*
- *Have there been requests or plans for equipment replacement or upgrades?*

Depending on the project, and the client's interest and comprehension, the EMP may ask some or all of these questions. There are many more questions that could be asked as well; experience should serve as a guide. Additionally, while the EMP may think about many of these questions, not all of them will need to necessarily be asked verbatim. The EMP should navigate the conversation wisely in order to obtain the necessary information without frustrating or insulting members of the project team.

For sample Client Consultation materials, including an outline of useful questions and a sample agenda, see Appendix A.

Appendix A

Sample Client Consultation Materials

1.B.2 Client Goals and Objectives

At this point in the process, the EMP focuses on working with the client to develop project goals and measurement strategies. A specific quantitative goal is the clearest possible motive. In some cases, the EMP may need to discuss with the client whether or not the desired degree of success is realistic. Many goals, however, are qualitative rather than quantitative, which makes the task of measuring eventual progress towards those goals more difficult. With some effort, however, even qualitative goals may be reframed to include certain quantitative aspects.

Establishing goals at the outset of the project is critical, because they will be used to shape the remainder of the Project Assessment and determine the trajectory of the entire project. The goals—as well as the performance metrics used to evaluate them—will impact how the project moves forward and how progress is measured.

Owner's Project Requirements (OPR)

Document outlining how a building is to be designed and operated to fulfill the needs of building ownership.

Many building engineering professionals are familiar with **Owner's Project Requirements (OPR)** as they relate to Commissioning or LEED for New Construction. The OPR outlines how the building is intended to operate. The requirements are typically set forth by the owner during the design and development of a new building.

As part of the EMA Energy Management Process, the EMP's goal is to clarify and, if necessary, update the building's existing OPR to specifically address building performance requirements. This modified OPR will reflect both changes in system operations and new performance expectations.

While "energy management" may automatically be associated with "energy efficiency" or "energy auditing," the scope of an energy management project that adheres to the EMA Energy Management Process extends well beyond a basic energy audit or obligatory efficiency assignment. Rather than simply focusing on energy savings, the overarching objective for EMPs that follow the EMA Energy Management Process is optimized building performance. As a result, facility-specific energy management projects address a comprehensive suite of tangible or intangible goals. Energy efficiency is one of the most important motivations, but it must not be the only motivation.

Certified EMPs who actively apply the EMA Energy Management Process in their work are delivering services that satisfy the requirements of ASHRAE Energy Audits and similar programs defined by the industry. Building owners and other types of clients who hire an EMP should realize that the services being provided to them adhere to statutes that reference ASHRAE Level 1, Level 2, and/or Level 3 Energy Audits.

Some project goals, such as those related to building performance and energy cost savings, will be able to be quantified using recognized industry standards, calculations, and physical measurements. Others, such as safety concerns or sale preparation, can be characterized as intangible. Regardless of the type of goal, project objectives should be identified and articulated clearly at the beginning. The EMP must have absolutely no doubt about what the project aims to accomplish and how progress towards those goals will be measured.

1.B.2.a Cost Savings and Building Performance

Cost savings is often a primary motivation for energy management projects. Energy-related cost savings can be realized through reduced energy consumption and improved building performance. Expense reduction goals may include decreases in direct energy costs, or operational savings due to complementary improvements in building performance. The latter may be realized by a sharp drop in the number of work orders for O&M staff, better management of labor expenses, and/or fewer unanticipated calls to materials or maintenance vendors.

Improved building performance, and the cost savings that nearly always accompanies it, is one primary reason clients pursue energy management. “Building performance” is admittedly a vague umbrella term that can include everything from how reliably equipment operates in the facility’s mechanical room to how hot or cold occupants feel on a daily basis. Performance improvement can lead to significant building-wide benefits and should be a primary measure of project success. In general, building performance is weighed by four key criteria:

- **Occupant Comfort**

  Providing a comfortable, healthy building environment is a key concern for clients who operate and manage buildings. This includes maintaining an acceptable range of temperature and humidity, and minimizing the number of hot or cold calls. A long-term commitment to improve ventilation, humidity, temperature, and lighting systems may encourage existing tenants to remain in the building and is a persuasive selling point when pursuing and leasing new tenants.

- **Operational Efficiency**

  Even when inefficient systems do not impact occupant comfort, they do impact cost, energy use, and ease of maintenance. Inefficiency has a substantial impact on the client’s bottom line.

- **Equipment Reliability**

  Maintenance issues are another major concern for building owners, managers, and staff. Equipment should not require repair much more frequently than intended. Such malfunctioning can lead to excessive energy use, increased maintenance and energy costs, and essentially wasted time. Building staff should be tasked with maintaining superior performance as opposed to averting mediocre performance.

- **Energy Service Consistency**

  For some buildings, such as healthcare facilities, maintaining high quality of power and avoiding brownouts or other service disruptions are vital. If energy is not being delivered to the building at the necessary intensity, even efficient equipment will not operate correctly.

1.B.2.b Intangible Goals

While expense reduction and improved building performance are often primary goals for energy management projects, the client may also have additional objectives that are not directly related to energy use or cost reduction. These may include:

- **Safety and Security**

  Building management or ownership may be concerned about improving safety and security at the building. For example, the client may seek to increase lighting for a building parking lot area, leading to a FIM that includes the installation of additional light fixtures, even if this is not related to energy use reduction. To minimize the client's energy expenditures while accomplishing the goal of improving parking lot safety, the EMP could provide general guidelines for energy-efficient lighting within the client's budget and recommend energy-efficient fixtures and lamps. These considerations should be integrated into project goals and, eventually, measures.

- **Preparation for Sale**

  A building owner may need to improve a building in preparation for a possible sale. Being able to demonstrate that building systems have been optimized and are operating efficiently is a strong selling point. Optimal performance increases the value of the property.

- **Sustainability Initiatives**

  Managing the building's environmental impact through energy efficiency, water use reduction, green technologies, or renewable energy sources may be included in project goals. Pursuit of LEED certification or a certain Energy Star score may also apply to the project. The rating system LEED for Existing Buildings emphasizes both commissioning and energy use optimization; a building seeking such certification would benefit greatly from a comprehensive energy management project.

- **Code Compliance**

  ECMs/FIMs that assist building staff in complying with applicable codes also add value. In some regions, EBCx has also been integrated into building codes. Not only do these measures optimize energy use, but they also minimize the building owner's risk. An EMP should maintain up-to-

date knowledge regarding building codes in the locations in which a majority of his or her work takes place. Having a thorough understanding of code and integrating this into value statements for ECMs, FIMs, and EBCx will give the client an accurate picture of the project benefits and explain the legal risk, if any, associated with not implementing certain measures.

Even though these types of goals are characterized as “intangible,” they often involve energy cost savings and other financial benefits. For example, consider a client who is aiming to sell the project building and initiates an energy management project largely to verify performance. If the owner finds it difficult to find a buyer due to the building’s higher-than-average energy bills, reducing energy consumption may become a top priority of the project. The EMP must consider how different types of intangible project goals intersect, and how they relate to any tangible goals, whether stated or unstated.

1.B.2.c Sustainability Goals

Client objectives related to sustainability issues may incorporate both tangible and intangible goals. Tangible effects could include energy cost savings resulting from the implementation of strategies to reduce carbon emissions, or improved occupant comfort resulting from a reduction in the concentration of airborne contaminants. As clients pursue “greener” building operations in response to customer or tenant demand, intangible effects such as specialized marketing campaigns and improved public relations are becoming increasingly common.

Some clients may have an existing sustainability plan for their buildings. Others may have recently prepared documents related to pursuit of LEED Certification or achievement of a certain Energy Star Rating. The EMP should make sure to incorporate such elements into project planning and outline the relationship between the existing plans or documents and energy management project tasks.

In some cases, green building certification itself may be incorporated into the objectives of the energy management program as a project goal. Program requirements depend on building type, project timeframe, and other factors that change every few years or even every year. Regardless of the specific program, the EMP will likely identify opportunities to contribute to a building’s certification. These sustainability goals may influence the types of ECMs that are approved and implemented later in the project. At a minimum, EMPs should be familiar with both LEED and Energy Star in order to facilitate compliance with program requirements as part of the energy management process.

A building owner or management company may retain an outside consultant to assist with achieving certification. If this is the case, the EMP should work with that consultant as a member of the project team to make sure that the building’s energy-related efforts are streamlined. They may also be able to offer valuable insight into ECMs/FIMs that may help the building achieve certification.

1.B.2.d Goal Development

When working with the client to articulate project goals, the EMP should ensure that these goals provide a strong basis for measuring progress and address all the facets of the project.

A strong approach to energy management should encompass:

- **Operations**

  Equipment should operate as efficiently as possible, without sacrificing occupant comfort and system performance. Improvement of equipment operational efficiency represents a significant opportunity for energy savings. Many modifications can be implemented inexpensively. Low-cost improvements to building equipment and operations include proper scheduling, sensible setpoints, and functional controls.

- **Procurement**

  Energy should be purchased on the best terms available. The EMP is tasked with identifying and proposing options for reducing supply-side utility costs. In states where energy is deregulated, this may involve suggesting that the building shop for the best price. In all states, this may involve confirming that each utility account is assigned to the optimal rate class. Most clients are accustomed to viewing energy budgets with respect to dollars spent rather than units consumed.

  Although the choice of energy procurement sources has no impact on energy use, a wise and timely energy purchase is one of the fastest, easiest ways to reduce cost-based energy budgets. Also, if unusual weather causes energy use to rise more dramatically than expected after ECMs have been implemented, a lower price helps mitigate the cost increase. The EMP can help the client manage the per-unit price and the normal level of use—but not the weather.

- **Equipment**

  Whenever feasible and beneficial for the project building, new energy-efficient equipment should be installed. While the EMP may replace some minor equipment at relatively low cost, robust energy management solutions usually require substantial capital investment. When recommending measures that involve the replacement of system components, the EMP should identify high-efficiency models of motors, lights, chillers, boilers, etc. and share this list with the client. A best practice is to conduct a life cycle analysis and present the client with replacement choices ranked according to their projected returns on investment.

The EMP must make sure that project goals for operations, procurement, and equipment are practical for the building. Specifically, these goals should be:

- **Realistic**

  The EMP should take care to confirm that the stated level of energy reduction is achievable within the allotted timeframe. For example, the client may aspire to 30% energy reduction in one year, a next-to-impossible task, while 15% is a much more likely target. Once utility bills have been analyzed, the EMP can better set an energy reduction goal.

- **Time-Sensitive**

  A series of goals is preferable to a single final goal. Setting goals that must be met throughout the project encourages awareness of incremental successes and outlines the course of work. Additional markers along the way will help the EMP and project team evaluate their effort and adjust their focus. For example, the client may aim to reduce electricity consumption by a certain number in one year, but that goal should be supplemented with mid-year and quarterly goals. Gauging progress towards the end goal from month-to-month or quarter-to-quarter is a best practice for ultimately realizing success.

- **Client-Driven**

  Quantitative goals should represent the client's project expectations. The EMP may have ideas about other ways of measuring progress that he or she may reason are superior, but the client's preferences are paramount. Ultimately, the client's representative at the building will be charged with maintaining performance, so the goals must be deeply ingrained in the client's organization rather than the EMP's mind.

- **Measurable**

  The EMP should make sure that progress towards project goals can be measured accurately and that building operations accommodate measurement. Changes at the operational level may be necessary. For example, if the client wishes to improve occupant comfort and reduce the number of hot or cold calls, the EMP should first ensure that the building is able to track the number of calls accurately.

1.B.2.e Performance Metrics

Developing quantitative goals that articulate the client's performance requirements is an effective way to express project objectives and track progress. The structure, metrics, and timeline of energy management goals will vary depending on building type, location, and the client's motivations for pursuing the project.

It is essential that the EMP and the client establish performance metrics by which progress towards goals will be measured. For some goals, this may involve reporting physical equipment measurements. For others, it may involve tracking energy usage or quantifying improvement in relation to an established industry standard.

Intangible factors should be packaged with financial metrics to more clearly reflect the client's goals and the potential benefits of the project. When possible, the EMP should work with the client to establish quantitative metrics or qualitative benchmarks to track progress toward achieving intangible goals. The EMP should work with the client to determine which metrics are most appropriate for measuring progress, including:

Carbon Footprint

Measure of greenhouse gas emissions produced by the activities of a building, operational process, or organization.

Energy Targets

- *Reducing energy consumption or electricity demand (kW) by a certain percentage within a specified number of years.*
- *Shrinking the building's **carbon footprint** by a specific amount.*
- *Achieving a desired Energy Star rating.*

Occupant Comfort

- *Maintaining an acceptable range of temperature and humidity.*
- *Reducing the number of hot or cold calls.*

Sustainability

- *Reducing environmental impact through energy efficiency, water use reduction, green technologies, or renewable energy sources.*
- *Pursuing LEED certification or a similar designation.*
- *Shrinking the building's carbon footprint by a specific amount.*

Expense Reduction

- *Cutting total energy costs by a specified percentage compared to a baseline.*
- *Controlling O&M labor expenses.*
- *Reducing the number of work orders or unanticipated calls to materials or maintenance vendors.*

Asset Value

- *Increasing property value to some degree through operational improvements and system upgrades.*

Capital Improvements

- *Justifying a proposed investment in building system retrofits by establishing positive **return on investment (ROI)** for the project.*

Return on Investment (ROI)

A metric used to calculate the efficiency of payback on a financial expenditure.

These metrics are just a few examples. The client may pursue a variety of other metrics and may consult with the EMP regarding which targets make the most sense for the project building.

CASE STUDY 1.2 — CLIENT GOALS | BUILDING B

The management and facilities staff of Building B, an all-electric, 65-story commercial office tower in Chicago, sought to improve the monitoring capabilities of the facility's BAS. An ongoing energy management project was established. The client outlined specific energy reduction targets and the goal of using the BAS as a continuous monitoring tool to ensure persistent savings and identify additional ECMs. The project team hoped to meet the target and install the monitoring system within one year.

The EMP and client identified two distinct project stages based on these goals. The first was to complete the EBCx process and identify an initial set of ECMs and FIMs. The second was to Implement ECMs/FIMs and install BAS upgrades so that it could continuously monitor building operations and lead to additional ECMs.

The BAS upgrades included server connections that allowed immediate data transfer, enabling analysis on a continuous basis from anywhere with an Internet connection. These improvements required the EMP to coordinate the efforts of the building engineer, building controls contractor, information technology personnel, and the local utility.

The EMP developed a regular reporting strategy to track Building B's progress towards its energy reduction goal. Report documents were developed and customized to the needs of the specific building and audience. Since executives unfamiliar with energy jargon would be viewing some of the reports, the EMP placed an emphasis on clarity and simplicity.

Following the retrofit, the BAS was able to trend various diagnostics for the building: pressures, temperatures, equipment power readings, and other vital measurements. Using the tool to examine energy use back in the office, the EMP identified additional operational adjustments and improvements that reduced the building's annual energy consumption by more than 7%, exceeding the client's goal.

The Energy Management Project at Building B is discussed further in Case Studies 3.1 and 7.1.

1.B.3 Project Financing

In addition to addressing the client's goals and learning additional details about the project site, it is important for the EMP to begin a conversation with the client about project funding.

1.B.3.a Measuring Return

Once the basic characteristics of a building and the client's performance requirements for the energy project have been documented, the EMP must ascertain the client's preferred method of calculating financial performance.

Simple Payback

A measurement (in years) of the time it will take for a client to gain back funds invested in an ECM. Calculated by dividing measure installation cost by annual cost savings.

One common metric is **simple payback**, which is an estimate of the time it will take for a measure to produce enough energy savings to cover the costs associated with its installation. Simple payback is often used as a default measure for project requirements or scopes of work, as well as in procedural standards.

In addition to simple payback, EMPs may use additional measures to quantify financial performance:

- Energy saved
- Asset value
- Return on investment
- Internal rate of return
- Carbon footprint
- **Life cycle cost**

Life Cycle Cost

A metric that incorporates costs and benefits over the course of a building's or product's existence.

Life cycle cost could include figures such as labor costs, productivity gains, good will, environmental impact, and others. For larger organizations, corporate policies will typically describe the standard metrics to use during the project.

Some payback metrics may correspond directly with those used to gauge progress toward project goals. For example, the Energy Saved figure, in appropriate energy units, indicates both the desired energy reduction and the return, in terms of reduced energy costs, on the investment in upgrades.

After starting the project, the EMP must determine which method of measurement is preferable to the client. Doing so ensures that the EMP and client employ a mutually acceptable form of measurement for analysis and calculations. The EMP's reports will be presented in the client's terms, eliminating any need for the results to be reinterpreted according to another metric.

At this point, the EMP is simply laying the groundwork for more detailed **energy use exploration** that occurs in Phase 2, when the EMP analyzes the building's current and historical energy consumption.

Energy Use Exploration

Use of field experience, data measurement, and analysis to define and quantify energy-saving possibilities as they relate to client goals.

1.B.3.b Funding

It is equally important to begin discussing how potential measures may be funded. At this point, the project's scope has not been determined and the EMP cannot offer the client savings projections. Nevertheless, the EMP is responsible for introducing and discussing potential delivery and funding methods with the client. While the client does not need to commit to a particular method or dollar amount at this point, this conversation should happen sooner rather than later.

The EMP urges the client to set in motion preliminary plans for financing the project, pending the outcome of more detailed analysis. Funding may be provided by existing resources held by the client or project building, additional outside funding from various entities, incentives related to tax structures, and/or the project energy cost savings themselves.

Existing Resources

Existing financial resources are a straightforward way to fund the remaining phases of the project. A client may have reserved financial assets for this purpose or secured energy efficiency grants or incentives from the government or local utility. The development of measures and planning documents will also likely be paid for directly by the client through various internal sources, such as deferred maintenance costs or funds from the operating budget.

If the EMP's client is an ESCO, utility, or other entity that does not directly own or operate the building, it is likely that funding will derive solely or significantly from internal sources, such as the ESCO's own project budget, or the utility's program pool. With such clients, the EMP should confirm whether or not there are additional constraints or requirements with respect to the funding stream, such as a minimum threshold for the ROI.

Without knowing the scale or expenses involved, the EMP cannot be certain that the client will have sufficient resources to finance energy management services or that they will choose to spend all of them on this project. Clients may be reluctant to discuss specific dollars available if they feel that disclosing that information could impact project results or costs. On the other hand, the EMP will benefit from knowing up front whether certain capital ECMs/FIMs are in line with client expectations or well in excess of the available budget.

The discussion of funding options allows the EMP to gain a sense of the client's position with regard to the financial aspects of the project.

Outside Funding

When the client owns or operates the building and does not have sufficient resources for a full-scale energy management project, outside funding may be available.

An EMP with local experience, or one who is aware of local opportunities, may be able to suggest potential external sources, such as:

- **Utility Company Rebates and Incentive Programs**

  An increasing number of utilities have incentive funds available for customers pursuing certain types of energy-related improvement projects, including audits, specific ECMs, and EBCx.

- **Government Energy Efficiency Grants**

  State and local funds may be available for businesses or non-profit organizations pursuing energy-related projects. If the client is not already aware of any programs, the EMP may wish to conduct a quick search of opportunities.

- **Loans**

  Loans for energy improvement projects from banks or venture capitalists are a potential option for some municipalities and large corporations. Under such arrangements, the energy savings serve as the guarantor.

- **Bond Initiatives**

  For government entities, including schools, bond initiatives can help raise financial support.

- **Managed Performance Contracting**

  An energy service company (ESCO) may be willing to front some initial project expense through managed performance contracting.

Tax Benefits

Another funding source for energy projects is related to taxes. After providing evidence of investment and implementation, the client may be able to recoup money in the form of tax benefits. The client will naturally have accounting services and other corporate resources available, but the EMP may be able to provide some background information on the subject. In addition, the EMP may be personally aware of instances where another organization in the same location successfully realized tax benefits for energy efficiency.

Favorable tax consequences can be significant for buildings that implement efficiency and/or sustainability measures. These incentives may be based on meeting energy standards or codes, achieving a certain percentage of energy savings, or upgrading to more energy-efficient equipment.

Energy Cost Savings

Energy cost savings—also referred to as "energy saved dollars"—is another potential funding source based on recouping the initial investment after implementation. In this scenario, some predetermined portion of the money saved through measures implemented earlier in a project is allowed to accumulate and used to fund later stages of the same project.

The feasibility of using energy cost savings as a funding source depends on the client's organizational accounting methods and other financial considerations. The EMP should be aware that if energy cost savings will serve as a funding source, the project timeline will need to be developed accordingly.

With respect to project funding, the role of the EMP is to guide the client through options. The EMP should be forthright with the client, sharing experiences and insights—as well as best practices and frequent complications—that agree with the client's preferred methods. Actual delivery methods will be determined once the scope, costs, and estimated savings from ECMs/FIMs and EBCx are determined and presented.

The Client Consultation will identify the client's objectives, provide the EMP with basic information about the facility, and determine goals and metrics for measuring project success.

1.C PRELIMINARY ASSESSMENT

The EMP must gather additional information about the building and begin to identify potential measures and strategies for energy savings. This process begins with the **preliminary assessment** at the project building.

Preliminary Assessment

Initial walk-through of a building in which the EMP observes building operations, interviews staff, and assesses potential opportunities for energy savings.

1.C.1 Preparation and Scheduling

A client consultation should take place at the subject building, allowing the preliminary assessment to immediately follow the formal consultation. The objective of the preliminary assessment, or walk-through, is to complete or verify data gained from the client consultation, whether that information was obtained from the owner, building management, building staff, or outside contractors.

Preliminary assessment usually lasts approximately one day. Actual duration will depend on project objectives, the type and size of building, and accessibility. The EMP may find it helpful to ask the Facility Manager and/or Chief Engineer to accompany him or her on the assessment to answer questions and provide information. Again, relative need varies with the nature of the project.

For the walk-through, the EMP should bring:

- Protective clothing and equipment
- Notebook and pen/pencil
- Clipboard and paper forms/tables
- Flashlights
- Digital camera
- Light meter
- Multimeter
- Thermometer
- Humidity sensor
- Flash drive, memory stick, or other portable digital storage device

If possible, the EMP should schedule the preliminary assessment during a time that reflects typical building occupancy and operations. For example, scheduling a preliminary assessment during a holiday when most workers are not at an office building, or during evening hours when an industrial site may not be operating at full capacity, will not provide the EMP with a meaningful perspective of typical operations.

The EMP should question the building operating staff about all systems that will be inspected during the preliminary assessment. Specifically, the EMP should make sure to learn about:

1. Perceived problems involving any of the building systems;
2. Fundamental design intent of each building system, including sequence of operation and service area;
3. General maintenance procedures and concerns; and,
4. Available documentation containing system descriptions (e.g., location, components, capacity, and condition).

Some of this information may be conveyed over the phone prior to the walk-through, but the EMP may need to raise these topics again on-site.

1.C.2 Elements of a Walk-Through

The aim of the initial walk-through is to gain familiarity with the building conditions and grasp a general sense of the potential for energy savings and performance enhancement. The walk-through is an experience-based set of observations that does not lead to final conclusions.

A basic walk-through includes the following components:

- **BAS Review (1–2 hours)**

  The EMP should start the preliminary assessment by reviewing the BAS and all equipment controlled by the BAS. Notes about specific pieces of equipment may help the EMP determine how best to examine each piece of equipment. If a computer interface exists, the EMP should review each operating screen, and obtain a general working knowledge of the points that are monitored and controlled by the BAS. Saving detailed computer screenshots to a flash drive is a best practice to assist with analysis after leaving the site. If possible, print out some of the screenshots and refer to them while touring the facility.

  Determine if the system can accommodate trend analysis, and determine if trending of any systems is currently being performed. Interview the operating engineer to determine the ways in which the BAS is utilized at the building and to gauge his or her skill and knowledge level. The EMP should make a note of the operating engineer's familiarity with various BAS capabilities, and the intensity of training that he or she has received—or may likely need to get the most out of the BAS.

- **Central Plant: Chiller Review (1–2 hours)**

  A building's cooling system consists of a decentralized system, a central plant, or a combination of both. Decentralized cooling systems, such as rooftop unit or split-system air conditioning systems, are described in the Rooftop Units section below. The central chilled water plant is discussed here. The chiller plant consists of the chiller(s), pump(s), and cooling tower systems. In addition to general questions required for all systems, the EMP should ask building staff detailed questions about how the plant is operated as a system:

  - *How are components paired?*
  - *How are the systems staged? Are they staged back and forth based upon load to minimize energy use?*
  - *Why were components chosen of unequal size? Or equal size?*
  - *Is any component oversized or undersized? Does this sizing cause any challenges or create any opportunities?*
  - *Are variable frequency drives (VFDs) used to conserve energy or to assist in modulating loads?*

- *Have any other energy-saving methodologies been tested or used?*
- *Are there any other devices restricting flow?*
- *Have building loads changed since the systems were installed?*
- *When was the last time the water flows were rebalanced?*
- *Does the building utilize primary, secondary, tertiary pumping?*
- *Are any electricity meters or submeters dedicated to serving the central chilled water plant?*

The EMP must understand the sequence of operations and system scheduling during both occupied and unoccupied hours. Furthermore, the EMP should describe any standby or redundant chillers, pumps, or towers, and their operation. Balance valves should be expected to determine the extent to which they are throttled down. The EMP should get a general feel for pump sizing (i.e., consider whether they might be oversized or undersized). Inspection of the tower is important to confirm its age, condition, and fill material.

The EMP should also determine how tower fans are staged and how load capacity is controlled. Every building has a pumping methodology. The EMP should become familiar with the methodology at the project building. For example, the EMP can determine what components are operated by the BAS and what components are independently controlled. If the facility uses district chilled water there is less equipment to review, but also potentially fewer opportunities for energy reduction.

- **Central Plant: Boiler (1–2 hours)**

  A central boiler plant system may be either a hot water system or a steam system. A hot water system will consist of the boiler and water pumps. A steam system, however, consists of many more components than a hot water system. The boiler, tray-type or spray-type deaerators, make-up water treatment system, and condensate return system that comprise the steam system may all need to be visually inspected. For either system, the EMP should record the type (e.g., fire-tube, water-tube, sectional, etc.) and size of the boiler (i.e., horsepower or Btus, or both). For steam boilers, the EMP should also determine the pressure rating, as well as operating pressures.

  Additionally, for steam systems in general, the EMP should inquire about the facility's steam trap maintenance program and, if possible, perform a visual observation of the steam vent, which can indicate the extent of steam trap leaks. (A small amount of flash steam is normal, but large amounts of steam, or a gap between the vent and flashing steam, may indicate failing traps.) For all types of systems, the EMP should inspect insulation on boilers, ancillary systems and valves, as well as on steam, hot water, and condensate piping.

While making general observations about the condition of the system, the EMP may wish to ask the operating engineer about the boiler system maintenance program. The age of the boiler and ancillary systems must also be recorded. If a dedicated boiler serves the boiler plant, consumption for that boiler can be used in EUI calculations. Many of the same operating, staging, pairing, and capacity questions noted above in the Central Plant: Chiller section also apply to boiler plant operation. If the facility uses district hot water or district steam there is less equipment to review, but also potentially fewer opportunities for energy reduction.

- **Rooftop Units (5–15 minutes per RTU)**

  Buildings that do not have a central chilled water plant will most likely have a decentralized cooling system. The EMP should start by reviewing the system's controls and service areas. Most such systems are scattered throughout a building, and they may be located in difficult and potentially unsafe areas such as rooftops. For the preliminary assessment, the EMP may wish to limit inspections to larger units or units that are not monitored and controlled by the central BAS. Components of decentralized systems are typically affected over time by the weather, because they are subject to the elements. Additionally, they are not usually maintained as well as central chiller plant systems. For these reasons, the EMP must note the general condition of the system components.

  When inspecting rooftop units (RTUs), the EMP should pay particular attention to the economizer capabilities and the condition of the economizer dampers and actuators. Economizers often fail at a high rate due to lack of maintenance. If easily accessible, the EMP should inspect the economizer controller and determine the economizer setpoint. (Maintenance issues are frequently aggravated by the fact that economizer controllers can sometimes be very difficult to access—whether by the EMP or building staff.)

  The EMP should determine if the RTUs are equipped with powered exhaust fans. Inspection of RTU exhaust dampers should indicate if any air is being exhausted from the building. The minimum outside air damper position should also be inspected, if easily accessible. If the RTUs are controlled independently, rather than via the BAS, the EMP should inspect the controller, document its setpoints, and determine if the unit is capable of recording start/stop times. These values should be recorded during the walk-through for comparison with those captured during the later site investigation. Finally, the EMP should record equipment nameplate and model information if he or she has not already received an equipment list with unit capacities from the client.

- **Air Handling Units (5–15 minutes per AHU)**

  Assessments of air handling units (AHUs) are very similar to those of RTUs. The first task is discussion of operational and maintenance issues with facility staff. The EMP should simultaneously begin to develop an understanding of the service area for each AHU as well as temperature and indoor air quality issues. The EMP should determine if an AHU has pre-heat, cooling, or heating coils, and if the coils are steam, hot water, chilled water, or direct expansion heat exchangers.

  The quantity, type, and size of fan motors should be recorded, along with a note indicating whether the motors are internal or external to the AHU. The EMP should note any types of fan air flow control such as variable frequency drives (VFDs), inlet vanes, or outlet vanes. In addition, economizer controllers, damper positions, sensor locations, and safeties should all be inspected.

- **Spaces, Terminal Units, and Lighting (30 minutes–3 hours)**

  The EMP should begin the space evaluation with floor plans. These may be as simple as fire evacuation plan drawings, or as complex as a reflected ceiling plan or HVAC duct system plan. In many cases, the EMP will be given architectural drawings or blueprints. Review of the mechanical, electrical, and plumbing (MEP) drawings is recommended either prior to or immediately following the walk-through. During the walk-through itself, the EMP should look for signs of potential occupant indoor environmental quality issues. Listening carefully for unusual mechanical system noises may also expose problems. Light fixtures that have make-shift shields, or have been delamped, suggest excessive illumination.

  With respect to airflow and temperature, the EMP should look for portable space heaters, personal fans, or air deflectors on grills. If possible and appropriate, the EMP may wish to ask tenants about their comfort. At a minimum, the EMP must interview the operating staff regarding comfort and indoor environmental quality. The types, condition, and quantity of terminal units, including both terminal air units (variable air volume boxes, fan powered boxes, unit ventilators, etc.) and terminal heat units (unit heaters, radiators, etc.) should be documented. The quantity of terminal units above the ceiling will most likely be obtained through MEP drawings.

  If a reflected ceiling plan is not available, the EMP may have to count light fixtures manually while touring the facility. The EMP should inspect several sample fixtures to determine the lamp and ballast types and quantities, and then record foot candle levels throughout the building. Types and locations of lighting controls should be noted and may reveal potential opportunities for motion sensors or daylighting controls.

- **Wrap-Up (30 minutes–1 hour)**

  As soon as possible after the walk-through has been completed, the EMP should organize his or her thoughts and notes. The use of templates, checklists, and forms during the walk-through is often very effective, but detailed handwritten notes are sufficient if they are well-organized. Prior to leaving the site, the EMP should arrange a wrap-up meeting with the operating staff to discuss findings and initial thoughts. This may result in modifications or additions to the EMP's walk-through notes. Documents should be collected and any photocopies produced.

  A list of items that require additional attention or information should be created and discussed with the staff. Next to each item, record the path to completion, the responsible team member, and due date. The EMP should always conclude the visit by informing the client of next steps and projected timelines. One best practice is to conclude the visit with agreement about the date and time for the next meeting or call.

For a full sample outline of items comprising a typical preliminary assessment, see Appendix B.

Appendix B

Sample Preliminary Assessment Outline

Each facility will merit different questions and data points. The system-specific list above is by no means exhaustive, although many of the standard questions that an EMP might ask were included. Examples of additional maintenance questions that the EMP might ask during preliminary assessment include:

- When is outside air being provided?
- How often are the filters cleaned?
- Is the bug screen on the louvers clogged?
- What types of plumbing fixtures are used?
- Do faucets have low-flow aerators or automatic controls?
- Are coils and belts maintained at appropriate tension?

The EMP should heed his or her own senses as they react to the building: Are equipment conditions and comfort level what one would expect? Is the air damp? Is the space dim? Are any areas drafty? The EMP's observations can drive realizations about what systems require further measurement and analysis.

The EMP's focus is basic observations and impressions. If the EMP believes that they are necessary, a few basic measurements (e.g., temperature, humidity, carbon dioxide concentration, and/or ambient illumination, etc.) may be taken. Of course, building problems can also be due to maintenance or operations practices rather than malfunctioning equipment.

While concerns raised by the client may have prompted the project, the EMP's assessment may lead to reconsideration and redirection. For example, the client may suspect that air-handling units must be replaced, but during the walk-through, the EMP discovers that the units themselves are fine. In reality, perhaps a faulty control sequence, or problematic delivery of chilled water from the central plant, is the cause of the issues observed and reported by the client.

1.C.3 Observation of Potential Measures

During preliminary assessment, the EMP will get to know the building and its systems. The walk-through is the EMP's first opportunity to observe system operations and ask questions about unusual behavior.

During the course of a project, the EMP will identify both ECMs and FIMs. An ECM involves energy payback, regardless of the upfront cost. (Some ECMs are classified as no-cost or low-cost, while others are considerably more expensive. A FIM simply focuses on improving the facility, regardless of cost or energy impact More advanced building security and better operational performance are examples of FIMs. The cost of a FIM, strictly speaking, may not be recovered (i.e., no payback), and some FIMs may actually result in greater rates of energy consumption and therefore energy expense.

While touring the building, the EMP should begin to mentally develop an initial list of potential ECMs and FIMs. For many clients and most energy management projects, low-cost ECMs/FIMs will be the EMP's area of focus, but large-scale or capital measures should also be noted.

Common examples of low-cost ECMs include:

- Temperature setpoint adjustments
- Equipment run-time adjustments
- Thermostat calibration
- Night setback

The EMP is responsible for representing the client's and/or building owner's best interests. Unnecessary, impractical, or hazardous ECMs/FIMs should never be recommended. The EMP is obligated to identify energy savings opportunities while maintaining efficient performance, system reliability, and sound maintenance practices.

Every project is different. An ECM/FIM that is cost-effective for one project may not prove to be so for another. EMPs should develop a unique list of items for each project. The EMP must be careful to avoid reverting to a "typical" checklist that—due to his or her overlooking special circumstances or unique items—may threaten project success. Moreover, "typical" checklists quickly become dated, as new technologies and best practices are continuously emerging.

In short, the EMP must keep in mind that the objective of the preliminary assessment is to become familiar with the building and gather information that provides reasonable support for benchmarking and further investigation.

For example, the client consultation may have revealed that one of the building's chillers is old and operating inefficiently. Replacing the chiller may be a potential ECM. However, it is important not to draw conclusions until further analysis confirms that a chiller of the same size is still necessary. Providing the client premature conclusions is counterproductive to energy management and to maintaining the client's confidence in the project.

Continuing with the example of the faulty chiller, the walk-through is an opportunity for the EMP to gather more information and begin to characterize the potential ECM. In this scenario, the EMP should:

- Identify the chiller by model, manufacturer, and nominal size.
- Learn more about how the system operates. Take static snapshots of the direct digital control (DDC) system screen (or produce printouts) and save preliminary trend data, if available. Discuss chiller functionality with building staff.
- Note any variable frequency drives installed on the pumps and the type of cooling tower associated with the system.

The preliminary assessment offers an EMP the opportunity to observe and gather system information to support the development of ECMs and FIMs.

1.C.4 Desired Outcome

At the end of the preliminary assessment, the EMP will have:

- Verified physical characteristics of the building described during the client consultation.
- Documented the client's concerns and listened carefully to feedback regarding their goals and motivations.
- Obtained energy bills and supply contracts if not previously received.
- Examined and noted important details about the building's energy-consuming systems.
- Developed a preliminary list of ECMs/FIMs for this particular site that warrant further investigation and analysis.

The EMP makes use of energy usage information gathered during the client consultation and preliminary assessment to benchmark the project building. Benchmarking provides the EMP and client with an initial picture of the building's current energy profile, and to some extent savings potential. The lessons learned through benchmarking, in combination with the potential ECMs/FIMs identified during the walk-through, are necessary to establish the case for proceeding with the next phase of the project.

1.D BENCHMARKING

Benchmarking

Quantifying the relative performance of a facility by comparing its performance metrics with those of similar facilities.

Benchmarking analysis provides a preliminary glimpse at a facility's potential energy savings through comparison with similar buildings.

Benchmarking is a valuable screening tool; however, it cannot be used in lieu of an actual site visit or solely as a foundation for an offer that ensures a reduction of energy use. There may be a good reason for a facility's level of energy use (whether higher or lower than that of similar buildings) that cannot be determined without an actual site visit. An EMP should not make premature judgments about a facility and its energy savings potential without actually visiting the site.

1.D.1 Industry Tools

There are several benchmarking tools available to the EMP. Two of the most common are Energy Star Portfolio Manager and the Commercial Building Energy Consumption Survey (CBECs). Both of them originated from departments within the U.S. federal government. City or state governments, local utilities, trade organizations, and larger corporations may also have made benchmarking tools available to their constituents, customers, members, or employees. The EMP should consider which industry tools provide the most helpful building comparisons on a project-by-project basis.

1.D.1.a Energy Star Portfolio Manager

Energy Star Portfolio Manager Online

Explore Portfolio Manager by starting from the Energy Star website:

www.energystar.gov

Energy Star Portfolio Manager is a popular way to benchmark a building's performance. Portfolio Manager is an online tool offered by Energy Star, a joint program of the U.S. Environmental Protection Agency and U.S. Department of Energy. As a government-backed resource, it is freely available to the public.

The inputs to Energy Star Portfolio Manager include utility history, occupancy data, and basic information about building operations. Once these attributes are entered on-line, Portfolio Manager assigns the building a score for its energy performance by comparing it with similar buildings.

Energy Star scores are dynamic and range from 0 (lowest) to 100 (highest), with a score of 50 indicating average performance. This score takes into account factors such as building type, location, size, space usage, and occupancy. Certain unique classifications of buildings or spaces are not currently supported by Portfolio Manager, but the most common ones are represented. In order to qualify for the Energy Star label, a building must earn a rating of 75 or higher.

The ratings are not static. As the energy efficiency of the national building stock increases over time, a building that does absolutely nothing to improve its rating will naturally see its score decline. A score of 50 will always reflect the average, but the definition of average performance will change.

In some cases, the client may provide an EMP with an estimate of the building's Energy Star score. Ideally, the client is already using Portfolio Manager to track energy usage for the project building on a monthly basis.

If the client or appropriate building stakeholder does not maintain a Portfolio Manager account, or the account does not include data for the project building, the following basic information is needed to characterize the facility and generate a score:

- Building square footage.
- Year of construction and any major renovations.
- Building use types (office, retail, school, hospital, etc.).
- At least twelve consecutive months of whole-building utility data, for all energy sources, with no gaps.
- Numbers of occupants, square footage, operating or occupancy hours, and number of computers for each type of space.
- Additional equipment and population information depending on space type designations.

Even if the building was profiled in Portfolio Manager before the project began, the EMP may wish to review the information for accuracy. The account was not necessarily established by a person familiar with the intricacies of the tool.

View a sample Energy Star Portfolio Manager input page in Appendix C.

Appendix C

Energy Star Portfolio Manager Tool

1.D.1.b Commercial Building Energy Consumption Survey

The statistical database that drives Energy Star Portfolio Manager is the Commercial Building Energy Consumption Survey (CBECS). Developed by the Energy Information Administration (EIA), a unit of the U.S. Department of Energy, CBECS is the result of a periodic study of the national commercial building stock. The survey is intended to capture the wide variety of commercial building types across the country. For purposes of CBECS, commercial buildings are defined as those in which at least half of the floorspace is used for a purpose that is not residential, industrial, or agricultural.

CBECS Online

Find CBECS tables by starting at the U.S. Energy Information Administration website:

www.eia.doe.gov

Energy Use Index

A building's or building system's energy use divided by the applicable area for a certain period of time. Often expressed as kBtu/ft²/year. Also referred to as "energy usage index" of "energy use intensity."

The EMP can use CBECS figures to estimate a building's **energy use index (EUI)**, which is a metric that expresses consumption of an entire building or specific system on the basis of both area and time. Within the industry, EUI is also known alternatively as "energy usage index" or "energy use intensity." A facility's EUI is commonly expressed in units of kBtu/ft^2 with the time period (e.g., one year) stated. EUI calculations will be discussed in detail in Phase 2.

CBECS tables are numerous and comprehensive in scope. They dissect characteristics such as census region and division, climate zone, floorspace, year of construction, principal building activity, employment and occupancy, and energy sources (electricity, natural gas, fuel oil, and district heat) and energy end uses.

Principal activities are grouped as follows: education, food sales, food service, health care (inpatient and outpatient), lodging, mercantile (retail and mall), office, public assembly, public order and safety, religious worship, service, warehouse and storage, and other.

Energy end uses are categorized as follows: space heating, space cooling, ventilation, water heating, lighting, cooking, refrigeration, office equipment, and computers. Summary tables report average energy consumption, expenditures, and intensities.

Traditionally, the actual building survey that is used to populate the CBECS database has been completed every four years. Results are published several years later. Due to the logistical challenges associated with gathering and analyzing raw data, the published figures always lag behind present reality. In addition, since CBECS is ultimately funded by the federal government, budget constraints can lead to delays in the release of initial field surveys and final data tables.

Appendix D

Commercial Building Energy Consumption Survey

Even though CBECS data may be a few years old by the time it is available to the public, it is a very useful source of information for the EMP and his or her client. CBECS helps them understand in general how the project building's performance compares to a set of similar facilities.

An excerpt of a typical CBECS data table is available in Appendix D.

CASE STUDY 1.3 — BENCHMARKING | BUILDING C

Building C is a 40-story all-electric office tower with over 1 million square feet of floorspace located in New York. The facility's primary source of heat is an electric baseboard system. At the start of the project, the EMP was provided with two years of monthly base building energy data, which included on-peak and off-peak usage, as well as peak demand.

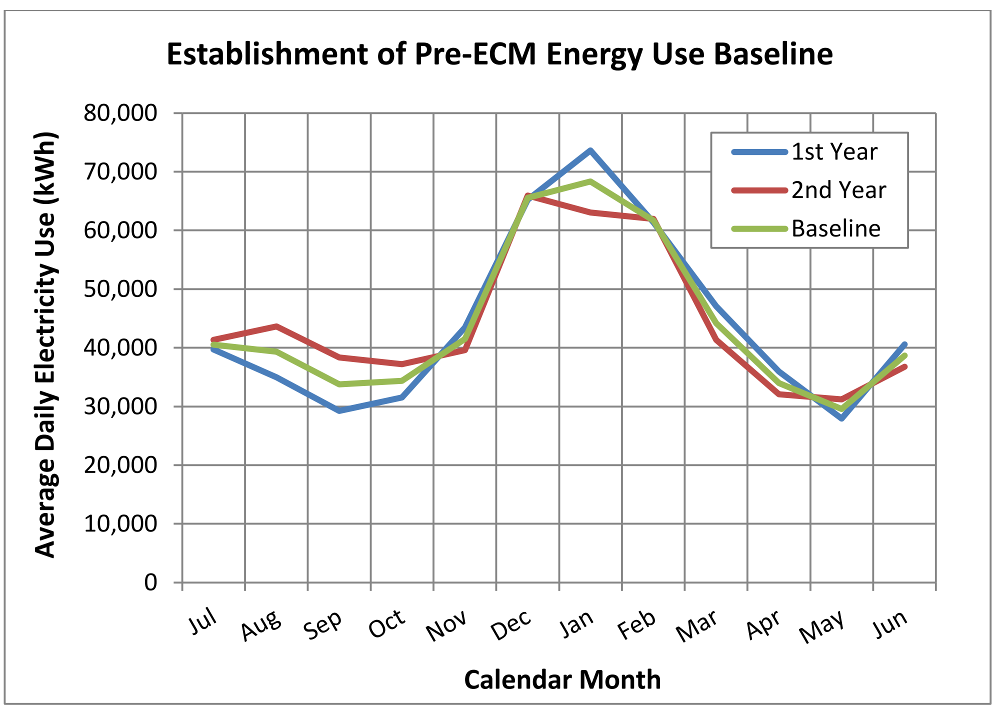
The client shared the building's Energy Star Portfolio Manager account login information with the EMP. After reviewing the Energy Star data available online, the EMP noted that the reported energy intensity was 78.3 kBtu/ft^2. The latest Energy Star rating was 71, meaning that the building was already performing better than average.

The latest data recorded in Portfolio Manager, however, were more than a year old. The EMP suggested to the client that bringing the Energy Star entries up-to-date was one straightforward way to help benchmark the building.

The project building was a relatively large one—an outlier in a set containing all office buildings. For that reason, the EMP did not consult CBECS tables for additional figures, because the underlying CBECS database was unlikely to contain many similar facilities.

When analyzing historical energy usage patterns, the EMP and building staff identified excessive energy consumption throughout the heating season, particularly during off-peak hours, when the building is largely unoccupied.

The EMP divided each month's usage by the number of days in the billing cycle. Next, the EMP plotted the two years of daily average energy consumption data, one data point for each month, superimposing the two figures for identical calendar months. Averages of 1st Year and 2nd Year values would serve as the baseline. The data are plotted below.



The EMP reasoned that this benchmark could be used later to confirm energy reduction achieved following ECM implementation. The EMP reasoned that comparing energy use for the full year following the retrofit to the baseline would verify the ECM's effectiveness.

The Energy Management Project at Building C is discussed further in Case Studies 2.4, 2.5, and 7.3.

1.D.2 Portfolio Considerations

Benchmarking indices like Energy Star and CBECS use data from across the U.S. While the results can be regionalized to some degree, independent analysis of a portfolio of similar buildings provides a better benchmark for those buildings.

Portfolio analysis enables an EMP to gauge the energy performance of a particular building by comparing it to others within a certain group. Some clients for whom this might be appropriate include:

- School districts
- Retail chains
- Military bases
- College/university campuses
- **Real estate investment trusts (REITs)**
- Property developers or building management firms

Real Estate Investment Trust (REIT)

A company that produces a majority of its income from property ownership and returns over 90% of its taxable income to shareholders.

When benchmarking a portfolio, the EMP should create comparison charts and graphs that differentiate the buildings. One objective of this exercise is to develop a general sense of how the portfolio as a whole is performing. Another objective is to identify the outliers—the "best" and "worst" performers at opposite ends of the distribution. The EMP should:

- **Use identical metrics to benchmark facilities.**

  The most common parameters are energy consumption (e.g., kBtu or kWh) and energy cost (dollars). Express numbers "per year" or in terms of a similar mutually agreeable unit. In order to account for buildings of different sizes, consider normalizing the data with respect to floorspace by calculating energy use or expense "per gross square foot per year."

- **Compare performance of similar building types to one another.**

  Benchmarking can be most useful when used to view a set of buildings that share common attributes. For example, compare the performance of elementary schools within the same district or residence halls on the same college campus. Buildings that are not used for the same activities and are not operating on the same schedules will almost always have different EUIs, however, even if all are performing well.

- **Document assumptions about building operations or occupancy.**

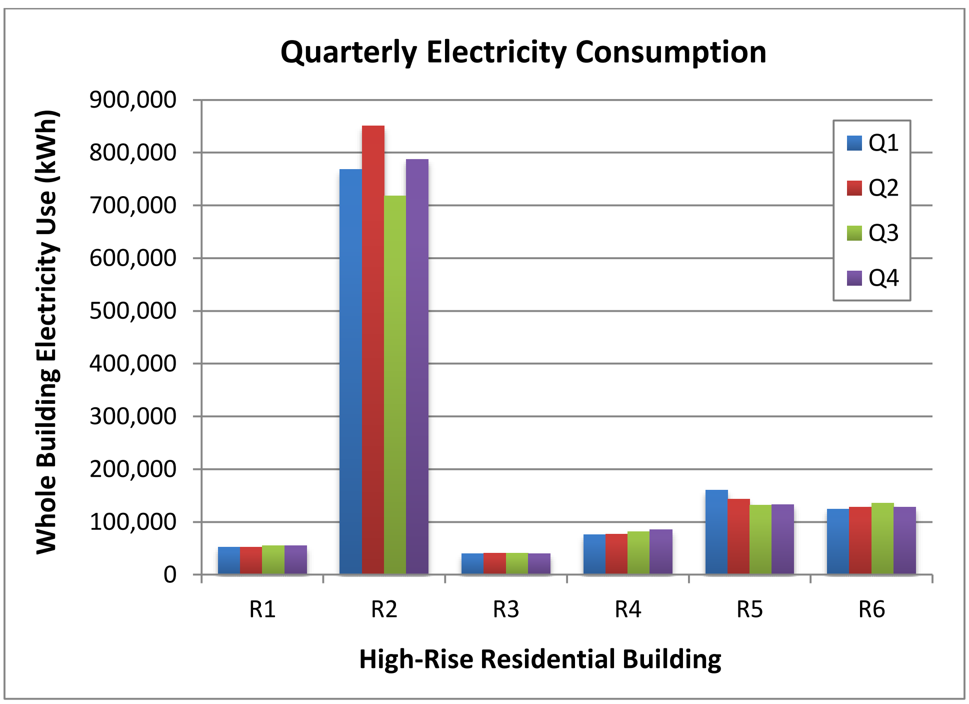
  These variables will have a significant impact on energy use. A military base has facilities that serve very different purposes, not all of which may be readily apparent to the EMP. Office buildings can vary significantly with respect to tenant activities and vacant space. The EMP should strive to validate any assumptions by asking questions and seeking confirmation from other members of the project team.

Benchmarking a similar group of facilities provides the EMP with a perfect opportunity to identify sites with poor, average, and outstanding performance. The most inefficient buildings may present the greatest opportunity for ECMs and EBCx. Meanwhile, those operating efficiently may be a source of good insights and practices that can be applied to the balance of the portfolio.

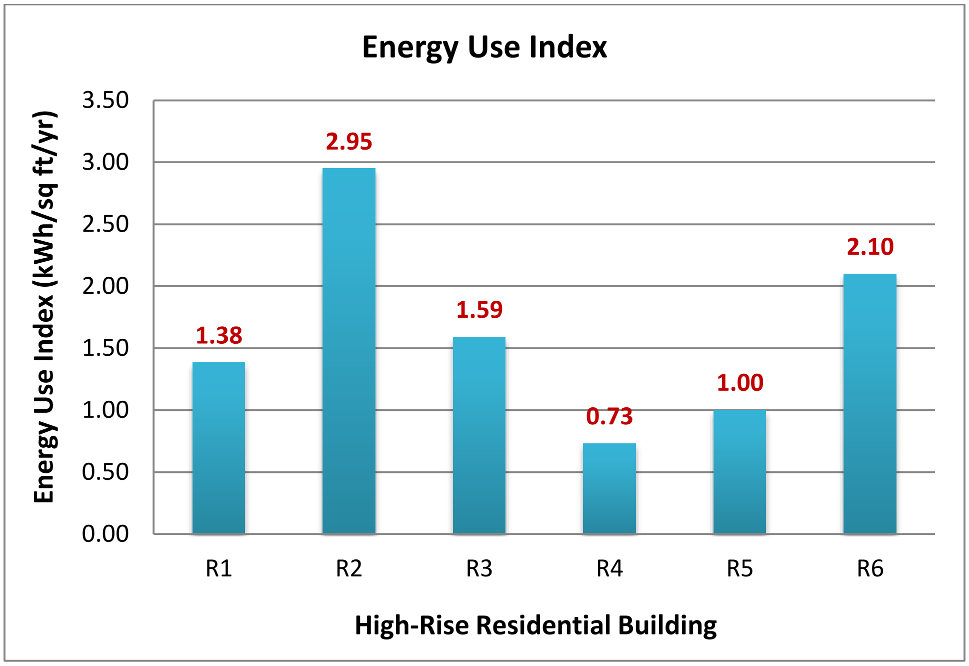
Graphs are useful for assessing energy use throughout a portfolio for a specific period of time. Such visual representations of the energy use comparison are also useful for illustrating benchmarking results to the client.

Facility comparison charts can illustrate a variety of metrics, one of the most helpful being EUI, which takes into account not only building energy usage, but also square footage. The two bar graphs below were generated to compare energy use and intensity of six high-rise residential buildings in California.

The first graph demonstrates that Residence 2 (R2) is clearly and consistently the greatest energy consumer for all four quarters of the year in question. Building size, however, has not yet factored into the analysis. If R2 is much larger than the other five, its level of energy use may be quite reasonable:



After dividing total annual energy use by the gross square feet for each of the six facilities, the bars are much more similar in height:



Nevertheless, the chart summarizing EUIs confirms that R2 is the most energy-intensive, at least according to this metric, while Residence 4 (R4) is the least energy-intensive. After confirming these findings, an EMP working on an energy management project for this portfolio should examine both Residences 2 and 4 in order to understand the root causes of these divergent EUIs.

The EMP's own experience, as well as proprietary data from previous projects, can also provide benchmarks for project buildings in the same geographic area. For this reason, a best practice is to construct and maintain a database of local projects. The database effectively serves as a building portfolio, which the EMP can consult when necessary to benchmark a new project building. The more real data that is available to the EMP, the more accurate the results of benchmarking should be.

Once the EMP has gathered information about systems and operations, performed a preliminary site assessment, and estimated energy use and savings potential, the next step is developing a proposal for further exploration.

1.E PROPOSAL FOR FURTHER EXPLORATION

With the information obtained in the client consultation, the preliminary assessment, and benchmarking analysis, the EMP develops and submits a proposal to the client. The proposal must present rationale for continuing with the energy management project.

The potential for energy savings and performance improvement must be sufficient to warrant additional project funding. In that respect, the proposal should address how the client's performance requirements can likely be achieved, starting with further exploration of the accumulated data and the project facility itself.

In format, the proposal is similar to Basis of Design documents commonly used in the context of commissioning.

The proposal should include:

- Summary of the client's motivations for pursuing the project.
- Overview of the observed conditions of the building and its systems.
- List of potential ECMs/FIMs that is understandably subject to change.
- Professional fees associated with the supplementary analysis and facility assessment necessary to identify and screen ECMs/FIMs.
- Outline of the scope of work for Phase 2.
- Timeline for upcoming steps in the project.

At this point in the project, the EMP has gathered enough information to visualize potential ECMs/FIMs, but not enough information to weigh, filter, and substantiate them.

1.E.1 Plan Development

The EMP should begin development of the proposal after first reviewing all results of the client consultation and walk-through. The proposal should describe the process by which the EMP plans to analyze the energy data and other information collected from the project building during Phase 1. General in nature, the proposal should demonstrate a solid understanding of the building in order to secure the client's confidence.

The EMP does not yet have the information necessary to assign costs to the development of specific ECMs and FIMs. Nevertheless, characterizing each element of the emerging plan in a reasonable level of detail is a best practice. A preliminary schedule will help the client understand the project timeframe. During Phase 2, the EMP will fully characterize building energy usage and begin evaluating the potential of specific ECMs/FIMs.

EBCx plays a central role in the EMA Energy Management Process. The EMP should begin to develop a plan for EBCx before entering Phase 2.

1.E.2 EBCx Scope

EBCx Scope

A document detailing systems to be examined, proposed functional performance tests, and TAB activities, to be included in the EBCx process.

A preliminary **EBCx Scope** should also be included in the proposal. EBCx is an essential part of an energy management project and will be part of nearly every phase. The commissioning of both newly-installed systems and existing building systems demonstrates the holistic view and extensive skills that EMPs bring to a project.

The scope of work for the commissioning of new systems that are installed during the project will be determined as ECMs/FIMs are developed and finalized. This point in the project is an ideal time for the EMP to begin developing the EBCx Scope.

The preliminary EBCx Scope should mirror the outline of the larger proposal. The EMP should make sure to include:

- Comments on merging the investigation for both EBCx and ECMs/FIMs.
- List of specific systems to be addressed by EBCx.
- Summary of proposed limited functional testing.
- Essential preparation for investigative TAB efforts.
- Professional fees associated with hiring TAB or other contractors.

The preliminary EBCx Scope should also propose a timeline for EBCx activities. Besides providing the client with a clear sense of when EBCx investigation will occur, the timeline also provides a summary of EBCx's role in future phases.

These documents should provide the client with clear information and present strong justification for moving on to further analysis and exploration.

PROJECT ASSESSMENT SUMMARY

*During **Phase 1: Project Assessment**, the EMP starts the project in close communication with the client.*

The EMP gains valuable insight into the client's motivations for undertaking the project and works with the client to articulate goals and develop funding strategies.

In addition, the EMP performs a quick walk-through of the facility and begins to collect equipment and operations data from the building staff.

Benchmarking strategies are developed so that the EMP can gauge the project's savings potential and track progress towards the client's goals.

*Finally, the EMP considers the available information and drafts a proposal that makes a solid argument for continuing on to the **Phase 2: Energy Use Exploration**.*

2 Energy Use Exploration

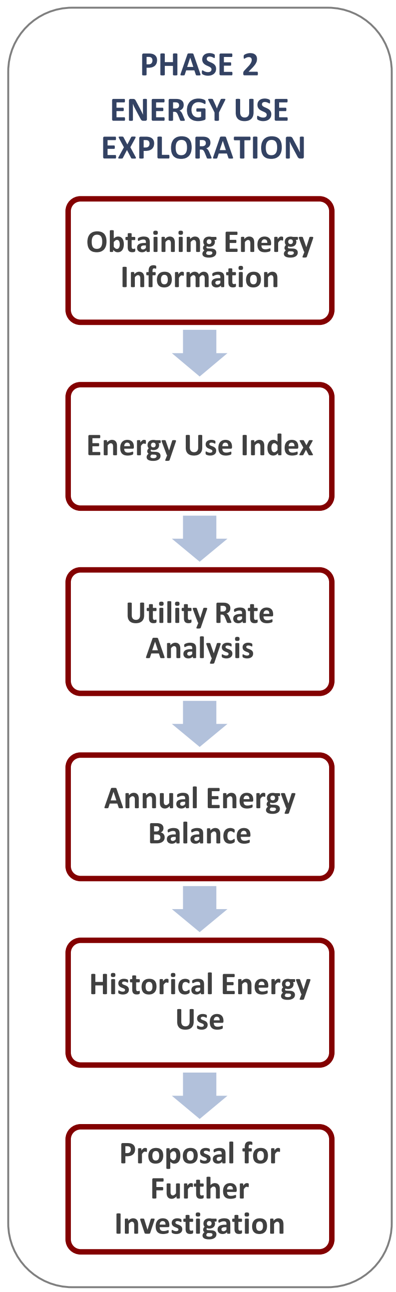
In the Energy Use Exploration Phase, the EMP combines field experience and preliminary building information with detailed data analysis and calculations. The examination of historical energy consumption and costs will help the EMP further refine potential ECMs/FIMs and anticipate their savings potential.

The mission of the Energy Use Exploration Phase is to:

- Use energy data to determine current and historical energy consumption characteristics.
- Analyze building energy use by fuel source and building system.
- Ensure that energy usage metrics accurately account for weather, time, and changes in building operations and occupancy.

This chapter should provide the EMP with:

- Tools for critically investigating building energy use.
- Step-by-step guidance for performing analyses.
- Methods to identify energy usage patterns and anomalies.



Energy Use Exploration Outline

This phase is divided into six major subsections:

During **Phase 2: Energy Use Exploration**, the EMP begins **energy consumption analysis (ECA)**. ECA is a framework for gathering information and performing detailed analysis of the facility's historical energy consumption data. ECA may also be referred to as utility consumption analysis (UCA) or some similar term. When performing ECA, the EMP uses energy use and cost data to determine utility rates for the project and create a building energy profile.

Energy Consumption Analysis

Detailed study of a facility's historical energy consumption.

2.A OBTAINING ENERGY INFORMATION

Energy consumption analysis is most effective when the EMP has at least three years of facility energy consumption data. Since gathering historical energy bills and spreadsheets can take time, the EMP should ask for this information during the client consultation described in Phase 1. The EMP should ask the client or appropriate project team member to provide:

1. **Monthly Utility Bills for All Energy Sources**

   Most bills should list consumption, customer rate class, meter read dates, specific charges, and possibly other helpful information. Electricity bills should also list demand (kW). Utilities across the country vary considerably in the level of detail they provide customers. Utility websites can be an important data source, providing access to the current ***utility tariff*** *structure, explanation of rate classes, and other pertinent information. Increasingly, utilities also host online portals that enable their customers to explore and download their usage and cost history. The EMP should ask the client for login details or suggest registering for the service.*

2. **Monthly Supplier Bills for All Energy Sources**

   In states where electricity and/or natural gas is/are deregulated, the facility may purchase energy from a retailer supplier instead of the utility. Supply bills will list charges that are distinct from those billed by the delivery utility. In some cases, the supplier will issue combined bills that include, in separate sections, its charges as well as utility charges.

3. **Copies of Energy Supply Contracts**

   If the facility does purchase energy from a retail supplier, past and current contracts will prove useful. At a minimum, these documents will describe the supply rates and the effective term. Suppliers offer a wide variety of products. In terms of electricity, some buildings will sign a contract that fixes the price for many months at a time, while others will pay a variable price that changes each month—or even each hour—in accordance with

Utility Tariff

A schedule of rates or charges associated with purchase and use of energy from a utility.

the energy commodity markets. These are just two examples of electricity supply contracts. The building may have hedged, or pre-purchased, natural gas at a certain price for future consumption. Contracts, as well as supply commitments that the building has already made, are important for the EMP to review, because they help explain the prices that the building expects to pay for energy in forthcoming months or years.

The EMP should make sure to collect bills for all energy sources. Electricity and natural gas are two common examples. Depending on the building, other sources might include propane, fuel oil, coal, and district sources such as heating (hot water or steam) or cooling (chilled water). Energy generated by onsite renewable sources that is consumed at the facility must also be factored into the EMP's analysis.

In some instances, a complete set of energy bills may not be readily available. Two common types of sites for which billing information may be limited are:

- **Multi-Building Campuses**

  Energy usage data may not be available for each specific facility at military bases, universities, and similar complexes. The EMP's objective should be to obtain information at the greatest possible level of detail. In such cases, the EMP will need to create a baseline preliminary ***energy model*** *analyzing individual buildings.*

Energy Model

A digitally-generated simulation of building systems operation. Also referred to as a "simulation model."

- **Multi-Tenant Facilities**

  When a facility houses multiple tenants, energy data may initially be provided for the base building only. This data will typically account for major mechanical equipment, common area lighting, and common area plug loads. In some instances, this information will be sufficient for the EMP's analysis. Calculation of an accurate EUI may be challenging due to difficulties in defining space boundaries and allocating square footage. If the EMP is tasked with exploring tenant areas, or the EMP learns from the project team that some base building equipment is actually billed through tenant accounts, the EMP should request the appropriate tenant bills and contracts as well.

Comprehensive data collection will enable the EMP to conduct accurate analysis of the building's consumption and costs. Gaps in the data should be addressed with the appropriate project team members. The EMP should also watch for possible discrepancies between information received from the building and reported on the bills.

2.B ENERGY USE INDEX

The energy use index (EUI), also referred to as “energy usage index” or “energy use intensity,” is a crucial and common metric. This value is a measure of the total energy use of the building on the basis of area and time (e.g., per square foot, per year). The EUI is commonly expressed in units of Btu/ft^2 or kBtu/ft^2 or kWh/ft^2 with the time period stated. Typically, an EMP calculates EUI by summing all energy used in common units and dividing it by the building area.

The square footage used for building area should include all spaces that are typically lit and/or conditioned. Depending on the type of facility, certain qualifications may be necessary. For example, a parking garage that is lit but not conditioned may or may not be included in a building’s EUI calculation. The EMP may wish to explore how Energy Star Portfolio Manager directs users to define space areas.

In order to prevent any confusion as to how the space is defined, the EMP should clarify these assumptions when reporting the EUI. Additionally, the EMP should acknowledge if the building experienced major changes in occupancy or operations that may have resulted in an unusual increase or decrease in the observed EUI. The EUI is the most common way to express the total energy consumption for a facility.

The EUI allows the EMP to discuss the building’s energy consumption with respect to area and compare its performance to others of various sizes. After collecting additional information about the building, the EMP can begin to recognize connections between the EUI and actual performance.

As a number, the EUI alone carries little value. The EUI is most helpful when the EMP analyzes it alongside building characteristics such as geographic location, construction type, age, building purpose, hours of operation, and occupancy. By considering all of this information together, the EMP can make informed conclusions about building energy performance.

Suppose that an EMP has calculated the EUI for an elementary school but has no other information about the site. It may be impossible to determine if the EUI is low, high, or about average for that type of facility. On the other hand, suppose that the EMP has the EUI but also knows that the school has a brick façade, was built in 1995, and is located in St. Louis. Considering the school’s EUI in this context, the EMP can compare its value to EUIs of similar buildings in the same geographic region. Such comparison can yield valuable conclusions about building energy performance and energy savings potential.

EUIs that apply to a base building or whole building are not the only option. One or more systems within a facility can also be described with unique EUIs. For example, an EUI can be developed to measure energy use for lighting, heating, cooling, fans, or any other energy-consuming system.

The EMP should also consider EUI (Btu/ft^2 or kWh/ ft^2) in relation to energy cost ($/ft^2). When combined together, the EMP can estimate energy usage and costs for tenant spaces or specific building spaces. The EMP may also calculate these metrics for specific building systems (e.g., lighting) as a convenient way to express current energy use and costs to the client.

2.C UTILITY RATE ANALYSIS

Utility Rate Analysis

Study of a facility's current and historical energy usage and cost in individual and common units of measurement.

Utility rate analysis addresses the building's energy use and cost in common units of measurement. The EMP carefully examines utility costs and energy consumption by source fuel in order to calculate applicable rates for the project.

2.C.1 Basic Procedure

The outcome of utility rate analysis is a set of energy rates that are used throughout the project for benchmarking and estimating cost savings of potential ECMs. The specific course of action depends on the quantity and quality of data available. Typically, the EMP will:

1. **Organize utility data.**

   If the data collected from the building's energy bills is not already organized in spreadsheets, the EMP should create a new file and populate sheets with data from the bills. "As billed" energy units must be recorded, particularly for natural gas, as units will vary.

   The EMP should identify line item charges that correlate with energy use (i.e., those that are applied per kWh, per kW, per therm, etc.) and record these in the sheets as well. Flat charges that appear on each bill regardless of the level of use (i.e., those that are applied per month, per meter, etc.) are less important to track.

2. **Determine the cost rates.**

   The number of months of data to summarize when calculating rates may vary from one project or client to another. Typically, the EMP's goal is to calculate an average rate that correctly reflects the actual costs incurred by the facility. Common timeframes include the most recent three months, the most recent twelve months, and the most recent fiscal or calendar year.

   For example, if the price of electricity was $0.10 per kWh for six months and then fell to $0.06 per kWh for the next six months, the average for *the most recent three months would still be just $0.06, but the average for the entire twelve months would be $0.08.*

Extenuating circumstances may warrant normalizing energy usage and/or costs over a shorter or longer period of time, depending on project requirements. Either one rate or a serimonttes of rates (e.g., seasonal, time-of-use, etc.) should be established for each energy source.

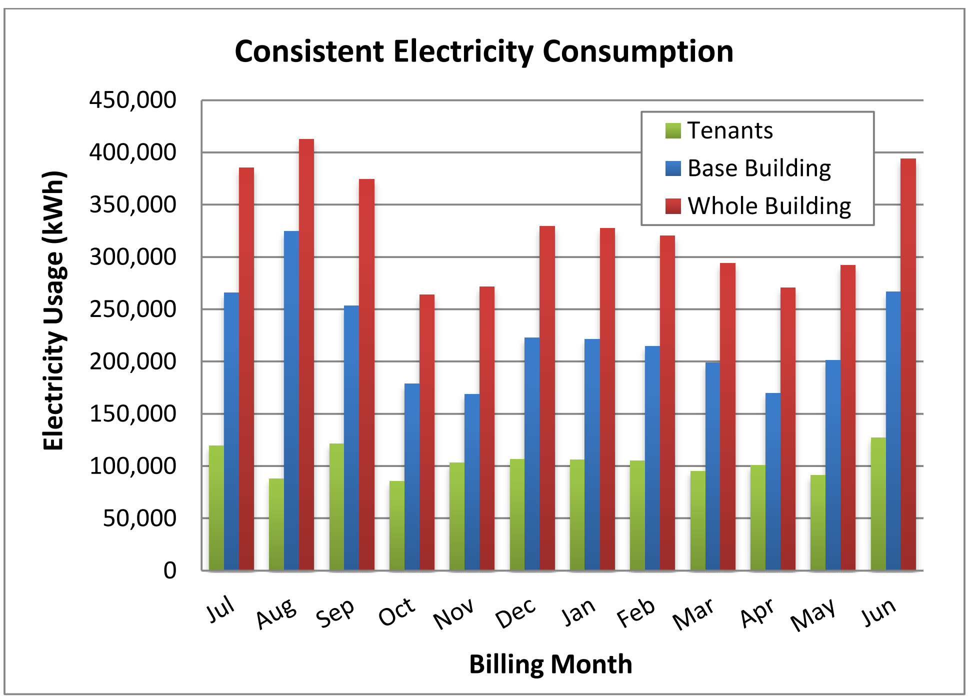
3. Produce graphs.

The EMP should develop graphs for each energy source reflecting twelve or more months of "as billed" usage and cost history. Depicting numbers graphically is a quick way to easily identify anomalies in building operations.

For example, imagine that one month shows excessive use or cost that is not explained on the basis of weather. The EMP may explore with the project team possible causes, which may be something as simple as a billing error or as complex as an equipment malfunction. Regardless of the cause, by taking time to address concerns raised by looking at the graph, the EMP may be in a position to help the client correct a problem and save money.

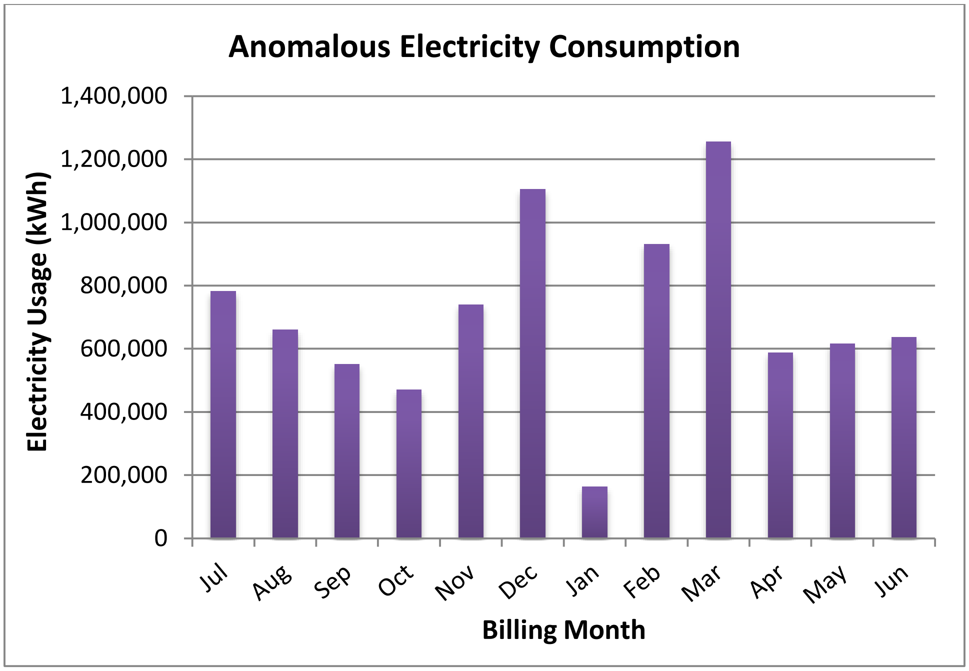
Two graphs below depict twelve months of electricity consumption at different commercial office buildings.

The first graph, below, divides consumption between the base building and tenant spaces in a building that uses electricity for cooling but natural gas for heating.



The graph above depicts typical seasonal variation, with greatest use in summer, significant use in winter, and least use during shoulder months of spring and fall.

The second graph, below, depicts whole building consumption at an all-electric facility.



Usage is significant in winter and summer months—typical for a building that consumes electricity for both heating and cooling. The reading for January 2011 is much too low, however, and the reading for March 2011 is likely too high. The EMP working with the building whose energy use is depicted in the second graph should take time to explore the reasons for the irregular appearance of the monthly data.

4. Convert to common energy units.

Since energy sources are reported in different units, the EMP may find it beneficial to convert all sources to common units in order to compare costs more equally. Depending on the project and types of sources, one particular unit or another may be most useful. Two classes of units that are regularly used to refer to multiple source fuels include the kilowatt-hour (kWh) and the British thermal unit (BTU).

Since the BTU is a relatively small amount of energy in the context of buildings, multiples of BTUs are encountered in practice. Multiples typically used by engineers include the KBTU or kBTU (1,000 BTUs) and the MMBTU or mmBTU (1,000,000 BTUs).

Appendix E

Energy Units and Conversion Factors

See Appendix E for common energy units and their conversions.

The following table lists electricity and natural gas consumption in two different units for each fuel source. The data is for a light manufacturing facility that uses electricity fairly consistently throughout the year.

Lighting Manufacturing Facility Electricity Consumption

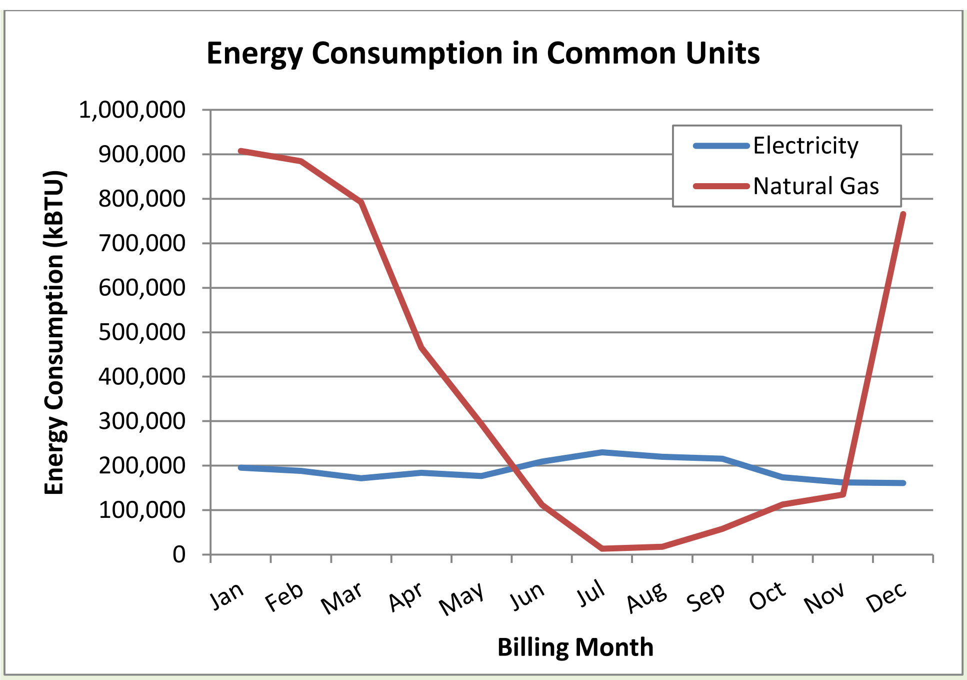
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
kWh	57,208	55,135	50,403	53,973	51,842	61,295	67,355	64,531
kBTU	195,202	188,128	171,982	184,163	176,892	209,147	229,825	220,189

Light Manufacturing Facility Natural Gas Consumption

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
therms	9,079	8,846	7,929	4,656	2,934	1,119	132	179
kBTU	907,909	884,576	792,863	465,577	293,377	111,874	13,161	17,892

The numbers of kWh (for electricity) are much larger than the numbers of therms (for gas). When these two units are converted to kBTU, however, it is clear that—except during the warmest months of the year—the building consumes the majority of its energy as gas. In terms of direct conversion, 1 therm is equivalent to 29.3 kWh.

The following graph summarizes the electricity and natural gas data (in kBTU) from the table above—plus an additional four months.



Utility rate analysis, combined with information gathered from building staff regarding renovations, systems upgrades, and operational changes, provides the

EMP with a comprehensive picture of the building's historical energy use. Properly executed, utility analysis begins to expose abnormal energy consumption patterns that will require resolution. Even at this early stage, the results of utility rate analysis will help the EMP identify potential ECMs.

CASE STUDY 2.1 UTILITY RATE ANALYSIS | BUILDING D

The EMP and project team are initiating a retro-commissioning project at Building D, a multi-story, multi-tenant, all-electric office building located in Dallas. Unfortunately, very few electricity bills were available from the client; only one utility bill was received, and it was ten months old. The EMP supplemented the single month of usage and delivery cost with an additional two years of historical usage and demand data from the utility.

The EMP was able to obtain this data by presenting a form acknowledging the client's authorization, account number, and meter number to the utility. Since the EMP had an old utility bill, the EMP learned about the current charges applicable to the building account's utility rate class through the tariff posted on the utility website.

Additionally, Building D is located in a state where electricity is deregulated, and during the past twelve months, a new supply contract was executed with a new retailer supplier just as another came to an end. The client was able to provide the EMP with copies of the old and new supply contracts.

After organizing the available information, the EMP selected the rate components from the utility tariff and from the current supply contract that were necessary to determine applicable rates per kWh and kW. These included charges for on-peak energy, off-peak energy, transmission, capacity, environmental issues, efficiency programs, demand, and taxes.

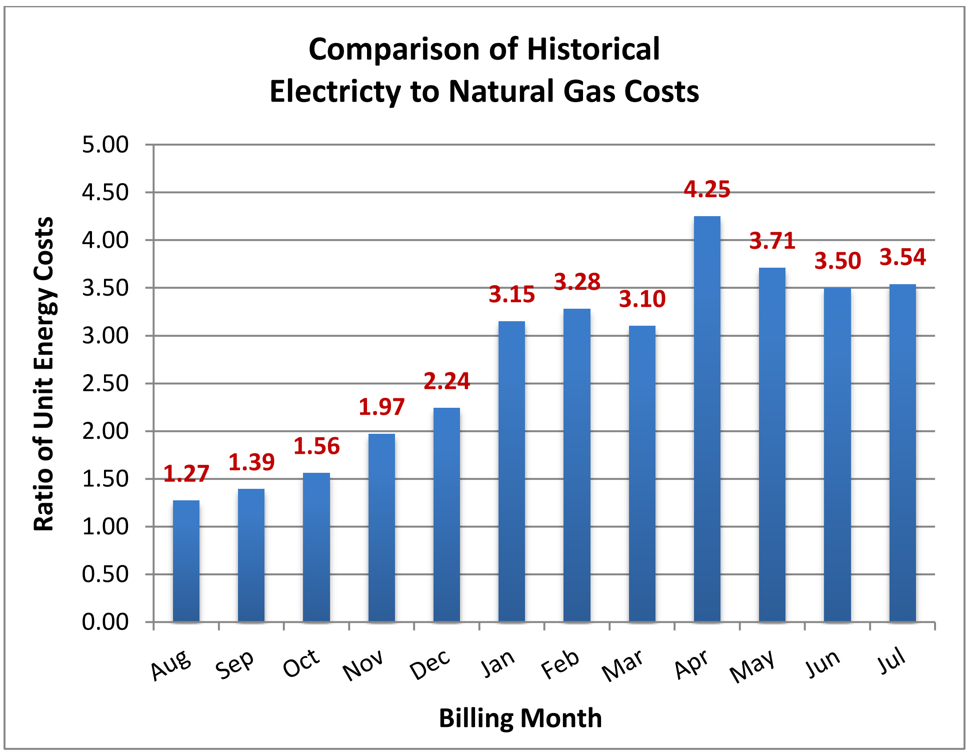
The EMP calculated a marginal demand rate of $7.35/kW and on-peak and off-peak energy consumption rates of $0.0773/kWh and $0.0615/kWh, respectively. Using the building's historical percentages of on-peak and off-peak use, a weighted-average around-the-clock (i.e., non-time-of-use) rate of $0.0724/kWh was established.

Graphs were produced to display two years of usage and demand, pairing data for the same calendar months (one year apart) in order to compare them more easily. The data showed no obvious anomalies, but the EMP observed that usage had generally been rising over the past twelve months, while demand had not followed suit. The EMP noted this observation for later analysis.

2.C.2 Fuel Source Multipliers

Widely divergent comparative costs for two different energy sources might lead the EMP to suggest replacing a specific piece of equipment with a newer model that uses a different fuel. For example, in regions where natural gas is much less expensive than electricity, the replacement of existing electric water heaters with more efficient gas-fired units will reduce energy costs more dramatically than it will reduce energy consumption.

The EMP determines the breakeven point for exchanging fuel sources by examining the dollar cost of one fuel source as a multiplier of another. The graph below compares electricity and natural gas unit costs for a project at a retail store where an EMP is considering replacing an electrical heat pump with a gas furnace. On an equivalent energy basis, the facility's electricity rate during the twelve months depicted in the graph varies from just slightly greater—to more than four times greater—than the natural gas rate. The cost of electricity also appears to have increased over the course of the twelve months.



During the three most recent months, the electric unit cost is about 3.5 times greater than that of natural gas. Factoring in 90% combustion efficiency for the proposed furnace, the breakeven point for replacement of the existing heat pump with a furnace is $3.5 \div 0.90 = 3.9$. This value will be used to determine if lower energy costs over time anticipated for natural gas more than offset the expense associated with purchasing and installing the new furnace.

While electricity has become more expensive (relative to natural gas) in this example, the EMP must also consider whether this divergence in rates is likely to be temporary or permanent. If natural gas costs rise such that the ratio of electricity-to-gas diminishes to 1.5 or even 1.0, the proposed retrofit may not be a good recommendation after all. In regions of the country where various fuel sources fluctuate in price relative to one another, such that no consistent comparative trend can be established, the EMP may be unable to calculate meaningful fuel source multipliers.

2.C.3 Additional Considerations

Utility rate analysis may lead the EMP to new conclusions and renewed questions that encourage further investigation. Depending on the project, the EMP in conjunction with the client may need to make several decisions about energy rates in order to advance the project. During this phase, the EMP should also understand:

Interval Data

Detailed data regarding building energy usage over specified periods of minutes, hours, and days. Available from many electric utilities.

- **Interval Data**

  Interval data*, or interval meter data, is highly granular energy information collected for a number of days. For example, the EMP may obtain electricity usage and demand data for the project building at fifteen-minute intervals, twenty-four hours a day, over a two-week span. Most electric utilities make this data available at a nominal additional cost. Interval meter data will help the EMP identify patterns in usage and demand over the course of a day or week. Situations that result in greater energy costs—such as an undesirable spike in demand in the middle of the day—will also appear. The EMP should also look for anomalies in the data that suggest building equipment malfunction or discrepancies between actual and planned equipment schedules.*

- **Utility Meter Accuracy**

  Conclusions drawn by analyzing meter data are subject to the accuracy of the meters from which the data were obtained. The EMP may choose to confirm when utility meters were last calibrated. If a number of years has passed since the utility last checked the meters, the EMP may recommend that the client request recalibration. Faulty meters make it very difficult for anybody to obtain reliable energy data. Moreover, malfunctioning meters prevent the client from receiving accurate energy bills and a true energy profile.

- **Blended Rates**

  For a given energy source, some facilities may not pay the same rate for all energy that is supplied during a given billing cycle. For example, 60% of electricity requirements may be purchased at a fixed rate that was *placed under contract, while the remaining 40% is bought at a variable index or market rate, which is subject to change monthly, daily, or even hourly. A price for a certain volume of natural gas, typically referred to as a block or hedge, may have been negotiated months or years earlier. The total supply cost for a facility may consist of a series of blocks or hedges, each individually representing 10–25% of estimated use, which in total comprise 80% of anticipated usage for that month. Any additional gas is purchased at a price established by the market.*

In order to reflect the purchases of different amounts of energy at different times and prices for a particular month or billing cycle, the EMP calculates a unified weighted-average rate. This sort of ***blended rate****, which typically results from different proportions of fixed and variable rates, simplifies the analytical process. Blended rates might be calculated for either individual months or billing cycles, or an entire season or year.*

Blended Rate

Energy supply rate that reflect a weighted average of both the fixed and variable market rates that are effective for various quantities of the same energy source during the same time period.

In some instances, the EMP may also wish to calculate rates that merge the unique rates of two or more energy sources. For example, the analysis of equipment that uses two types of fuel, or the impact of changes in one building system on other systems, may prompt the EMP to consider the combined cost of electricity and natural gas. When working with multiple fuel types, however, the resulting combined rate is not typically referred to as a blended rate within the industry.

- **Project's Effective Energy Rates**

  The EMP must explain clearly to the client the particular rates selected for the project. Both parties should agree to them prior to continuing on to the next phase of the project. Ideally, the EMP and the client will reach mutual understanding about energy rates during the client consultation described in Phase 1. Some clients may anticipate greater energy costs in the future and request that calculations be based on price projections. Other clients may prefer historical rates calculated during utility rate analysis. Still others may have prepared operations budgets several years in advance and will ask that the EMP use the rates referenced in those budgets.

- **Peak Demand Curves**

  Peak demand graphs are also useful for analyzing electricity trends. Such data should be examined at the most detailed level available from the utility. A consistent demand profile, without significant and unexpected volatility, is ideal for most buildings. Distributing load throughout the day, if possible, will tend to minimize electricity costs related to demand. Significant fluctuations in demand, and especially spikes in demand at one or more times of the day, call for additional analysis and recommendations. In such cases, the EMP might be able to pinpoint behavioral or scheduling factors that contribute to excessive peak demand.

- **Special Demand Considerations**

  Utility rate classes, as well as ongoing monthly charges, are often linked to the facility's greatest integrated peak demand during the preceding month or year. The period during which this level of demand can be established for each customer (e.g., weekdays, between 8 am and 7 pm) may also be noted in the tariff.

  The distinction between integrated demand and instantaneous demand is an important one. An instantaneous demand spike due to multiple pieces of HVAC equipment starting simultaneously will not necessarily translate to the highest fifteen-minute integrated demand for that day, week, or month. High inrush current, also known as switch-on surge, is an immediate result of turning on electrical equipment, but it only explains a spike in instantaneous demand, not peak billing demand.

  Even for buildings that exhibit optimal performance, there will be times when integrated peak billing demand is considerable, such as during the hottest afternoons of a scorching summer, when cooling equipment is operating near full capacity. Nevertheless, minimizing peak billing demand throughout the year, and especially during those months when it reaches a maximum, should be a priority for the EMP.

  This is particularly true in regions where the utility has ratcheted demand policies, whereby the utility sets the customer's billing demand rate according to the highest integrated demand anticipated during a predetermined period of time. Facilities that operate on a seasonal or inconsistent basis, demonstrating significant demand for energy at some times, and very little demand at other times, are prime candidates for ratcheted demand charges. The utility must reserve that energy year-round and have it available for the customer to use, whether or not the facility actually uses it.

- **Rate Optimization and Energy Supply Opportunities**

  Energy procurement is not an ECM or FIM, but the EMP may very well want to consider making clear recommendations as a way to deliver additional value. The EMP may be in a position to negotiate with a utility or retail energy supplier on behalf of the client to optimize rate structure or mitigate burdensome pricing practices. Regardless of whether the client is in the middle or near the end of an existing supply contract, the EMP may suggest whether or not better rates may be available now or in the future. Energy costs should be reviewed periodically, not simply when a contract is up for renewal. The best time to extend a supply contact may even be a few months after another was signed.

CASE STUDY 2.2 ADDITIONAL CONSIDERATIONS | BUILDING E

Building E is a small industrial facility in Newark that uses both electricity and natural gas. The EMP observed that usage follows a consistent pattern. Most increases and decreases could be explained on the basis of changes in either production or weather. Facility staff reported that the meters had been recalibrated ten months earlier, suggesting that the meters were most likely functioning properly.

In order to better understand how lighting, manufacturing apparatus, and the space conditioning systems were operating in conjunction with one another, the EMP ordered two full weeks of interval data from the utility. After producing daily use and demand curves, the EMP learned that demand was peaking at particular times each weekday. The EMP examined electricity bills for corroboration. Both monthly peak demand and related charges were unusually large given the size and load.

The EMP made a note to explore, as one potential ECM, the optimization of equipment schedules to reduce peak demand and thus cost. The problem was not inrush current, which explains instantaneous demand, not integrated billing demand, but rather the unnecessary simultaneous operation of much of the facility's production machinery—even while sitting idle—along with the HVAC system. Through careful scheduling, the EMP reasoned, peak demand could be reduced without negatively impacting either the speed of production or occupant comfort.

While working through the utility rate analysis, the EMP calculated a blended rate for one piece of manufacturing equipment that used both electricity and natural gas. Through the process of reviewing the bills, the EMP learned that Building E was purchasing electricity from the utility, despite the fact that the facility was located in a state where both electricity and natural gas were deregulated. After further investigation using the utility's website, the EMP determined that Building E's current electricity rate class was far from ideal.

The final recommendation, given current market conditions, was to pursue a contract with a retail electricity supplier authorized to do business within the state. Electricity could be purchased more cheaply on the open market. In addition, the EMP reasoned, if peak demand was reduced substantially, Building E could move to a utility rate class with a smaller demand threshold, resulting in substantially lower delivery bills each month.

In addition to historical marginal rates, the EMP calculated new marginal rates taking into account the projected change in electricity account structure. The client and EMP were in agreement that potential ECMs/FIMs should be evaluated using both historical and projected marginal rates.

2.D ANNUAL ENERGY BALANCE

Annual Energy Balance

Estimated measure of the amount of energy consumed by various building systems.

A building's **annual energy balance** is an estimate of the energy consumption of all building systems: HVAC, lighting, plug loads, etc. The energy balance provides the EMP with context to determine the size and scope of the project. The energy balance helps qualify the degree of energy savings related to a proposed ECM. For example, a lighting retrofit in a building where lighting represents 35% of all energy usage will have a larger impact, relatively speaking, than a lighting retrofit in another building where lighting accounts for only 10%.

Unless individual systems are separately sub-metered—a rare occurrence—the EMP should estimate the energy balance based on energy bill analysis, site investigation, experience, and preliminary energy modeling. If no historical consumption data is available, the EMP must rely on computer-based energy modeling, industry-developed tools, and professional experience.

Estimating consumption attributable to each building system establishes a basis for calculating potential savings from ECMs that affect those systems. The EMP should calibrate the results of an energy model, or other estimation methods, with available data. If the results are not validated, the ECM may risk making clearly erroneous and embarrassing recommendations. For example, the EMP may analyze an ECM and propose energy savings that are greater than the total baseline energy usage of the components affected by the ECM.

2.D.1 Four-Step Process

The EMP should follow a four-step process to develop the energy balance:

1. **Create a pie chart of baseline energy usage by fuel source.**
   For most buildings, this chart will be divided into electricity and natural gas usage. Urban and campus environments may also include district chilled water, hot water, or steam. Use a common unit (e.g., kBtu).

2. **Define the energy balance for each energy source.**
   Working with each slice of the pie chart, determine the energy balance of that particular source. For example, electricity would be attributed primarily to HVAC, lighting, and plug loads. In some cases, plug loads may be further distinguished by subcategory.

3. **Subdivide the largest energy-consuming systems.**
   Further analyze the biggest categories by breaking them down into separate system components. For example, the HVAC load can be divided

into fans, chillers, pumps, miscellaneous, etc. The lighting load could be divided by floor, common space vs. tenant space, or even specific types of lamps—if such detail is available at this stage of the project. Depending on the data and tools available to the EMP, common methods for subdividing systems into their components include:

- ***Estimate.*** *This method is less accurate than measuring but can usually be performed relatively quickly. As a result, it may be the most sensible option for Phase 2 of the project. With basic information about loads and schedules, the EMP can calculate how much energy various systems use over the course of a week, month, or year.*
- ***Measure.*** *This is the most accurate method but also may be the most time-consuming, and it may require data logging that the EMP does not perform until Phase 3. Individual equipment sub-meters, data loggers and/or detailed data from the building automation system (BAS) are essential. Measured use can be extrapolated for the month or year. Ideally, the EMP has several data sets collected during different seasons.*
- ***Model.*** *If the project team includes an independent energy modeler, or the EMP is already planning to create a model, larger building systems can be modeled as a collection of multiple components. Energy modeling is discussed below.*

The pie charts for individual systems supplement the primary pie chart that includes all fuel sources for the building.

4. **Establish a benchmark.**
Develop a benchmark against which estimated energy consumption can be measured. The EMP should focus on the largest energy-consuming systems and components and/or those with the largest energy savings potential. Depending on project needs, this data may be used to create a baseline energy model that is refined throughout the project as more information becomes available. Additional information on developing and calibrating an energy model is included in Phase 3.

2.D.2 Energy Model Development

Depending on project scope and budget, as well as the client's objectives, a simulation program may be used by the EMP or another contractor to create an energy model of the building.

If the client is focusing on no-cost and low-cost energy-saving improvements, an energy model is probably not necessary. If the client is anticipating capital improvements that involve significant equipment replacement or building renovation, however, an energy model may be useful.

At this stage, an energy model can be used to verify the results of the utility consumption analysis and help determine the building's energy balance. Through iterative calibration, the EMP may be able to account for various items that are difficult to quantify at this stage:

- Duct leakage
- Infiltration
- Poor systems control
- Occupancy patterns
- Equipment usage patterns

A model is only as good as its ability to accurately represent actual building operations. The EMP can use historical energy consumption data, when available, to verify model performance. Simulation models can report monthly results for each fuel source; these in turn can be compared with recent bills. If historical consumption data is unavailable, the EMP can use the model to estimate baseline usage. In this case, the baseline is established by using a combination of available building systems information and default simulation values.

Models are also useful for the identification, development, and analysis of ECMs and FIMs. The energy model is intended to serve not as a static, idealized picture of the project building, but rather as a dynamic tool that increases EMP knowledge and improves over time. For example, faulty equipment and poor conditions that contribute to inefficient building performance can be realistically modeled. As the experienced modeler makes adjustments to variables in order to better reflect actual building operations, potential deficiencies may emerge from the data and lead to ECMs. Through this process, the energy modeler generates output that is representative of actual building operations.

A well-calibrated model should result in less than 10% error with respect to energy consumption each month. On an annual basis, the model should be calibrated to successfully predict energy use to within 5–10% of actual use. Model calibration is critical. Mirroring historical data is important, because this same model will be used to forecast energy use reduction potential for proposed ECMs. Further calibration should occur in later phases after more detailed analysis of the building has been completed and potential measures have been formalized.

2.D.3 Estimating Use and Allocating Loads

Since the EMP is almost never able to acquire all the information that is desirable for a project, he or she will need to make assumptions when determining the annual energy balance.

She EMP should consider the following general guidance when working with specific energy consumption and building characteristics:

Electricity

- *Load profiles for both energy consumption and peak demand illustrate electricity use and highlight **seasonal peaks** and **seasonal troughs**.*
- *Unusual ratios of on-peak to off-peak usage may indicate unexpected after-hours consumption.*
- *The electricity pie chart is divided into all systems that consume it. These may include: HVAC, lighting, elevators, PCs, and other plug loads. Industrial facilities may also include process loads.*

Natural Gas

- *The load profile depicts consumption throughout the year. If gas is used to heat the facility, seasonal peaks and troughs should be apparent.*
- *If the facility's HVAC system does not include reheat by design (simultaneous heating and cooling) and is operated properly, the summer seasonal trough establishes the baseline for the domestic hot water load.*
- *The natural gas pie chart is divided into domestic hot water and possibly heating loads. If data is insufficient, estimate the percentages by considering the building type and HVAC system. Industrial facilities may also include process loads.*

Building Types

- *Building types that use energy to perform unique functions require special energy balance considerations. These types include factories, restaurants, hospitals, laboratories, and other facilities with service or process HVAC, or other nonstandard machinery.*
- *Industrial activities such as manufacturing, refining, cooking, baking, metals, chemicals, glass, and paper are particularly energy-intensive. Buildings that serve any of these functions will tend to use proportionally less energy for standard HVAC, lighting, and plug load needs.*
- *After developing experience with common building types, such as strip malls, office towers, elementary and high schools, big-box retail stores, and quick-service restaurants, the EMP should be able to predict and recognize patterns of use for one or more of these groups.*

Seasonal Peak

In terms of climate, a high point in a building profile related to changes in outside air temperature, during which the greatest amount of energy usage is required.

Seasonal Trough

In terms of climate, a low point in a building's profile related to changes in outside air temperature, during which the least amount of energy usage is required.

- *Hospitals and laboratories must meet air quality standards that will impact energy use required for ventilation.*

Typical Occupancy

- *Daily, weekly, and monthly operating hours as well as the number of occupants are important for the EMP to consider. Energy use is typically influenced by building occupancy, even if there is no exact correlation between the two. The energy balance should be adjusted accordingly.*
- *Not all buildings are fully occupied for all twelve months of the year. Usage in most schools declines during summer months, as well as during breaks in the academic calendar.*
- *Buildings vary in the number of hours each day that they are occupied. Compared to offices, grocery and retail stores are generally open longer hours each day, and the vast majority are open on weekends. Hospitals and residential facilities, of course, are occupied 24 hours a day, 7 days a week, 365 days a year.*
- *The actual number of people in the building also influences the energy balance. An office tower with only 70% occupancy will use less energy than one with 100% occupancy. The EMP should clarify how much of the project facility is vacant or otherwise operating at less than full capacity.*

System Energy Use

- *The EMP will often need to estimate the energy use of certain individual building systems. These "first pass" results should be validated through additional research conducted during Phase 3 and beyond.*
- *To estimate consumption attributable to lighting, the EMP should determine the numbers and types of fixtures and ballasts in the building. Summing the wattages and dividing by floor area produces the metric of wattage per square foot. Multiplying this figure by annual operating hours is one way to estimate total lighting energy use for a full year.*

District Energy Sources

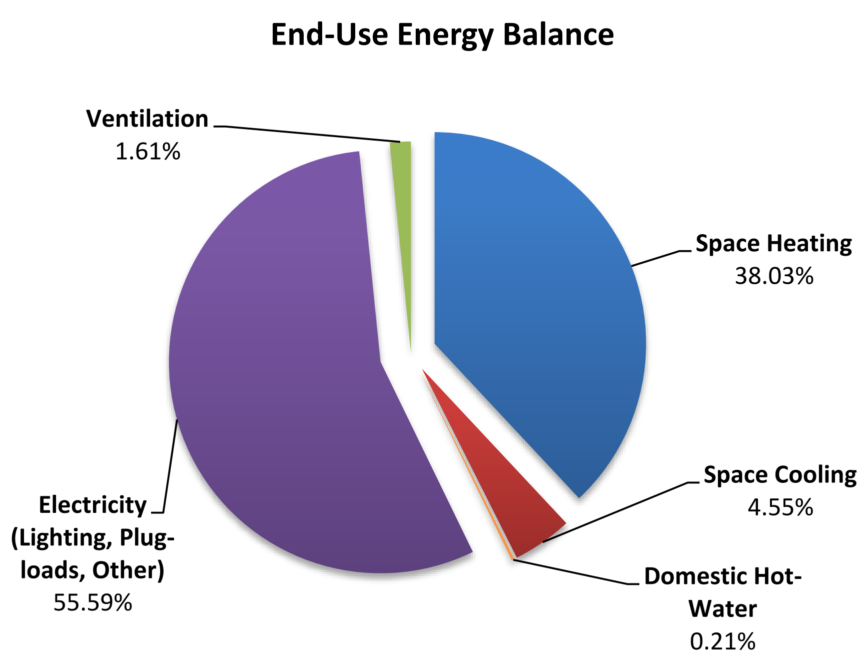
- *District energy source such as steam, hot water, chilled water, fuel oil, or coal must be included in the annual energy balance. Data for these sources may not be readily available, however, and so the EMP may have to develop a creative but reasonable approach.*
- *The EMP may need to estimate annual consumption of district sources from a variety of information or from documented figures for similar buildings.*

While estimating use and allocating loads, the EMP must be careful to consider each building as a truly unique project. Assumptions that work for one building will not necessarily translate to another building, even if both buildings are quite similar in many ways. The EMP should collect enough information about the project building to present a complete picture of the annual energy balance that is supported by the available data.

CASE STUDY 2.3 ENERGY BALANCE | BUILDING F

The pie chart below demonstrates the annual end-use energy consumption for Building F, which consists of a big-box retail store and warehouse. The facility comprises 1.7-million square feet outside Washington, D.C. The EMP generated the pie chart by tallying the rated energy use for all major equipment—lighting, heating, cooling, elevators/escalators, computers, fans, and other plug loads—and considering the operating hours for each. Individual percentages were calculated.

The pie chart represents energy use for all HVAC equipment (in detail) and other electricity-consuming equipment. Note that lighting, plug loads, and other sources (e.g., elevators, escalators) are grouped in a single electricity category. (The project focused on understanding the distribution of energy consumption throughout the HVAC system—not lighting or plug loads.) The EMP calculated this energy balance using each piece of equipment's rated energy use and hours of operation. Final results were compared with figures tabulated from one year of actual energy bills.



The EMP estimated the energy balance for Building F using information gathered from the building. Alternatively, if sub-meters or data loggers were installed for a sufficient length of time, the EMP could have measured actual energy use consumed by each piece of equipment. While such a course of action would have produced highly accurate results, it was deemed too impractical and expensive for this particular project.

2.D.4 Working with Campuses

An EMP may need to estimate an individual building's energy use from aggregate data for a collection of facilities. This situation is frequently encountered when working with a campus. If each building is not sub-metered, the EMP may be presented with pooled billing, or billing that combines fuel sources for multiple buildings at some times and divides the sources into separate bills at other times. Common campus projects include colleges and universities, military bases, healthcare complexes, and similar large collections of buildings.

In these instances, the EMP may need to begin the annual energy balance by preparing a single pie chart of all the buildings. Individual building pie charts will be developed later. The EMP should allocate consumption data from the main campus utility to each of the buildings in the pool. If one building serves as a central plant, the energy it produces must be assigned to the plant itself as well as to the collection of buildings to which it provides energy.

The EMP may start by prorating energy use according to the relative square footage of each building, making sure that no buildings are accidentally excluded. Not all building types are the same, however, and so the allotted energy use based on square footage may need to be increased or decreased, depending on how each particular building is used and when it is occupied.

The EMP should look for broad patterns of energy use and occupancy. For example, on a college campus, some systems may be turned off completely during the summer or between semesters. Administration buildings may function for twelve months while residence halls function for nine. At a military base or healthcare complex, some buildings may have significantly greater energy use or extended operating hours.

As monthly energy consumption is allocated to different buildings, the EMP should ensure that the results make sense. For example, the estimated monthly usage for all buildings must add up to the actual total monthly usage reported on any pooled bills. While these estimates will always bear some uncertainty, a carefully executed process should provide the EMP with a good understanding of the annual energy balance within the individual buildings.

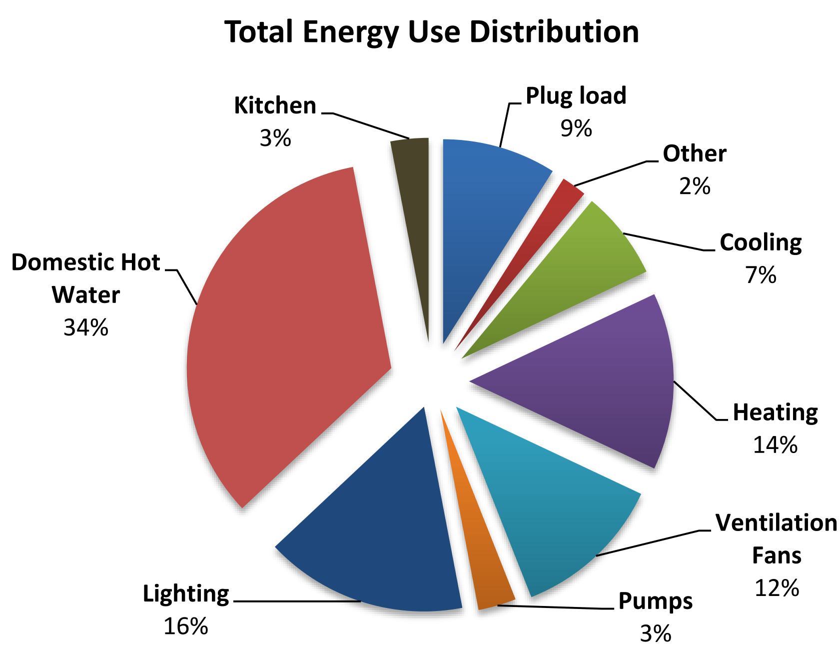
2.D.5 Analyzing the "Miscellaneous" Category

While energy loads associated with HVAC and lighting can be calculated relatively easily, remaining loads may be more difficult to define. For that reason, such loads are often categorized as "miscellaneous."

Plug loads—electrical devices that use an electrical outlet—often make up a significant share of the miscellaneous energy use in most types of buildings, including residential and commercial spaces. Computers, printers, telephones, copiers, televisions, microwaves, table and floor lamps, stereo systems, personal electronics, vending machines, dish washing machines, clothes washers and dryers, and refrigerators and other appliances are all examples of plug loads. These loads may be broken out in greater detail by the EMP if they are known with a reasonable level of accuracy.

Other examples of unique energy uses within buildings that might be categorized as miscellaneous include data centers, clean rooms, elevators, escalators, and certain manufacturing processes. Whenever possible and practical, the EMP should try to specify individual loads rather than lump them into the "miscellaneous" category, particularly if the energy use of those loads is not insignificant.

In the sample graph below, which an EMP generated for a hospital that consumes electricity and natural gas, end uses categories and percentages reflect the facility type:



This hospital, like every other hospital, uses a lot of energy to produce hot water for laundry and sterilization. Kitchen use is also distinguished from lighting, plug load, and standard HVAC categories. In this case, the EMP also included 2% for "other" miscellaneous uses.

The EMP should evaluate whether or not the relative size of the miscellaneous portion makes sense for the project building. Important steps for the EMP to follow when reviewing miscellaneous loads include:

- **Identify unexpected or erroneous results.**

  Basic building information will help the EMP identify potential errors and areas for further analysis. For example, in an office environment, allocating 50% of energy to miscellaneous uses is likely incorrect, unless the building houses a sizeable data center or electric resistance heaters sit beneath every desk.

- **Revisit data and calculations.**

  If analysis produces an unexpectedly large miscellaneous figure, the EMP should take a second look at HVAC and lighting system consumption. Miscellaneous use estimates that are too high may be an unintentional result of HVAC and lighting estimates that are too low. Erroneous numbers can lead the EMP to identify mistakes in calculations and to revisit building data that may explain the puzzling estimates.

- **Justify with estimates.**

  If a large miscellaneous load is justifiable based on the building type and its occupants, the EMP should investigate these points of consumption and document the findings. If possible, usage estimates for the largest contributors to the miscellaneous load should be estimated. For example, the EMP may be able to approximate the energy use of a data center, clean room, or elevator bank, and break it out separately from the miscellaneous figure. If the project building has an unusually large number of computers per person, the annual energy balance should include an estimate for computer energy use. The EMP should verify that miscellaneous usage estimates are reasonable.

- **Rely on experience.**

  With the completion of each project, the EMP develops additional experience. Over time, the EMP will begin to recognize energy consumption patterns for specific building types in his or her location. For example, the EMP may discover that a typical office building requires 65% of its annual energy consumption for HVAC, 20% for lighting, and 15% for miscellaneous uses. The EMP should develop a growing awareness of energy trends and the kinds of spaces that appear in buildings. This practical knowledge serves as an invaluable reference guide while the

EMP prepares the annual energy balance for other projects in the same geographical area.

The objective of an energy balance is not to determine exact numbers, but to develop a context for future calculations. Armed with this knowledge, the EMP will be able to evaluate ECMs successfully.

Once the utility rate analysis and annual energy balance are complete, the EMP can begin more detailed analysis of the historical energy use within individual building systems.

2.E HISTORICAL ENERGY USE

Building energy use is not constant and regular. It changes over time. The weather, alterations in operations or occupancy, recent efficiency measures, installation of new equipment, and malfunctioning systems will all impact energy consumption. For this reason, surveying energy usage over time provides a more complete picture of a building than a single utility bill or an energy balance pie graph. An EMP may use utility analysis software, common industry tools, or proprietary spreadsheets to accomplish this task. At least two years of energy data, and ideally three, are necessary to gain maximum insight from the various analytical methods outlined below.

2.E.1 Annual Usage Profile

A building's **annual usage profile** provides a snapshot of energy use by year. The EMP may establish a single profile featuring total energy use, or multiple profiles that treat electricity, natural gas, and other fuels individually. Graphs generated from the data illustrate differences in consumption during heating, cooling, and shoulder periods. The EMP uses these graphs to determine whether a facility's energy use is dominated by internal or external factors. Typically, consumption is affected by one of these two primary factors:

Annual Usage Profile

Illustration of historical building energy consumption over a one-year period.

- **Climate - External**

  A building with a climate-driven profile exhibits seasonal peaks and troughs in energy consumption that are related to changes in outside air temperature. The EMP should identify distinct patterns of use in the winter, spring, summer, and fall.

- **Building Loads - Internal**

  A building with a load-driven profile does not exhibit seasonal patterns in energy consumption. Instead, most fluctuations in usage are tied to changes in the operation of energy-consuming systems. The EMP will not be able to detect an obvious correlation between usage and the weather.

The annual usage profile is influenced heavily by specific building characteristics, such as facility type, HVAC system, number of occupants, and local climate. Most buildings in the U.S. are cooled with electricity, or chilled water—which itself is often produced by electricity. Buildings may be heated by electricity, natural gas, or another source such as propane or fuel oil.

The EMP's primary objective is to develop a complete picture of the building's energy source distribution over the past two or three years. For a building with electric heating and cooling in a climate with distinct heating and cooling seasons, an EMP should expect the annual profile to adopt a capital "W" shape, with high peaks on either side during winter (heating) and in the middle during summer (cooling). On the other hand, a building with gas heating and electric cooling will profile only one peak for electricity, which is associated with summer (cooling), but the profile for natural gas will adopt a capital "V" shape, with peaks during winter (heating).

When reviewing monthly energy consumption, the EMP should identify outliers and other indicators of potential inefficient operation. If seasonal peaks and troughs are anticipated, but they are either missing or abnormal, the data may suggest facility problems. For example, the EMP may discover:

- **The presence of excessive or unusual seasonal peaks.**
  Seasonal weather produces peaks, but a particular building's envelope and/or outside air loads may produce spikes in energy consumption that are more pronounced than those observed for other buildings. Temperature and humidity are only a couple of factors involved in energy exchange inside and outside the walls of a facility. The ratio of a building's exposed envelope to its floor space is a key variable. A multi-floor building with a relatively small square footprint will have less exterior exposure than a single-story building with a large but narrow rectangular footprint. The greater the exterior exposure, the greater the impact of changes in outside air temperature on energy use.

- **The absence of seasonal troughs when they are expected.**
  In many areas, buildings with a climate-driven profile exhibit minimal energy consumption during the shoulder seasons of spring and fall, when the need for either heating or cooling is not significant. In many regions of the U.S., heating demand drops to a negligible level in summer, and cooling demand drops to a negligible level in winter. If a building's energy use profile and climate suggest that it should illustrate seasonal low points, but it does not, the EMP should consider possible causes for the

extra energy consumption. For example, the abnormal usage pattern may indicate simultaneous heating and cooling or other system inefficiency.

The annual energy balance and annual use analysis are essential to the EMP's successful completion of the energy management project. Historical use analysis and knowledge of building characteristics enable the EMP to identify areas where building systems are wasting energy. Further investigation into these matters will factor into the development of ECMs and the EBCx plan.

2.E.2 Long Term Usage Trend

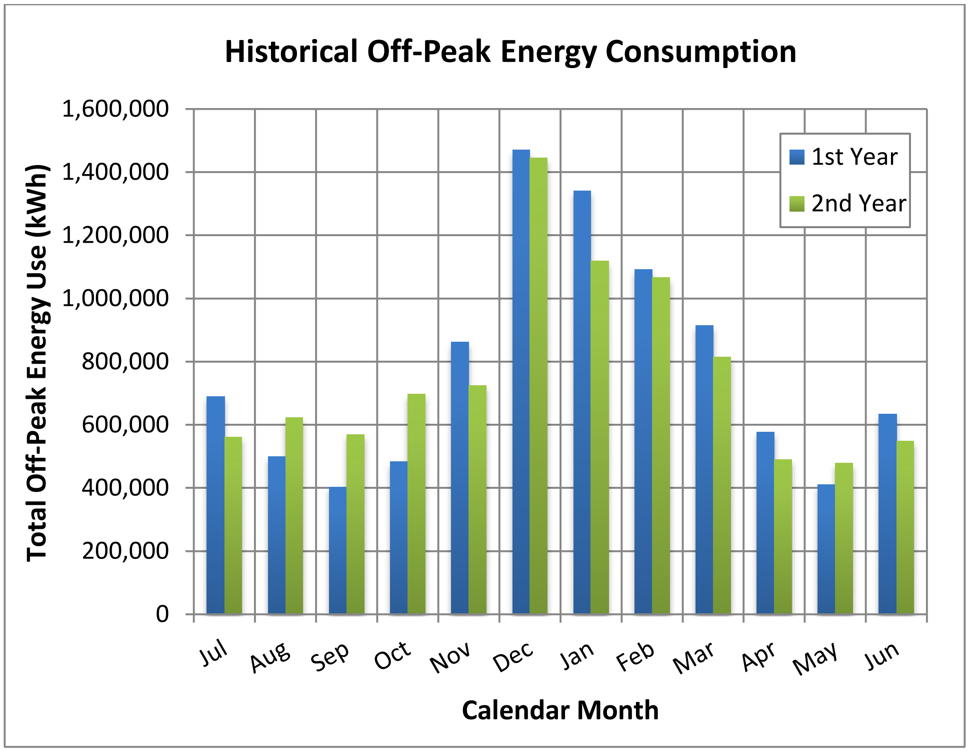
If multiple years of energy consumption data are available, the EMP can analyze long-term trends for electricity, natural gas, and other energy sources. Original data may be used without modification, or factors may be applied to account for variances in consumption caused by the weather. Such weather-normalized data allows for accurate comparison of usage across months or years, assuming that other variables such as occupancy and operations have been consistent.

Provided that occupancy and operations have not changed substantially in several years, but total energy consumption has increased, implementing EBCx may help return a building to a lower level of usage. The EMP can create a long-term consumption trend chart to illustrate the building's energy consumption over time. This picture of historical energy use enables the EMP to determine a baseline performance level for the building. The EMP should quantify the potential consumption reduction—and cost savings—that would result from returning the building to this baseline.

CASE STUDY 2.4 HISTORICAL ENERGY USE ANALYSIS | BUILDING C

The EMP had received two years of energy data provided by the project team for Building C, an all-electric office tower in New York. As discussed in Case Study 1.3, that data was plotted to produce a baseline for continual reference. At this stage of the project, the EMP sought to understand historical energy use in greater detail.

After plotting on-peak and off-peak energy consumption separately, the EMP acknowledged the unusually high level of off-peak use. The building is largely unoccupied during off-peak hours. Moreover, the EMP observed that this trend was particularly pronounced during winter months. Off-peak energy consumption for the base building is graphed below.



This analysis confirmed that the building was using too much energy. The walk-through and further discussions with building staff led the EMP to discover that the electric baseboard heaters responsible for handling much of the building's heating load were operating continuously, even during unoccupied hours.

The baseboard system was not allowing spaces to set back temperature during unoccupied hours. This fact explained the significant jump in energy use for December, January, and February. The EMP developed an ECM recommending adjustments to baseboard heating controls.

Correction of the night setback function was a straightforward but significant ECM recommended for Building C. Additional ECMs that the EMP continued reviewing involved the optimization of chilled water pump operation and AHU fan start/stop schedules.

Adjustment of the night setback temperature setpoints, however, would account for more than half of the facility's energy savings from low-cost ECMs, according to the EMP's rough estimation. The EMP continued to develop these ECMs.

The Energy Management Project at Building C is discussed further in Case Studies 2.5 and 7.3.

2.E.3 Consumption Correlation Analysis

Factors that impact annual energy consumption at a given building include changes to occupancy, the operating schedule, and specific equipment loads throughout the day. Weather, however, is arguably one of the most significant factors, particularly in regions with significant seasonal heating and/or cooling needs. Outside air conditions, particularly temperature, can have a substantial impact on energy consumption.

Consumption correlation analysis, a type of regression analysis, is a statistical method that an EMP may employ to better understand the influence of weather on historical energy consumption. One common motivation for consumption correlation analysis, in the absence of sub-metering, is the determination of electricity usage attributable to the HVAC system and its ancillary components. A portion of that usage depends on the weather, but much of it does not. The EMP's goal is to determine the relative share of each. Proper technique requires the EMP to obtain historical energy and weather data for the same period of time.

The EMP compares energy use and ambient temperature patterns to determine the specific impact of weather on electricity and/or natural gas consumption. The results of the regression analysis indicate whether or not there is strong correlation between consumption data and historical weather data. The impact of temperature on energy needs can be described in terms of **heating degree days** (HDD) and **cooling degree days** (CDD) per day. Both CDD and HDD are typically defined with respect to a base temperature of 65°F, although the EMP may use a different reference temperature, if appropriate for a particular facility or location. The EMP may find degree day statistics for U.S. locations on websites maintained by the National Oceanographic and Atmospheric Administration (NOAA) and Weather Underground.

In addition to considering CDD and HDD, the EMP must also factor in the lengths of billing cycles, which often differ from one month to the next or one year to the next. For example, a 28-day billing interval may follow a 35-day billing interval. In order to apply the same scale to different billing cycles, the EMP should divide the total energy use and total degree days within each cycle by the whole number of days within each cycle. Using these results, the EMP can compare all billing intervals legitimately on the basis of average use/day and degree days/day.

Successful consumption correlation analysis leads to differentiation between energy use that is—and is not—attributable to weather. With this knowledge, the EMP can continue to define the calculated portion of consumption that is not dependent on the weather. This level of usage is considered the building's baseload energy consumption. Baseload consists of lighting, plug loads, constant volume fan systems, and other energy-consuming systems whose energy use is largely independent of the outside air temperature.

Consumption Correlation Analysis

Regression analysis that determines the correlation between building energy consumption data and historical weather data.

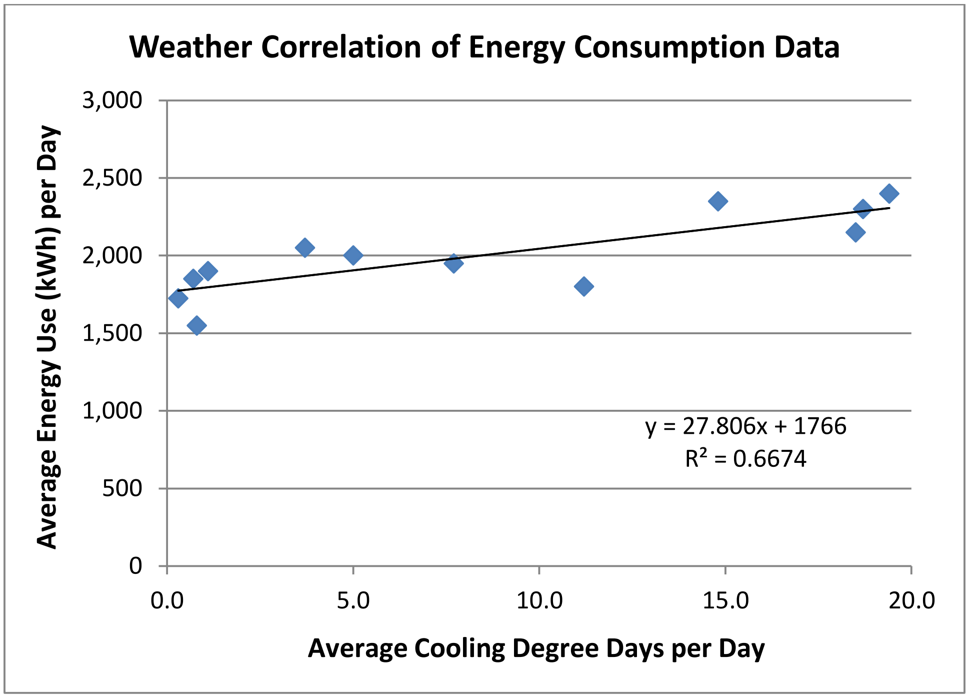
Heating Degree Day

Measurement of the positive difference when actual average daily temperature is subtracted from base temperature of 65°F. Used to characterize the demand for energy needed for heating.

Cooling Degree Day

Measurement of the positive difference when base temperature of 65°F is subtracted from actual average daily temperature. Used to characterize the demand for energy needed for cooling.

The graph below illustrates the result of regression analysis performed by an EMP to estimate a commercial building's baseload energy consumption. The building uses natural gas for heating and domestic hot water but electricity for cooling. Average daily electricity consumption and cooling degree days were plotted for twelve months. Points further to the right in the graph indicate warmer months that generated larger numbers of cooling degree days.



Correlation Coefficient

Metric representing the strength of correlation between the predicted value of a statistical model and actual value. Measure ranges from 0 (no correlation) to 1 (exact correlation).

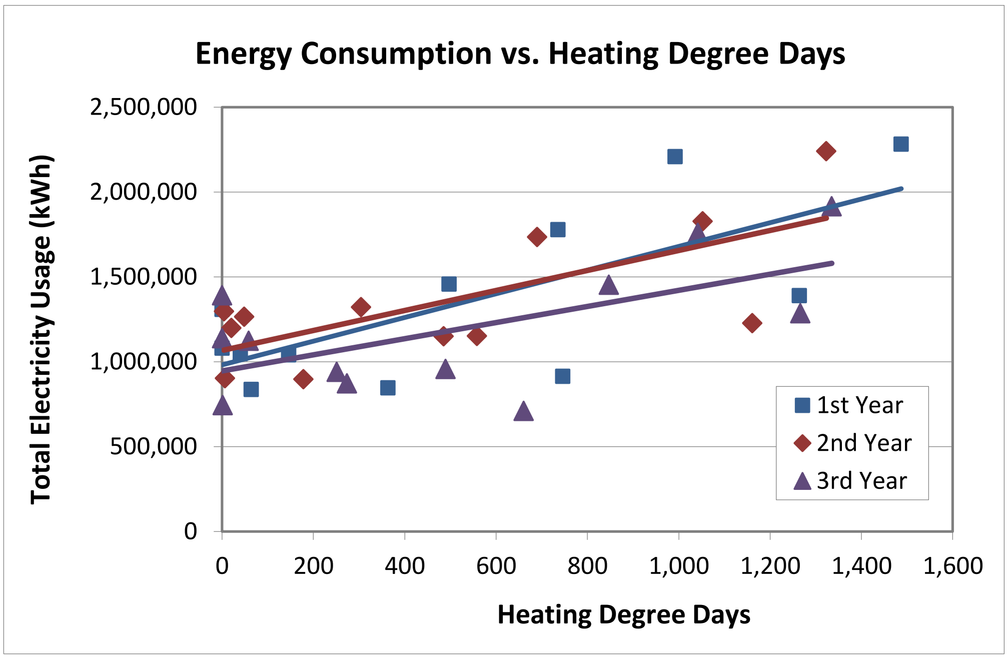
The point where the regression line intersects the y-axis (1,766 kWh per day) represents the building's estimated baseload energy consumption. This figure should serve as the EMP's baseline level of use before factoring in the effects of weather. The **correlation coefficient**, or R^2 value, of about 0.67, displayed below the linear equation, provides reasonable—though not great—confidence in the result. A correlation coefficient closer to 1 suggests strong correlation, while a figure closer to 0 suggests weak correlation.

CASE STUDY 2.5 CONSUMPTION CORRELATION ANALYSIS | BUILDING C

The EMP working with Building C sought to understand how energy use was influenced by the weather. The two-year period represented by the raw monthly data included some seasons that were unusually warm or cool. In order to compare energy use following ECM implementation to the historical energy use, the baseline had to be corrected for the weather.

By plotting monthly degree days on the x-axis and energy use on the y-axis, the EMP could start to determine baseload electricity consumption. The process is somewhat more complex for an all-electric building that uses electricity for both heating and cooling, because months with 0 CDD will likely log positive HDD, and vice versa. (There are virtually no months with both 0 CDD and 0 HDD.)

Ideally, the EMP should generate two plots, one on the basis of CDD, and the other on the basis of HDD. A graph of base building electricity usage and HDD for the two years prior to ECM implementation (1st and 2nd Years) as well as the year following implementation (3rd Year) appears below.



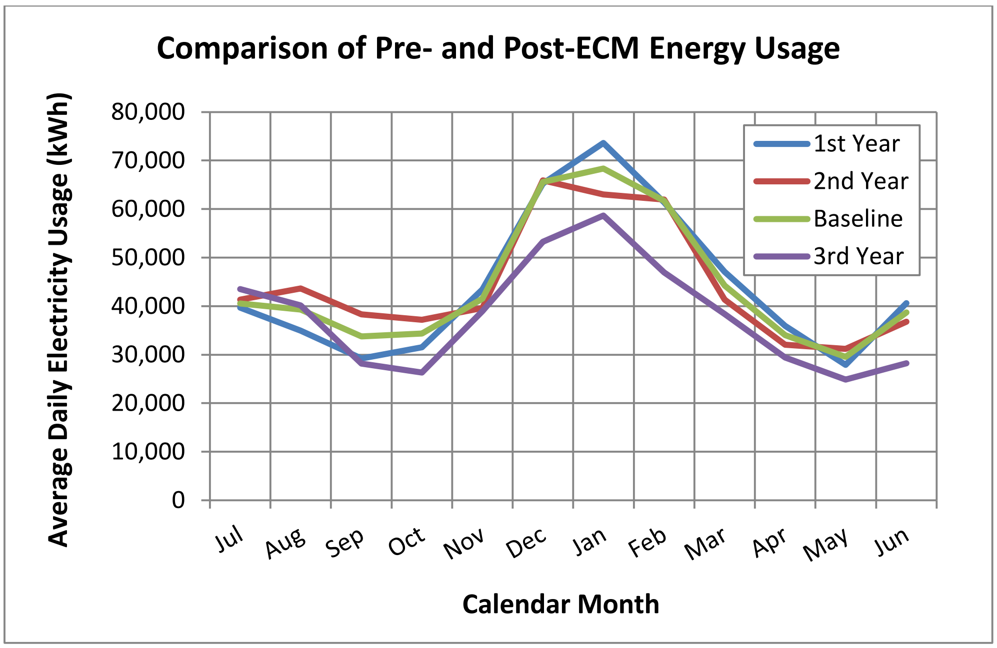
Each of the three annual plots produces a distinct linear equation, but their y-intercepts (the point where each regression line crosses the vertical axis) are similar. Analyses comparing usage and CDD were also performed.

The linear correlations above include data for the 3rd year, including twelve full months of data collected after ECM implementation. In addition to producing a variety of graphs, the EMP calculated normalized total energy consumption by multiplying energy use per HDD by the three-year average total number of HDDs.

The weather-normalized data suggest that total energy consumption was actually much greater the 1st Year than it was the 2nd Year. Implementation of ECMs occurred during the fall of the 3rd Year. Data for this 3rd Year was compared to data for the 1st and 2nd Years. The results are summarized in the table below.

	Total Annual Energy Consumption (kWh)	Total Annual Heating Degree Days	Energy Use per Heating Degree Day (kWh/HDD)	Three-Year Average Heating Degree Days	Normalized Total Energy Consumption (kWh)
1st Year (Before ECM Implementation)	16,211,680	6,334	2,559	6,128	15,685,282
2nd Year (Before ECM Implementation)	16,156,061	5,829	2,772	6,128	16,985,714
3rd Year (After ECM Implementation)	14,464,122	6,222	2,325	6,128	14,246,378

The graph below is repeated from Case Study 1.3, except that the 3rd Year has been included.



As the graph illustrates, energy use fell dramatically following implementation. Annual energy usage decreased by about 2 million kWh. A majority of those savings were achieved during winter as a result of corrections to the electric baseboard heater controls.

The dramatic energy savings that the EMP achieved at Building C demonstrates the importance of analyzing energy use over time and comparing observations with lessons learned about "normal" use at other facilities. In this instance, the EMP recognized that a spike in energy consumption for heating during occupied hours in winter should not necessarily extend to unoccupied hours.

After determining baseload consumption, the EMP can plot usage that is and is not weather-driven on the same graph. (Weather-driven usage is assumed to be all consumption that is not included in baseload usage.) Components of building energy consumption that respond to an increase in dry-bulb temperature and humidity include chilled water systems, boiler systems, and VAV system fan motors. For buildings where both electricity and natural gas are used to run HVAC equipment, the EMP may wish to consider each fuel source separately with respect to weather.

After controlling for fluctuations due to operations and occupancy, the EMP should observe that non-weather-driven electricity and natural gas consumption remain relatively flat.

For facilities in many parts of the U.S., total energy consumption (including electricity and/or natural gas) attributable to the HVAC system will rise through winter months, return to baseline during the spring shoulder season, rise again through summer months, and then return to baseline during the fall shoulder season. These transitions will be more pronounced in some areas (e.g., extreme northern and southern latitudes) but less pronounced in relatively temperate regions (e.g., the West Coast).

A correlation coefficient of 0.70 or greater for the regression line indicates acceptable correlation. A value closer to 1 suggests strong correlation, while a figure closer to 0 suggests weak correlation. If the correlation coefficient is any lower than 0.70, there may not be a statistically significant relationship between the building's energy consumption and ambient temperature. Strong correlation is the desired outcome, but the data may simply not provide such a result.

The EMP should bear in mind that, depending on location, some types of buildings may simply show little weather influence. When a good correlation coefficient is not demonstrated by the data, one cause may be a very high proportion of miscellaneous energy consumption that overwhelms any fluctuation due to weather. Very large factories and data centers, for example, have enormous baseload consumption independent of the weather.

When the EMP expects strong correlation based on the building type, but there is none, the data may suggest simultaneous heating and cooling or system degradation resulting from inferior facility control.

2.F Proposal for Further Investigation

Phase 1 concluded with a review of buiding information and a proposal for continuing with the energy management project. The steps included preliminary project plan development and the drafting of an EBCx Scope. Throughout the project, the EMP should reaffirm the value of adhering to the EMA Energy Management Process by moving seqentially from one phase to the next.

At this stage, the EMP has reviewed energy data in detail. The results of these analyses may reveal problems at the building, but he or she will need to perform a thorough site investigation in order to confirm these thoughts.

While no new formal documents are written at the end of Phase 2, the EMP may apply the results of energy use exploration to revise the developing project plan and EBCx Scope. These should be viewed as evolving documents, subject to change throughout the project as the EMP generates new insights.

The EMP should communicate the most important findings from the analysis of energy data to the client and other members of the project team. Doing so will build project momentum, demonstrate the EMP's expertise, and direct building staff to the types of systems that the EMP will likely want to examine during the site investigation.

Energy Use Exploration Summary

*During **Phase 2: Energy Use Exploration**, the EMP analyzes current and historical energy information for all energy sources.*

The EMP calculates the building's EUI, identifies anomalies in building energy usage over time, and calculates rates that will be used later to evaluate ECMs and FIMs.

Completion of the annual energy balance enables the EMP to understand usage with respect to the facility's various systems. The charts, graphs, and metrics produced from energy, cost, and weather data help the EMP formulate a preliminary perspective on potential ECMs/FIMs and EBCx tasks.

*Along with building data compiled in Phase 1, the knowledge generated in this phase helps the EMP understand building performance. Careful review of the data should reveal the specific systems that the EMP should make sure to examine in person during **Phase 3: Site Investigation**.*

3 SITE INVESTIGATION

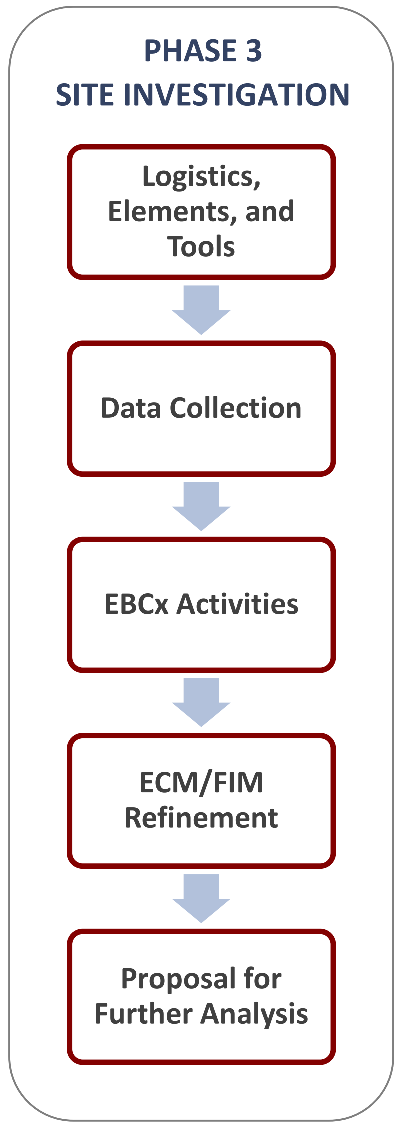
During the Site Investigation Phase, the EMP spends time at the project building to collect comprehensive data. Together with the energy analyses performed in Phase 2, this data will inform further development of ECMs/FIMs and the EBCx in the form of an Energy Plan Outline and Investment Proposal.

The mission of the Site Investigation Phase is to:

- Gather more detailed information about how and when building systems operate.
- Capture data regarding building occupancy and scheduling.
- Draft and refine ECM and FIM narratives.

This chapter should provide the EMP with:

- Guidance for scheduling and planning future site visits.
- Tools for assembling and analyzing detailed building data.
- Insight regarding the development and articulation of ECMs.
- Procedures for preliminary EBCx investigation.



SITE INVESTIGATION OUTLINE

Site Investigation

This phase is divided into four major subsections:

During **Phase 3: Site Investigation**, the EMP will develop a "hands-on" feel for how the building operates and begin to envision the project's impact on energy use. The EMP will conduct one or more site visits, take series of measurements, and basically strive to gain as much knowledge as possible about the project building. The results of these tasks are used to develop ECMs, FIMs, and an EBCx plan.

3.A Logistics, Elements, and Tools

Building Investigation involves additional site visits, data collection, and analysis. This process results in additional information about building operations, occupancy, and energy use that will aid the EMP in further screening and developing energy conservation measures (ECMs) for the project. When preparing for each site visit, it is important for the EMP to consider the timing, equipment, and process of further building investigation. These elements can significantly impact the usefulness of the data gathered.

3.A.1 Planning and Timing

Building investigation requires careful preparation and painstaking foresight. The challenge for the EMP is to plan investigative tasks effectively around the scope of work.

The purpose of the site investigation is to thoroughly assess the building's systems. Thoroughness does not necessarily mean exhaustiveness. During a typical site visit, the EMP is neither constantly taking new measurements nor testing every piece of equipment. Such a course of action would generate a lot of data but little direction and may be a waste of time.

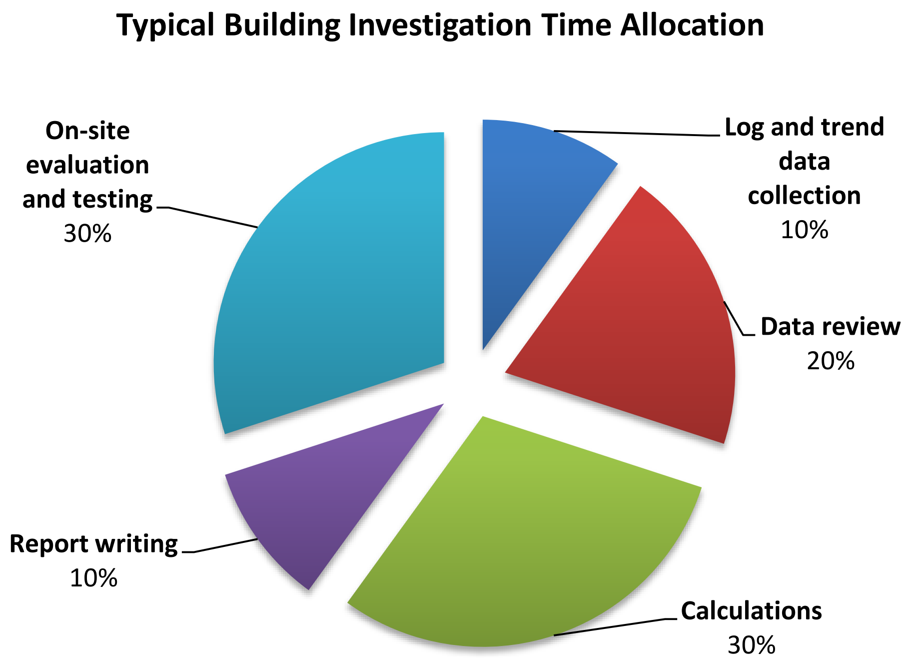
The scope of the investigation is structured around and based on the EMP's findings from the previous two phases. This information helps the EMP concentrate on the specific attributes and components of the building that will most significantly impact the project's success. Specifically, in order to design the investigation prior to arriving at the building, the EMP uses:

- Specific goals communicated by the client.
- The initial list of ECMs/FIMs.
- Results of energy use exploration.
- Benchmarking anomalies.
- Predetermined systems identified by the client.

Building Investigation

Examining and testing building systems in-depth, collecting data regarding systems, operations, schedules, occupancy, and energy use.

Whatever the circumstances, specific project needs will dictate the focus of the site investigation and influence the EMP's approach to the work. Typical investigation tasks and the relative amount of time the EMP usually devotes to each are characterized in the following pie chart:



The EMP must take into consideration a number of variables when planning and timing investigation of the project building:

Seasonal Considerations

Evaluations of equipment should be conducted when the systems are operational. On-site work may need to be conducted in phases. For example, space conditioning equipment currently in use will depend on the season. A project that requires analysis during both cooling and heating seasons could spread the work across a period of eight to twelve months.

Data Collection

Adequate time and scheduling should be allocated for the collection of data. Typically one to two weeks of logged data is required to get a good representation of how equipment operates. This data will be critical in developing a baseline case for your ECMs.

Operating Schedules

Conducting the investigation while spaces are occupied is preferential but not always possible. When evaluating equipment performance, real conditions provide the most meaningful data. An after-hours walk may be included to record how the building operates when the facility is unoccupied. Comparing results gathered during occupied and unoccupied times may yield surprising trends and opportunities for ECMs or FIMs.

Contractor Meetings

Allow time for scheduling meetings with the building automation contractor should the building automation system (BAS) be used to collect trended data. The BAS, along with data loggers, will account for the majority of the data collected on the project.

3.A.2 Elements of a Site Visit

Site investigation includes some tasks that resemble those completed by the EMP during the preliminary assessment described in Phase 1, but in substance they are quite different. At this stage in the project, the EMP's objective is to follow an intensive methodology rather than make a cursory scan. During this phase, the EMP endeavors to understand equipment operations in detail.

The preliminary assessment involved a shallow look at many systems, but site investigation involves an in-depth examination of building operations on a system-by-system basis, bearing in mind the project's trajectory. For example, the EMP may not need to further explore those systems, if any, that do not affect the existing project and its outcome.

This focused approach requires the EMP to become familiar with many aspects of the facility, including its:

- Sequence of operations
- Control points and BAS
- Operational setpoints and equipment schedules
- Location and layout of particular systems and their service areas

In addition to planning the agenda for the site investigation in advance of travel to the project building, the EMP should also review documents and hold conversations that may help structure the visit. Collecting sequences of operation and schematic drawings during the preliminary assessment will greatly help the EMP schedule and prioritize site investigation tasks.

It is best to hold phone conversations with the operating staff and the BAS contractor in the weeks or days before the investigation. These discussions will help the EMP prepare for the visit and save valuable time when on-site.

After meeting with facility staff, the EMP should start the investigation by collecting baseline electrical data for motor-driven equipment such as fans and pumps, and recording pertinent variables such as temperature, humidity, carbon dioxide, and air and water flow rates and pressures.

Next, the EMP performs basic tests of equipment operations. This involves operating the system under various modes of operation, such as:

- Start/Stop
- Heating
- Cooling
- Economizer
- Safety (e.g., smoke, fire, freeze, high/low static pressure)

Tests are typically conducted by a team of two consisting of the EMP and a member of the building's operating staff. The EMP should never—or seldom— be expected to conduct an operation on any building system without the advisement and/or supervision of facility staff.

At the very least, frequent communication among the EMP, the client, and the staff is critical. The EMP should clearly outline when, where, how, and why a specific piece of equipment is going to be tested for operational performance and, as part of the testing process, request staff assistance in advance.

One best practice by which the EMP is most likely to gain acceptance of and support for these tests is to develop a formal testing plan and present it to the operating staff. The better the work is outlined, the more positively it will be received by the client and building staff.

Operational testing is typically the most time-consuming portion of a site visit. Ample preparation and coordination prior to testing day will enable the EMP to conduct tests as smoothly and efficiently as possible.

3.A.3 Tools and Equipment

The equipment needed for in-depth investigation depends on the project's scope and focus. The EMP will need the same general tools that he or she brought to the walk-through, including protective clothing and equipment, notebook, flashlights, camera, and a flash drive or memory stick.

Through training and field experience, the EMP should be familiar with the use of multiple diagnostic tools. The EMP must understand the purpose of—and be comfortable using—instruments that measure various space conditions:

- Light
- Temperature
- Humidity
- Pressure
- Carbon monoxide (CO)
- Carbon dioxide (CO_2)

The EMP should also be prepared to utilize tools that measure building operating conditions and equipment performance. The following list of equipment, while not exhaustive, includes many types that EMPs use most frequently during the site investigation:

Equipment	Purpose
Air balancing hood	*Measures air flow rate (volume per unit time) at grills and diffusers.*
Air data multimeter	*Measures pressure and velocity of air with significant precision and sensitivity. Some units may also measure air temperature.*
Anemometer	*Estimates low-velocity air flow rates.*
Bourdon gauge or electronic pressure gauge	*Measures air pressure and differential pressure. Digital units usually offer greater accuracy than mechanical units.*
Combustion analyzer	*Analyzes combustion efficiency of a burner unit (e.g., a boiler).*
Data loggers	*Record data for multiple space variables such as light, temperature, amperage, and relative humidity, at predetermined intervals (e.g., every 1, 5, 10, or 15 minutes).*
Digital multimeter	*Measures voltage, current, and resistance at a single point.*

Equipment	Purpose
Electronic hygrometer or sling psychrometer	*Measures air temperature, wet-bulb temperature, and humidity.*
Inclined manometers	*Measure air pressure and differential pressure with relative ease and minimal expense. Units are usually supplemented with static probes.*
Power analyzer	*Measures less common electricity variables such as power factor and reactive power (kVar), and analyzes harmonics.*
Tachometer, strobe tachometer, or stroboscope	*Measures the speed at which motor shafts rotate.*
Thermographic (infrared) camera	*Records infrared radiation emitted from an object or entire building, and is used to maintain mechanical and electrical equipment as well as to evaluate the building envelope.*
Water data multimeter	*Measures pressure and differential pressure of water in equipment (e.g., pumps, chillers, cooling towers) with significant precision and sensitivity. Some units may also measure water temperature.*

The EMP should be able to demonstrate expertise in the use of most if not all of these tools, each of which has unique applications and serves particular functions. The EMP should verify that all measurement devices are maintained in excellent working order and properly calibrated in a timely manner. Since the EMP will usually need to transport all testing equipment to the project building, careful planning is crucial so that no important equipment is excluded and no unnecessary equipment is included.

When appropriate, the EMP should wear proper protective clothing. This may include a hard hat, safety classes, gloves, and possibly other attire that is deemed necessary for the unique project site. Demonstrating cooperation with the facility staff as well as respect for the risks inherent in the work, the EMP should confirm and observe proper lockout and/or tagout procedures and building safety practices.

Due to safety regulations, union rules, and liability exposure, an electrician should be hired by the client or EMP to install a power meter. Consult NFPA 70E, the Standard for Electrical Safety in the Workplace, from the National Fire Protection Association, for additional information about personal protective equipment in situations that present an arc flashing hazard. If any doubts, questions, or concerns arise with respect to installing pieces of test equipment, the EMP should resolve them before proceeding.

3.B DATA COLLECTION

The EMP's execution of building system diagnostics depends on adequate data collection. Some preliminary information was collected during Phase 1. In this phase, the EMP collects additional data about facility operations and energy consumption. The emphasis should be on gathering data at a level of granularity sufficient for the EMP to fully understand equipment behavior and building performance. Detail is essential to generate valuable, material insight into the building. Data collection is not a single exercise but rather the end result of thorough process in which the EMP has invested much time and thought. This data serves collectively as the foundation for calculations that produce estimates for ECM/FIM costs and energy savings during later phases of the project. For this reason, the EMP must make sure to collect the right types of data during the site investigation.

3.B.1 Trending/Data Logging Plan

Prior to the site visit, the EMP should develop a plan for obtaining the data needed to support the case for potential ECMs/FIMs. This plan should include a list of specific physical tests and measurements to be completed at the facility, as well as a matrix describing the types of data to be gathered via the BAS or **data loggers**. Because loggers measure multiple variables across intervals of time, as opposed to one measurement captured at a single moment in time, loggers can provide significant insight into equipment information.

Prior to the site visit, if possible, the EMP should outline how many loggers will be needed and where they will be placed. At the site, a best practice is to maintain a record specifying exactly when and where each logger was installed. This is especially true for larger buildings where dozens of data loggers may be needed. Since the number of loggers is necessarily limited, a careful plan will help make sure that they are placed at the most critical locations throughout the building.

Data Loggers

Commercially available digital devices installed temporarily on a specific piece of equipment or specific building area in order to measure and record variables such as light, temperature, amperage, and relative humidity at certain time intervals.

Trend Data

The collection of data for a point or points at a given frequency over a specific timeframe. Often gathered via a BAS.

Data loggers are an essential tool for energy management, but they are not the only means of collecting data that reflects changes over a certain period of time. The EMP can specify a time frame for **trend data** obtained from the building's BAS. Before traveling to the site, the EMP should write down a list of trends to retrieve from the BAS, specifying the points and equipment to capture.

While developing data collection plans prior to the site investigation will save time and maintain focus, the EMP must bear in mind that adaptation and flexibility can prove to be critically important. Data collected from one test or piece of equipment may refute or confirm the EMP's previous hypotheses and redirect the course of the investigation. An EMP may need to make changes to the existing data collection plans based on the results of more in-depth investigation. It is better to have a plan that changes, however, than to arrive at the site without a plan. Invariably, if no plan is developed beforehand, the EMP will return to the office and discover that there is incomplete information to conduct thorough analysis, necessitating a return to the project building.

3.B.2 Methods and Sources

In order to effectively refine and screen ECMs and FIMs, the EMP can employ a number of different methods and consult several different sources. These methods and sources include:

- **Building Staff**

  Engineering and management employees are a vital source of general information. They provide data that cannot be measured with the use of technology or extracted from files, papers, and drawings. Occupancy information and building schedules are two examples of important documents to collect from building staff.

- **Diagnostic Tools**

  The application of test equipment to specific building equipment and systems will be an essential source of information during the site investigation. The EMP will perform targeted testing of specific systems rather than comprehensive testing of all systems. When used properly, various tools, outlined above, provide the EMP with data describing general conditions in the building and equipment functionality in different modes of operation.

- **BAS Trend Data**

  Trends from the BAS are the first data source to review after speaking with building staff. Information pulled from the BAS must not be accepted without question, however, because of the possibility that a malfunctioning sensor or other operational issue has produced corrupt or *inaccurate data. Data gathered from the BAS should always be corroborated with information collected by other methods.*

The EMP is also expected to have some familiarity with typical types of building automation systems. Different manufacturers and evolution of the technology over the years have naturally led to a variety of systems with different capabilities and limitations. At a minimum, the EMP must know how to navigate the various graphic screens and how to locate schedules and set-points.

The ability to create trend logs is also important. Each BAS has unique procedures for creating trend logs, however, and so expecting an EMP to know exactly how to examine trends in every possible system is unrealistic. Instead, the EMP should know how to identify the points to be trended and how to define the characteristics for trending, such as frequency and capacity. The EMP will often need to work with the client, building staff, and BAS contractor to set up the necessary trends. For this reason, communication about the BAS prior to the site visit may be extremely helpful.

- **Data Loggers**

  Temporary data loggers help confirm BAS trend reporting and may serve as the primary data collection method when BAS equipment is not present. Data loggers monitor systems and record measurements such as temperature, relative humidity, run time, and power usage over time.

- **Independent Field Survey**

  A field survey by an independent TAB professional enables the EMP to understand system operations and compare field measurements to intended design. This action may help inform potential ECMs/FIMs. For example, measurements may show that a VAV terminal unit is not under control, or that its air volume is constant rather than variable.

- **Thermographic Imaging**

  Thermographic imaging *evaluates heat transfer irregularities. It can be used to confirm concentrated heat loss in regions of the building envelope, such as insulation gaps between studs or ineffective flashing. The EMP may also find this technique helpful for inspecting non-visible conditions, such as clogged cooling coils or air locks in condenser tubes.*

Thermographic Imaging

Process for evaluating heat transfer irregularities, often used to identify heat lost via the building envelope.

Observations during the site investigation may differ from measurements captured during the initial walk-through earlier in the project. If usage or occupancy has evolved over time, such discrepancies may be easily explained, in which case additional research is warranted to justify the changes.

The EMP follows a three-step process for data treatment:

Collect Data

- *Use specialized diagnostic tools, data loggers, and BAS trending to collect sufficient data for the building.*
- *Acquire a full data stream for at least one or two weeks, without interruption.*
- *For all systems that are monitored, record data at a frequency of at least every five minutes.*

Manage Data

- *Scrub, clean, and/or format the data.*
- *Convert data files to prepare them for other software packages, as necessary.*
- *Load the data into spreadsheets or databases, and display numbers as time-dependent or scatter plots, or another appropriate graphical or pictorial form.*

Analyze Data

- *Determine proper operating qualities for the building and its systems, and establish a minimum level of desirable performance.*
- *Review the actual collected data and compare it to the*
- *Confirm that the data either supports or refutes the suggested ECMs/FIMs and the savings potential of specific ECMs.*
- *Suggest additional data needs, if necessary, to reach satisfactory conclusions.*

These three steps comprise an iterative process, in the sense that data analysis may expose the need for further data collection and data management. In short, the EMP will be expected to manage and then analyze the data collected through the BAS, by data loggers and similar tools, or via both methods.

The EMP is responsible for designing site visits and asking questions that will lead him or her to assemble enough data to advance the project and make confidence ECM/FIM and EBCx recommendations.

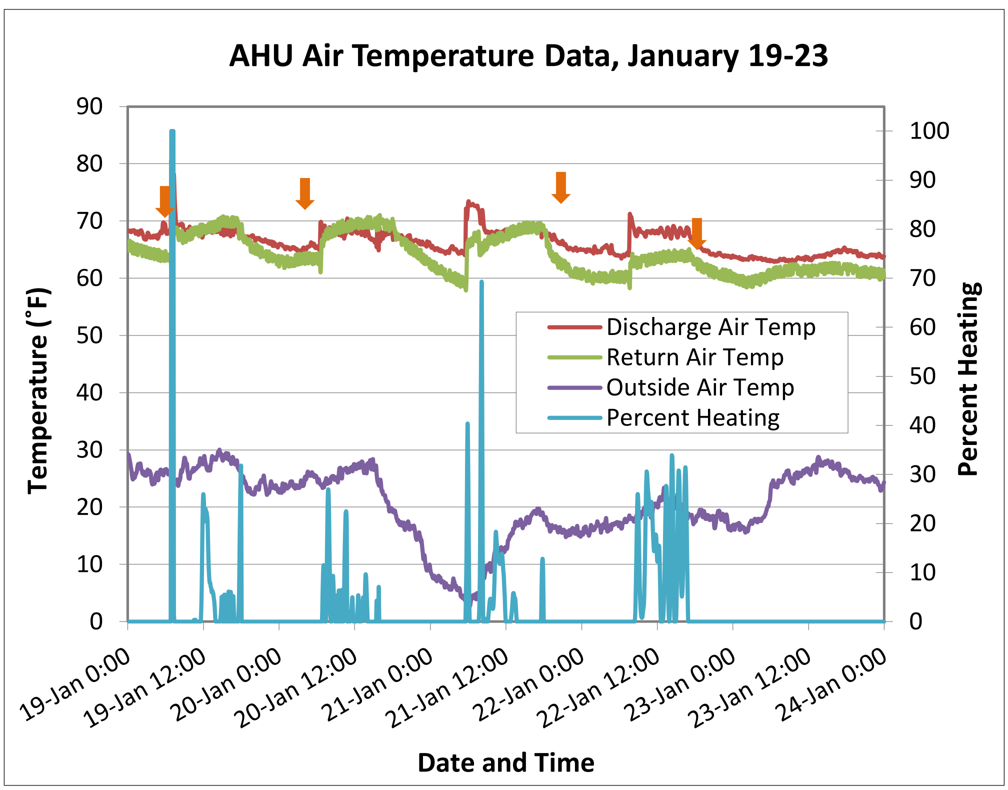
CASE STUDY 3.1 — DATA COLLECTION | BUILDING B

The EMP collected most of the available data at Building B via BAS trending. As the project progressed, the EMP was able to access data from building equipment via the Internet through the monitoring systems installed on-site. This data enabled the EMP to set baseline performance levels, identify operational inefficiencies, and demonstrate energy savings persistence after ECMs were implemented.

At one point in the project, the BAS was used to collect operational data on an air handling unit. The EMP worked with the controls contractor to identify and set up trends of the data points that are monitored and controlled through the BAS. Over a period of fifteen days, the BAS collected the following data every five minutes:

- *Discharge air temperature (DAT)*
- *Return air temperature (RAT)*
- *Outside air temperature (OAT)*
- *Percent heating*

Data for five of the days, covering the period January 19 –23, is plotted below.



Read the temperatures along the left vertical axis and the percent heating along the right vertical axis. The signal for percent heating is understandably greatest during normal occupied hours and when the OAT is the coldest. Morning warm-up was standard practice at Building B throughout much of the winter.

The EMP analyzed the data and made a startling discovery about startup conditions. Morning warm-up often had little or no impact on RAT at startup, meaning that conditions within Building B at 8:30 am were about the same, whether or not warm-up was initiated. (The orange arrows above the plots are positioned around 8:30 am.)

This data prompted the EMP to develop and recommend an ECM that involved eliminating morning warm-up when OAT was above a certain threshold. (On the very coldest days, warm-up was still deemed necessary.) This ECM was later implemented by the building, resulting in significant energy savings.

3.B.3 Occupancy Profile

Occupancy Profile

Data set representing the typical hours a building is occupied, as well as occupancy numbers and locations.

A building **occupancy profile** is an important piece of information for the EMP to have when analyzing ECMs/FIMs and characterizing operations requirements. If an energy model is being used in the project, this profile will also help the EMP or other energy modeler calibrate the model.

The occupancy profile outlines:

- Numbers of building occupants
- Spaces in the building that are occupied
- Hours that each building space is occupied

Simulation programs typically include default occupancy profiles that may be applied automatically to the project building. Such default numbers are a poor substitute for real data. In order to depict accurately how and when a building is occupied, the EMP should work with building staff to complete an occupancy profile. Detail is critical, because the profile will affect the EMP's final recommendations for reducing energy use and improving building performance.

The difficulty of obtaining this information will depend on the building. Collecting data from a smaller facility occupied by a single organization will generally be much simpler than working with a dozen companies that lease space in a commercial building. The EMP may need to enlist building management to assist with this process. Several best practices for gathering occupancy data have been identified. For example, the EMP should:

- **Stress the value of this information.**

  When asking tenants and/or office/building managers for their cooperation, communicate that the primary goal is creating a high-performance space. The EMP should explain that occupancy data is critical to profiling the building and ultimately achieving the desired level of energy reduction and improving facility performance.

- **Provide a clear but detailed template.**

  A form that can be filled in with space, time, and occupancy numbers will make the job easier. A spreadsheet will encourage the tenants or office/building managers to provide exactly those types of figures that are necessary, in the format that is most useful. The EMP should take the time to produce a customized template for the project building, accounting for each individual floor and special spaces (e.g., gyms, cafeterias, data centers, training rooms, etc.).

- **Emphasize the ultimate positive impact.**

  The energy management project can have profound, tangible effects on indoor air quality, occupant comfort, and reduced energy costs. If they understand that full and truthful answers will ultimately influence their own comfort and satisfaction within their space, they will be more motivated to comply with the EMP's request.

Project-specific occupancy data is important for the EMP to consider when choosing and qualitatively analyzing ECMs/FIMs. An ECM applicable to a building with a highly variable occupancy profile is not necessarily applicable to one with a constant occupancy profile. For example, the EMP may have initially suggested demand ventilation as a potential ECM, but after learning that the building is 100% occupied throughout the day, such an ECM is not practical, and the EMP can remove it from consideration.

The EMP can draw a number of conclusions from a timeline that describes daily, weekly, and annual occupancy at the project building. The information may be used to affirm or refute ECMs as either possible or impossible before physical measurements are made within the space. The occupancy data therefore help the EMP save time and focus his or her efforts.

The table below is an excerpt of an occupancy form that an EMP completed. Employees at the project building are divided among multiple weekday shifts and an additional Saturday shift. The number of people and percentage of peak occupancy are specified for each hour of a typical weekday and weekend:

Occupancy Profile: Whole Building

Typical Weekday		
Peak Occupancy (weekday)	80	**Comments**
Typical Daily Visitors (weekday)	8	*Data applies to bays and first floor (three shifts)*
Peak Visitors (weekday)	15	

Persons	40	40	40	40	40	40	56	64	64	80	80	64
Occupancy	50%	50%	50%	50%	50%	50%	70%	80%	80%	100%	100%	80%
Time (AM)	0	1	2	3	4	5	6	7	8	9	10	11

Persons	40	64	64	80	48	40	40	40	40	40	40	40
Occupancy	50%	80%	80%	100%	60%	50%	50%	50%	50%	50%	50%	50%
Time (PM)	12	13	14	15	16	17	18	19	20	21	22	23

Typical Weekend		
Peak Occupancy (weekend)	50	**Comments**
Typical Daily Visitors (weekend)	2	*Data applies to no more than one Saturday shift per month*
Peak Visitors (weekend)	10	

Persons	0	0	0	0	0	0	15	25	25	40	50	50
Occupancy							30%	50%	50%	80%	100%	100%
Time (AM)	0	1	2	3	4	5	6	7	8	9	10	11

Persons	15	15	10	10	0	0	0	0	0	0	0	0
Occupancy	30%	30%	20%	20%								
Time (PM)	12	13	14	15	16	17	18	19	20	21	22	23

Occupancy Profile: Individual Spaces*

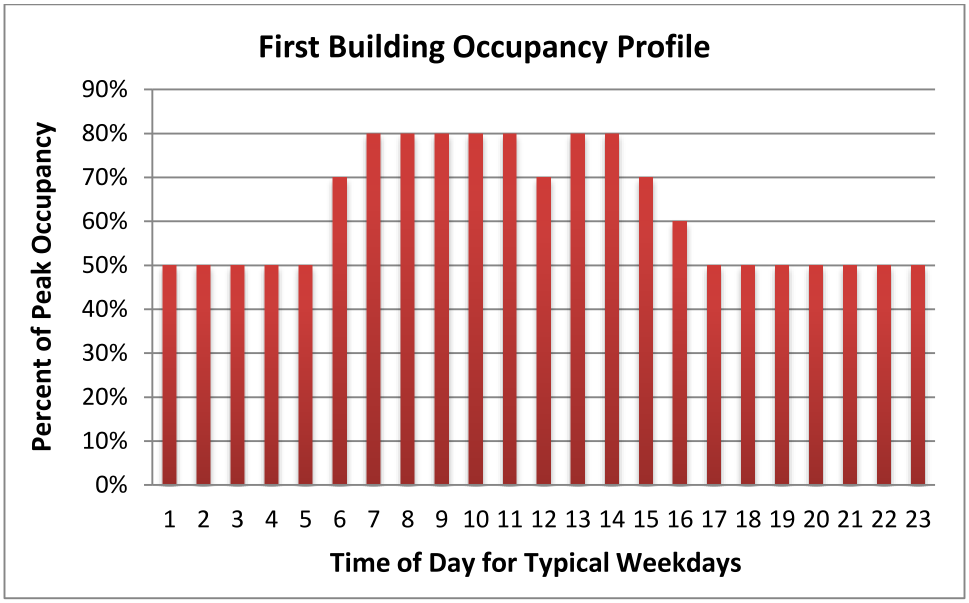
Space Name	Square Footage
2nd Floor Offices	30,000
3rd Floor Offices	15,000
Cafeteria	10,000

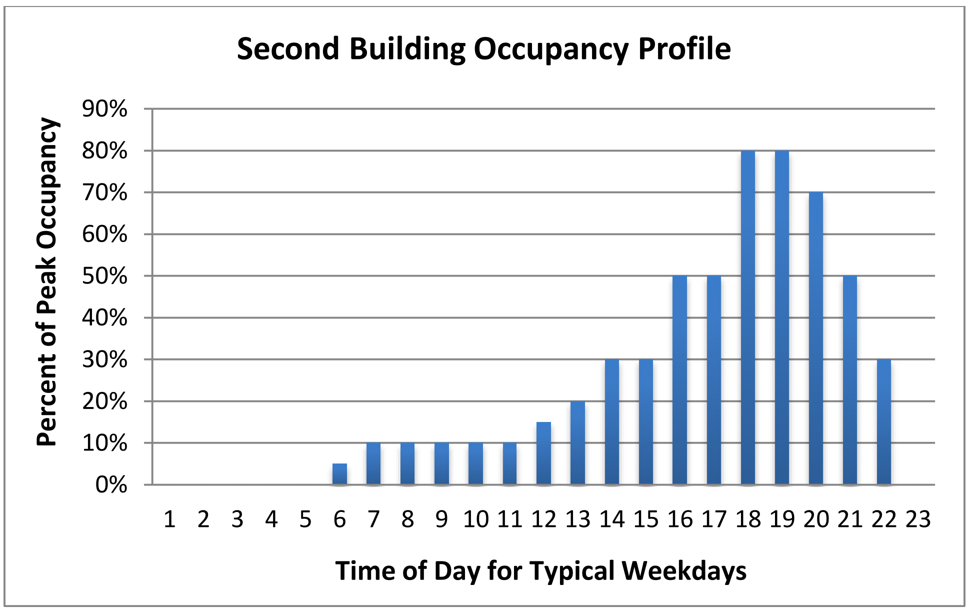
* Complete an Occupancy Profile for each additional space where hours and occupancy differ from those of the whole building.

Once the raw occupancy information has been gathered, the next step is to transform it into a more useable form. The EMP should generate graphs illustrating whole building occupancy patterns and—depending on specific ECMs and the nature of the project—additional graphs for individual spaces. A graphical illustration of occupancy is a strong visual tool to use when reviewing the project with the client.

Occupancy profiles for typical weekdays at two different buildings are presented in the two graphs below. The first building, whose occupancy is depicted in the red graph, is never “unoccupied.” At least 50% occupancy is maintained throughout the entire 24 hours.

On the other hand, the second building, whose occupancy is depicted in the blue graph, is heavily occupied only between 4 pm and 10 pm. Additionally, the second building is completely unoccupied, or nearly so, for the first twelve hours of every weekday.





Until this stage, the EMP may have been considering ECMs such as setting back the space temperature or shutting off outside air during unoccupied hours. The occupancy profiles indicate that such ECMs are only feasible for the second building. ECMs and FIMs must make sense for the specific project building.

3.B.4 Building Schedule

The occupancy profile is related to another important piece of information, the building schedule. The hours that people typically occupy the building define the master operating schedule and, in turn, sequences of operations for each building system. The building schedule will not only establishes the equipment operating patterns, but will also be important to the EMP when scheduling site visits and determining the best times to test or analyze certain pieces of equipment.

An office building may have the following building schedule:

Monday	7:00 am – 6:00 pm
Tuesday	7:00 am – 6:00 pm
Wednesday	7:00 am – 6:00 pm
Thursday	7:00 am – 6:00 pm
Friday	7:00 am – 6:00 pm
Saturday	8:00 am – 1:00 pm
Sunday	No hours

Meanwhile, a retail store might have longer evening and weekend hours:

Monday	9:00 am – 10:00 pm
Tuesday	9:00 am – 10:00 pm
Wednesday	9:00 am – 10:00 pm
Thursday	9:00 am – 10:00 pm
Friday	9:00 am – 10:00 pm
Saturday	10:00 am – 9:00 pm
Sunday	11:00 am – 7:00 pm

In each example, the spaces must reach their occupied setpoints by the time indicated for each day of the week. These times, in turn, dictate when the building engineers need to start the systems early in the morning in order to achieve those setpoints, as well as when the systems can be shut down at the end of the day.

Obviously, each building will have its own schedule based on type and need. Some buildings operate continuously, 24 hours a day, every day. Residential towers, most data centers, some factories, and of course hotels and hospitals fall into this category. The EMP must understand the building schedule, because it can reveal and later validate many opportunities for ECMs and FIMs.

Even buildings with continuous operations may be improved through the EMA Energy Management Process. A common assumption is that since such buildings never shut down, current operations cannot be modified significantly. The role of the EMP is to identify those specific points within the continuous building schedule when energy usage can be reduced and performance can be optimized.

3.B.5 Building Setpoints

Building setpoints are the target conditions for a given facility. Ideally, the setpoints also frame the environmental conditions that should be realized throughout the year. Setpoints also serve as reference values that the EMP should compare to data collected during the preliminary walk-through and site investigation. Equipment can be evaluated with respect to how well it achieves and maintains applicable setpoints.

Consistent conditions are critical to occupant comfort and thus building performance. Space temperature setpoints and relative humidity setpoints are two of the most common types. The EMP should be familiar, however, with the use of many other types:

- Carbon dioxide setpoints
- AHU discharge air temperature setpoints
- Static pressure setpoints
- Hot water temperature setpoints
- Chilled water temperature setpoints
- Summer/winter changeover setpoints
- Economizer setpoints

Setpoints may vary with the time of day, month of the year, geographic location, microclimate, and specific space functions. In some instances, there may be no effective setpoint. In many areas of the U.S., winter occupied space temperature setpoints will be lower than those for the summer. The reason for this difference is energy and cost reduction, because occupants tend to wear heavier clothing in winter, and lighter clothing in summer. The building can use less energy for wintertime heating, and less energy for summertime cooling, without negative impact on comfort.

Regardless of building location, people tend to be comfortable under a certain set of building conditions. ANSI/ASHRAE Standard 55, titled Thermal Environmental Conditions for Human Occupancy, describes six fundamental factors that influence occupant comfort: metabolic rate, clothing insulation, air temperature, radiant temperature, air speed, and humidity. Those variables may be in flux over the course of a day. Collectively, they determine whether occupants will feel comfortable or uncomfortable. For example, humidity will affect how warm or cool spaces with the same temperature will feel.

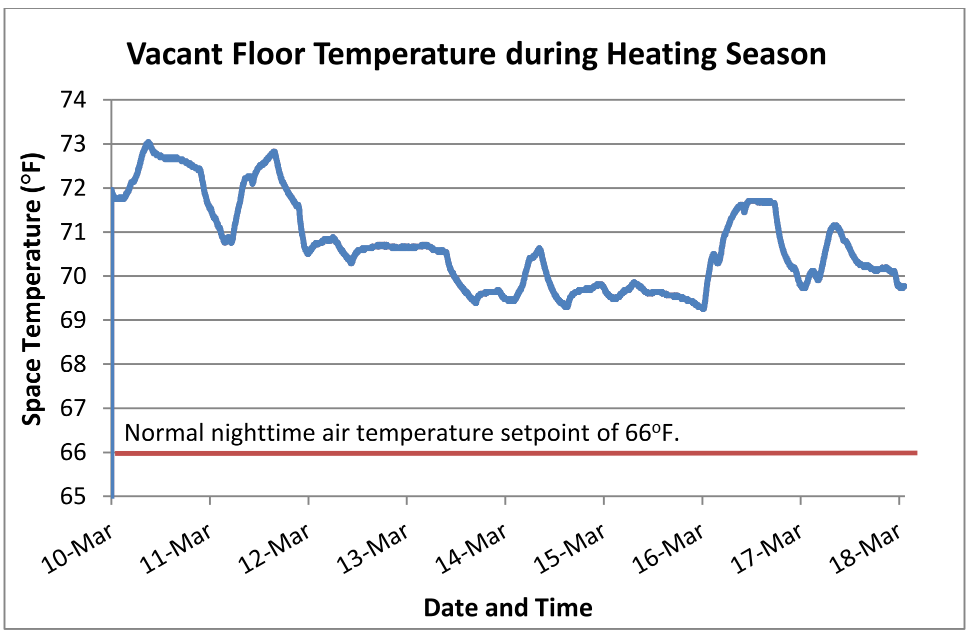
Space temperature setpoints are one aspect of a much larger system. The EMP should fully understand and itemize the types of equipment that are used throughout the facility to maintain space temperature. In addition, he or she should determine how each piece of equipment helps maintain that temperature. Questions that the EMP might ask include:

- Are temperature sensors or thermostats used?

- If thermostats: Is there a single thermostat for the entire service area of the HVAC unit? Or are there multiple zones, each with individual temperature control? Can occupants adjust the thermostats? How often are they calibrated?
- If temperature sensors: Where are the sensors located? How often are they calibrated?
- Is space temperature controlled with a digital-down converter (DDC), electric, or pneumatic system?
- Does the space temperature setpoint vary throughout the day and night? What about throughout the year?

Similar questions should be asked for every type of setpoint that the EMP encounters at the project building. For example, in terms of relative humidity setpoints, the EMP may ask where humidity sensors are located, when the setpoints are maintained, whether or not humidifiers are used, and how outside air dampers are controlled to help maintain the setpoints. Other types of setpoints will naturally require unique sets of questions.

The graph below depicts the space temperature profile for a vacant floor in a building over a nine-day period in mid-March. The building is located in Boston. The temperature data indicate that the space temperature is never allowed to return to 66°F at night, a setback that is normal for this type of unoccupied space in this location. In short, the data indicate that this vacant space is being conditioned continuously—and unnecessarily.



During daytime, the space temperature setpoint is 70°F – 72°F, and the relative humidity setpoint is 45% – 55%. During nighttime, there is no relative humidity setpoint. In this case, an obvious ECM involves either fixing temperature sensors or, more likely, correcting nighttime setpoints.

If the EMP finds that the actual values for space temperature or any other parameter never achieve setpoint, the sensor may be malfunctioning or improperly located, or the setpoint outside the capable range of the larger conditioning system. The failure to meet a setpoint usually corresponds to excessive equipment operation or poor space conditioning. In either case, correcting the problem will definitely improve building performance.

3.B.6 Follow-Up Visits

The EMP will conduct follow-up visits, as necessary, to gather information that was not available during the primary site investigation, or to collect data loggers and retrieve other information that was trended by the BAS. These visits can also be opportunities for the EMP to observe the same building operating under a different set of conditions.

The follow-up visit could be a **night walk** conducted during unoccupied hours. The EMP will often benefit from the unique perspective on building equipment and operation that can only occur when the spaces are empty and the systems are supposed to be silent.

Night Walk

A follow-up visit to investigate and observe building systems conducted during unoccupied hours.

As the EMP continues to investigate the building, gathering additional data and observing building operations during different conditions, the list of ECMs will be further refined and ready for additional development.

3.C EBCx Activities

Many buildings have never undergone commissioning. For this reason alone, EBCx offers significant opportunities to improve operational efficiency. Even buildings that have been commissioned, however, will benefit from EBCx. Whether they were commissioned following construction or during a previous EBCx project, factors such as maintenance neglect, component deterioration, and improper operation can impair equipment efficiency and performance.

These factors, in addition to the emergence of new technologies and shifting owner concerns, demonstrate the need for the EMP to investigate and address the existing building systems. The EMP must ensure that the systems are operating at their optimal efficiency and interacting properly with equipment and systems that are newly installed during the energy management project.

The EBCx process will ensure that systems that are expected to remain in the building following project completion are operating as efficiently as possible and in accordance with the building's operational needs. Investigation for EBCx will involve limited TAB and functional testing of equipment, as well as interviews with building management, key O&M personnel, and existing vendors and service providers. The EMP's objective is to become familiar with reported operational or comfort problems.

During Phase 1, the EMP developed a Preliminary EBCx Scope for the client. This will form the basis for EBCx-related data collection, TAB, and limited functional tests during Phase 3. Many data collection tasks related to potential ECMs and FIMs will also inform EBCx.

3.C.1 Investigative Test, Adjust, Balance

It may be beneficial for the EMP to include TAB services at this point in the EBCx process to evaluate if air and water distribution systems are still balanced in accordance with the initial design intent. These services will often involve an outside TAB contractor, although an EMP with the necessary professional qualifications may offer them as well.

TAB will provide a more in-depth investigation of air and/or water flow, which will inform further investigation and analysis of building systems. For example, if an air or water flow measurement does not correspond to initial design intent, the EMP needs to determine if it was misadjusted or if a modification was made to address an operational issue. Either result could provide insight into potential ECMs or FIMs. If the change was made intentionally, the impact of this change on other sections of the system may not have been considered.

Before measurements are performed, the EMP should work with the TAB contractor and client to identify baseline metrics. Identification of an issue during TAB may uncover opportunities for energy reduction by allowing fans or pumps to operate more slowly. If speed or air flow can be modulated, less outside air could reduce heating and cooling loads.

During and after the TAB process, the EMP should discuss the results with a building engineer or another member of the O&M staff. This conversation will also provide the EMP with a platform to asking important questions based on the TAB measurements:

- Have any building additions or renovations included modifications to the distribution systems? Were the systems balanced after those modifications?
- Is airflow through the outside air dampers of air-handling units evaluated regularly? If so, what is the frequency of the checks?

- Has the nature of space usage changed since the original design and construction? If so, are the original airflows still appropriate?
- Have the minimum airflows been reduced? If there are variable air volume boxes, have the minimum damper settings been adjusted?

Analysis of these measurements can highlight areas of inefficiency or poor indoor air quality that may need to be corrected during EBCx implementation. For example, if a hospital remodeled an area that was previously used for patient care but now consists of offices, the newly designed space will not require as much ventilation. If the space was not balanced after the remodeling, however, TAB should uncover higher-than-normal airflow measurements.

For additional guidance and information on TAB for EBCx, see the *ACG Commissioning Guideline, Section 7.2.1.5: Site Survey.*

3.C.2 Limited Functional Testing

Conducting limited Functional Performance Testing (FPT) will provide the EMP with additional data to evaluate issues with HVAC equipment O&M. This functional testing is not meant to be exhaustive. Instead, the EMP should use his or her best judgment to determine, along with the client, the appropriate systems and equipment to target. In some cases, every single piece of equipment should be tested, while in other cases, random sampling may be the better choice.

When working with buildings in which a comprehensive BAS is not installed, functional testing may become a larger portion of the site investigation. Since operational data cannot be easily collected from the BAS and analyzed to confirm sequences of operations, that information must be obtained by other means, such as FPTs.

Even when the EMP does have access to extensive BAS data, however, there are cases in which the data is not trustworthy. For example, data may be skewed for any of these reasons:

- A valve is leaking.
- A damper does not seal properly.
- An actuator is defective.
- A temperature sensor is defective.
- A temperature sensor is misplaced, especially in the mixed air plenum.
- A door from the AHU to the mechanical room is left open.

In these instances, FPTs are a valuable way for the EMP to generate accurate data that correctly represents systems operations. FPTs can also be employed to investigate indicators discovered while measuring data during Phase 2.

The results of EBCx Investigation will both confirm existing ECMs and FIMs and perhaps lead to the identification of additional measures. If additional measures are identified, the EMP should develop narratives and cost estimates for each, similar to those developed for existing ECMs and FIMs. These descriptions should include where these additional FIMs would fit into the project timeline.

3.D ECM/FIM Refinement

At this point, the EMP has developed a tentative list of ECMs/FIMs that he or she plans to analyze in greater detail in Phase 4. These measures must be further developed before the list of potential ECMs/FIMs is formalized. A brief narrative description should be drafted for each ECM or FIM.

More detailed cost and savings calculations that are performed in Phase 4 will produce estimates that are added to these narratives later in the process. For the time being, the ECM/FIM narratives should simply enable the client to better understand the overall scope of proposed work for each measure. Specifically, for each ECM or FIM, the narrative should describe:

- The nature of the work.
- The space or area of the building that will be involved.
- The system(s) that the proposed change will affect.
- The specific system components that will be addressed.

Once the ECM/FIM narratives are drafted, they must be revised, filtered, and ranked. The steps for completing each of these tasks are described in detail below.

3.D.1 Anatomy of an ECM/FIM

An ECM/FIM narrative provides important information to the client and serves as a helpful synthesis of the EMP's thoughts and analyses. At a minimum, the narrative for each ECM or FIM must include:

General Information

- EMP Firm
- Project Name
- Date of ECM/FIM Identification
- EMP Responsible for the ECM/FIM

Measure Summary

- ECM/FIM Number
- ECM/FIM Description/Narrative
- Effected Systems
- Effected sub-systems

Savings Calculation

- Analysis Summary
- Trending and Data Collection
- Baseline Data
- Supporting Graphs

Cost Estimates

- Material
- Labor
- In-House
- Contracted

Implementation Plan

- Scope of Work
- Sequence of Operation
- Material
- Labor
- Major Hurdles

Verification Matters

- Summary of Completed Work
- Changes to Measure or Scope
- Changes to Savings Calculations
- Functional Testing
- Trending
- Persistence
- Training

The EMP may wish to list ECMs and FIMs separately. They may be numbered in the order in which they were developed. Obviously, the EMP will not be able to populate all of this information at once, particularly at this early stage. Additional work during Phases 3 and 4 will provide the EMP with further insight necessary to fully develop ECMs and FIMs.

> *For an example of a completed ECM narrative that illustrates the items above, please see Appendix F.*

Appendix F

Sample Detailed ECM Description

3.D.2 Further Revision

After the individual ECM/FIM narratives have been developed, the EMP will often discover that some measures require further refinement. This process can involve collecting additional data from the building and/or the client, clarifying current operational practices with building staff, and grouping ECMs to better illustrate the proposed modifications. The EMP's need for information may range from clarifying the operating schedule for a certain piece of equipment to collecting data under different operational conditions during another site visit.

In addition to acquiring new information, the EMP will often need to refine the structure and presentation of the ECMs and FIMs. Some ECMs/FIMs may be interdependent and therefore best presented and described as a group. This step is especially helpful in advance of developing more detailed financial estimates and implementation plans in Phase 4.

Consider a commercial building that was participating in a utility-sponsored energy efficiency program. The EMP's services were underwritten by the utility. The objective was to develop a set of low-cost ECMs. Among others, the EMP developed this group of three ECMs:

Number of ECM	Name of ECM	Description of ECM
ECM 1	Repair Controls for Electric Baseboard	Repair unoccupied temperature setback control for electric baseboard heaters. Trending of the space temperatures, space temperature setpoints and power draw from the electric baseboard heaters, indicated that unoccupied setback control function was not operating correctly. Unoccupied temperature setpoints were set to 65°F, and trending of space temperatures and baseboard power draw revealed that spaces were never going below 70ºF and continuous heater power draw.
ECM 2	Correct Variable Speed Chilled Water Pumping Freeze Operation	Change programing in the BAS so only one chilled water pump progressively increases speed as OAT decreases from 40°F to 20°F. Currently the chilled water pumps are operated during the heating season to prevent freezing of the chilled water coils. VFDs were recently installed on both of the pumps and during the heating season both pumps operate at 60 Hz when the OAT falls below 40° F for freeze protection. The system is also protected by an ethylene glycol mixture with a freezing point of approximately 20°F.

ECM 3	Implement Optimum Start / Stop Sequencing for main AHUs	Incorporate the use of an optimum start in the BAS to reduce the duration air handling unit (AHU) fans operate during unoccupied hours. Currently the AHUs are scheduled to start between 5:00 AM and 5:30 AM (depending on the AHU) on Monday through Saturday using the BAS. High-rise west AHU fans amperages were logged and actual fan starting times were observed to vary from 1:30 AM to 5:00 AM.

Close communication with the client and/or building staff is critical at this stage. The EMP must strive to maintain the favor of the building staff because of the frequent need to ask them for their time and assistance.

Thus far, data related to potential ECMS/FIMs has come from site assessments, utility analyses, and—for some projects—energy modeling. For some measures, the distinction between a measure being an ECM or FIM may be uncertain at this point. The EMP may need to collect additional data related to these opportunities in order to clarify potential energy savings.

At this point in the project, the EMP has generated a list of preliminary ECMs/FIMs, developed a basic scope of work for each one, and collected additional building data. These steps will assist in the next task—screening ECMs and FIMs.

3.D.3 Ranking and Filtering

The client will want to understand the relative degree of confidence in each ECM or FIM. The EMP must divide the list of ECMs/FIMs into categories of high, medium, and low confidence.

To screen ECMS/FIMs, the EMP should start by reviewing his or her initial observations and a few basic site measurements. Consistent patterns in the data will indicate equipment or control problems. After producing a preliminary ranking, the EMP should move each ECM/FIM above or below the cut line, or even off the list. The order of ECMs and the breakpoint for their acceptance may be impacted by FIMs that are integrated into the project.

The distinction between ECMs and FIMs may not be readily apparent prior to the detailed calculations that occur in Phase 4. Inclusion of potential ECMs that eventually become FIMs allows necessary building improvements to be included in the assessment, even if they do not result in reduced energy consumption. The inclusion of FIMs alongside the ECMs also suggests a funding source for the FIMs—energy savings secured following ECM implementation.

Before performing highly-detailed analysis of a proposed ECM, the EMP screens each measure with the available data to assess the possible benefits associated with that ECM. Screening is essentially "go" or "no-go" analysis intended to filter the potential ECM list, narrowing it down to those meriting more detailed, and costly, analysis in Phase 4.

Depending on project goals and client needs, the EMP may screen the ECMs using one or more criteria:

- **Potential Savings**

  How likely is a measure to produce the indicated level of savings? The list of potential ECMs may or may not support the original projected energy savings. In some cases, the energy savings could surpass the target, while in others, the energy savings may fall short.

- **Estimated Payback**

  How economically feasible is the ECM? No energy savings will come from a measure that is never implemented. A capitally-intensive measure with a long payback period may be less likely to be implemented than a group of low-cost ECMs. Although the EMP will be able to calculate various types of payback metrics, he or she should already know the client's budget and intentions.

- **Client Motivations**

  How does an ECM line up with the client's motivations and project goals? Is the client specifically hoping to make capital improvements? Or avoid them? Is rapid payback essential? Are there specific building systems that the client desires to overhaul? The EMP must clearly understand and take into account the owner's objectives, and likelihood of implementation, when screening ECMs.

The most important screening factor is the client's acceptance of the ECM/FIM recommendations. The EMP should screen ECMs/FIMs regularly to make sure that his or her recommendations are line with the client's priorities and goals. For example, if an EMP is developing measures for an industrial plant, and the ECMs negatively impact the manufacturing process, the client is almost certainly going to be averse to implementing them. In many cases, this screening process will determine if an ECM is a "go" or a "no-go."

Secondary screenings may involve back-of-the-envelope calculations, citing factors such as general operating hours, gross estimated energy usage, equipment age, industry practice, and similar examples from other projects. For these types of estimates, the EMP may rely on:

- **Rules of Thumb**

  The EMP's general experience, as well as various sources of published literature, provides common rules of thumb for saving estimates based *upon system types. For example, the EMP may reference, "General savings of 33% are possible when switching from T12 to T8 lighting." Or, "A geothermal heat pump system will reduce energy use by 40–50% for cooling, and by up to 75% for heating."*

- **EUI Benchmark Savings**

  EUI values summarize the energy use of a specific building, and, in some cases, specific systems. These benchmarks were described in Phases 1 and 2. EUIs that describe the total energy use per square foot for particular systems, such as lighting or cooling, may be most helpful for this task. Combining rule of thumb savings estimates with EUI provides a slightly more accurate estimate of potential energy savings.

- **Simplified Analysis Programs**

  Simplified calculations can provide more accurate results than either rule of thumb or EUI estimates. The calculations can be contained in simplified "plug-and-play" spreadsheet programs, or the EMP may prepare custom spreadsheets.

  "Plug-and-play" applications include vendor-specific calculation tools (e.g., for lighting, pumps, energy recovery, and motors), web-based savings calculation tools offered by the utility (e.g., for high efficiency air-conditioning), and spreadsheets that capture temperature "bin" data and calculate building envelope savings and reductions in outside air requirements. If the EMP uses tools from a third-party source, he or she should make sure to validate the tools before relying on them.

  The EMP may also use custom spreadsheets that rely on simplified engineering formulas. As the EMP gains more and more experience, he or she can use as a starting point the calculators that were created for earlier projects. Eventually, the EMP should develop a library of tools.

In addition to these common methods, an EMP may also prepare estimates based on walk-through observations, the age and quantity of pieces of equipment, or perceptions of cost-effectiveness. If building characteristics are similar, the EMP may also consider the results of previous projects. Some measures, such as those involving lighting or water usage, lend themselves well to straightforward counting and simple calculations. Others may involve comparative analysis or general calculations of feasibility.

No quantified energy savings or cost projections will be presented to the client at this stage of the project. The information is macroscopic, providing an "order of magnitude" assessment of the feasibility of each ECM. Given that only preliminary measurements have been gathered, attaching specific savings percentages or cost figures to each ECM may risk raising a client's expectations or overestimating implementation costs.

ECMs and FIMs remaining on the list after preliminary screening warrant the client's investment in EMP consulting fees. During Phase 4, those ECMs/FIMs will be analyzed in much greater detail than they have been previously.

3.E PROPOSAL FOR FURTHER ANALYSIS

At this point in the project, the EMP has completed thorough analysis of building operations, energy use, and savings potential. ECMs and FIMs, as well as an EBCx Scope, have been developed, but they must be refined and validated before the EMP can legitimately make the case for implementation.

In order to continue with the EMA Energy Management Process, the EMP summarizes results to date and submits a proposal for future work to be completed in Phase 4, the last stage prior to implementation. The EMP must produce two important strategic and tactical documents: an Energy Plan Outline and an Investment Proposal.

Energy Plan Outline

- Compiles results of building walk-through and initial data analysis.
- Presents proposed ECMs, FIMs, and other project elements.

Investment Proposal

- Outlines costs for further developing ECMs, FIMs, and an EBCx Plan.
- Includes a projected timeline for the entire project.

3.E.1 Energy Plan Outline

Energy Plan Outline

A review of building analysis and investigation, as well as proposed ECMs, presented to the client. May be developed into a full Strategic Energy Plan depending on project.

The **Energy Plan Outline** is an opportunity for the EMP to present the client with results and propose further development of ECMs and FIMs, as well as EBCx, during Phase 4.

The EMP will fully develop the Energy Plan Outline into a detailed plan of action after the ECMs and FIMs have been exhaustively reviewed and the client has agreed to them. More comprehensive planning for ECM/FIM implementation is featured at the end of Phase 4 and the start of Phase 5. Planning at this stage is an intermediate step that serves to summarize the project's direction on behalf of the client, EMP, and the rest of the team.

The Energy Plan Outline includes:

- **Results of Energy Use Exploration**

  Provide the client with a summary of findings that have resulted from the exploration of energy consumption. Include graphs, charts, and related elements to give the client a vivid picture of the facility.

- **Ordered List of Potential ECMs/FIMs and EBCx**

  Include a list of ECMs/FIMs that have been identified as potential measures for the project, as well as remarks about the anticipated EBCx process. Organizing the ECMs/FIMs according to the proposed order of implementation will help the client understand the installation process. This list should align with the project timeline, which is subject to change as the EMP continues to investigate the building.

- **ECM/FIM Confidence Matrix**

  Present a table of likely ECMs and FIMs along with commentary about the level of confidence in achieving them. The EMP should include ECMs/FIMs that were initially considered, but later invalidated, as well as those that are still being pursued. This matrix gives the client a visual representation of the ECMs/FIMs under consideration and illustrates the range of project possibilities and the expertise required to narrow down those options. The matrix is preliminary; the rankings are not final. They will likely change after the EMP conducts further analysis in Phases 4.

- **Summary of Additional Project Elements**

  Include synopses of special project issues or initiatives that were discussed during Phase 1. These might include a greenhouse gas (GHG) emissions reporting plan, a measurement and verification plan, power purchasing options and strategies, or other analyses as specified by the project goals. If the particular matter is important to the client, the EMP should be certain to include it in the Energy Plan Outline.

The Energy Plan Outline describes the process, tools, and methodology that the EMP will use to further investigate the site and explore potential measures. At this point, the EMP has only conducted a preliminary walk-through, not a thorough site investigation. The EMP should specify the logistics of next steps:

- Comprehensive site investigation
- Potential for follow-up visits
- Equipment metering and monitoring needs
- Interviews of O&M and facility personnel
- Collection of other types of information

The objective is for the EMP to communicate to the client the steps that are necessary to further develop potential ECMs/FIMs. The EMP should characterize each element of the Energy Plan Outline's scope at a reasonable level of detail. For example, the EMP may specify that he or she needs to conduct a night walk during the next visit to the facility. A preliminary schedule of future activities provides the client with knowledge of the project timeline.

3.E.2 Investment Proposal

Investment Proposal

Proposal submitted for client consideration that details costs and savings estimates for ECMs/FIMs, as well as the EBCx scope of work.

The EMP also drafts and presents an **Investment Proposal** for further work. In contrast to the Energy Plan Outline, the Investment Proposal addresses the financial aspects of the project. It includes:

- Proposed investment costs to analyze and develop each ECM and FIM.
- Proposed investment costs to analyze and develop the EBCx Scope.

ECMs/FIMs and EBCx tasks have not been finalized at this stage, of course, but the EMP should still have a relatively good sense of the results that he or she will hope to produce through additional investigation, measurement, and analysis. The EMP should generally be able to envision, even at this stage, the work that will be required to complete the energy management project.

For each ECM and FIM in the Investment Proposal, the EMP should specify the scope of work, energy consumption reduction estimate, projected construction cost, and possibly a schematic design. The proposed ECMs/FIMs will be confirmed and approved in Phase 4, when detailed cost estimates, the energy savings potential, and comments on project timing will be generated for each ECM and FIM. In the same way, the treatment of EBCx in the Investment Proposal must be systematic and thorough. All of this analysis will eventually feed directly into the final energy management project plan, and—if the client has requested one—a Strategic Energy Plan.

To prevent the client from possibly thinking that the project is nothing more than an endless string of consulting fees, the EMP should incorporate expenses for Phase 4 into the Investment Proposal. The client will then have a relatively stable figure for the EMP's fees up until Phase 5. Reaching agreement about expenses at this stage will enable the EMP to focus on performing technical work rather than securing compensation.

When discussing the Investment Proposal with the client, it is critical for the EMP to explain the timeline. In Phase 4, the EMP will devote a significant amount of time to developing and analyzing ECMs/FIMs and EBCx at a very fine level of detail. The client may not understand this fact, and the EMP should not assume that the client is aware of the considerable effort that is required behind the scenes. Many clients will have experienced basic energy audits or other limited efficiency initiatives that demand less planning time and less investment—and may have produced inadequate results.

The client may not perceive the complexity of the EMA Energy Management Process until the EMP delivers the Energy Plan Outline and Investment Proposal.

If the client has never participated in an energy management project led by an EMP, the detailed timeline will provide the client with rationale for the proposed consulting fees and ensure that the EMP and client share project expectations.

The client may still question the additional costs associated with planning prior to implementation, however, and the EMP should be prepared to offer a clear explanation of the importance of careful preparation. The EMP should convey to the client that the work presented in the Energy Plan Outline as well as the development costs included in the Investment Proposal will lead to the final project plan. This final plan will include the agreed scope of work, costs and benefits, funding sources, implementation schedule, team members, and task assignments. For those clients and projects requiring one, a full Strategic Energy Plan will include even more information.

Presenting the scope and fees associated with the forthcoming phases of the project allows the client to review, modify, add, or delete proposed project tasks. The client's unique budget and timeframe, as well as the EMP's current assumptions and financial estimates, feed into this process. The desired result of the Energy Plan Outline and Investment Proposal is an approved scope of work for Phase 4, and a commitment from the client to invest in the further development of ECMs, FIMs, and EBCx.

SITE INVESTIGATION SUMMARY

*At the end of **Phase 3: Site Investigation**, the EMP has gathered comprehensive information about the building systems, its operations, and occupancy patterns.*

This new data, combined with earlier energy consumption analyses, provides the EMP with the information necessary to carefully identify ECMs and FIMS.

Armed with the results of limited TAB and functional performance tests, the EMP during this phase also lays the groundwork for development of EBCx. These services also help inform ECMs/FIMs.

Finally, the EMP delivers an Energy Plan Outline and Investment Proposal to the client that makes a case for continuing to fund and move forward with the energy management project. ECMs and FIMs are developed, ranked, and filtered.

*All of this preparation sets the stage for in-depth analysis of the most promising recommendations, which is the subject of **Phase 4: ECM/FIM and EBCx Analysis**.*

4 ECM/FIM AND EBCX ANALYSIS

After returning to the office with a variety of information collected at the project building, the EMP begins the ECM/FIM and EBCx Analysis Phase. In-depth analysis of each measure includes energy savings calculations, construction costs, and the consideration of financial return. The EMP will develop reports and metrics to help the client evaluate ECMs, FIMS, and EBCx, and the project as a whole. This final analysis sets the stage for the implementation of recommended measures.

The mission of the ECM/FIM and EBCx Analysis Phase is to:

- Produce accurate costs and savings estimates for all potential measures.
- Thoroughly assess all ECMs, FIMs, and EBCx.
- Articulate financial metrics and goals for the project.
- Provide the necessary detailed analysis for the client to make decisions regarding EBCx and ECM/FIM implementation.

This chapter should provide the EMP with:

- Tools for developing cost estimates for ECMs and FIMs.
- Strategies for reporting detailed ECM, FIM, and ECBx-related information to the client for evaluation.
- Information about project financial analysis and project performance metrics.

ECM/FIM AND EBCx ANALYSIS OUTLINE

This phase is divided into five major subsections:

During **Phase 4: ECM/FIM and EBCx Analysis**, the EMP examines in greater detail those ECMs and FIMs that are most likely to be installed. Planned EBCx tasks are also evaluated. The EMP, client, and/or building owner agreed on this short list of recommended measures and activities during Phase 3. The detailed study in this phase considers energy and financial impacts as well as installation cost analysis. This requires the EMP to have thorough technical knowledge of the measures themselves as well as familiarity with the economic considerations of importance to clients.

4.A Engaging the Project Team

During this process, the EMP completes detailed analyses of the ECMs and FIMs proposed in the Energy Plan Outline and approved by the client. One of the EMP's responsibilities is to develop the ECM/FIM list and perform the measurements, examinations, and calculations needed to convert the list into a full plan.

The EMP also serves as project manager and team leader, however, and those roles are especially important in this phase. Every EMP has unique qualifications and areas of expertise. Effective project coordination leverages the special skills of all team members and factors their insight into plan development. Additionally, the EMP will avoid wasting time on unproductive efforts.

For example, if one potential ECM involves an air-to-air energy recovery system in a situation in which there is no place to put the box, an experienced general contractor might immediately identify that issue, while the EMP may not. That particular ECM might need to be altered or dropped.

Additional team members whose expertise may be valuable during this phase include:

Building Staff

Building operations and maintenance staff can also play a valuable role. They know the logistics of the building and may also be able to provide information about funding sources and new equipment processes.

Contractors

Mechanical or electrical contractors will be helpful in conducting tests and developing accurate construction estimates. By contributing their help up front, they can also anticipate work downstream. For example, a TAB contractor may be engaged to perform flow measurements for chilled water if one potential ECM is chiller replacement.

Engineers

The client may already have a relationship with a consulting engineer who can contribute to elements of the project. Integrating this engineer into the project will give him or her insight into the building and reassure the client that the plan and project details are being vetted by an independent and trusted professional in addition to the EMP. For example, a design engineer may be consulted to determine if conditions will allow a new 100-ton chiller to work as well as an existing 200-ton chiller.

4.B Cost and Savings Estimation

Cost considerations are an essential part of the development of ECMs and FIMs. Accurate cost estimates will enable the client to consider the value and feasibility of potential measures with confidence.

4.B.1 Evaluating Construction Costs

Cost of Construction

Detailed costs associated with the implementation of an ECM, FIM, or group of measures.

In addition to the calculation of energy consumption reductions, detailed ECM analysis includes preliminary design development necessary to estimate the **cost of construction** and to validate each ECM's constructability.

First, the EMP should draft a narrative description that includes:

- Equipment capacity (e.g., air handler size, chiller size, flow rates)
- Auxiliary apparatus (e.g., pipe sizes)

- Modifications required for existing systems
- Necessary control sequences for new or existing controls

Regarding the last bullet, the EMP should specify if existing controls can implement desired sequences, or if ne controls will need to be installed. To generate the best possible construction cost estimates, the EMP should also include:

- Equipment specifications
- Schematic design drawings
- Marked-up existing construction plans

Since the EMP will need construction documents and permit drawings later in the project, a construction contractor may be engaged at this point to produce drawings and estimates. Doing so expands the professional expertise of the project team, provides fresh data for the EMP and client to review, and secures future work for the contractor. The information contained in detailed ECM/FIM narratives will often be sufficient for a contractor to accurately price construction costs.

The following ECM example illustrates a level of specificity that a contractor can use. Despite cryptic acronyms and frequent shorthand, these detailed descriptions also benefit the client and/or building owner. The sequence of steps provides a general overview of the ECM. Organized details are easy to track and manage.

ECM Example

1. Replace outside air dampers on air handling units 1A, 2A and 3A.

2. Size replacement dampers to fit existing openings.

3. Replacement damper minimum characteristics:

- *Airfoil blades*
- *Aluminum edge seal*
- *Double edge blade seal design*
- *Opposed blade control dampers*
- *Minimum leakage: 6 cfm/ ft^2 at 4" w.g.*

4. Replace damper actuators with new electronic actuators. Appropriate models and recommended manufacturers will be indicated.

5. Size replacement actuators to close off at least 10% larger than the actual close off size. If actuator is less than 10%, the next size must be used or two actuators must be supplied.

6. Provide all new mounting hardware for the actuators. This includes all linkages, shafts, pinions, and turnbuckles.

7. Provide all testing and programming required to re-establish BAS control of the dampers.

8. Provide a minimum of eight hours of labor to coordinate setting and calibrating the damper positions with the TAB contractor and owner's representative. Set and record the minimum outside air positions.

9. Allow four hours of labor to work with the owner's representative or commissioning agent to complete functional testing.

10. Provide submittals for approval of all new equipment prior to purchase.

11. Provide damper and actuator schedules.

12. Set up BAS trend logs for air handling units 1A, 2A, and 3A. Work with the owner's representative or commissioning agent to identify trending points, duration, and frequency.

Construction cost documentation is necessary to obtain accurate cost estimates and to select equipment. If an energy model of the project building has been developed, detailed ECM/FIM descriptions should also reflect the model's output. The economic feasibility of an ECM is confirmed when the contractor's cost estimates match the EMP's energy consumption and cost reduction estimates.

Construction costs may be refined repeatedly until implementation. The EMP will determine which ECMs warrant comprehensive construction cost estimates. These estimates must be prepared with great precision and accuracy, and attention to detail is critical. Suggest construction costs that are at best rough estimates are not sufficient. Variable figures may lead to either inflating the success or nullifying the value of the ECM.

For example, consider a hypothetical project that with estimated construction costs of $100,000 and net energy cost savings of $10,000. With these estimates, the return on investment is 10.0% ($10,000/$100,000). If those estimates diverge by 10% in opposite directions (i.e., $110,000 for construction and $9,000 for net savings), the return decreases to 8.2%.

On the other hand, if those estimates diverge by 10% in the same direction (i.e., $90,000 for construction and $11,000 for net savings), the return increases to 12.2%. The difference between 8.2% and 12.2% savings is dramatic—an increase of almost 50% from the lower figure to the higher figure.

Although actual costs and savings will always vary to some extent from estimates, the EMP should stress the importance of delivering precise and accurate estimates that are as close as possible to reality.

As the team leader, the EMP must:

- **Obtain reasonable estimates that are agreeable.**

  The EMP should facilitate team discussions to ensure that estimates are reasonable. Estimates should be neither extremely aggressive nor conservative. A "safety net" for the contractor is generally a good idea, but the estimates should not be understated to the point they are impractical.

- **Stress the importance and relevance of construction costs.**

  The EMP's experience and communication are critical when working with contractors, who are expected to generate focused, balanced, and effective construction costs. A contractor who has an existing and ongoing relationship with the client should be expected to deliver its best work.

- **Work effectively with client bid processes.**

  Depending on the nature of project funding, the presentation of construction costs may be determined by a funding entity. For example, public funding sources may have instituted requirements such as detailed cost specifications or a minimum number of construction bids. If more than one bid is required, the EMP may encounter difficulties in soliciting from two contractors the necessary level of construction cost detail when only one of them will receive the work. The EMP should shape the bid language and process to obtain numbers that are as accurate as possible.

Final construction costs will greatly influence project savings and payback. Detailed estimates for the expenses associated with ECM/FIM installation provide solid data for confirming financial feasibility.

4.B.2 Calculating Financial Feasibility

Further calculations will either support the financial feasibility of an ECM or remove it from consideration. It is vital for the EMP to communicate the results of this analysis to the client and/or building owner. Assumptions should be clearly stated. The EMP may use internal tools to perform calculations, particularly if no energy model exists.

4.B.2.a Introducing Assumptions

The EMP should document the assumptions and data sources that provide the foundation for financial calculations. More transparency is always preferable to less transparency. This is an opportunity for the client to assert his or her knowledge and expertise. Clearly stating assumptions up front enables the EMP to:

- Ensure "open book accounting" with respect to project cost estimates.
- Inform the client and/or building owner about the methodology for calculating very meaningful numbers that will influence decisions.
- Encourage the client to provide input during analysis (rather than during installation).

It is important for the EMP to be as transparent as possible regarding cost assumptions and to gain the client's approval. The client or building owner may question the accuracy or suitability of certain assumptions, and the EMP should listen and respond. For example, they may recommend adjustments to the energy rate used for calculations, the occupancy schedule, or anticipated maintenance savings.

4.B.2.b Employing Internal Tools

Some types of ECMs, such as those involving lighting fixtures or water usage, are easily calculated with spreadsheets. One advantage of working with tools generated internally is that the EMP understands how each spreadsheet has been programmed and why it yields certain results.

An experienced EMP can build complex spreadsheets and modify existing tools to accurately calculate costs and savings for a variety of ECMs as part of a specific project. The EMP knows how each variable and expression affects the bottom line. If the tool has been expertly constructed and each input is valid, the end result is justified. The EMP must ensure that the numbers accurately portray how the proposed system will work. The figures must make sense under real-world conditions and reflect the actual project building.

CASE STUDY 4.1 — CALCULATING FINANCIAL FEASIBILITY | BUILDING G

Building G, a high-rise office building in Minneapolis, decided to pursue an energy management project. Goals included improving whole building energy use and potentially investing in a chiller retrofit. The EMP's investigation revealed that the building's three chillers—two 1,600 ton units and one 600-ton unit—were nearing the end of their functional lives and operating inefficiently.

The EMP developed the chiller replacement as a potential ECM. The information gathered during the site investigation was supplemented with input from the client regarding new types chiller systems they were considering. The EMP produced estimates of the potential energy savings and financial return from installing new chillers.

> *First, the EMP calculated simple payback for investment in both "standard" and "premium" systems. Next, the EMP factored current energy metrics, estimated marginal rate increases, maintenance costs over time to calculate a net present value (NPV) figure. Using conservative estimates for repair costs and chiller lifespan of the chillers, the exercise yielded a positive NPV of $250,000. All financial calculations also took into account incentive funding that was presently available through multiple local utility programs. The EMP estimated that a chiller retrofit could save the building over 1,100,000 kWh annually.*
>
> *In addition to providing quantitative financial calculations, the EMP communicated non-quantitative value of the retrofit in the Detailed ECM/FIM Report. For example, the existing chillers used CFC-based refrigerants that were in the process of being phased out slowly across the country. New systems use safe, alternative refrigerants. The new chillers would not only improve the building's operational efficiency and reduce harmful environmental impact, but also make near- and long-term refrigerant sourcing easier and cheaper.*
>
> *Due to the building's operational needs, standard efficiency units produced satisfactory energy savings with an acceptable payback. The premium efficiency models were only slightly more efficient than the standard models, but they added five years to estimated payback. For these reasons, the owners of Building J decided to replace the three chillers with the new standard efficiency models, which netted substantial energy savings relative to the existing system.*

4.B.3 Energy Model Calibration

Depending on the project and specific ECMs/FIMs to be implemented, the EMP may be using an energy model for project analysis or working with an energy modeler. If this is the case, calibrating the model is the next step in detailing financial feasibility for the project. The model at this stage should accurately characterize the building's functions and energy consumption. The EMP or energy modeler will then need to run a series of simulations and note special building circumstances that simulations may not fully capture.

4.B.3.a Simulation Exercises

The model, which should mirror historical usage as closely as possible, will serve as the scientific "control." Unless the building has system-specific submeters, the original figure will represent the whole building (or base building). The EMP or energy modeler typically compares the results of simulated ECM performance with an extrapolated original consumption figure. This method of **ECM-isolation simulation** can be used for each individual ECM. Ultimately, the

ECM-Isolation Simulation

Energy simulation model that represents the results of implementing an individual ECM.

Whole-Building Simulation

An energy model that represents the operations of all building systems simultaneously, as opposed to addressing a specific ECM, system, or area of a building.

simulations for individual ECMs will be fed into and judged by a **whole- building simulation** to develop perspective on real consumption reductions that take into account the interactions among multiple measures.

Using the model, the EMP or energy modeler will conduct:

- **ECM-Isolation Simulation**

  Simulating the results of implementing each ECM individually assures the EMP that the estimated savings for each measure are as accurate as possible. For example, an ECM could involve replacing the air handling units in a building. Isolation simulation might reveal that this ECM will take much longer to achieve payback than was originally expected.

- **Simulation of ECM Clusters**

  Next, ECMs that are interrelated (e.g., they affect the same system) should be grouped together. The experimental results of simulating the performance of these clusters can be compared to the original control model derived from accurately reproducing historical usage.

- **Whole-Building Simulation: Grouped ECMs**

  For separate equipment components, individual simulation and calibration may be sufficient, and the EMP may move on to other analyses. When ECMs involving components are combined with ECMs that add control functions and new equipment, however, whole building simulation is necessary to produce an accurate model of the project outcome.

  For example, isolation simulations might result in savings of 10% each for chillers, air handling units, and direct digital controls. Instead of yielding a combined 30% consumption reduction, the whole building simulation may yield only a 23% reduction. In this case, the savings for measure reduce the available savings from another measure.

  Whole building simulation of ECMs within the same group is important, because the sum of individual simulations often overstates the actual reduction. In practice, the model may predict—and the actual project building will demonstrate—energy savings that amount to only 60–80% of the sum of individual ECM simulation results.

- **Whole-Building Simulation: Combined ECMs**

  Finally, all proposed ECMs should be incorporated into a whole building simulation. The EMP should not be surprised to discover some differences between the results of these experiments and those of the simulation for grouped ECMs. Building systems that may not seem to have anything to do with one another may actually relate. For example, a comprehensive lighting retrofit may drastically reduce the heat emitted by lamps in the *space, resulting in a greater need for heating in winter but less need for cooling in summer.*

At this point, the EMP has gathered actual consumption, a control model that closely replicates the actual consumption, and an experimental model, based on the proposed ECMs, that estimates future consumption. The model must be examined in detail and calibrated to ensure that the results it produces are reasonable.

For example, if the HVAC system only uses 40% of a building's energy, and the proposed ECMs for that system result in a whole building simulation that suggests 42% savings, the model will need to be re-examined. The results of a building energy simulation program should be checked on the front end by calibrating the model and on the back end by auditing the output at a greater level of detail.

4.B.3.b Special Circumstances

Some energy-related analyses and calculations may not be possible with either standard simulation software or internal tools. For these types of scenarios, one approach is to load the output from the simulation program into a spreadsheet and perform additional calculations until satisfactory results are achieved.

One category that often requires extraordinary calculations is heat recovery, especially when heat is being withdrawn from one system and applied to another. For example, an EMP may recommend an ECM that involves transferring heat from the chiller to pre-heat domestic hot water. Such complicated ECMs are generally beyond the capabilities of current simulation programs. In this example, the simulation program might provide an estimate of the available heat load from the chiller. The EMP plugs these numbers into a spreadsheet, and after multiple iterations, determines the extent to which the domestic hot water load can be successfully reduced.

These types of hybrid calculations will likely be needed in situations with simultaneous heating and cooling loads. In order to provide accurate recommendations to the client, the EMP must adjust the output of the model. Energy transfer between the systems is the key variable. Dedicated air-to-air heat recovery systems, and some control sequences, may also require adjustment following simulation exercises.

In short, the EMP should not simply accept the output of energy model simulations without question, particularly if the EMP is not directly responsible for modeling. More often than not, the results of simulation will be overly optimistic. The EMP may seize this opportunity to temper savings estimates that may be too large. Intentional downward adjustments of 20–25% will prevent unduly raising the client's savings expectations beyond what is possible. The EMP is ultimately responsible for the estimates that are presented to the project team, and he or she must take great care to deliver them with confidence.

While energy models provide great value, simulation modeling is still an imperfect representation of building operations. It allows an EMP to come close to actual results, but isolating and reworking problematic calculations on the side can go a long way to "closing the gap" between simulation and reality.

4.B.4 Savings Statement

Savings Statement

Detailed estimates of energy savings, cost savings, and other metrics as identified by the client, associated with the implementation of ECMs and FIMs.

The **Savings Statement** is tremendously important. It summarizes the EMP's estimates of savings generated by the ECMs. The statement is customized for each client and reflects specific project goals and criteria. The client will understandably be very interested in this information.

Savings may be communicated in the form of energy units, dollars, and/or greenhouse gas emissions. Depending on client needs, project savings may be presented in one or more categories:

- Individual ECMs
- Grouped ECMs
- Whole-Project Savings
- FIM Benefits

ECMs may be grouped individually as well as collectively, with projected savings summarized for each. All of these will feed into the whole-project savings. FIMs do not provide energy-related payback, but they should improve performance.

When developing the Savings Statement, the EMP should:

- **Use the client's desired metrics.**

  In all cases, express anticipated savings in one or more metrics that the client prefers. These could include simple payback, return on investment (ROI), internal rate of return (IRR), net present value (NPV), increased asset value, and other measures specified during the client consultation.

- **Group ECMs as needed.**

  For some ECMs, presenting a savings figure for the individual measure can be confusing if not misleading. Actual savings from a particular ECM may depend on the construction and installation costs associated with the final list of ECMs. In this case, estimating total savings for a group of related ECMs is a better course of action. The EMP may refer to ECM groups that were assigned during energy model simulations, if they were performed for the project.

- **Consider project timing.**

  Grouping ECMs by proposed date of implementation can also be beneficial. If the installation of an ECM or group of ECMs requires significant financial investment, lower-cost measures can be scheduled first to earn payback for the project. Such scheduling issues are addressed later in this phase.

- **Outline FIM benefits.**

  At this point, the EMP will have a good idea of measures that will result in cost or energy savings, and those that likely will not. Among those measures that will probably not reduce energy consumption, the EMP may recommend some of them as FIMs. A list of these FIMs should be provided to the client. In the Savings Statement, in place of savings metrics, the benefits of installing each FIM can be outlined.

ECM savings estimates and FIM benefits provide the client with the framework to understand the long-term value of the energy management project. It is essential that savings are outlined openly, accurately, and in the client's chosen metrics.

4.C SUMMARIZING RECOMMENDATIONS

The EMP must now bring everything together. The measures and EBCx Scope developed through Phase 3 need to be supplemented with detailed financial information. These elements combine to form summary documents that will be presented to the client for approval. A realistic timeline for implementing measures and EBCx is established. The Detailed ECM/FIM Report further describes the scope and value of ECMs and FIMs.

4.C.1 Implementation Schedule

The EMP drafts an implementation timeline for ECMs and FIMs. Both the client and contractors need to examine and agree to it. When developing the draft timeline, the EMP takes into account:

- **Implementation Costs**

  The EMP should develop the initial draft so that early savings from no-cost and low-cost ECMs help fund more cost-intensive measures. The importance of this factor depends on whether or not the client decides to implement capital measures, and whether or not other funding has been secured.

- **Client Priorities**

  If the client has prioritized certain building systems or ECMs to prioritize, the EMP should make sure to consider those as early in the scheduling process as possible. The project is focused on the goals of the client, although the EMP should still serve as a building owner advocate if the client and building owner are not one in the same.

- **Occupancy**

  Construction windows must be aligned with building occupancy patterns. Hospitals, laboratories, factories, and schools all have periods when their facilities simply cannot be taken out of operation. For such building types, the EMP should have asked about implementation scheduling during Phase 1.

- **Safety**

  Sometimes, site investigation reveals system deficiencies that can pose serious hazards to building occupants or O&M staff. In such cases, the facility is probably not in line with code. The EMP should prioritize the implementation of ECMs that will not only save energy, but also maintain a safe building environment.

An EMP may have a set of 200 standard ECMs that were initially considered for a project. Fifteen may be selected for implementation. Collectively, those measures have a payback of ten years. Given an equipment life expectancy of 15–25 years, an EMP should be able to convincingly determine optimal timing and savings estimates to cover project costs, based on these and other factors.

4.C.2 Detailed ECM/FIM Report

ECM/FIM Report

Report prepared for a client outlining in-depth analysis performed for proposed measures, including savings estimates, implementation costs, and preliminary timeline.

The EMP prepares a detailed **ECM/FIM Report**, which typically contains a one or two page summary of each ECM. In some cases, the report will include a longer summary of an associated group of ECMs.

For each ECM, the report narrative should include:

- Projected savings using the preferred metrics
- Estimated implementation costs
- Criteria for scheduling and timing

When drafting the detailed ECM/FIM Report, the EMP should consider:

- **Language**

  Detailed ECM analysis naturally involves engineering, construction, and energy management jargon. ECMs are evaluated with short, simple, and direct financial metrics. This abbreviated style is sufficient for members of the project team that are familiar with such language.

For projects that involve a Strategic Energy Plan, that document should be structured and worded as a business case. It should include standard business language that is easily understood by CEOs, CFOs, and financial institutions that may lend funds. The Strategic Energy Plan will often require additional layers of financial analysis as well.

For projects that will not produce a Strategic Energy Plan, however, the EMP may want to draft the ECM/FIM Report with universal language and a focus on clarity, because that document may well be reviewed by client representatives that do not have a background in energy management.

- **Logistics**

  The EMP must understand all aspects of the ECMs/FIMs under consideration and outline them for the rest of the project team. From costs, scheduling, feasibility, and implementation, the EMP is responsible for navigating a great deal of information. The EMP is in the unique position of needing to articulate the process to a wide range of project participants, including the principal client, engineers, building O&M staff, building management and ownership, and contractors. The team will understand the many moving pieces of the project only as well as the EMP organizes and communicates them. Therefore, the EMP must make sure that he or she masters the logistics of the project.

- **Owner Access**

  The EMP may be engaged by an energy contractor or a utility company rather than the building owner. In these instances, direct access to the owner may be impossible. All of the EMP's communication about the project will be relayed to the owner by the client intermediary. The EMP must try to provide simple and clear statements that cannot be misunderstood or otherwise "lost in translation" as they are shared with other members of the project team.

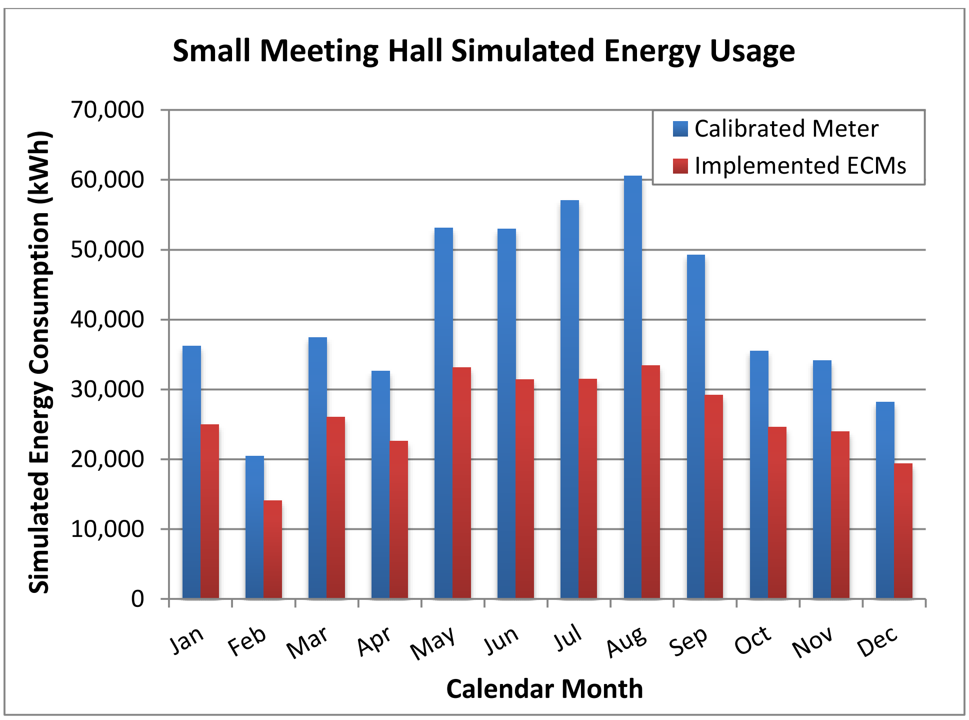
The extended example below includes reformatted excerpts from a detailed ECM/FIM Report produced for an energy management project involving a small meeting hall. Three distinct ECMs were developed as part of the project. The contents of each excerpt are described briefly. The actual ECM/FIM Report for this project is much more comprehensive than the notes and figures included in the excerpts.

The EMP should provide a concise summary that includes basic methodology, assumptions, and results. This provides the client and other members of the project team with a quick overview and a framework for understanding the facts and figures that follow.

In the case of the small meeting hall, an energy model was produced and calibrated in order to simulate the impact of implementing the three ECMs.

Building	Small Meeting Hall
ECM-01	Install Direct Digital Control (DDC) System
ECM-02	Replace HVAC Systems
ECM-03	Demand Ventilation/Adaptive Building Pressurization
Calculation Method	System and whole building simulation by economic analysis software.
Assumptions	1. Occupancy scheduling by survey results with users. 2. Temperature setpoint during occupied periods is 75–68°F and during unoccupied periods is 85–55°F. 3. Kitchen hood operation from 9 am–3 pm. 4. Existing steam boiler system heating efficiency modeled 60%.
Calculation Results	Calibrated Meter: 497,485 kWh/year Group of ECMs: 316,249 kWh/year Estimated Savings: 181,000 kWh/year

The EMP should present rationale for all projected savings figures. Graphs convey a lot of information and can make a strong visual impact. Comparing either historical energy use or simulated energy use under existing conditions with projected energy use following ECM implementation can be particularly helpful. This graph for the small meeting hall compares energy model results.



In addition to graphs, the EMP should also include narrative that describes the data and the EMP's methodology. The financial feasibility calculations must be supported by a straightforward approach.

The following excerpt from the ECM/FIM Report for the small meeting hall discusses reasons for electricity savings.

Exceptional Calculations	None
Discussion	Rationale for electricity consumption savings from ECMs: 1. Temperature setback during unoccupied periods (nighttime). 2. Reduction of outside air load introduced to the HVAC system during occupied periods (daytime). 3. Significant increase in efficiency related to primary cooling energy due to the utilization of a NEW air-cooled chiller that replaces the existing 31-year-old split-system DX equipment. 4. New central station AHUs are variable air volume, resulting in fan energy savings during part load operation.

The detailed ECM analysis should also include financial savings and payback estimates in the client's desired metrics. Depending on the structure and scope of the project, different figures and graphs may be used. In every ECM/FIM Report, it is essential to provide the client with straightforward estimates of the financial impact of ECM/FIM investment.

In the small meeting hall example, the EMP provided a savings statement, performed payback calculations, and produced a cash flow graph.

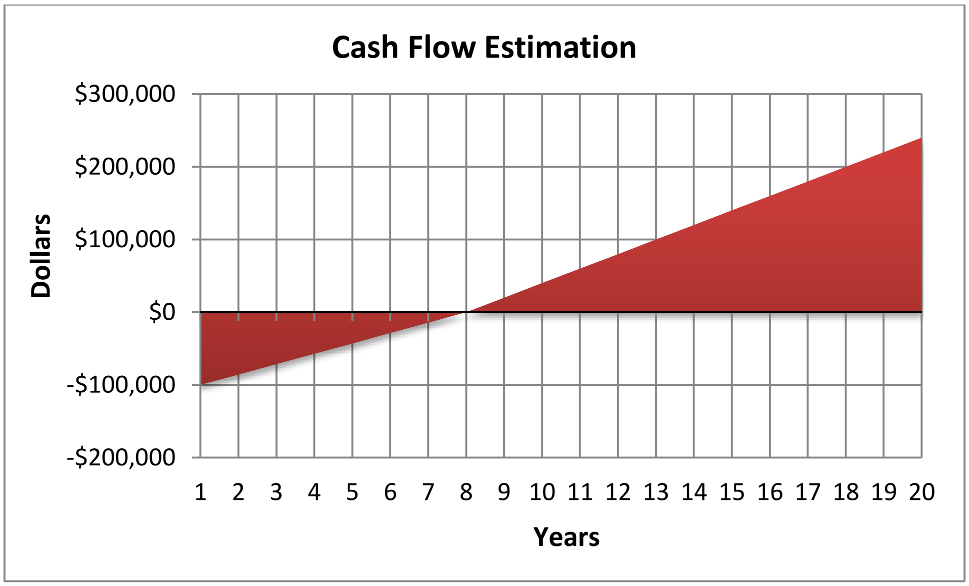
Savings Statement	Electricity Savings: 181 MWh/year Gas Savings: 617.8 Therms/year
Special Notes	None

Financial Feasibility Calculations

Savings	SPP	DPP	IRR	
$8,000	12.5	10	11%	
$9,000	11.1	9.1	13%	
$10,000	10	8.3	14%	
$11,000	9.1	7.7	16%	
$12,000	8.3	7.1	18%	SPP- Simple Payback Period
$13,000	7.7	6.7	19%	DPP- Discounted Payback Period
$14,000	7.1	6.3	21%	IRR- Internal Rate of Return

ECM/FIM & EBCx Analysis

Financial calculations in this instance included simple payback, discounted payback, and internal rate of return. Savings are presented in dollars. If the client had requested that savings be presented in a different format, the EMP would have generated different numbers and tables. The plot below depicting cash flow indicates that cash flow will be positive eight years following ECM implementation.



While the structure and appearance of the ECM/FIM Report will vary from client to client and project to project, the EMP must make sure that all of the information necessary to understand the ECM or FIM has been included.

ECMs are only one half of the energy management project. The EMP must return to the EBCx Scope and expand it based on construct cost estimates and other new information.

4.C.3 Detailed EBCx Scope

Based on systems investigation and analysis to date, the EMP develops a full scope of work for EBCx. This scope addresses systems and equipment that will remain in the building but need to be tested, verified, and, if necessary, adjusted to operate with optimum efficiency. This detailed EBCx Scope should complement the detailed ECM/FIM Report.

EBCx involves charges primarily for time and labor. Fine-tuning and other operational changes are the focus, not capital expenses and other purchases. Additional ECMs for inclusion in this or future energy management projects may be discovered over the course of implementing EBCx. The EBCx process is distinct from the commissioning process performed on new building systems and equipment installed during ECM implementation.

For example, one ECM may involve chiller replacement. Following installation, that new equipment will require commissioning. When EBCx is performed on the systems associated with the chiller, however, the EMP may discover that the new chiller may actually be smaller than the existing unit. Regardless of the size of the chiller in this example, the EBCx process will also ensure that the facility's existing air handling units and building control systems are operating in accordance with current building design needs.

The detailed EBCx Scope includes:

- A list of proposed EBCx activities.
- A brief narrative regarding each activity.
- Cost of the full **Existing Building Commissioning (EBCx) Plan**.

The full EBCx Plan will be developed during the next phase of the project. The EMP should review and discuss the proposed activities with the client, who will ultimately have to approve continuing the EBCx process. This plan will identify and describe the tests, checklists, procedures, and estimated costs and benefits associated with EBCx, as well as those responsible for carrying out the work.

Existing Building Commissioning Plan

Detailed outline of procedures, costs, and responsibilities associated with the commissioning of existing energy-consuming systems that will remain in the building.

4.D CONFIRMING THE BUSINESS CASE

As the EMP begins to finalize project details with the client, a clear business case must be made for continuing with a comprehensive project that includes the planning, funding, and implementation of ECMs, FIMs, and EBCx. The approach described in the EMA Energy Management Process is uniquely effective, because it is employs a wide range of tools and strategies, and leverages the EMP's comprehensive knowledge base.

While some measures may provide fast returns and involve little cost, the process as a whole is not a quick fix. The process aims to achieve the client's energy-related goals, including managing and reducing energy consumption, as well as solutions for issues related to maintenance, safety, code compliance, occupant comfort, sustainability, and more.

Through the first three phases of the project, data has been gathered and analyzed through energy analysis, site visits, and measure development. The EMP has developed and refined lists of recommended ECMs, FIMs, and EBCx elements in consultation with the client. The following subsections provide additional guidance on using this information to present the business case.

During this phase, the EMP, in cooperation with the client, formalize approval of detailed components of the energy management plan. Of course, the EMP and client have been in close communication since the project began. Mutual agreement on the plan's direction, goals, ECMs/FIMs, and EBCx should be the rule rather than the exception. The EMP is not presenting any new information. The summary presents the business case for implementation.

4.D.1 ECMs/FIMs

The EMP should develop a basic framework of ECMs and FIMs that is more tactical in nature than the documents that have been produced previously. The detailed ECM/FIM Report can be used to develop a specific list of tasks for each ECM and FIM. The crucial pieces of information at this stage include:

1. A brief description of each task and its objective.
2. An outline for finishing the task.
3. Project team members assigned to the task.
4. Design and installation costs and funding sources.
5. Proposed timing for completion relative to other project tasks.

ECM Matrix

A table that outlines ECM costs, payback periods, and other potential value for the purposes of ranking by the EMP and client.

At this stage, the EMP knows detailed cost estimates, the total value of each ECM, and the anticipated operational improvements from each FIM. The ECMs should be presented in a tabular format such that all the measures can be viewed on only one or two pages. This **ECM Matrix** will enable the client to prioritize and select measures easily. Graphs that summarize groups of ECMs can also be generated to illustrate energy savings and cost reduction potential.

The EMP should include value statements that relate to other client objectives such as building certification or greenhouse gas emissions reduction. For example, information about the ability of an ECM to meet LEED requirements or reduce a building's carbon footprint should be presented along with payback metrics. This will add additional value to the measures being considered.

Appendix G

Sample ECM Matrix and Sample FIM List

Examples of an ECM Matrix and FIM list can be found in Appendix G.

4.D.2 EBCx

ECMs/FIMs are essential components of the EMA Energy Management Process and may have initially motivated the client to engage an EMP. The potential energy savings, cost savings, and efficiency gains related to ECMs are detailed by the EMP as the project develops.

EBCx is just as important as ECMs/FIMs in the EMA Energy Management Process, but it is fundamentally a different service. The commissioning of existing equipment does not always produce quantifiable energy use reduction, either for a specific system or for EBCx as a whole. Nor does EBCx necessarily guarantee cost savings, as it is focused on ensuring that equipment is operating efficiently and meeting the building owner's requirements.

Nevertheless, increased systems efficiency and improved building performance are often expected (and realized) through the EBCx process. Because the financial and operational benefits of the process may not be as concrete as those for ECMs, however, it is helpful for the EMP to stress to the client that EBCx is vital to robust energy management. The EMP should also consider explaining to the client a number of the reasons for implementing EBCx:

1. **Design Intent**

   EBCx assures the client that building systems and equipment components are operating in accordance with design intent. The EMP can claim legitimately that the building is not deriving full value from pieces that are not operating effectively.

2. **Client/Owner Needs**

   The EMP determines how existing equipment can be optimized to meet the owner's project requirements. This includes evaluating whether the equipment condition, functionality, and controls can support current building needs and occupancy levels. Indoor air quality and space design loads are important concerns that EBCx addresses.

3. **Code Compliance**

   The EBCx process also addresses compliance with current code. This usually translates to more energy-efficient operations and minimizes the building owner's risk exposure.

4. **Accurate ECM Evaluation**

   Once building operations are optimized by EBCx, monthly energy bills will generate a true baseline level of use. ECMs can be evaluated accurately, because there will be few or no extenuating circumstances that prevent the realization of savings. The EBCx process reveals problems such as plugged reheat coils, fans weighted with residue, overheating motors, dirty filters, and improper control strategies. If these problems are not identified and resolved prior to the installation of ECMs, many of them are likely to produce only limited benefit.

Although the reasons for pursuing EBCx are strong, the benefits can be difficult to quantify. ECMs may be measured by energy consumption and cost reductions, but EBCx is naturally much more complex than any individual ECM. As a result, the EMP should be prepared to draw on a wide variety of tools that may help express the value of EBCx or rationalize the cost of EBCx to a client or building owner:

- **Energy Savings Estimates**

  Sometimes, the EMP may be able to estimate savings for specific solutions uncovered through EBCx. For example, if poor performance was observed during site assessment, the EMP may predict some savings by fixing issues such as dampers that are not actuating or coils that are underperforming. The numbers will be different for each project and each issue, of course, but some EBCx activities do have the potential to reduce energy usage and costs.

  If the owner incurs $100,000 in energy costs each year, and the repair estimate for issues discovered through EBCx is $4,000, annual energy savings of $10,000 may be a reasonable outcome. In this example, the EMP will help the building achieve a 10% reduction in of utility expenses following a 4% investment.

  For buildings of a similar type and level of maintenance that are situated in the same geographical area, the EMP can refer to other projects to estimate potential savings. Although they are no guarantee of future results, case studies can demonstrate savings that have been realized previously.

- **Statements and Metrics of Value**

  Including metrics in detailed statements that explain how EBCx can help achieve stated client goals may also be a beneficial strategy. For example, the EMP may include a statement describing the reduction in use: "This EBCx process is estimated to achieve a 15% energy consumption reduction and improve indoor air quality." Or the EMP may align EBCx with another sustainability initiative: "EBCx is also a component of achieving a specific LEED credit."

- **Separate Line-Item Expense**

  To emphasize the purpose of the evaluation and apply a direct expense to the EBCx costs that are not well understood, it may be useful for the EMP to create a separate line-item expense: "Verify Owner's Project Requirements (OPR)." Activities included under this line item would be associated with EBCx and include planning, functional testing, reporting, meetings, and project site visits. This is particularly useful for buildings that require an OPR for LEED certification or other purposes.

- **Alternative Fee Categorization**

  EBCx provides the owner with an understanding of building operations and delivers documentation that will benefit O&M staff for years. For this reason, the fees associated with EBCx can be categorized as administration or measurement and verification expenses.

- **EBCx Cost Allocation**

  For owners working from a financial pro forma who require ROI analysis, an EMP can allocate a portion of the commissioning process for both existing and new systems to each individual ECM.

- **Local Incentives**

  In some areas, utilities or other organizations offer refunds, rebates, or other types of financial incentives for pursuing energy efficiency through EBCx. Such incentives can be substantial—possibly paying for all professional services associated with EBCx. Incentives are a very strong selling point and make the process more affordable to the building owner. The EMP should be prepared to discuss such incentives with the client during Phase 1.

EBCx is a necessary expense and a critical element of the EMA Energy Management Process. Without EBCx, the building will not demonstrate optimum performance, and ECMs will not generate the significance and persistence of savings that would otherwise be possible. For any comprehensive energy management project, the bottom line is that the value of EBCx outweighs its cost.

4.D.3 Project-Level Financial Analysis

Funding and cost estimates have been part of ongoing project discussions and ECM/FIM analysis. As the project progresses and measures are finalized, these financial strategies can be refined until they satisfy the client and provide sufficient detail.

If the EMP has not initiated funding discussions with the client and/or building owner, or if these strategies need to be revisited, they must be discussed before progressing further. The EMP and client must establish a strategy for funding all ECMs, FIMs, and EBCx prior to implementation. Depending on the project, all measures may be funded in the same way, or different methods may be used to fund different aspects of the plan.

At this stage, it is vital that the client and EMP have addressed:

- **Performance Metrics**

  These will be applied to both individual measures and the overall project. The metrics that the EMP and client agreed to during the early phases should apply for the remainder of the project.

- **Funding Strategies**

  The EMP and client should have a solid financial plan that is practical for the building and sufficient to fund the chosen activities. Funding *strategies may include the use of energy cost savings, local utility or government incentive programs, managed performance contracting, or other strategies discussed during the client consultation.*

- **Energy Purchasing Options**

  Optimizing a client's commodity purchasing strategy may help offset the costs of ECMs and provide long-term savings for the client. This is particularly true for buildings located in states where energy is deregulated.

  If current electricity market supply prices are lower than the price that the client is paying, because a contract was signed when the marker was stronger, the EMP may suggest that the client attempt to renegotiate the contract. Some suppliers, for example, allow the option of blending and extending the contract, which lengthens the agreement while bringing forward some of the future savings.

  Similarly, reworking a natural gas contract that locked in high prices during a time of market volatility will immediately help reduce energy supply costs before any ECMs are implemented. The EMP should be prepared to discussion options that are potentially available to the client.

Although funding was discussed during the initial client consultation and throughout ECM development, it may be necessary to revisit the topic at this stage. For example, a client may have originally been planning to self-fund an ECM, but has decided instead apply for participation in an incentive program. Some funding sources that were identified earlier in the project may no longer be viable. New funding sources that were recently developed may now be included in the mix, requiring the EMP to help the client suggest ways to reallocate the capital, or pursue one or two additional ECMs that require a sizeable investment.

The worst possible scenario is a combination of poor planning and insufficient funding that leads to an incomplete project. Although unplanned events can occur, and economic situations can change in a single day, full project funding should be outlined before proceeding to implementation.

If the client or building owner is still unable to provide sufficient capital to cover implementation costs, the EMP may suggest other funding options:

- **Managed Performance Contracting**

  If funding is not available through any other means, performance contracting managed by the EMP is an option for the client. There are a wide variety of performance contracts, and each energy service company (ESCO) will have its own standard terms, methods, and practices. After a Request for Proposal is drafted and sent out to a selected list of performance contractors, the EMP and client review the responses and select a contractor. The EMP represents the client's and building owner's interests throughout the performance contracting process to ensure that *the project moves forward smoothly and correctly. The contractor completes its work in the traditional manner, earning payment through stipulated savings, a measurement and verification process, or another model.*

- **Asset Depreciation**

  For building owners who face peaks and troughs with respect to profits, it may be possible to manipulate asset depreciation of equipment such that it coincides with profitable tax years. Assuming that equipment costs remain identical, this arrangement generates savings by reducing the tax burden. The client's accounts will need to be consulted to determine if this strategy is feasible.

- **Book Value**

  An enhanced book value generated by improved systems and equipment offers loan possibilities which affect cash flow analysis. Monies that result from a loan taken out upon substantial project completion can be used to pay the contractors for their work on ECMs/FIMs. Re-payment of the loan can be spread over a number of years into the future. The building owner must be advised to confer with its bankers to determine whether or not such loan structures are available.

- **Tax Liabilities**

  An organization's tax liabilities can also influence its readiness to contribute capital to the implementation of ECMs/FIMs. The building owner will need to confer with its accountants and/or tax advisors to determine if the tax structure presents any opportunities or obstacles. The EMP should be aware of the various factors that will influence this potential funding category:

  - ***Corporate Structure.*** *The "pass-through" taxation structure of S corporations and limited liability corporations (LLCs) affects the owner's personal tax burden. Specifically, there are specific rules regarding when the owner needs to spend funds. Similarly, C corporations face a host of considerations that create time windows when spending is alternately more or less beneficial. The EMP may negotiate with equipment manufacturers and construction contractors a payment schedule that is in the client's best financial interest.*

  - ***Expense Type.*** *Expenditures for professional fees and capital costs are handled in different ways according to tax law. Careful analysis may lead to efficient cash flow that ultimately reduces the expense that is attributed to the project.*

ECM/FIM & EBCx Analysis

- ***Government Programs.*** *Local, state, and federal programs that support energy efficiency projects can offset the expense of implementing an energy management program. The building owner, with advice from the EMP, should endeavor to learn about tax increment financing (TIF), special rebates, and specific tax benefits that are available in the building's location.*

- ***Maintenance Reduction.*** *Operating cost avoidance is similar in concept to energy cost savings. Repairing or replacing equipment that would otherwise require future maintenance can save money in the long run. Expenses associated with staff or third-party contractors are avoided. The savings resulting from the reduction in maintenance duties can be retained and applied to more capital-intensive activities.*

CASE STUDY 4.2 — PROJECT- LEVEL FINANCIAL ANALYSIS | BUILDING H

The owner of Building H, a multi-tenant office building in Atlanta, enlisted an EMP for an energy management project. After completing the first few phases, the EMP identified ten potential low-cost ECMs. Measures included adjusting temperature setpoints, implementing controllable lighting systems, adjusting lighting schedules, and rescheduling several pieces of HVAC equipment. In addition, the client was considering one capital ECM, the installation of a new BAS.

Beginning with the site investigation, the EMP began estimating electricity consumption and demand savings as well as implementation costs. The EMP took into account potential incentive dollars available from the local utility for implementing energy efficient improvements. Simple payback was the client's metric of choice for measuring financial return.

The EMP was asked to review the rationale both for and against proceeding with the implementation of a new BAS. The operational efficiency of the current system, implementation costs for the new system, and the potential energy savings were factored into the EMP's detailed analysis of the ECM. The EMP also reviewed current control strategies and proposed changes to those strategies.

The EMP provided potential savings for each individual ECM, including the BAS upgrade, as well as for the implementation of all ECMs. Based on these calculations, the client was able to choose which ECMs would be most feasible—both financially and logistically—to implement. Much of the savings were projected to result from optimizing performance during unoccupied hours.

Financial analysis also indicated potential energy cost savings of nearly $20,000 per year directly related to installation of the new BAS. The EMP assisted the client with applying for a utility incentive program that could help underwrite the cost of the new system. Funding was achieved successfully, and the client chose to install the new BAS.

Not all of the other ECMs were implemented. The client decided not to implement changes to the chilled water system that carried a moderate upfront cost and a payback of greater than two years. Adjustments to night temperature setbacks for the whole building and specific spaces, however, involved minimal upfront costs and offered greater energy savings potential. The client approved the lowest-cost ECMs.

Confirming the business case for individual ECMs was a critical step in the project, but addressing the economics on a project-level basis was equally important. Combining the data for lost-cost and capital ECMs provided a clear and complete picture for the client. The EMP's careful analysis and presentation enabled the client to prioritize building system upgrades with a clear understanding of the financial benefit of those improvements.

The Energy Management Project at Building H is discussed further in Case Study 5.2.

4.E SECURING CLIENT APPROVAL

The EMP can assist the client and/or building owner in evaluating each potential ECM or FIM to determine whether or not it should be pursued. The owner must make a decision for each EBCx task, ECM, and FIM in consultation with the EMP. They must also agree on the order in which activities should be executed.

Working with documents developed during previous phases, the client and EMP will decide which items are included in final project plans. These tasks will fall into the three primary categories:

1. **Energy Conservation Measures (ECMs)**

   At this stage in the project, ECMs have been described in the detailed ECM/FIM Report and ranked in an ECM Matrix.

2. **Facility Improvement Measures (FIMs)**

   The FIMs should be listed by order of importance for the client and/or by relevance to project objectives. Like the ECMs, the FIMs have been described in the detailed ECM/FIM Report.

3. **Existing Building Commissioning (EBCx)**

   The EBCx process for the project was first outlined as a preliminary EBCx Scope in Phase 1, and then as a detailed EBCx Scope in this phase.

If questions remain regarding funding or project team responsibilities, the EMP should work with the client to develop appropriate strategies to resolve them. The EMP must secure approval to move the project forward through implementation. An owner's approval of the contract for implementing ECMs, FIMs, and EBCx validates the expertise delivered to date and conveys the full value of the project. Financial obligations, means of payment, and the implementation timeline should be detailed in project plans. Phase 5 will begin with a final round of project planning.

ECM/FIM, and EBCx Analysis Summary

During ***Phase 4: ECM/FIM and EBCx Analysis****, the EMP examines potential measures in great detail. Their costs and benefits are discussed. If an energy model was created for the building, it is refined and used to simulate the impact of various ECMs.*

EBCx is an equally critical part of the energy management project. The EMP considers the impact EBCs will have on building operations and performance.

Results of the detailed financial analysis of both ECMs/FIMs and EBCs are summarized for the client. Plans for implementation are described in the detailed ECM/FIM Report and EBCx Scope.

The EMP's goals by the end of the phase include a clear business case for implementation, a clear understanding of available funding resources, and a clear path to obtaining final approval.

The ECMs/FIMs and EBCX process identified here, once approved, will be implemented during ***Phase 5: Implementation****.*

5 IMPLEMENTATION

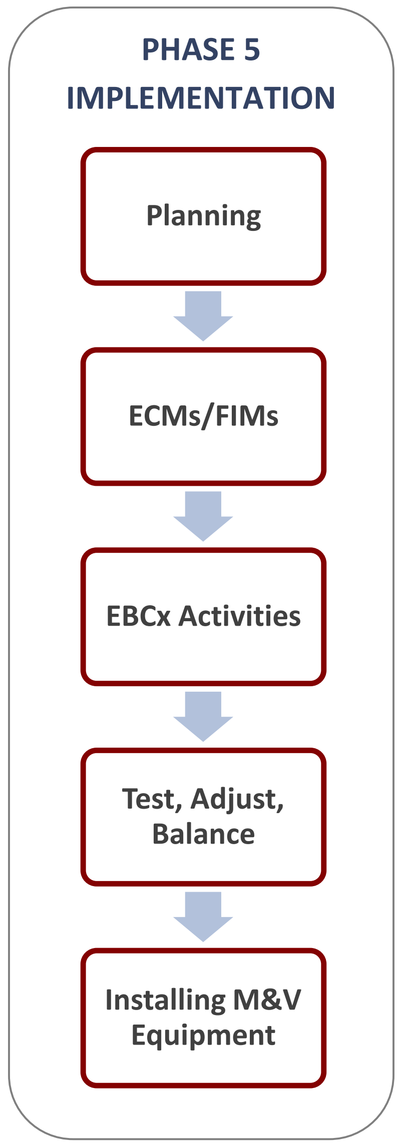
The Implementation Phase starts with final planning of ECMs/FIMs and EBCx, measurement and verification, and other initiatives. Installation follows in accordance with the plans. The EMP works closely with the client, building staff, and construction team to implement ECMs and FIMs. Additionally, the EMP oversees the EBCx process for existing equipment and regular commissioning process for new equipment.

The mission of the Implementation Phase is to:

- Develop effective plans that guide the installation of ECMs and FIMs.
- Implement final set of measures.
- Plan and execute commissioning activities for new and existing systems.
- Ensure that ECMs, FIMs, and EBCx are successful and satisfy the client's goals.

This chapter should provide the EMP with:

- Strategies and best practices for developing ECM/FIM and commissioning plans.
- Methods used to implement ECMs and FIMs.
- Important considerations when working with design and construction teams.
- Understanding of TAB role and importance of M&V.



Implementation Outline

This phase is divided into five major subsections:

During **Phase 5: Implementation**, the EMP will prepare final plans for implementing ECMs, FIMs, and EBCx, and then put those plans into action. The completion of ECMs and FIMs requires the EMP to coordinate closely with the client, building staff, and construction contractors. Substantial new building equipment will need to be commissioned. Following TAB activities, implementation concludes with the installation of measurement and verification (M&V) equipment, which will help ensure the installation of measures and persistence of energy savings.

5.A PLANNING

Careful planning is central to the EMA Energy Management Process. The EMP develops several types of implementation plans based on his or her assessment the facility's current and historical operations and the client's energy management goals. While each plan addresses a different facet of the project, the overriding objective is enabling the client and building staff to effectively manage their energy usage and ensure continuous improvement. Plans also include performance indicators and strategies for tracking and reporting.

The development of final plans for the implementation of ECMs/FIMs, EBCx, and M&V is the culmination of data collection, investigation, and analysis completed by the EMP during the previous phases. These documents can only be completed if the EMP has gained sufficient understanding of the project facility, the client's needs, and the building's energy savings potential.

5.A.1 Best Practices

The EMP must first understand exactly which plans need to be developed for a particular project. The specific needs of each project will determine the extent to which plans must be developed and the level of detail that they contain. The ECM/FIM Report, the EBCx Plan, and the M&V Plan are not optional. They should be developed for every project.

On the other hand, a comprehensive Strategic Energy Plan may only be developed for clients who request an organizational framework for addressing energy use in the present as well as the future. Every energy management project is strategic to some extent, but not all require the breadth of a Strategic Energy Plan. Many projects may focus more on immediate tactics and less on methodical strategies.

Early in the EMA Energy Management Process, the EMP and client should come to mutual agreement about the types of plans that will be developed during the project. The EMP should include the client, and other project team members, as needed, in plan development. Early conversation and ongoing discussion about project plans and intentions allows the EMP—and the entire project team—to efficiently coordinate the plan's directions, goals, and performance metrics.

At this stage, many project plan elements, such as ECM narratives or results of utility consumption analysis, will have already been developed during earlier phases. In this phase, they will need to be updated and refined with additional levels of detail. Depending on the nature of the project and team, the EMP may need to rewrite or revise these documents in the final planning stages. The EMP's objective should be to provide a straightforward outline for all team members involved in implementing measures and EBCx.

When preparing plan documents, the EMP should:

- **Incorporate changes requested by the client.**

  Any changes or omissions to ECMs/FIMs or EBCx proposed during Phase 4 should be incorporated into the final plans. The EMP should also confirm that those changes have been communicated in detail to the appropriate contractors. Updated cost estimates may need to be requested if changes are significant.

- **Clearly outline responsibilities.**

  Responsibilities for each task and project oversight should be detailed in the ECM/FIM installation plans. These responsibilities should be articulated clearly. The EMP should verify that all project team members understand their roles and have agreed to perform their jobs according to the project timeline. Efficient communication from the EMP to each team member is essential for successful project delivery.

- **Develop detailed timelines.**

  The EMP should develop a detailed schedule of when each and every Implementation task for ECMs, FIMs, and EBCx will occur. The EMP must work with the client and building staff to ensure that this schedule does not conflict with building occupancy and space accessibility. It is best not to schedule heavy construction directly outside a set of windows during peak occupancy. If the building is used during weekdays, for example, such work should be performed at night or on weekends, if at all possible. The presence of tenants should be confirmed prior to installation that requires entry into tenant spaces.

- **Maintain flexibility.**

  Making thorough plans for project implementation is a best practice, but the EMP should not expect to follow them rigidly. Several unanticipated issues or events can force the EMP to make adjustments to these plans.

> *Severe weather, equipment malfunction, or last-minute scheduling difficulties at the building may impact the established project plans or timeline. When developing the primary project plans, the EMP should have in mind various back-up plans for aspects of the project that are most likely vulnerable to external factors. Above all else, the EMP should maintain a flexible attitude and adjust activities so that the client's goals are satisfied. An experienced EMP should be able to minimize the effect of unavoidable delays on the overall implementation timeline.*

The EMP should generate all project plans with a consistently high level of detail and accuracy. Whether developing a detailed Strategic Energy Plan or plans for ECM/FIM installation, the EMP's aim is to create guides that are as useful as possible during the actual execution of project tasks.

5.A.2 ECMs/FIMs and EBCx

Implementation of ECMs, FIMs, and EBCx is a high point—but not the end—of the EMA Energy Management Process. Detailed final planning helps ensure that measure implementation and system commissioning fulfills the intent of the project.

During the planning process, the EMP should communicate as needed with contractors who will play a role in executing the plans. For example, a TAB professional should be engaged to support both ECM/FIM implementation and EBCx. These contractors will be able to provide updates with respect to project costs and their construction timelines. The EMP can incorporate this feedback directly into planning documents.

5.A.2.a ECMs/FIMs

Final planning for installation of ECMs and FIMs will be based heavily on the ECM/FIM Report developed during Phase 4. After receiving final approval from the client, the EMP makes additions and revisions to this Report and then transforms it a final planning document. This last set of updates should include:

- Final project timelines
- Additional elements or changes as desired by the client
- Updated pricing, financial calculations, and savings estimates
- Roles and responsibilities for ECM/FIM implementation and oversight
- Preliminary tasks and schedule for EBCx
- Preliminary tasks and schedule for commissioning

Once the EMP and client have finalized the list of ECMs and FIMs, the EMP should incorporate EBCx and commissioning activities into project task descriptions and

Commissioning Authority

An independent professional responsible for planning, organizing, and implementing commissioning activities for newly-installed systems.

Commissioning Report

Document detailing commissioning activities, results of functional performance testing, and strategies for resolving further deficiencies.

ACG Commissioning Guideline

The Guideline is available online:

www.commissioning.org/commissioningguideline/

Implementation

the master timeline. Unless another team member is specifically designated to fulfill this role, the EMP will serve as the **Commissioning Authority (CxA)** for all existing building systems and newly-installed equipment. The EMP will need to communicate and work closely with the client and contractors to integrate commissioning activities during installation. Shrewd integration is especially important for projects that involve significant equipment replacement.

The EMP will develop a final **Commissioning Report** after the installation of ECMs and FIMs. This document will describe the tests and checks that must be performed, as well as potential problems that were discovered as any ECMs involving major new pieces of equipment were implemented.

> *Additional information regarding the structure, timing, and specific checks and functional tests for Commissioning of new systems can be found in the ACG Commissioning Guideline.*

If a project does not include major renovations or systems replacement, formal commissioning may not be necessary. If this is the case, the EMP should still include functional performance tests in the scope of work and implementation plan. These checks, performed by the EMP, will ensure that any new equipment is functioning as required by design.

5.A.2.b EBCx

The functional tests applied during EBCx will serve as a capstone to the project. EBCx verifies that all building systems perform as designed and that ECMs/FIMs have been effectively installed. Following EBCx—and commissioning of new equipment, if necessary—the building should operate in a synchronized, efficient manner. The EBCx Plan includes an outline of checks, tests, and procedures for resolving issues that are discovered during the process.

Based on the detailed EBCx Scope developed during Phase 4, the EMP develops a detailed EBCx Plan. The EBCx Plan builds on the EBCx Scope by including:

- Detailed descriptions of EBCx procedures and protocols
- Estimated costs and anticipated benefits of the EBCx process
- Specific functional performance tests to be performed
- Checklists for use while testing equipment

With respect to commissioning, HVAC is the principal system typically addressed during the preliminary assessment and site investigation of an energy management project. Additional systems, beyond mechanical, may be included in the full commissioning process. They include:

- Building Envelope
- Lighting

- Electrical
- Plumbing
- Communications
- Fire Protection
- Elevators/Escalators

If they are important to the client and applicable to the building, the EMP may be asked to include one or more of these additional systems in the EBCx Plan. Of course, the specific systems to be included should be discussed earlier in the project, because the EMP will need to factor them into fee negotiation. The advantage to the client of including all relevant systems is the convenience of addressing everything in the same document. The EBCx Plan can be refined as the project progresses to include additional details and adjustments. New ECMs and FIMs may also be discovered during the implementation of the EBCx Plan.

When developing the EBCx Plan, the EMP needs to thoroughly understand current building operations and issues, including sequences of operation. The EMP should have accomplished this in earlier phases by reviewing programming, interviewing the building manager and/or controls contractor, and confirming using trend data.

As changes and adjustments in systems are identified in the EBCx Plan, descriptions of these changes need to be outlined as clearly as possible. For example, it is not sufficient for the EMP to recommend optimizing outside air damper operation. A clear sequence of operation that will result in optimization must be described in the document.

If an outside air damper (OAD) is opening right after an air-handling unit (AHU) exits from morning warm-up because the discharge air temperature is switched from 85°F to 65°F, this information should be stated in the narrative. The proposed change to the system should then be described. In this case, the OAD should be placed on a timer after morning warm-up and not allowed to open for another 30 minutes—other than to satisfy minimum outside air requirements.

Similarly, if the economizer locks out too early for mechanical cooling, the EMP should specify the exact temperature at which the damper should lock out. Other variables, such as enthalpy, may also be considered. If another variable is chosen, the EMP should indicate the desired setpoint. The EMP will also need to note the precise locations within the system where the relative humidity and temperature readings should be taken. If the AHU heating coil is active and the main OAD is still open, the EMP should describe how to eliminate the overlap.

As the example above illustrates, it is important for the EMP to include as much detail as possible in the EBCx Plan. The client will receive a complete picture of commissioning activities that will occur in the building and an explanation of how and why they will improve system operations. A detailed EBCx Plan will also simplify the process of providing documentation to contractors who assist with the EBCx process.

Finally, the EMP should confirm implementation costs and update the analysis of financial feasibility within the EBCx Plan. The latest and most detailed calculations will provide greater assurance to the client, and they serve as a resource for contractors involved during implementation.

Additional information regarding the structure and tasks associated with EBCx can be found in the ACG Commissioning Guideline, Chapter 7: HVAC Commissioning in Existing Buildings.

5.A.3 Measurement and Verification

The measurement and verification (M&V) process ensure that the building's energy usage is characterized accurately and that ECMs and EBCx are producing anticipated savings. For this step, which follows implementation, the EMP uses the building's energy meters and other tools to confirm energy reduction and optimized operation.

Nearly all buildings are metered for energy consumption, primarily by the local utility to determine the cost of delivering and supplying energy. The majority also have water meters. Submeters may be installed to measure the energy usage of specific systems within large buildings that have single utility meters. For example, a building may have submeters that measure electricity use for indoor lighting and outdoor lighting. Water consumption is also routinely submetered, typically for uses such as general domestic needs (i.e., kitchens, bathrooms), the cooling tower, and irrigation for landscaping. Campus environments (e.g., colleges and universities, military bases, corporate complexes) may employ energy submeters to allocate consumption to buildings that are not individually metered by the utility.

Before drafting an M&V Plan, the EMP should outline the process for the client and emphasize its importance. The periodic site visits and testing that take place during M&V confirm that ECMs and FIMs were implemented correctly and are producing the expected level of energy savings. M&V also helps ensure that systems continue to operate as intended. M&V protects the client's investment in energy management and prolongs the EMP's involvement in the building.

The M&V Plan should be designed carefully so that the process results in data that is as accurate and representative of actual equipment operations as possible. The EMP must select the temperatures, pressures, currents, voltages, and/or airflows that are the most appropriate for analyzing equipment performance over time.

The EMP should also consider the specific M&V objectives in the context of a particular project. For example, in performance contracting situations, M&V will provide the confirmation of energy savings that forms the basis for contractor payment. In other projects, M&V will not be linked to payment, but is still a critical check on the effectiveness of ECM/FIM and EBCx implementation.

With the client's input, the EMP should develop an M&V Plan that includes:

- Schedule for site visits and verifications
- Refreshed and/or additional baseline measurements
- Desired metrics for rating system or equipment performance
- Potential systems and equipment identified for monitoring
- Plans for the automatic generation of BAS trend reports

The EMP should determine an appropriate timeframe for reviewing and responding to trend reports, especially those which are generated automatically. Hiring a professional services firm to perform data analysis may be appropriate in some circumstances. At the direction of the EMP, the firm can assemble the data and institute a regular review schedule. Assigning this responsibility to an outside firm releases the EMP from the burden of analyzing large amounts of data. Energy efficiency programs sponsored by utilities or other groups may require that M&V be performed by a third party rather than the EMP, although the EMP will need to be available if necessary to provide and interpret data. M&V reporting is discussed in more detail in Phase 6.

5.A.3.a Refining Baseline Measurements

At this stage, baseline measurements have been used to gauge building performance and quantify energy savings potential. Over time, the baseline may need to be refined to more accurately reflect building operations and energy usage. The EMP should work with the client to develop baselines against which progress can be measured. Baseline metrics should be specified in terms of energy demand and consumption, not simply in terms of cost. These metrics will also serve as a foundation for ongoing monitoring discussed in Phase 7.

To the extent possible, M&V is used to track the performance of specific ECMs or groups of ECMs. Since various building systems are integrated in practice, M&V can also often be used to track building-level performance. Every project should include the identification of whole-building baseline measurements. In some cases, it may be appropriate to establish baseline measurements for a specific space (e.g., a data center) or a particular system (e.g., outdoor lighting).

If whole-building baseline measurements are refined, or individual space or system baselines are determined, these metrics should be included in the M&V Plan and in all subsequent M&V reporting.

5.A.3.b Additional M&V Metrics

In addition to analyzing data recorded by building energy and water meters, the EMP may also be charged with tracking the building's Energy Star score or carbon footprint as part of the M&V process. These metrics may be included to demonstrate the client's progress towards specific sustainability or energy efficiency goals at the project building. They also provide a quick, high-level look at overall building performance that can be communicated easily.

While energy usage is the essential consideration when measuring project effectiveness and ROI, labor is still the greatest expense incurred by most building owners. For this reason, the EMP may wish to track hot/cold calls, the number of which should relate directly to the amount of staff time needed to respond. Other metrics that are unrelated to energy include indoor air temperature and concentration of carbon dioxide. Collectively, these alternative measures help gauge not only whether or not energy is being used efficiently, but also whether or not the new normal level of energy consumption is producing adequate indoor air quality.

The ultimate focus of the EMA Energy Management Process is improved building performance. Reduced energy use and demand are no tradeoff for either inferior performance or poor living and working conditions.

5.A.4 Optional Initiatives

The client may have originally discussed with the EMP various side initiatives related to energy or sustainability. In such instances, the EMP should also help develop plans related to these initiatives.

If a Strategic Energy Plan is being developed for a project, the EMP can include these additional objectives and plans in that document. If a Strategic Energy Plan is not being developed, the EMP will incorporate these additional objectives into the plans for ECMs/FIMs, EBCx, and, as discussed later in Phase 7, ongoing energy management activities.

The subsections below describe common energy management initiatives that clients may pursue and the EMP may be asked to include in project plans.

5.A.4.a Energy or Carbon Tracking & Reporting

Tracking and reporting energy usage and/or greenhouse gas emissions data can be an effective way for building owners or managers to highlight their energy use reduction efforts and demonstrate progress towards stated goals.

Regularly reporting basic energy usage metrics, such as energy intensity (kWh/ft^2) or annual or quarterly energy usage (kWh), is a best practice. The more energy data is visualized by an organization, the more it will do to improve the numbers. Energy reporting also benefits clients who wish to demonstrate the decreased energy consumption or increased operational efficiency of their buildings to the general public, customers, and other stakeholders.

In addition to energy reduction, greenhouse gas emissions reduction is a common sustainability objective. The interest in carbon footprints and related issues has been spurred in part by discussions at the local, state, and federal levels of government. Carbon emissions have increasingly become an economic and image concern for businesses, not to mention a challenging puzzle for policymakers. Reporting laws for a given location in the U.S. vary widely.

Some organizations require their facilities to document and report emissions in accordance with standard internal environmental sustainability practice. Whether pursued as an organizational initiative or due to public policy, the EMP should acknowledge that some clients may want to prioritize measures that specifically reduce the building's greenhouse gas emissions.

ECMs that include systems modification or adjustment are often one means of reducing the facility's carbon footprint. If emissions reduction is a stated client goal, the EMP should include estimates of the potential for each ECM and FIM to mitigate greenhouse gas emissions in the detailed ECM/FIM Report. Emissions reduction potential and implementation cost are not always directly proportional. Low-cost measures as well as capital expenditures may both have the capacity to reduce emissions.

Depending on the extent of the project and the client's requirements, the EMP may choose from a variety of resources to initiate ongoing emissions reporting. The client may, of course, have explored the options and selected a particular standard. The EMP should be familiar with the most current versions of the most popular methodologies.

One of the most common is the Greenhouse Gas Protocol (GHG Protocol), which is a widely-recognized international accounting standard for calculating and reporting an organization's carbon footprint. The GHG Protocol was developed by a partnership of the World Resources Institute and the World Business Council for Sustainable Development. Beyond the GHG Protocol, more and more large corporations are voluntarily submitting data to the Carbon Disclosure Project (CDP) every year.

GHG Protocol Online

Standards for emissions calculation and reporting are available online:

www.ghgprotocol.org/standards

For each metric to be tracked and reported, whether related to energy, emissions, or both, the EMP should outline the tracking mechanisms, frequency of measurement, and responsibilities. Project planning documents should also include descriptions of reporting strategies and format. Reporting strategies may be developed for:

- **Internal Purposes**
  Many organizations have internal reporting mechanisms. A building or entire organization may have published a goal of reducing energy usage or carbon emissions. Metrics detailing progress may be included in annual reports, sustainability reports, or customized energy-specific reports released to the media, investors, management, and staff.

- **Public Disclosure**
  Especially relevant to large organizations, energy and/or sustainability numbers may be released to the public via online reporting, press documents, or more general statements of progress. Increasing demand for disclosure is driving organizations to devote time and money to track report their energy consumption.

- **Third-Party Verification**
  Some clients may choose to formally report metrics to an independent party, such as the Carbon Disclosure Project, Energy Star Portfolio Manager, or, if pursing LEED, the Green Building Certification Institute. The EMP should become familiar with the reporting requirements of the organizations relevant to the client to ensure that planned reporting metrics and strategies are sufficient.

5.A.4.b Energy Purchasing Options

Reconsideration of energy purchasing must not be neglected during the EMA Energy Management Process. Changes to a client's current procurement strategies can have an immediate impact on energy costs. Although cost minimization is the most common motivation, a client may wish to address purchasing from the perspective of fuel source optimization as well.

For clients seeking to reduce monthly costs through changes in their energy purchasing strategy, the EMP should consider proposing one or more of these options:

- **Manage peak load to develop "demand avoidance."**
  The EMP may implement a load-rolling strategy so that peak load is maintained below a certain maximum threshold. This strategy will reduce monthly charges related to peak electrical demand. This option is only feasible if building performance is not impaired.

- **Correlate energy use with hourly price.**
  This strategy allows the building to use the same amount of energy, but at less cost, by optimizing electricity consumption with respect to the time of day. The EMP may suggest that the facility employ real-time electrical metering and align periods of maximum use and minimum price. Some relatively new software packages, supported by recent technology throughout the building, manage use by automatically increasing load

when power is at its lowest price and vice versa. This opportunity may not be available in all locations, and the utility rate structure and current supply prices will influence the level of savings.

- **Review utility rebate and incentive policies.**
  The EMP should spend some time reviewing the facility's current rate structure for electricity, natural gas, and other fuels. Contacting the address's utility representative on the client's behalf may also be helpful. Utilities are increasingly offering benefits for energy reduction, load shifting, or the installation of new systems. Refunds, rebates, and other financial incentives may help reduce the effective energy price.

- **Negotiate rate plan changes with the utility.**
  After the EMP reviews the facility's rate structure, and similar rates in the utility tariff, a case may be able to be made for switching the facility to an alternative rate class. The rate class may be outdated, or it may have been appropriate when the building was much larger, or much smaller, than its present size. A customized rate may even be available. Buildings that have unusual demand or consumption patterns are often the best candidates for unique rates.

- **Execute contracts for "block" purchases of electricity or natural gas.**
  For clients with buildings in deregulated states, electricity and natural gas requirements can often be fulfilled by buying "blocks" of usage. This strategy is a way to time the market to lock in a favorable price for a certain quantity of energy, without committing to buying all energy at that price. Timing the market is difficult. No EMP can predict the future. Nevertheless, energy prices tend to be lower in shoulder seasons and higher in the middle of summer and winter.

  Block purchases help manage cost by hedging one's bets with respect to anticipated pricing trends. If an aggressive strategy is buying all energy at the index price during the month of use, and a conservative strategy is buying all energy at a fixed price several years in advance, buying a series of block purchases over time is a reasonable middle ground, and may help to reduce the weighted average price.

Clients may also revise their energy purchasing strategy to account for different types of fuel sources. Building management might wish to offset carbon emissions by buying renewable energy. For example, a business may seek to advertise legitimately that they operate on "100% wind power." A university with available funding might support renewable energy generation for a variety of reasons. Special commodity goals should be described in the Strategic Energy Plan, if one is being developed for the client.

In these instances, when the client wishes to purchase greater quantities of renewable energy or otherwise differentiate its energy supply, the EMP should consider:

- **Electricity Generation Mix**
  The local utility should be able to provide the breakdown of the fuel sources that make up its profile. In some areas, the utility is required by law to do so on a regular basis. The client may be interested in knowing the percentages of coal, nuclear, natural gas, and wind or other sustainable sources that generate the power its buildings consume.

- **Unconventional and Renewable Sources**
  If the client is not comfortable with the utility's standard mix of sources, other supply options may be available, including on-site generation of power. Larger facilities that are equipped with central heating plants may explore unconventional sources such as methane captured from landfills. Smaller facilities will have few options other than standard installations of on-site renewable energy, which are discussed further below.

- **Renewable Power Purchases**
  Many utilities offer their customers the opportunity to purchase certain percentages of renewable power. For example, the client may have the option of paying a slight cost premium on every bill to ensure that 25% of the costs ultimately pay for energy derived from sustainable sources.

  Alternatively, in most areas, renewable energy credits (RECs) or other types of carbon offsets are available for purchase. Prices vary over time and across the country, in accordance with the usual laws of economic supply and demand. REC purchases are fairly straightforward and can simply be integrated into an existing purchasing strategy.

  RECs are an indirect way of buying renewable power, in the sense that the funds are often used to develop renewable resources far from the client's actual building. Certifying bodies exist to ensure that RECs are legitimate. If the client is seriously considering RECs, the EMP may wish to vet the client's short list of REC providers.

Whether the client is hoping to reduce energy costs or integrate alternative sources into its energy supply mix, the EMP should maintain an extensive knowledge base regarding energy procurement options. The client may look to the EMP for guidance and recommendations.

5.A.4.c Other Sustainability Pursuits

The client may incorporate sustainability into an energy management project in a number of different ways. Priorities related to sustainability initiatives will vary depending on location, building type, and client objectives.

If the client has an existing sustainability plan or specific environmental initiative, it should be referenced in project planning documents. The EMP should use it to inform project development and outline the relationship between specific energy management activities and the plan. During Phase 1, the EMP should have inquired about potential measures or activities the client is considering in support of sustainability goals.

A successful energy management program may encourage the client to develop a sustainability plan or initiative. In this case, the scope of work for the project as a whole should include the drafting of a plan that specifies sustainability goals, strategies, responsibilities, and timeframe. The EMP describes the steps that the client and/or facility staff must take to advance sustainability efforts beyond the project's end date.

Common existing or forthcoming organizational sustainability plans that the EMP may be asked to help manage might include:

- **Green Building Certification**

  LEED and Energy Star designations are frequent sustainability goals for building owners and management. Certification programs are one means of publicly validating a building's excellent performance.

  If green building certification itself is a project objective, the EMP should work with the client to articulate a plan, timeline, and series of goals. The EMP or other members of the team may also be responsible for documenting certain aspects of ECM installation or for tracking the impact of energy management activities for the purpose of meeting certification requirements. The EMP should make sure that these responsibilities are integrated into implementation plans and all applicable scopes of work and contract documents.

  When developing EMCs, FIMs, and EBCx, the EMP should note how potential measures may contribute to a building's certification efforts. This adds specific value to the project beyond energy savings. For example, an ECM that involves the installation of energy-efficient lighting fixtures may also meet the criteria for a LEED credit. Or the EMP might calculate the boost in Energy Star score that a building might enjoy from one or more ECMs. The EMP should report this estimated figure in the detailed ECM/FIM Report.

- **On-Site Renewable Energy**

  A client may also wish to pursue significant measures that integrate renewable energy sources, such as geothermal, biofuels, wind, solar, or recaptured methane, directly into the building's energy supply.

  Installing systems to generate renewable energy at the project site often involves significant capital expenditure, and feasibility will depend heavily on building type and location. If installing an on-site renewable energy system is one of the primary objectives, it will likely be addressed by the client during the initial client consultation. Proposed systems installation(s) should be described in detail, using a format similar to the *detailed ECM/FIM Report. The description of the system must include costs, payback periods, and energy savings and emissions reduction estimates.*

Accurate cost and payback estimates are vital to the client's ability to invest in this type of upgrade. The more the renewable energy upgrade is integrated into ECM/FIM implementation plans, the more cost-effective it will likely be. Project financing may be structured so that energy cost savings from the low-cost ECMs are allowed to accrue and fund on-site renewable energy developments.

- **Organizational Initiatives**

  While some clients may pursue individual sustainability goals related to green building certification programs or emissions reduction strategies, many organizations have their own internal sustainability initiatives. In some cases, the energy management project itself may be one such initiative. In other cases, the client may prioritize ECMs or FIMs that contribute to environmental initiatives at the facility. Increasingly, organizations are developing robust sustainability programs that address building energy use and performance in addition to other factors.

  During the client consultation, the EMP should ask the client for information regarding sustainability initiatives and obtain copies of program documents. Whether or not they are directly related to system energy usage, the EMP should take these goals into account during project development and execution. If a client aimed to double the percentage of waste material that is currently recycled, the EMP could ensure that the recycling of demolition and construction waste is incorporated into contractor specifications. Even ECMs and FIMs that are not directly related to the building's sustainability plan can still be aligned with those corporate efforts.

Implementation

5.A.4.d Innovative Technologies

Sometimes enhancement of an existing building system or replacement with a comparable system is not the most effective solution for a given building. The building technologies marketplace is rapidly evolving. Innovative products and services may provide more efficient, long-lasting, and cost-effective solutions than conventional options.

Innovative technologies may be relatively complex or simple, extensive or small. The installation of a geothermal heating system incurs significant upfront costs, but it is a renewable energy source that could provide significant ongoing energy savings for the project building. A geothermal heating system is a major retrofit and has an obvious dramatic impact. On the other hand, switching from an incandescent lamp to a LED lamp, while still representing a technological leap over the replacement of an incandescent lamp with a fluorescent lamp, will probably not be as noticeable.

Innovative technologies that are beneficial to the building should be considered whether or not they are ultimately implemented during the project. At the very least, they could be included in plans describing potential future investments. These kinds of solutions may range from incorporating daylighting into a building's lighting design to installing tankless water heaters, or from geothermal heating to LED lamp fixtures. An EMP should maintain a working knowledge of innovative building technologies and industry advances. Financial incentives will often be available for implementing these types of measures, because governments and utilities are interested in advancing the industry.

One caveat that the EMP should bear in mind, however, is that not all innovative technologies are fully guaranteed. Just because the product or service has entered the marketplace, it may not be as reliable as something that has become established. Before recommending a particular technology to the client, the EMP should perform due diligence by researching both the benefits and drawbacks of the potential solution. Many innovative technologies are proven to be effective in certain circumstances, but that does not necessarily mean that a given technology will be a perfect match for every single building.

5.B ECMs/FIMs

At this point, the EMP and the client have determined which ECMs and FIMs will be implemented. When drafting implementation plans, the EMP outlines the schedules and procedures for installing individual ECMs and FIMs or groups of measures.

The EMP is responsible for verifying that all ECMs/FIMs are implemented according to these final plans. With this goal in mind, the EMP should facilitate the design and construction process, communicate with contractors, and develop resource materials for building staff.

5.B.1 Final Preparation

The extent to which ECM/FIM implementation involves design and construction elements will depend on the specific measures to be implemented. For projects that involve low-cost measures that are implementable by building staff, these elements will play a minimal role. For projects that involve systems replacement or significant equipment repair—for example, a large chiller retrofit—design and construction will play a major role.

Regardless of the specific ECMs/FIMs installed, the EMP must verify that the new and/or improved systems are operating as intended through the commissioning and/or EBCx processes.

5.B.1.a Design Development

Depending on the type, scope, and complexity of the ECMs, additional design activities may be necessary before construction documents can be developed.

For EMPs who are not design engineers, or who are not associated with a firm that can deliver this service, the EMP should work with the client to engage a design engineer as part of the project team. Ideally, this person is a licensed Professional Engineer (PE) who is regularly engaged in design work. During design development, the EMP and/or design engineer transition the ECM from schematic or narrative form to contract (or construction) documentation. The EMP also works with the design engineer to incorporate commissioning requirements into those documents.

Whether or not the EMP, or the EMP's firm, is producing the design documents, he or she should be involved in reviewing them for each measure that will be implemented. This check is necessary to ensure that the original intent of the ECM is carried through design and construction. When the energy and cost calculations associated with an ECM are based on specific equipment selections, verifying the design is particularly important. These critical components must be included in the ECM design and installed properly through the delivery method selected by the client.

CASE STUDY 5.1 **ECM IMPLEMENTATION | BUILDING I**

Building I is a 200,000-square-foot facility in Seattle. The EMP was hired to investigate and develop low-cost ECMs. Because the building serves primarily as a data center, ensuring consistent space temperature was essential. Eight ECMs were identified for potential installation. The client decided to implement six of them.

One ECM identified during the site investigation involved turning off chilled water pumps that were not needed. The estimated energy savings potential of this measure alone was 430,000 kWh for one year, which translated to energy cost reduction of $35,000 and nearly instantaneous payback.

Despite the compelling economics, before implementing the measure, the client wanted to be certain that turning off unneeded equipment would not prevent automatic system backup in the event of a catastrophic failure of one of the functioning pumps or other technical problem. Therefore, in addition to modeling the recommended changes, the EMP also modeled various emergency scenarios, outlining the backup mechanisms that are activated in the event of pump failure. The EMP reassured the client that, following ECM implementation, the equipment and protocol necessary to ensure temperature consistency in an emergency would still be active.

The measure itself involved adjusting the building schedule to eliminate the use of extra pumps, as well as monitoring by the EMP and building staff to ensure proper sequences of operation. Implementation was performed primarily by the building's mechanical contractor under the existing contract. Building O&M staff also provided the EMP with feedback.

The financial investment was minor, because the necessary adjustments to controls and equipment were covered in an existing contract. The client's return on this investment was extremely high.

The Energy Management Project at Building I is discussed further in Case Study 6.2.

5.B.1.b Construction Documentation

If an ECM requires substantial design and construction, the design engineer must prepare drawings and specifications to finalize the ECM. All required mechanical, electrical, and associated system construction necessary for implementation should be described in detail. The design engineer may also be asked by the client or the EMP to assist in the preparation of up-to-date construction cost estimates.

Depending on the nature of the project, a bidding process to select the lead construction contractor may be required once the construction documents are prepared. This is the case for most government and other public projects. Construction documents prepared for a specific ECM or FIM can be used as bid documents and then as contract documents. While the EMP develops the language and specifications of the construction contract on behalf of the client, the client is responsible for executing these contracts. The EMP is obligated, however, to review all construction contracts to ensure that they lay out the specifications in a manner that will satisfy the intent of the ECMs.

If the project involves a bid process, the EMP distributes the construction documents to a list of potential contractors. In their responses, each contractor identifies costs and dates for implementation. If several bids are not required for the project, these documents will most likely be directed to a single contractor or construction manager. Typically, the EMP is the point of contact who will respond to questions from contractors during the bid process.

When the submittals are returned, the EMP should review them on behalf of the client or building owner and facilitate the development of contracts. Again, once the contracts are prepared with assistance from the EMP, it is the client or owner who is responsible for executing them.

After a contract has been signed, the EMP should emphasize that construction documents must be completed prior to the actual start of implementation. This will prevent inefficiencies during the construction process and ensure that work is documented accurately.

Design Engineer	EMP
• Works with the EMP to develop proper design. • Prepares all drawings and specifications for construction involved in ECM/FIM Installation. • Assists with updating construction cost estimates.	• Works with the design engineer to develop proper design. • Reviews all design documents to ensure the intent of ECMs/FIMs is maintained. • Distributes design documents to contractors bidding for the work. • Joins client in reviewing bids received from contractors. • Develops construction contract language and specifications using design documents.

5.B.1.c Project Delivery Methods

The bidding and contracting step in ECM/FIM implementation can be delivered by various means. The chosen method for a particular project will depend on the measures to be implemented. Sometimes, no bidding or contracting will be necessary, because the existing project team members can easily complete the ECM/FIM implementation tasks.

In the case of no-cost or low-cost ECMs, the energy management project team itself can implement the measures. Minor mechanical adjustments or changes to sequences of operation are typical examples of measures that require no major design or construction effort. Such tasks are often carried out within the existing scope of work for the ECM. For example, incorporating an enthalpy control economizer into an existing economizer sequence does not require a design

Implementation

engineer's assistance. This procedure could be executed by the building controls contractor under the direction of building staff.

For many projects, however, third-party contractors will need to be engaged to help implement capital ECMs. The following three delivery methods are commonly used within the industry for the implementation of large-scale measures that require design engineering and construction expertise.

- **Design–Bid–Build**

  The design–bid–build method begins with the design and bid processes described above. Typically, the EMP and client engage a design engineer to help with the design. After reviewing one or more bids, a construction contractor is selected to implement each ECM or FIM.

  Once the design documents have been developed and bids have been received, reviewed, and approved, the construction process begins. All work is completed according to the current design. The EMP works with the construction manager to oversee the contractor's work and must authorize any changes to the existing design documents to ensure that the intent of each measure is maintained.

- **Design–Build**

  The ECM/FIM Scope itself may be packaged and bid, or negotiated, as a design–build contract. Unlike performance contracting, which is described below, the design–build process does not take into account energy savings, but instead guarantees only that the ECM/FIM or group of measures will be installed according to the plan.

  If the EMP and client agree to the design–build route, they must engage a contractor who provides both design and construction services. Due to this structure, the design and construction processes are more heavily integrated into this method of project delivery than they are in others.

  Under a design–build contract, the EMP's role is to make sure that the ECM/FIM implementation achieves anticipated energy savings without undermining building performance. The EMP should coordinate the development of an implementation schedule that is reasonable for the client and/or building owner as well as the contractor. The EMP also reviews suggested material or equipment substitutions, and other changes to the original plan, to maintain quality control of the process.

  Because the EMP was principally involved in the development of ECMs and FIMs, he or she knows the intent of each measure and its connections to other measures. For this reason, the EMP must advise and oversee the design–build process.

- **Performance Contracting**

  The client may choose to implement measures via performance contracting, particularly if alternative funding sources are not available for whatever reason. Performance contractors guarantee a certain quantitative increase in energy efficiency that is specified in units of energy consumption. Under this contracting model, the contractor fronts the funds necessary to implement each ECM and earns revenue based on the energy savings actually achieved.

  Performance contracting is in many respects a variation on a design–build contract, because the performance contractor typically assumes that role. The only difference is that the client receives a guarantee of reduced energy consumption and cost. In some cases, this model may allow the client to hold and apply those savings to future projects.

  In a performance contracting situation, the EMP's role is to work with the construction manager and monitor progress. The EMP should ensure that ECM/FIM implementation follows design intent and should review any proposed changes with the client to confirm acceptance.

Regardless of the chosen delivery method, the EMP fulfills an important leadership position on the project team. He or she must balance the optimization of energy savings, building performance, and operations and maintenance—all as specified by the client’s goals. The EMP is centrally involved in design and construction activities during the implementation of ECMs and FIMs. This includes facilitating the energy management process, as well as assuming the role of CxA and commissioning systems following construction. The EMP is responsible for ensuring that the project team succeeds in delivering the design intent and full potential of each measure during implementation.

5.B.2 Construction Administration

The EMP must monitor the construction process and maintain communication with design engineers, construction teams, other contractors, and building staff. In most cases, a separate construction manager will oversee the day-to-day construction activities.

The EMP’s role involves supervision and administration. For example, the EMP should make periodic inspections to ensure that the equipment and materials used in the installation of each ECM are consistent with planning documents and will achieve the desired results.

The EMP, client (or building owner), and construction manager have specific sets of duties:

EMP

- *Serves as the CxA or works with another commissioning agent.*
- *Communicates with the construction manager regarding changes to ECMs/FIMs.*
- *Reviews proposed changes to ECM/FIM design with the client.*

Client

- *Makes final decisions regarding the implementation of measures.*
- *Oversees the work of the EMP and the construction manager.*
- *Works with the EMP to outline changes in O&M practices for facilities staff.*

Construction Manager

- *Oversees the work of subcontractors.*
- *Maintains communication with the EMP regarding changes to ECM/FIM design.*
- *Ensures that construction remains on schedule and budget.*

The EMP advises the construction team on minor modifications to the original plans. If one of the contractors proposes a major change order that may alter the intent or value of an ECM or FIM, the EMP must review it and advise the client and facilities staff accordingly.

In summary, the EMP during this phase serves as the CxA to facilitate the commissioning process, confirms that the intent of ECMs/FIMs is maintained, and verifies their installation according to project documentation.

CASE STUDY 5.2 — ECM IMPLEMENTATION | BUILDING H

At the outset of the energy management project at Building H, an office building in Atlanta, the client had already been considering an upgrade to the facility's BAS. Before the EMP was engaged, builing management had reviewed various BAS brands and models and made a decision about which system, in their view, was best for Building H. The EMP received information from management about the system being considered. Detailed analysis of this potential ECM was integrated into the scope of work for the project.

The BAS retrofit was an ECM as well as a FIM, since the advanced capabilities of the new system would effect better performance and enable tighter energy control. The energy savings from installing and using the new BAS were calculated to be relatively modest.

The EMP worked extensively with the building's chief engineer and general manager to ensure that financial estimates and time characterizations were as accurate as possible. After analyzing all available data, the EMP produced a true representation of the costs and benefits associated with the proposed BAS retrofit.

The EMP listed the BAS upgrade as a potential ECM, and the client selected it for implementation. The client also approved eight low-cost measures that the EMP had identified and developed. These low-cost ECMs were implemented prior to installing the new BAS. To maximize energy savings, ECMs involving changes in setpoints and schedules were implemented in the existing system, even though it was soon going to be replaced.

Implementation of the BAS upgrade was a substantial undertaking for all of the staff at Building H. Loading and testing of the new software platform took about five months. Next, with the guidance of the EMP, management coordinated the installation of terminal units throughout the building. Under the supervision of the chief engineer, an additional engineer was contracted to perform this work. Since the building was still in use, a detailed construction plan spanning several years was developed.

The building prioritized installation in vacant spaces and common areas in order to minimize disruption to occupied tenant spaces. As often as possible, construction was scheduled after an existing tenant departed and before a new tenant arrived. For the remaining areas, which were continuously occupied, the building worked with tenants to gain access to their space and, as necessary, facilitate the utilization of temporary spaces elsewhere in the building.

While construction proceeded, the low-cost ECMs were transferred to the new BAS. A series of automated trends was established to monitor systems performance on a regular basis. The EMP reviewed the data with the client to confirm that the significant investments at Building H increased operational efficiency and reduced energy consumption as expected.

5.B.3 Installation Checks

Also referred to as "pre-functional checks," installation checks are one-time inspections following construction. They are performed to verify that the correct components have been installed and that the equipment is set up properly. These basic checks ensure that equipment is ready for functional testing. Unless another team member is specifically assigned the task, as a CxA, the EMP is responsible for running these tests following installation.

Installation checks involve a number of typical inspection points, including:

- Sensor calibration
- Wire terminations
- Valves and damper travel
- Fan start and stop
- Point-to-point checkout

The EMP concludes installation checks by performing basic tests for entire systems. The HVAC system will often receive the most attention. For example, the EMP should follow a three-step process for testing HVAC:

1. Turn the system off and look for normal positions. Valves that are normally open should be open, and dampers should travel correctly.
2. Restart the system and look for the correct safety "on" positions.
3. Perform position checks at 0, 25, 50, and 100% of flow-through.

Once installation checks are complete, the EMP also confirms that M&V equipment and tools are in place. The EMP may wish to set up BAS trends at this point and review the initial set of trend data after a few weeks. Individual functional tests and spot measurements alone may not reveal as much about equipment operation as trend data that reflects a longer timeframe.

AABC Systems Verification Checklist

A full systems verification checklist is available for download at the ACG website:

Commissioning.org/commissioningguideline

5.C EBCx Activities

EBCx activities can often be performed at the same time that new equipment is installed. Certain tasks that involve the interaction of existing and new systems, however, may need to be scheduled for a later time. The EBCx process will ensure that systems that will remain in the building are operating optimally. As a CxA, the EMP is responsible for EBCx.

5.C.1 Final Preparation

Final preparation for EBCx should include scheduling additional site visits, client communications regarding objectives, and the engagement of necessary contractors (e.g., a TAB practitioner) who will be involved with EBCx. The EMP should continue to refine and adjust test checklists, if necessary. Although various industry organizations publish standardized lists of functional performance tests for HVAC and other building systems, the EMP should customize the lists to reflect the project's specific characteristics.

The objective of commissioning and EBCx is to determine whether or not building systems are performing in accordance with the Owner's Project Requirements, the Basis of Design (or design intent), and construction documents. If any systems are not performing correctly, the EMP must work with the team to fix the problems. For EBCx, the EMP also assures that the systems meet current operational requirements based on occupancy, space type, climate, and other factors that may change over the life of a building.

During the commissioning and EBCx processes, the EMP:

1. Executes functional performance tests. This type of systems testing consists of a standard, sequential process as described in the *ACG Commissioning Guideline*.
2. Identifies any deficiencies The Commissioning Deficiencies Log, which may also be referred to more informally as an "issues log," should also be updated.
3. Resolves the deficiencies or works with other members of the project team to fix the problems.
4. Prepares and submits a Commissioning Report to the client and/or building owner after any equipment deficiencies have been resolved.

The first three steps take place primarily during this phase of the project. Additional work with respect to the third and fourth steps occurs in Phase 6.

5.C.2 Execution

Thorough functional testing and assessment of existing systems comprise EBCx. After performing functional tests, the EMP analyzes test results and addresses them with the client. If additional systems issues are identified during the process, the EMP should recommend appropriate corrective actions. Further rounds of final testing may take place during Phase 6.

Functional Performance Test Resources

Sample functional performance tests can be found in the ACG Commissioning Guideline, Appendix D.

EBCx involves a more comprehensive review of the building than previous assessments and building investigation. The process includes not only testing of HVAC and lighting systems, but also potentially emergency power and life safety systems. EBCx builds on investigation performed and information collected earlier in the project. If an EBCx task was already completed as part of the earlier site investigation, the EMP should consult with the client to determine whether or not it is appropriate to revisit that task as part of the EBCx project scope.

The EMP should also communicate with the client and building staff to gather additional information as needed. If possible, a building staff member should be available during the execution of EBCx activities to provide equipment access and answer questions.

During EBCx, the EMP investigates building systems and documentation and answers a number of questions. While specific tasks and qustions may vary from one project to another, the discussion below provides representative examples.

When exploring the BAS from the user workstation, the EMP should bear in mind that he or she is evaluating the existing capabilities of the system. Typical questions the EMP might answer include:

- Are the graphics accurate?
- Are alarms and safeties functioning properly?
- Is the number of monitored points sufficient to properly control all systems?
- Do observations of actual operations during system testing align with documented sequences?
- What data trending capabilities are available and how can they be used for EBCx? What data is already being trended and for which systems?
- Are any measurement and verification programs installed?

In many cases, the EMP will also be asked to investigate the life safety management characteristics of the building, including emergency power and transfer switch operations, as well as the utility meter network. In these instances, several questions for the EMP to consider include:

- Which types of lighting controls and security systems are present?
- How is the building metered and sub-metered?
- Are current metering capabilities sufficient for advanced analytics?
- Do the utility meters interfaced with the BAS or are they isolated?
- Is emergency power sufficient for the building's current needs?

Although the EMP has probably reviewed all applicable documentation at this stage in the process, he or she may benefit from taking a second look at design, construction, and operation materials, particularly drawings and specifications. Standard questions include:

- What as-built documentation and design schematics are available?
- Are written plans for O&M procedures in place? What sequences of operation have been outlined by O&M staff?
- How is preventative maintenance performed at the building?
- Are current maintenance practices adequate?
- Are maintenance practices being documented usefully?

- What maintenance records, schedules, control sequences, TAB reports, and equipment submittals are readily available?

Further investigation may be necessary to confirm or obtain additional information about the facility, particularly in relation to TAB and commissioning assignments. Depending on the results of investigative TAB in Phase 3, the EMP may recommend another round of TAB during the execution of EBCx. To help determine whether or not additional TAB measurements are necessary, the EMP should answer these and similar questions:

- What were the results of previous TAB and/or commissioning activities?
- What recent TAB and/or commissioning documentation is available?

The EMP will use these measurements, results of testing, and systems assessment to identify underperforming equipment. Some of these issues may be resolved through basic changes to systems or operations by building staff or contactors. Others may require more intensive and/or costly implementation of additional ECMs and FIMs. If this is the case, the EMP will need to consult with the client to prioritize the implementation of additional FIMs and ECMs. If measures are added, the EMP should work with the project team to integrate these into the existing plans, timeline, and funding.

For additional information regarding the structure and activities involved in EBCx, sample checklists, and more detailed report structure, see the ACG Commissioning Guideline, Chapter 7: HVAC Commissioning in Existing Buildings.

5.D TEST, ADJUST, BALANCE

Once construction and EBCx are substantially complete and the EMP has performed installation checks, another round of TAB should be performed. TAB should be conducted from a whole-building, whole-system perspective.

Depending on the project timeline, TAB activities associated with both commissioning and EBCx may coincide. Additional TAB services may also have been included as an FIM or an ECM identified by the EBCx process. In this case, an additional scope of work should be developed for the TAB contractor dealing specifically with these activities.

AABC Test and Balance Procedures Manual

The manual is available online at the AABC website:

AABC.com/publications

The purpose of TAB at this stage in the project is to help verify that systems are operating as expected and identify additional areas of concern.

The procedures required to test and balance both air and water systems are detailed in the "AABC Test and Balance Procedures Manual." The AABC website offers additional TAB-related publications and resources.

5.E INSTALLING M&V EQUIPMENT

The commissioning process will validate that systems installed during ECM/FIM implementation perform as expected and that anticipated energy savings are on target. Meters and other M&V equipment must be in place to collect this data for both commissioning and eventual continuous monitoring.

The EMP should verify that the necessary M&V equipment is installed or available to measure energy consumption, air flow, and water flow. In addition, the EMP should set up BAS trends for data collection and analysis. Additional systems, such as steam, hot water, or chilled water may also need to be considered.

The installation of additional meters or submeters may have been the subject of one or more implemented measures. If this is the case, specifications will have been provided previously to contractors performing the work. Installation will often require coordination between the local utility or energy supplier and the EMP and building staff. The EMP should make sure that all existing building meters are calibrated according to the manufacturer's requirements, and that those requirements are included in project documentation for building staff.

M&V equipment must be installed and calibrated properly in order to produce useful data. Without accurate and granular data from such equipment, the client and EMP will only be able to use utility bills to evaluate the effectiveness of EBCx and ECM implementation—a difficult if not impossible task.

The presence of accurate measurement tools in the building will also save time and effort in the event that inefficiencies are identified in the future. Without submeters and related tools, concerns about building system efficiency may not be addressed very quickly. The EMP will suggest the need for M&V equipment, and following installation, several more months will likely pass by before the EMP has collected enough data to properly identify the problem.

Depending on the ECMs that were implemented and the needs of the client, M&V can be system-specific or ECM-specific. When possible, M&V tools should be programmed to measure building-level performance in addition to system-level performance. By comparing both sets of data, the EMP will be able to analyze the extent to which each individual ECM contributed to overall building performance.

Comparison of these different readings may suggest that whole building systems operation is forcing a particular system to reach capacity more frequently than anticipated. For example, increasing chilled-water discharge in an effort to reduce chiller energy use may raise demand for fan power (i.e., constant operation and greater frequency) in order to maintain the space temperature setpoint. In order to confirm sound ECM/FIM implementation and building-level performance, M&V equipment must be functioning properly and producing the types of accurate datat that the EMP requires.

IMPLEMENTATION SUMMARY

During ***Phase 5: Implementation****, the EMP completes final planning for the ECMs, FIMs, and EBCx activities developed during earlier phases. These are installed according to project plans that outline the tasks, schedules, and responsibilities involved in the implementation of each measure and EBCx task.*

The EMP coordinates among various members of the project team to ensure that the project plans are articulated clearly and executed correctly.

Unless another contractor is assigned the responsibility, the EMP also performs commissioning activities for both existing and newly-installed equipment. The EMP confirms that the building is outfitted with the necessary M&V equipment.

Implementation represents substantial action following multiple rounds of anaysis, but it is not the final step in the process. The EMP must demonstrate to the client and/or building owner that ECM/FIM and EBCx implementation was effective. This is the principal topic of ***Phase 6: Final Acceptance****.*

6 FINAL ACCEPTANCE

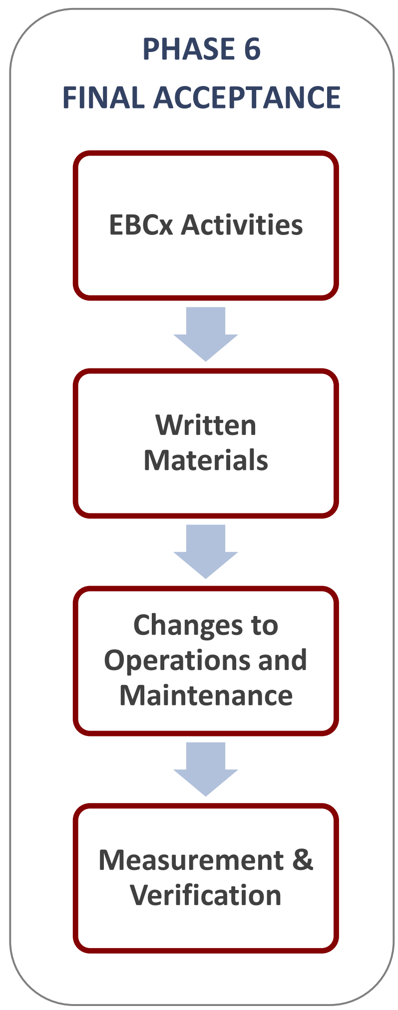
During the Final Acceptance Phase, the EMP affirms the desired level of whole building performance has been achieved following implementation. The EMP finalizes and documents commissioning activities and all changes made to building systems. Resources are developed for the client and building operations staff, and the EMP executes measurement and verification to ensure that ECMs and FIMs were installed properly and are operating as intended.

The mission of the Final Acceptance Phase is to:

- Complete and document commissioning activities.
- Produce useful summaries of completed retrofits and manuals describing the building in its new state.
- Update O&M procedures to reflect energy management best practices.
- Confirm through M&V that ECMs and FIMs were installed and are functioning correctly.

This chapter should provide the EMP with:

- Best practices for documenting newly-installed systems and commissioning activities.
- Ideas for optimizing O&M activities through training, clear communication, and detailed written materials.
- Guidance on effectively performing M&V and reporting the results.



Final Acceptance Outline

This phase is divided into four major subsections:

During **Phase 6: Final Acceptance**, the EMP facilitates final testing and report development for systems commissioning, develops resources for building staff, and works with the client to optimize building operations and maintenance practices. The measurement and verification (M&V) process should verify that measures were correctly installed and are realizing the anticipated level of energy savings. If M&V reveals any deficiencies, the EMP must work with the project team to correct the performance issues.

6.A EBCx Activities

As a certified Commissioning Authority (CxA), the EMP is responsible for facilitating the commissioning of newly-installed systems as well as existing systems. Depending on the project, the EMP may or may not actually perform the commissioning. Some projects may require a third-party contractor to perform the commissioning services .The commissioning of new equipment was incorporated into the implementation process. Installation checks by the EMP during Phase 5 have verified that equipment was installed as intended.

The ECMs and FIMs being commissioned at this stage will only be those completed prior to Phase 6. The EMP may have identified ECMs/FIMs that the client has approved, but await funding or implementation at a later date. During Phase 7, the final phase of the EMA Energy Management Process, the EMP will provide guidance for implementing additional measures on an ongoing basis.

For both new and existing systems, the majority of functional testing for commissioning and EBCx has already taken place by Phase 6. The EMP is now ready to complete final testing.

6.A.1 Final Testing

The EMP must perform final testing to ensure systems are operating in agreement with the Owner's Project Requirements. These final tests support testing already performed during Phase 5.

In many cases, additional functional testing at this stage will address systems that were modified or subject to operational changes identified during the commissioning or EBCx processes. The Commissioning Deficiencies Log, which is maintained by the EMP throughout the commissioning process, should provide a record of these issues. The EMP should monitor and document test results, verifying when issues have been resolved and providing a record adjustments over time. This log will be included in the final Commissioning Report, which is described further below.

An EMP is likely more familiar with some systems and less familiar with others. When the EMP is working with building systems that are not in his or her area of expertise, especially in cases where more extensive testing is needed, it is helpful to consult industry organizations and standards. This is especially true when extensive system testing is required.

6.A.2 Commissioning Reports

EBCx Report

A document detailing the results of functional testing, TAB, and O&M review during the EBCx process.

After commissioning processes are complete, the EMP develops and submits final reports to the client. The **EBCx Report** details EBCx activities performed on systems that will still remain in the building throughout the energy management project. When the project involves significant equipment replacement, the EMP should also produce a Commissioning Report about activities performed on newly-installed systems. These reports will be based on the activities outlined in the original EBCx Plan and commissioning plans.

The EBCx Report will document the testing and corrective work performed, as well as potential items to be addressed in the future. It serves as a reference for building staff during and after the transition to normal operations.

The EBCx Report should include:

- Completely revised as-built documentation
- Record of activities and measurements
- Functional performance test checklists
- Test results and observations
- Recommended O&M practices
- Summary of potential OM staff training opportunities
- Updated System Manual and O&M Manual

The Commissioning Report produced for newly-installed systems has a purpose very similar to that of the EBCx Report. Unlike the EBCx Report, however, the Commissioning Report deals exclusively with systems installed as ECMs or FIMs.

The Commissioning Report should include:

- Executive summary describing new systems
- Installation, start-up, and functional performance test checklists
- Test results and observations
- Log of problems, issues, and other deficiencies
- Summary of corrective actions and results of re-testing

- Systems design and documentation references

All EBCx and commissioning documentation should be verified and signed by either the EMP or the contractor who executed the tests.

For additional information regarding commissioning and EBCx report development, see the ACG Commissioning Guideline, where report development is described at the ends of Chapters 5, 6, and 7.

6.B WRITTEN MATERIALS

Providing the client and building staff with the resources to maintain operational improvements is an essential element of every project. Specifically, the EMP should collect as-built documentation and produce both System and O&M Manuals. This documentation will help the building operations staff maintain energy savings and optimum performance on a day-to-day basis.

6.B.1 As-Built Documentation

The EMP is responsible for providing the client with accurate and complete documentation of all system modifications. Without this documentation, building staff, the EMP, or other contractors may have difficulty resolving issues that arise later. As-built documentation provides the detailed information necessary to understand systems operation without the need for in-depth physical inspection. It also identifies deviations between original contractor specifications and final construction.

The EMP should ask contractors for as-built documents in both paper and electronic formats. Paper copies are conveniently referenced and annotated. Electronic files are safely stored and easily incorporated into future work plans.

To obtain as-built documentation, the EMP should follow a five-step process:

1. The EMP determines the control points and benchmarks that the contractor should use to frame the as-built information. The contractor must identify all existing equipment encountered during construction and record location information accurately.

2. The contractor provides a written description of all points and the systems to which those points belong. Location can be identified by x-y-z coordinates—position north or south, east or west, and distance above or below ground level—or in relation to walls, ceilings, etc.

Final Acceptance

3. The contractor describes any as-built alterations to the original specifications, including all changes in size, materials, components, and location.

4. The contractor supplies as-built drawings of the same size and format as the originals, unless another style is requested and authorized by the EMP or construction manager. A competent draftsperson should prepare the drawings to scale and with appropriate dimensions.

5. The EMP, construction manager, or other authorized representative should verify all entries and dimensions on the drawings.

Upon completion of the project, as-built drawings are delivered to the construction manager and passed on to the client. Typically, as-built documentation and updated drawings are most critical for mechanical, electrical, and plumbing (MEP) systems, as well as for the BAS and sequences of operation. Of course, specific documentation needs will vary from project to project.

6.B.2 System Manual

A System Manual, also referred to as a “Building Owner’s Manual,” should be produced for the systems commissioned during the project. This resource will help building staff maximize building performance. The EMP develops this document as part of the commissioning process for both new and existing building systems. If a System Manual already exists for the building, the EMP can update it, adding information based on new systems installed as ECMs/FIMs, as well as issues addressed and corrected during EBCx.

A typical System Manual includes:

- Basis of Design or design intent documents
- System single-line diagrams
- Control drawings and set points
- As-built sequences of operation
- Operating instructions and checks for integrated building systems
- Recommended tasks and schedule for maintenance
- Recommended tasks and schedule for retesting systems
- Recommended tasks and schedule for calibrating sensors and actuators

When developing the System Manual, the EMP should provide sketches and narrative descriptions of the sequences of operation. Alarms should be listed separately. Manufacturer performance test data for all major plant equipment, such as chillers, cooling towers, boilers, air handlers, and pumps, should be included. Using field measurements, the EMP may also determine benchmarks that should be recorded in the manual for future reference.

Periodic performance checks of the HVAC system should be outlined. For each piece of equipment, task descriptions, best practices, and the ideal frequency of checks should be identified. For example, to establish that the systems operate efficiently, the EMP might compare graphs of actual and desired system performance.

The EMP should also include blank test forms from the Commissioning Report. These regular checks should be viewed as a diagnostic exercise rather than as an opportunity to overhaul control sequences. For example, if equipment energy usage is trending upwards, building staff may be allowed to make minor adjustments, but not change the control strategy itself.

Although they both include information and procedures for building staff, the System Manual is separate and distinct from the O&M Manual. The System Manual provides information about system design intent and operations, while the O&M Manual focuses on tactics, schedules, and assignments specific to the building staff.

The forms, diagrams, instructions, tasks, schedules, and other documents that comprise the System Manual provide a starting point for the building staff. They equip the client with guidance about the work that should be performed on a regular basis.

To encourage the ongoing use of the System Manual, the EMP should:

- Assist the client and building staff with establishing a standard operating procedure (SOP) that identifies the staff member responsible for resolving each type of mechanical or control problem. When an issue is discovered, the staff member either applies the SOP and notifies the appropriate party or seeks approval from a supervisor to take corrective action personally.
- Strongly recommend the documentation of all future changes to equipment, set points, sequences of operation, control strategies, and schedules. The responsibility for keeping the document current should be written into the job description of the appropriate building staff member.
- Customize the contents so that they are meaningful and practical for building staff. Processes and functions included in the document should be applicable to the unique systems actually installed in the building.

Once the System Manual is created, it should not simply sit on a shelf. The EMP should stress its importance as a living document that staff can read and update on a regular basis.

6.B.3 O&M Manual

The EMP will also provide the client and building staff with an O&M Manual. This document contains resources, such as checklists, schedules, and drawings, which inform day-to-day facility operations. The O&M Manual is intended to guide staff responsible for running the building and solving equipment problems.

In the O&M Manual, the EMP should include:

- **Schedules and Timelines**

  Establish a general schedule for maintenance work that is practical for both building staff and contractors who work with the building on a regular basis. Coordinating the schedule between staff and contractors at the outset will prevent misunderstandings that may block or delay the completion of assignments.

- **Checklists and Forms.**

  Include documents that can be photocopied repeatedly and used during O&M activities. The EMP should define the tasks and include blanks for recording measurements and documenting results following completion. The forms should contain the expected performance data and the nameplate data for each piece of equipment to be tested or examined.

- **Measurement Tools**

  Recommend to the client that data loggers and other measurement devices be provided for staff. The EMP can suggest useful tools that building management should consider purchasing.

- **Calibration Requirements**

  Provide calibration schedules for measurement instruments. Only reliable measuring instruments correctly represent how the building is operating. Sensor calibration is generally performed more frequently than other O&M tasks.

- **Operating Schedules**

  Provide operating schedules for all equipment that is not required to run continuously. These systems may include HVAC, lighting, kitchen or cafeteria equipment, and office equipment. The EMP should specify that these schedules be reviewed periodically and updated to reflect the current needs of building occupants.

- **Staff Responsibilities**

  Work with the client to outline O&M staff responsibilities with respect to energy-related activities. Indicate the staff member responsible for documenting various O&M activities. Suggest that a staff member be *assigned to conduct periodic audits during nights and weekends to differentiate between equipment that should and should not be running.*

- **Seasonal Schedules**

  Identify and schedule pre-activities and post-activities specifically related to the heating and cooling seasons (e.g., changing filters, adding oil, etc.).

As appropriate, the EMP should also include documentation and resources specific to the building, or specifically requested by the client. The objective of the O&M Manual, like the System Manual and other project documentation, is to describe the implementation of new equipment and processes as well as to serve as an ongoing resource that can be consulted by facility staff.

6.C CHANGES TO OPERATIONS AND MAINTENANCE

To maximize the impact of the EMA Energy Management Process, the transition from the development and implementation of ECMs/FIMs to normal building operation must be as smooth as possible.

Creating quantitative measures and detailed plans for O&M activities is an effective strategy for maintaining the building performance settings established over the course of the project. Examples include:

- **Regulating staff responsibilities with respect to BAS alterations.**

  In a building where several O&M staff have access to the BAS, setpoints may be adjusted much too frequently. In order to avoid excessive changes, each staff member should be assigned either a set of devices or an allowable range of adjustment for each device. These limitations will prove more beneficial than allowing all staff to make any change.

- **Setting problem thresholds for facility-wide adjustments.**

  The EMP should suggest that O&M staff establish a matrix that specifies the required minimum number of issues or complaints before adjustments are implemented. For a large building, problems must be logged in a certain number of areas—not just a single area—before it is acceptable for the staff to adjust settings for the whole site.

- **Instituting lighting checks and managing lighting control access.**

  Lighting must be monitored regularly. A typical building has dozens if not hundreds of light switches and hundreds if not thousands of individual fixtures. The EMP should help O&M staff design checks and determine responsibilities for adjusting lighting controls. It is all too easy for no-cost lighting schedule ECMs to degrade quickly because the lamps in a space *are left on 24 hours a day and controls that would have powered down the lights at night have been disabled.*

O&M processes help in maintain the level of building performance established during the energy management project. Changes in O&M practices can also result in reduced maintenance issues, leading to further cost savings. These strategies should be developed by the EMP in consultation with the client.

6.C.1 Defining Responsibilities

One of the most significant factors in determining the ongoing efficiency of system operation is the team that works with the building. In cooperation with the appropriate leadership, the EMP should define and synchronize the responsibilities of building ownership, management, staff, and contractors. Information gathered during previous phases will inform this task. The EMP should:

- **List ongoing O&M activities and their respective goals.**

  With the client or appropriate building staff, the EMP should develop measurable goals for operating efficiency, work schedules, and staff responsibilities. This will enable management to anticipate and evaluate O&M work and provide them with greater understanding of and support for the O&M staff.

- **Anticipate changes to current O&M practices.**

  Use information collected during interviews with building staff in Phases 1 and 3 to gain insight into likely changes and updates to current O&M practices. Obtain additional feedback from staff, as necessary, and ensure that the entire team accepts and comprehends the new standards.

- **Outline the roles of third-party contractors**.

  Additional parties, such as ESCOs, controls, and/or mechanical contractors, and the EMP, have responsibilities at the project building. Facility staff needs to understand these third-party roles and the extent to which interactions will occur. If necessary, the EMP should work with the client to determine a scope of work for ongoing contractor support if one does not already exist.

The implementation of ECMs and FIMs leads to changes in building operations. The opportunity for the client to optimize additional O&M practices at the same time, with the guidance of the EMP, must not be overlooked.

6.C.2 Staff Training

In many cases, additional training will help building staff learn about newly-installed systems, updated technologies, and best practices. The EMP should provide recommendations for training organizations and resources, and integrate training into existing project documents where appropriate. Specifically, the EMP should help the client:

- **Identify useful training opportunities.**

  Equipment and software manufacturers often provide ample training opportunities for building staff who need to become familiar with the new installations. Training builds staff confidence in working with new equipment and using powerful technology to its best advantage. Training can often be linked directly to financial returns. For example, the initial cost of a BAS training package may be recovered rather quickly through energy savings and reduced hot or cold calls. Topical seminars and local college or university classes may also be helpful.

- **Join professional organizations and affiliations.**

  The EMP might suggest that building staff join organizations that provide support and training for activities related to O&M. Events that bring together groups of like-minded practitioners can allow for the exchange of information that is tremendously and immediately beneficial. Many organizations hold conferences and make other resources widely available to its members. AABC and ACG, and EMA offer substantial training opportunities related to TAB and commissioning.

- **Use online training and webinars.**

  Many companies and professional organizations offer online training opportunities and webinars that may be useful to the client and building staff. Due to easy accessibility and low cost, this form of instruction is increasingly common within the industry. The EMP should suggest some of the best available resources that the client may wish to consider. Many online opportunities are offered for no or minimal cost.

- **Consider funding.**

  Depending on the project, the EMP may plan to discuss with the client financial resources to pay for training. The EMP should stress the importance of regular training to leadership that may be skeptical of spending still more money on the energy management project. If the EMP encounters resistance, he or she can explain the value of training with respect to persistence of ECMs/FIMs and energy savings. Plans for one-time and/or ongoing training should be listed in the O&M Manual.

The training of various members of the building staff is an excellent investment for the client. Enhanced education tends to result in operational improvements and optimized building maintenance. The EMP's holistic knowledge of building energy management should be applied to directing clients to useful training opportunities and resources.

Case Study 6.1 Changes to Operations and Maintenance | Building A

During the project at Building A, the EMP recommended several practical updates to O&M practices to ensure the persistence of energy savings. The EMP noted that the building staff was already extremely knowledgeable, but the ECMs that were identified and implemented had rendered the facility unfamiliar in some ways. The EMP explained to the management and operations staff of Building A how O&M practices could help maintain the reduction in energy usage over the long run.

Building A is located in Denver, which experiences significant seasonal variations in temperature. As a result, many of the O&M changes that the EMP identified involve adjusting the BAS based on outdoor conditions. For example, temperature setpoints could be adjusted seasonally in areas such as lobbies, common areas, and vacant spaces.

The collective effort to pursue LEED for Existing Buildings certification at Building A led to additional changes in O&M. The EMP participated actively as a member of the LEED project team. Energy-related aspects of LEED were considered as part of the energy management project, and the EMP interpreted LEED credit requirements for the operations staff.

The EMP developed an ECM that involved switching out inefficient ballasts and lamps in certain areas of the building, which not only reduced energy usage, but also helped meet the criteria of LEED credits related to lighting. Fulfillment of this ECM required building staff to switch out some ballasts and lamps. In addition, the EMP worked with the staff to develop an O&M plan that enabled Building A to continue phasing out relatively inefficient lighting in favor of high-efficiency equivalents.

The EMP offered suggestions to help building staff reallocate their responsibilities. Plans developed by the EMP included recommendations for updating and reviewing practices on an ongoing basis. In addition to maintaining energy savings from ECMs, the O&M updates were also intended to create a more comfortable environment for building tenants.

The Energy Management Project at Building A is discussed further in Case Study 7.2.

6.D MEASUREMENT & VERIFICATION

The goal of the measurement and verification (M&V) process is to collect data and demonstrate that building systems are achieving the anticipated levels of energy savings. In the previous phase, the building's existing meters may have been supplemented with additional monitoring equipment. This equipment, in addition to manual testing tools, will be used to gather data for M&V. Further information regarding metering strategies and ongoing measurement is covered in Phase 7.

After M&V equipment is installed, the EMP will take measurements to verify that the implementation of ECMs/FIMs was successful. The strategies for doing so were outlined in the M&V Plan in Phase 5. Ideally, actual energy usage data confirms the savings goal. If this is not the case, the EMP may need to modify the ECMs or review the commissioning and EBCx activities to see if additional gains in efficiency are possible.

It is possible that savings may go unnoticed because the new data has not been cleansed and correlated properly. The EMP may need to revise the raw energy consumption data to account for different real operating conditions. These corrections will produce a higher degree of accuracy. The following factors may positively or negatively influence M&V data and savings figures:

- **Weather Variability**

  The commissioning of affected systems must be conducted during both heating and cooling seasons. Heating and cooling degree days, which gauge the severity and duration of heating or cooling requirements, may also have been abnormal. Normalizing the data to remove weather as a variable is an important first task for the EMP. The results may suggest that performance is actually better or worse than initially suspected.

- **Usage Patterns**

  Changes in the use of building equipment may not align with the assumptions that the EMP made previously. A hotel that begins to host conventions may experience an increase in the number of events and visitors. Plug loads in office spaces may change as a result of employees connecting larger numbers of personal electronic devices. Previously unoccupied space may be repurposed and used. Staff may have started working night or weekend hours. All of these examples, and many more, will impact the apparent results, but they are a direct result of evolving building usage. These issues require the EMP to revisit the original ECM calculations and qualify expectations before it is possible to determine whether or not realistic energy savings have been achieved.

- **Equipment Installation and O&M**

  While major equipment was examined during the commissioning and EBCx processes, smaller components that were not covered during that review may negatively impact energy savings if they were not properly installed. The EMP should verify the correct installation of even the smallest pieces of equipment. Just as important, staff must be informed of changes in O&M that need to be made once ECMs/FIMs are implemented. For example, if a building installs new lighting, but a faulty ballast is replaced with an old, inefficient model rather than the new one, energy use will increase. The EMP can prevent such misapplications by creating a standard procedure that involves retaining the last set of boxes used for equipment replacement. The operations staff will then be more likely to swap a part out for one of the same type. The EMP should also identify acceptable replacement parts in the System Manual.

- **Operational Decisions**

  Frequent overriding of the BAS schedule and setpoints or other operational changes may impact savings. For example, if a building staff member modifies a schedule so that a particular frequency drive is operating 100% of the time, or a temperature setpoint is set to a temperature that cannot possible be reached, the building will use more energy than the EMP had intended.

If an energy model is being used for the project, the EMP will also need to coordinate adjustments to the model with improvements in the M&V strategy. Changes in the model lead to changes in simulation exercise results, and thus changes in anticipated measurements of energy use reduction. The actual measurements, in turn, will inform recalibration of the energy model.

Resources such as the building energy model, EBCx and Commissioning Reports, and System Manual provide background information, baseline measurements and verification records for use by the client. These resources will help building staff continue to monitor the performance of ECMs over their life cycles.

CASE STUDY 6.2 — MEASUREMENT AND VERIFICATION | BUILDING I

Eight ECMs were installed as part of the energy management project at Building I, a facility in Seattle with a sizeable data center. These ECMs included turning off unneeded chilled water and condenser pumps, installing lighting sensors, and adjusting setback modes for specific AHUs. The challenge was that certain temperature and ventilation conditions had to be maintained for the data center to function correctly.

Following the implementation of these low-cost ECMs, the EMP executed an M&V plan to ensure that measures were producing anticipated savings. The EMP used BAS trend data, as well as data loggers and field testing, to accomplish this evaluative step. M&V also included further adjustments to ECMs. For example, the original occupancy setpoints were adjusted to account for actual building conditions and to produce maximum energy savings in office spaces without harming the data center.

The EMP presented the client with reports that included graphs and trends indicating measures had been implemented as intended. The narrative for each measure reported the changes, specific M&V methodology, and additional adjustments made following implementation. One specific ECM involved an air-handling unit for an office. AHU operations were altered to include night setback and setforward modes. During M&V, the EMP installed data loggers to monitor the status of the AHU and the temperature in the affected space.

Trend data for valve positions as well as outside air temperature was monitored for several weeks. Based on when the office space was actually being used, the original operating schedule, from 8:00 am to 5:00 pm, was shifted two hours earlier, from 6:00 am to 3:00 pm. The EMP also moved the sensor from its original location in a sparse area to an adjacent occupied area where physical data more closely represented real conditions. These changes were outlined in the client's M&V report.

The EMP used the new data to update energy savings estimates for Building I. Additionally, the EMP communicated the findings to building staff so that O&M practices would continue to achieve savings. The M&V process provided the client with a clearer picture of the timeline by which those energy savings would be realized.

The improper installation of some measures and the revised calculations resulting from occupancy conditions required the EMP to modify energy reduction estimates. In the end, electricity savings at Building I were less than originally anticipated, but natural gas savings were slightly greater.

6.D.1 Reporting Strategy

Reporting is an essential aspect of the M&V process. Data that is generated but never examined serves no purpose. The EMP should work with the client to develop an M&V reporting strategy that will provide timely process updates and highlight anomalies that need to be addressed to realize energy savings.

Typical M&V savings metrics involve calculations that compare baseline energy use and post-installation energy use. As discussed above, these measurements may need to be corrected for factors such as weather or occupancy.

When developing an M&V reporting strategy, the EMP should consider:

- **Metrics**

  Energy savings metrics that are used for M&V should be consistent with those agreed upon and used during earlier phases of the project.

- **Specificity**

  Performance measurements may apply to an entire system or an individual ECM, depending on the nature of the implemented measures and client preferences.

- **Format**

  Graphs that illustrate current performance relative to baseline and anticipated energy performance are useful visuals for both the EMP and client to examine. While graphs convey a lot of information, they should be supplemented with brief narratives that characterize the performance and explain unexpected results.

The EMP must also consider M&V when developing the reporting method. For a project that utilizes performance contracting, payment is dependent on verified energy savings. In this case, the ESCO involved in the project will likely perform its own M&V, but the EMP should make sure that the ESCO's figures are in agreement with the EMP's own results.

If performance contracting is the project delivery method, then M& V reporting will by necessity be strong and elaborate. If another delivery method is employed, then M&V reporting is more informational in nature and will be used for evaluating the success of the project in general. In either case, the EMP should focus on ensuring that all measures are implemented as expected and that all equipment is operating properly.

> *Industry guidelines such as the* "International Performance Measurement and Verification Protocol" (IPMVP)" *and the California Commissioning Collaborative's* "Guidelines for Verifying Existing Building Commissioning Project Savings" *are helpful resources for additional guidance on M&V development.*

6.D.2 Energy Model Refinement

If an energy model was created for the project building, the EMP should work with the client to establish procedures for the ongoing calibration and use of this model. The energy model should be updated according to the results of the M&V process. Additional planned updates to the energy model should be timed to coincide with a regular schedule, changes in building O&M practices, and/or the installation of additional ECMs and FIMs.

The baseline energy model developed earlier in the project to evaluate potential ECMs ("existing conditions") must be updated to include all modified and new systems ("as built"). As additional data from M&V becomes available, the EMP or energy modeler will continue to refine the model using this information. For example, in addition to including energy usage, demand, and cost data as inputs, the energy model may be linked to specific energy sources (e.g., to take advantage of co-generation), the timing of consumption (e.g., for less expensive off-peak power), and greenhouse gas emissions.

A thorough approach to M&V ensures that the EMP and building staff will be able to track energy use effectively on an ongoing basis. At this stage, the client has committed resources of both time and money to the project. The difference between temporary results and permanent results, however, is the capacity for the client to pursue energy management as standard practice in the months and years after the project draws to a close.

Final Acceptance Summary

*During **Phase 6: Final Acceptance**, the commissioning process is completed for both existing and newly-installed systems. The EMP prepares appropriate documentation for delivery to the client and building operations staff.*

The EMP works with the client to develop effective strategies for identifying issues related to building O&M and suggest staff training resources.

Using the meters and tools installed during the previous phase, the EMP also sets M&V in motion to verify the effective implementation of ECMs and FIMs.

*In order to maintain the new level of performance, the EMP builds on the M&V platform with ongoing data collection and analysis during **Phase 7: Continuous Energy Management**.*

7 CONTINUOUS ENERGY MANAGEMENT

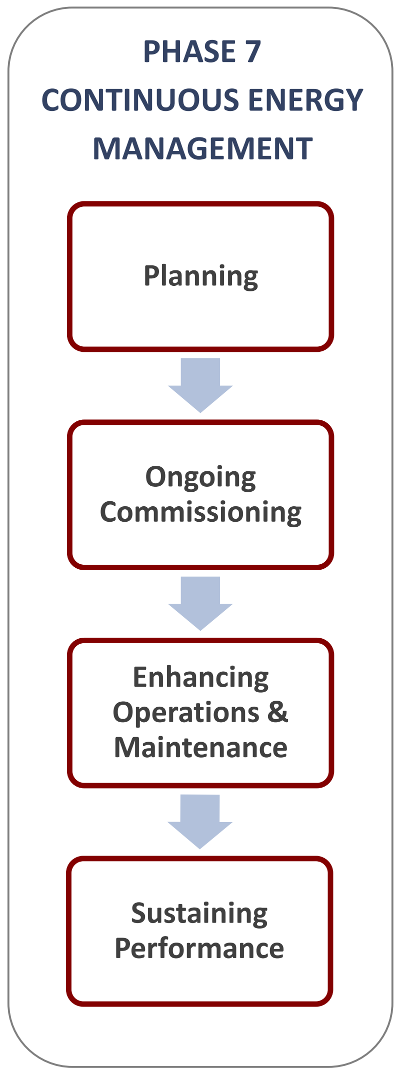
The final phase of the energy management process—Continuous Energy Management—ensures that the building maintains quality performance over time. Phase 7 involves planning and execution of strategies to continually enhance building energy usage, efficiency, and operations and maintenance. The EMP's goal is to establish energy management as an ongoing practice at the building.

The mission of the Continuous Energy Management Phase is to:

- Develop and implement an Ongoing Commissioning (OGCx) Plan.
- Use OGCx to continuously monitor energy savings from ECMs and identify problems.
- Recommend practices that will further optimize operations and maintenance.
- Establish strategies for periodic benchmarking and regular updates to energy management plans and practices.

This chapter should provide the EMP with:

- Guidance for OGCx planning and execution of various project types.
- Strategies for maintaining accurate, useful data collection during OGCx.
- Tools for continuous monitoring and periodic benchmarking.



Continuous Energy Management Outline

This phase is divided into four major subsections:

During **Phase 7: Continuous Energy Management**, the EMP assists the client with establishing energy management as an ongoing process. Regardless of the measures implemented during the project, a facility's performance will degrade over time and new issues may arise. The EMP will develop strategies for monitoring building systems, tracking energy usage, and implementing continuous improvements to ensure ongoing energy efficiency and optimum performance.

7.A PLANNING

There are several aspects involved in creating and sustaining continuous energy management. Ongoing collection and analysis of accurate data from meters and utility bills will help track success and highlight unusual usage patterns. The EMP must also account for the impact that those who operate and use the facility—including building management, operations staff, and occupants—have on energy use. The application of statistical analysis to both utility consumption data and system operating data can be used to identify points of degraded performance.

Even after M&V is complete, it is necessary to implement a strategy for ongoing monitoring and adjustment of building systems. Efficiency tends to decrease over time due to several factors. A plan for the **ongoing commissioning (OGCx)** of building systems can prevent this from happening and lay out procedures for dealing with systems issues when they do arise. Continuous performance monitoring should be detailed in an Ongoing Commissioning Plan.

Ongoing Commissioning (OGCx)

A continuous process to monitor building energy usage and resolve system inefficiencies with the goal of sustaining energy efficient performance.

The OGCx Plan may incorporate ongoing monitoring and systems adjustment, regular intervention to fix problems, implementation of new technologies, and reevaluation of energy purchasing options. These elements will ensure that energy management is established as an ongoing process at the building, continuing the progress made during the earlier phases of the project.

7.A.1 Ongoing Commissioning Plan

The scope of OGCx may vary widely depending on the facility. At some buildings, OGCx may include continuous monitoring of systems data via the BAS and digital data analysis software. For others, the process will include less intensive tasks such as monitoring a building's Energy Star score or adding additional checks to existing O&M practices.

Despite differences in scope, every OGCx Plan has two similar objectives:

1. Monitor building energy performance to confirm the persistence of energy savings from installed ECMs/FIMs.

2. Identify additional opportunities for systems optimization, which can then be resolved via new ECMs or FIMs.

When drafting the OGCx Plan, the EMP should outline how the building will monitor energy usage and how problems and inefficiencies will be addressed. These activities are assigned to one of two primary categories, continuous monitoring and issue resolution.

With respect to continuous monitoring, an OGCx Plan should include:

- List of monitored equipment
- Specific data points for each system
- Baselines used for comparison
- List of meters and submeters
- Calibration schedule for meters and submeters
- Reporting structure and schedule
- Methods of tracking EUI and energy usage data
- Testing procedures and schedule
- Description of sampling protocol

With respect to issue resolution, an OGCx Plan should include:

- Protocol for fixing identified problems
- Responsibilities of building staff and contractors
- Ongoing record of resolved issues

In a similar manner to commissioning and EBCx, OGCx should address more than just the HVAC systems. In addition to including methods for gathering, recording, and analyzing operating trend data from HVAC systems, the EMP should also include tracking of water usage, lighting energy use, and other data as appropriate.

When developing the methodology for OGCx, the EMP should establish performance baselines and indicators specific to the building's systems to verify the operational "normalcy" of implemented measures. Metrics used for analysis during OGCx should be consistent with those used throughout the project. Common metrics enable clear comparisons of the facility before and after implementation and maintain consistency as results are reported.

Measurement tools and data collection methods will have been verified during M&V. During OGCx, the EMP develops a strategy for confirming sequences of operation, monitoring systems behavior during typical building operating conditions, and resolving issues as they are identified.

7.A.2 Strategic Energy Plan

For some projects, it may be appropriate to develop a more detailed Strategic Energy Plan (SEP) that incorporates planning for installation of measures, EBCx, and other energy-related objectives as specified by the client. An SEP addresses a wider range of energy-related initiatives, and covers a longer time span.

The purpose of a comprehensive SEP is to:

- Guide the implementation of ECMs, FIMs, and EBCx.
- Describe additional energy-related project objectives and strategies.
- Propose future energy management activities.
- Provide an ongoing reference for the client and building staff.

The basic elements of an SEP will identify the information and processes necessary to commission existing and newly-installed building systems, implement ECMs and FIMs, and facilitate ongoing energy management activities in the building. The SEP will also provide a greater level of detail regarding these and other initiatives pursued by the client.

A typical SEP includes:

1. Executive Summary
2. Introduction
3. Goals and Objectives
4. Resource Use Management
5. Resource Supply Management
6. Resource Data Management
7. Financial Analysis
8. Roles and Responsibilities
9. Measure Results
10. Cost Allocation
11. Resources
12. Appendices

Many SEP's will also contain additional, more detailed planning documents, such as a plan for updates to energy purchasing, a sustainability plan, or a periodic benchmarking strategy. These additional elements may also be explored and pursued by clients when an SEP is not being developed. These and other additional elements that may be incorporated into the energy management process can be found in the "Planning: Optional Initiatives" section of Phase 5.

A detailed SEP outline is provided in Appendix H.

Appendix H

Detailed Strategic Energy Plan Outline

7.A.3 Energy Model Maintenance

The client's investment in the development of an energy model can be leveraged to provide additional value over time. Periodic updates to the model that reflect real operating conditions will enable its use as an ongoing source of building energy use information. The model can also be used to inform potential systems adjustments that may correct issues identified during OGCx.

If an energy model is prepared for a facility, it may be used to simulate specific conditions, installed equipment, operating schedules, and utility rates. Typically, the EMP or energy modeler develops simulation models with specific results or metrics in mind. The most common metric is potential energy use reduction, which is directly relatable to energy cost savings. The EMP may model a defined list of ECMs to determine the extent to which the client might benefit.

For projects that involve an energy model, the procedures and frequency for regular updates to the model should be specified in the OGCx Plan. Approaches for determining the timing of these updates may include:

- **Periodic Scheduling**

  The client may engage the EMP, or a modeling contractor, to calibrate the model on a quarterly, semi-annual, or annual basis. In the months immediately following ECM implementation, this will include updating the model to reflect the most recent M&V data. After that point, the model should be calibrated to reflect real operating conditions and real data from recent energy bills. The update schedule should take into account the importance of capturing data for both heating and cooling seasons.

- **Building Operational Changes**

  Updates to the model may be completed on an as-needed basis if a regular schedule is not sufficient to capture changes at the project building in a timely manner. For example, the EMP or energy modeler might update the model to reflect the replacement or repair of major equipment, or significant changes in building occupancy.

- **Inefficient Performance**

  Updates to the energy model may be made for the purpose of determining the causes of poor performance. When energy consumption, demand, or cost increase unexpectedly, or when potential inefficiencies are identified during OGCx, a system may be underperforming. A recalibrated energy model could help highlight the problem and determine necessary corrective actions.

7.B ONGOING COMMISSIONING

The implementation of OGCx is a continuous process involving building staff, BAS and other equipment contractors, and possibly the EMP. OGCx involves regular monitoring of building energy usage data, benchmarking, equipment inspection, and updates to baseline measurements when needed.

7.B.1 Equipment Sampling

Regular equipment inspections are included in the OGCx process to help ensure that issues and malfunctions are resolved on a timely basis. The faster potential problems are addressed, the less often they lead to long-term inefficiencies or major repair costs.

The best practice for inspecting equipment is to examine all of it. Random sampling is generally not targeted or distributed across all areas, and the process may leave essential components unaddressed. In some cases, however, sampling is appropriate or the only feasible practice. For example, an EMP may encounter hundreds of fan-powered boxes, each located in a separate tenant space, within the project building. While it would not be practical to monitor every one of these units, careful sampling will allow the EMP to monitor a representative subset.

The appropriateness of sampling also depends on the objective of the test. If the EMP is checking for a systemic issue, sampling may be a useful tool. For example, if a test is meant to identify a potential BAS programming error, this would likely impact all pieces of equipment. Testing every component would not be necessary in this instance.

Sampling may be necessary because of large numbers of equipment, testing for systemic issues, or budgetary restraints. Several strategies can be employed to produce a sample set that accurately reflects the whole. Specifically, the EMP should:

- Change the sample set during each testing period to obtain representative data. If the EMP sampled ten fan-powered boxes during one test period, ten boxes in different spaces should be tested during the next period.

- Use tests to target specific issues impacting large numbers of equipment. If the building has 300 reheat coils, the EMP might check 30 of them. Among those 30 coils, if 15 are clogged, the EMP could either recommend that all 300 be cleaned or proceed to check the remaining coils individually.

- Conduct functional performance tests on a sample of representative systems. If the system operates correctly as a whole, separate components of the system are most likely also functioning properly. The EMP should perform a test for each unique operating sequence. Sampling primary system equipment, such as chilled water plants, hot water plants, and central station air handling systems, however, is not recommended.

- Check components at the end of the system or areas that are most likely to deliver the worst results. If airflow and temperatures are correct at the end of the line, points along the way are probably operating properly as well.

When developing an OGCx proposal, an EMP might recommend sampling 100% of equipment components when possible but also develop sampling methodologies where appropriate. The EMP should be straightforward with respect to the costs associated with each strategy. The client will need to make the final decision regarding the extent of sampling.

7.B.2 Intentional Monitoring

In addition to equipment testing, energy meters and measurement tools are essential to the continuous monitoring of building operations and energy usage. The EMP should work with the client to establish ongoing strategies for gathering and analyzing trend data, refining baseline measurements, and setting performance expectations. This information will be used to continuously monitor building systems and gauge performance.

The client may also wish to pursue additional strategies to gather more detailed information regarding occupant comfort, operational efficiency, or the feasibility of advanced digital monitoring. The EMP can recommend areas for additional analysis based on project priorities:

1. **Audit for Actual Operation**

   Perform tests defined in the OGCx Plan and compare results to baseline performance or an expected sequence of operation. When results exceed thresholds based on expected performance, an equipment or programming issue may be the cause. For example, the EMP might perform an audit of building operating trends in the BAS to determine the system setpoints and the programmed occupied hours for the building. This BAS data can be compared to the actual occupancy schedule, allowing the EMP to determine if the scheduled operation matches actual use within the space.

2. **Perform a Comfort Survey**

   Energy consumption is only one aspect of building performance. If building occupants are not comfortable, utility cost savings may be negated as a result of the extra time spent by O&M staff responding to comfort calls, or by reductions in lease renewals as a result of tenant dissatisfaction. With client approval, it may be helpful for the EMP to perform a comfort survey to determine if occupants are satisfied with temperature, air quality, humidity, and lighting.

   The EMP should work with building management to develop questions and determine the best means of distributing the survey. It is also important to define specific corrective actions to be carried out by operations staff if the results fall outside of predetermined limits.

3. **Implement Digital Monitoring Strategies**

   Ongoing data collection and analysis via a digital monitoring system can provide an additional level of support for OGCx. Software platforms synched with the BAS are able to track the operations and energy use of HVAC systems. The building staff and the EMP may be alerted automatically when operations are abnormal or inefficient. The EMP and/or members of the operations staff investigate the issue and correct any outstanding problem.

   While digital monitoring programs involve upfront costs for software and BAS programming, continuous digital data collection can reduce energy waste. Such programs regularly identify problems more quickly than they might have been noticed by traditional means. As a result, systems adjustments or repairs can be made sooner, leading to greater energy savings. For some clients—especially those with large buildings and advanced controls—digital monitoring can hold significant value.

The EMP should work with the client to ensure that the tools used for intentional monitoring of building systems are both effective in their collection of representative data, and practical for implementation at the building.

CASE STUDY 7.1 **ONGOING COMMISSIONING | BUILDING B**

Building B, located in Chicago, pursued an ambitious ongoing commissioning process that included continuous digital monitoring of building HVAC systems. The process was meant to ensure persistent energy savings from eight ECMs implemented during EBCx. The BAS installed in the multi-tenant office tower monitors the operations of Building H's fifteen AHUs and four chillers, in addition to associated chilled water pumps and cooling towers.

The EMP worked with the building's chief engineer and controls contractor to install digital monitoring software that would collect data from the BAS and relay it to the EMP for analysis.

Ongoing monitoring accomplished two energy-saving objectives:

1. *It ensured that systems were performing efficiently on an ongoing basis by highlighting malfunctions or operational anomalies.*
2. *It helped identify new ECMs that may not have been otherwise recognized, even through regular monitoring of the BAS output.*

In the year following the implementation of the digital OGCx platform, the EMP identified six additional measures for implementation. These measures collectively achieved annual energy reduction numbering in the hundreds of thousands of kWh, which translated to tens of thousands of dollars in energy savings.

Because of the granularity of data provided by the new system, detailed variations in equipment operations were readily apparent. The EMP used this data to identify and develop additional ECMs, such as the measure involving the elimination of unnecessary building warm-up described in Case Study 3.1.

In addition to identifying new ECMs and monitoring the savings persistence of those measures already implemented, the EMP also developed monthly reports for the client. These two-page reports used a combination of graphs, tables, and brief narrative to describe progress towards meeting the energy savings goal outlined at the start of the project. The client was tremendously pleased with the outcome of the project and clearly recognized the value of continuing to fund OGCx.

7.B.3 Periodic Benchmarking

Benchmarking is essential during the initial phases of the project but should also be a part of continuous energy management practice. The OGCx Plan should identify the frequency of benchmarking and the team members responsible for performing it.

Ongoing monitoring via the BAS may not be feasible at the project building due to system, staff, or resource constraints. Particularly in these instances, benchmarking the building's performance on a monthly, quarterly, semi-annual, and/or annual basis will help gauge the impact of installed measures and label inefficient performance. Even if a building has a digital monitoring system in place, however, regular benchmarking still provides value. While it is essential to know how the building is performing relative to existing sequences of operation and estimates of energy use, it is also helpful to know how it is performing relative to similar buildings, or other buildings in a portfolio.

The ongoing benchmarking strategy should parallel the benchmarking practices determined during the Project Assessment Phase:

- **Use consistent metrics and units of measurement.**

  The same metrics that were used during the Phase 1 should also be used for ongoing benchmarking. This enables continual comparison of the facility's recent performance with the building's performance prior to the start of the energy management project.

- **Add additional metrics when necessary.**

  While consistent metrics should be used as the project progresses, alternative metrics and/or advanced measurements may be added. If the client is interested in gauging system-specific or emissions-related performance, the OGCx Plan can be updated to include these figures.

- **Compare results to past performance and/or similar buildings.**

  The EMP may use Energy Star Portfolio Manager, CBECS, building portfolio data, or other sources to benchmark the project building. The EMP should ensure that benchmarking standards are updated to reflect the most recent data available. Also, a best practice is to track benchmarks over time to measure project success.

Several tools are available to the EMP to assist him or her in benchmarking the building on an ongoing basis. Even if a certain tool was not used for preliminary benchmarking in Phase 1, it may be useful as the building's energy management efforts expand and diversify. Not every building is a candidate for every program. Nevertheless, the EMP should consider the following programs when developing an ongoing benchmarking strategy:

- **Energy Star**

  The EMP or client should continue to monitor the building's Energy Star rating as part of the OGCx process. The OGCx Plan should specify that the building's monthly utility bills be entered into Portfolio Manager. Some utilities offer automatic transfer of monthly billing data from the utility's database to the Energy Star database. If this service is not available, the EMP or client should assign this responsibility to a member of the building staff.

  The EMP and client should establish targets for the building's Energy Star score. Exact targets will depend on the building's type and location as well as ECM selection. Not all building types are eligible for an Energy Star rating. Since an Energy Star score is developed using the past twelve months of utility data, one full year must pass following an energy project to determine the total improvement in the Energy Star score.

- **Greenhouse Gas Accounting**

  Ongoing calculation and tracking of greenhouse gas emissions may also be included in benchmarking. The OGCx Plan should specify the scope of emissions, outline calculation methodology, and identify a tracking mechanism. Internal tracking mechanisms may be established, or an existing tool, such as Energy Star Portfolio Manager, may be used. The plan should also specify benchmarks, which may come from an internal initiative, a third-party policy document, a common industry threshold, or some other source.

  The building may benchmark only carbon dioxide, or additional greenhouse gases, such as methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride may be counted. The EMP should be as detailed as possible when laying out the chosen tracking protocol and scope of emissions.

- **LEED**

  LEED certification is a common benchmark for the design, construction, and operation of high-performance sustainable (or green) buildings. In some cases, achieving LEED certification may be a requirement for grant awards or tax advantages. In most cases, the EMP and client will have discussed certification goals during Phase 1.

  Depending on the credits pursued by the LEED project team, the documentation of EBCx and/or OGCx may be included in a building's LEED certification efforts. When this is the case, the EMP should ensure that credit requirements are taken into account when developing and executing plans throughout the entire project.

- **ASHRAE Building EQ**

  Voluntary benchmarking programs such as ASHRAE's Building Energy Quotient (Building EQ) also rate buildings on the basis of energy use. In a pilot phase at the time of publishing, Building EQ provides building ratings based on building performance as designed and as operating. Each building that participates is assigned a grade that ranges from A+ (representing net zero energy) to F (representing unsatisfactory energy use). The targeted grade level should be specified in the OGCx plan for buildings pursing Building EQ.

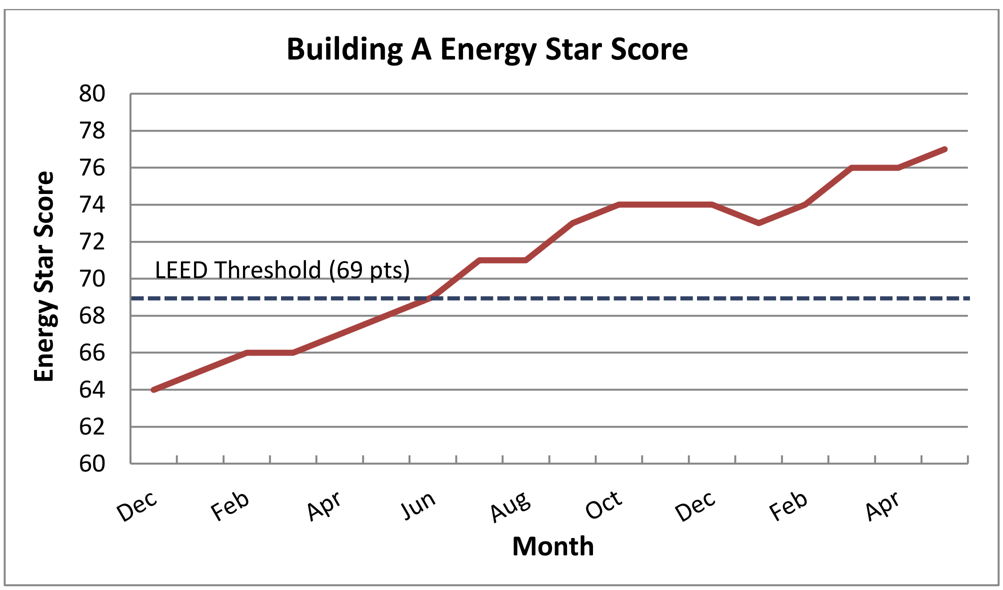
Many of the tools and programs on the list above deal not only with optimizing energy usage, but also with implementing more sustainable building operations. Sustainability has become an integral part of many buildings' energy management goals for public relations, marketing purposes, and cost savings. Incentives to encourage efficient and sustainable operations may also be available. Some utility providers and government entities provide low-interest loans and grants that are tied to energy benchmarking. For example, attaining a certain Energy Star score may release certain funding opportunities.

The EMP should facilitate the development of useful benchmarks and goals to be implemented on a long-term or ongoing basis. Even if a building is not eligible for a specific benchmarking program, the EMP should still develop an ongoing benchmarking strategy. The building's EUI may be tracked relative to CBECS data or information from similar buildings in the client's portfolio.

CASE STUDY 7.2 PERIODIC BENCHMARKING | BUILDING A

As part of the energy management efforts at Building A, the EMP helped building staff implement ongoing benchmarking through Energy Star Portfolio Manager. Since building management was hoping to achieve LEED Certification, the client was required to document its Energy Star score. During the initial phases of the project, the EMP developed several ECMs intended to reduce building energy consumption and raise the building's score. These ECMs were implemented at Building A.

Ongoing tracking through Portfolio Manager enabled the client to monitor energy use and observe the impact of their energy management efforts and the implementation of ECMs. Most of these measures were no-cost and low-cost ECMs implemented by the building's operations staff and controls contractor.



The measures were implemented in December. As the graph above indicates, Building A's Energy Star score rose steadily in the months following implementation. This trend indicates that the ECMs were achieving the goal of reduced energy consumption.

Continuous Energy Management

The LEED team working with Building A achieved LEED certification seven months after implementing the measures. Building staff continued tracking and managing their energy use after certification. The ongoing energy management strategies recommended by the EMP during the project continued to result in additional energy use reduction. The end result was an increase in Building A's Energy Star score of more than thirteen points during the eighteen months following ECM implementation.

7.C ENHANCING OPERATIONS AND MAINTENANCE

Proper operations and maintenance (O&M) practices are among the most cost-effective methods for ensuring building systems reliability and safety, as well as persistent energy efficiency. Inadequate maintenance and systems neglect are major causes of energy waste. Quality O&M ensures that the design life expectancy of equipment will be achieved, and in some cases, exceeded. Conversely, when equipment fails earlier than anticipated, replacement or repair costs usually have not been budgeted, and building management may have to scramble for a solution.

7.C.1 Recommended Practices

To ensure O&M is optimized to maintain building systems efficiency, the EMP should recommend updates to O&M practices that emphasize a reduction in financial losses related to equipment failure and poor performance. Strategies such as keeping a rigorous Maintenance Activities Log, establishing a regular maintenance schedule, and providing training opportunities for staff cost very little. These and similar best practices, however, tend to reduce maintenance costs and prevent equipment malfunctions.

The marketplace features an assortment of maintenance management systems that can assist building management and staff with their goal of maintaining a preventative maintenance program. It is important to integrate performance monitoring and maintenance programs to ensure that equipment performance degradation and equipment failure are both addressed. The EMP and client share the same goal of identifying potential issues before the piece of equipment actually fails.

The EMP should build on the O&M practices established during Phase 6 to further optimize maintenance procedures. A standard process should be followed at the onset of significant events, such as pump motor failure, fan coil unit replacement, or the release of a new version of the BAS software. The EMP should provide the

O&M staff and third-party contractors with a form to track maintenance activities. For example, the EMP could recommend that the building establish a Maintenance Activities Log. The Maintenance Activities Log records:

- Date and time
- Type and specific piece(s) of equipment
- Maintenance service performed
- Responsible staff member or contractor
- Necessary follow-up tests or additional maintenance

The O&M Manual should specify which staff members and contractors have the authority to conduct various equipment maintenance activities. The document should include references to specific chapters or tables that will provide building staff with assistance in performing routine equipment maintenance. The O&M Manual should also include lists of appropriate replacement parts and the building's authorized equipment vendors, if applicable.

The EMP may recommend the development of a regular schedule of maintenance activities. After scheduled activities are completed, the record could then be submitted to a qualified authority to ensure that the maintenance has been performed satisfactorily. For example, the in-house staff might review the work of third-party contractors, while the EMP or the EMP's colleague might review the work of the in-house staff. The results of the scheduled inspections, already verified at least once, are then sent to the appropriate manager.

Instituting O&M tracking and scheduling mechanisms may be a more significant undertaking for some clients than for others. For example, maintaining an accurate Maintenance Activities Log will be a much more detailed endeavor for a large building with several O&M staff members, as well as BAS, mechanical, and other third-party contractors. These practices can be tailored to suit the particular needs and practicalities of any building. In some cases, O&M tracking mechanisms may already in place, in which case energy management may be an effective platform from which the client can further optimize existing practices.

7.C.2 Comprehensive Training

In addition to familiarizing staff with new systems and O&M changes, training should also be an ongoing consideration for the client and the EMP. Up-to-date training for building staff will help maintain high skill levels, instill self-confidence, and leverage new technologies and strategies. Even staff who have worked with the building for years or decades will benefit from training that exposes them to current best practices and emerging trends.

7.C.2.a O&M Staff

For most buildings and their staff, O&M focuses on the component level of preventive maintenance. This perspective can easily lead to missed opportunities. Equipment may be well-maintained, but if it operates with inadequate control strategies or improper scheduling, the results may include a significant waste of energy, a reduction in its useful life, and poor indoor environmental quality.

Component-level responsibilities should only be one aspect of the training delivered to operations staff. Thorough knowledge of building operations and controls will benefit everyone who works with the facility.

Additional areas of knowledge in which it may be helpful for the EMP or another resource to provide in-depth internal training to operations staff include:

- Equipment operation schedules
- Recognition of short cycling
- Reasons that various systems cycle on and off
- Methods for locating proper setpoints
- Understanding of the parameters used in control strategies
- Return of abnormal schedules (e.g., from lockout or alteration) to their original positions
- Changes in office equipment and furniture type and placement that adversely affect temperature control

Depending on the experience level and structure of the building's O&M team, these topics could also be used to facilitate internal discussions that lead to strategies for further training and process improvement. These meetings would be coordinated with the client and/or building management. Additional information describing systems-related and equipment-related training offered through professional organizations, manufacturers, and other resources was provided in Phase 6.

7.C.2.b Non-O&M Staff

Energy management also provides an opportunity for all building staff, not simply operations staff, to optimize activities and processes related to energy and/or building operations.

Practices that efficiently address potential equipment problems or emergency situations may be relevant to additional members of the building staff. Staff members involved with tenant communications will also have an impact on the timing and accuracy of resolving issues related to systems operation in occupied spaces. Sufficient training and open communication channels for all staff will help ensure prompt and efficient responses to potential issues.

All building staff should coordinate their activities with those performed by third-party contractors and other internal teams. The work performed by one party should not cancel out, or duplicate, the work performed by another. Similar to the best practices outlined for operations staff, creating logs and schedules, outlining responsibilities, and taking advantage of training opportunities will help other staff members who manage building operations.

Activities might include establishing a clear communication protocol in the event that equipment malfunctions or an occupant reports a problem. Training in the specific areas for which they bear some responsibility should also be provided to staff members. The EMP may suggest training resources to the client or building owner. For example, building management staff should be trained in the use and troubleshooting of emergency response systems.

Depending on building type and function, occupants may need to be trained in the use of lighting controls and thermostat functions, such as allowable temperature adjustment range or temporary unoccupied override. Familiarity with the systems in their spaces will, ideally, reduce the number of maintenance calls and lead to reduced energy usage in individual spaces.

The O&M Plan should also confirm or require that third-party contractors undergo training specific to the equipment on which they are contracted to work.

7.C.2.c Re-Train & Refresh

Due to employee turnover and intentional or unintentional departure from standard procedures, staff training often constitutes “re-training.” The EMP could recommend scheduling an annual training session to refresh staff knowledge and cover the mechanics of each system and component.

Building management can engage expert in-house staff to conduct the training for other staff members. It may also be helpful to have representatives from manufacturers provide annual educational sessions regarding the use of their equipment.

If the EMP is contracted to be involved in training sessions, the EMP might use this opportunity to ask and field questions about vibration, leakage, excessive cycling, and other issues. Staff may offer observations regarding the mechanics of a system that may warrant further investigation but not emergency repair. Effective energy management at a building requires the collective effort of all staff involved in some capacity in its daily operation.

CASE STUDY 7.3 ENHANCING OPERATIONS AND MAINTENANCE | BUILDING C

At Building C, located in New York, three ECMs were identified and implemented as part of the energy management program. These measures involved adjusting night temperature setpoints, optimizing chilled water freeze protection operation, and implementing optimum start and stop on AHU fans. All three of these measures were implemented by building staff in coordination with the EMP and the controls contractor.

Trends were put in place so that building operations staff could monitor the changes made during ECM implementation and ensure that energy savings were realized continuously. The implementation of these measures also required staff to become accustomed to changes in building operations. For example, the AHUs started running much later in the morning due to the optimum start programming.

The EMP helped coordinate a training session for building staff. This event included a review of changes implemented during the project as well as a training update by the building's BAS contractor. The facilities manager used the training as an opportunity to implement formalized tracking for general systems maintenance, BAS changes, and responses to occupant hot and cold calls. One junior member of the staff was put in charge of maintaining accurate logs tracking O&M activities.

In addition to implementing ECMs and updating O&M practices at Building C, the client used the energy management project to develop best practices for use at another building on the same city block. This building, which the client also managed, had a similar BAS, occupancy profile, and O&M practices.

Due to the success of the measures at Building C, the ECM involving optimum fan start and stop was implemented at the other building as well. The other building also implemented some of the O&M changes pursued at Building C, including the staff training and up-to-date O&M activities logs.

7.D SUSTAINING PERFORMANCE

Energy management is an ongoing process. The EMP should emphasize to the client that for energy management to be sustainable, it must be continual.

The EMP, in consultation with the client, should determine appropriate intervals at which project planning documents, goals, and baselines should be updated and revised. Items that may be reviewed regularly include:

- Utility Consumption Analysis
- M&V Reporting (1st and 2nd years following project completion)
- OGCx Reporting (subsequent years)
- O&M Manual

Depending on project structure, these updates may also provide an opportunity for refreshing project elements such as emissions reporting or revisiting the commodity purchasing strategy. The EMP may wish to schedule occasional meetings with the client to review building performance, energy savings, and any new performance problems.

Assuming that no major issues are discovered, the EMP's review with the client may include:

- A general overview of the facilities operation.
- Advice about the implementation of new technologies.
- Specific recommendations that involve minor capital expenses and operational changes.
- Suggestions for local incentive programs or tax credits for additional energy management activities.

If significant issues are discovered, such as an unanticipated spike in energy usage, or a major equipment malfunction, resolution will be addressed as part of the OGCx process.

By engaging an EMP to follow the EMA Energy Management Process, the client has invested in a thorough and rigorous project. The EMP led the process, developing project analyses, reports, and plans to meet the client's energy and sustainability goals.

These plans were implemented through the installation of ECMs and FIMs, commissioning of new and existing building systems, and establishment of continuous energy management activities. Resources have been provided to support the ongoing development of the staff responsible for operating the building on a daily basis.

In order to achieve its maximum level of effectiveness, energy management must be an ongoing consideration for the client. The EMP has laid the groundwork for continuous work with respect to increasing energy efficiency and optimizing performance at the project building.

CONTINUOUS ENERGY MANAGEMENT SUMMARY

During ***Phase 7: Continuous Energy Management****, the EMP develops an Ongoing Commissioning Plan to ensure that measures produce the expected level of energy savings, and to routinely monitor building operations to identify any new issues.*

Recommendations are made for optimizing O&M practices, incorporating benchmarking into operations, and revisiting project documents. Current building operations are continually examined to refine the baseline level of performance and further advance the client's goals.

By the close of the project, the EMP has provided the client with documents, plans, and strategies to sustain a high level of building energy performance on a continuous basis.

G GLOSSARY

Annual energy balance	Estimated measure of the amount of energy consumed by various building systems.
Annual usage profile	Illustration of historical building energy consumption over a one-year period.
Blended rates	Energy supply rate that reflect a weighted average of both the fixed and variable market rates that are effective for various quantities of the same energy source during the same time period.
Benchmarking	Quantifying the relative performance of a facility by comparing its performance metrics with those of similar facilities.
Building Automation System (BAS)	Computerized control system designed to monitor mechanical and lighting systems in a building.
Building investigation	Examining and testing building systems in-depth, collecting data regarding systems, operations, schedules, occupancy, and energy use.
Carbon footprint	Measure of greenhouse gas emissions produced by the activities of a building, operational process, or organization.
Client consultation	Initial discussion between a client and EMP to gather basic information about the site and establish goals for an energy management project.
Commissioning Authority	An independent professional responsible for planning, organizing, and implementing commissioning activities for newly-installed systems.
Commissioning Report	Document detailing commissioning activities, results of functional performance testing, and strategies for resolving further deficiencies.
Consumption correlation analysis	Regression analysis that determines the correlation between building energy consumption data and historical weather data.

Cooling degree day	Measurement of the positive difference when base temperature of 65°F is subtracted from actual average daily temperature. Used to characterize the demand for energy needed for cooling.
Correlation coefficient	Metric representing the strength of correlation between the predicted value of a statistical model and actual value. Measure ranges from 0 (no correlation) to 1 (exact correlation).
Cost of construction	Detailed costs associated with the implementation of an ECM, FIM, or group of measures.
Data loggers	Commercially available digital devices installed temporarily on a specific piece of equipment or specific building area in order to measure and record variables such as light, temperature, amperage, and relative humidity at certain time intervals.
EBCx Report	A document detailing the results of functional testing, TAB, and O&M review during the EBCx process.
EBCx Scope	A document detailing systems to be examined, proposed functional performance tests, and TAB activities, to be included in the EBCx process.
ECM/FIM Report	Report prepared for a client outlining in-depth analysis performed for proposed measures, including savings estimates, implementation costs, and preliminary timeline.
ECM matrix	A table that outlines ECM costs, payback periods, and other potential values for the purposes of ranking by the EMP and client.
ECM-isolation simulation	Energy simulation model that represents the results of implementing an individual ECM/FIM.
Energy conservation measures (ECMs)	Building operational improvements, equipment installations, or other upgrades that provide energy payback, regardless of initial cost. Reduced energy consumption leads to savings on monthly bills.
Energy consumption analysis (ECA)	Detailed study of a facility's historical energy consumption.

Energy model	A digitally-generated simulation of building systems operation. Also referred to as a "simulation model."
Energy Plan Outline	A review of building analysis and investigation, as well as proposed ECMs, presented to the client. May be developed into a full Strategic Energy Plan depending on project.
Energy service company (ESCO)	A business that develops, installs, and arranges financing for projects focused on improving energy efficiency.
Energy use index (EUI)	A building's or building system's energy use divided by the applicable area for a certain period of time. Often expressed as kBtu/ft^2/year. Also referred to as "energy usage index" of "energy use intensity."
Energy use exploration	Use of field experience, data measurement, and analysis to define and quantify energy-saving possibilities as they relate to client goals.
Existing building commissioning (EBCx)	A process that implements improvements to existing building controls and other systems. EBCx also involves testing and balancing.
Existing Building Commissioning (EBCx) Plan	Detailed outline of procedures, costs, and responsibilities associated with the commissioning of existing energy-consuming systems that will remain in the building.
Facility improvement measures (FIMs)	Actions or installations that improve building performance but provide no energy payback. Most benefits are not related to energy. Many, but not all, FIMs have a positive impact on operations.
Heating degree day	Measurement of the positive difference when actual average daily temperature is subtracted from base temperature of 65°F. Used to characterize the demand for energy needed for heating.
Interval data	Detailed data regarding building energy usage over specified periods of minutes, hours, and days. Available from many electric utilities.
Investment proposal	Proposal submitted for client consideration that details costs and savings estimates for ECMs/FIMs, as well as the EBCx scope of work.

Leadership in Energy and Environmental Design (LEED)	A green building certification program that helps design teams and building operators construct and maintain facilities in an energy-efficient and sustainable manner.
Lifecycle cost	A metric that incorporates costs and benefits over the course of a building's or a product's existence.
Night walk	A follow-up visit to investigate and observe building systems conducted during unoccupied hours.
Occupancy profile	Data set representing the typical hours a building is occupied, as well as occupancy numbers and locations.
Ongoing commissioning (OGCx)	A continuous process to monitor building energy usage and resolve system inefficiencies with the goal of sustaining energy efficient performance.
Owner's Project Requirements (OPR)	Document outlining how a building is to be designed and operated to fulfill the needs of building ownership.
Preliminary assessment	Initial walk-through of a building in which the EMP observes building operations, interviews staff, and assesses potential opportunities for energy savings.
Real estate investment trust (REIT)	A company that produces a majority of its income from property ownership and returns over 90% of its taxable income to shareholders.
Return on investment (ROI)	A metric used to calculate the efficiency of payback on a financial expenditure.
Savings statement	Detailed estimates of energy savings, cost savings, and other metrics as identified by the client, associated with the implementation of ECMs and FIMs.
Seasonal peak	In terms of climate, a high point in a building profile related to changes in outside air temperature, during which the greatest amount of energy usage is required.
Seasonal trough	In terms of climate, a low point in a building's profile related to changes in outside air temperature, during which the least amount of energy usage is required.
Simple payback	A measurement (in years) of the time it will take for a client to gain back funds invested in an ECM. Calculated by dividing measure installation cost by annual cost savings.

Strategic Energy Plan (SEP)	A living document prepared for a client that establishes long-term energy consumption goals as well as financing strategies and plans for equipment replacement
Thermographic imaging	Process for evaluating heat transfer irregularities, often used to identify heat lost via the building envelope.
Trend data	The collection of data for a point or points at a given frequency over a specific time frame. Often gathered via a BAS.
Utility consumption analysis (UCA)	Detailed study of a facility's historical energy consumption, also referred to as "energy consumption analysis".
Utility tariff	A schedule of rates or charges associated with purchase and use of energy from a utility.
Utility rate analysis	Study of a facility's current and historical energy usage and cost in individual and common units of measurement.
Whole-building simulation	An energy model that represents the operations of all building systems simultaneously as opposed to a specific system or area of a building.

Appendix A | Sample Client Consultation Materials

During the client consultation, the EMP meets with the client to gather initial information about the building, operating practices, and project objectives. The EMP should develop a list of questions to ask and information to gather prior to the meeting. It may also be helpful to develop a brief agenda based on this outline, which can be sent to the client in advance. This will help both the EMP and the client prepare for the consultation and can be used to guide the meeting itself.

Client Consultation Outline

I. Project Goals and Objectives

Why are we meeting?

- Costly energy bills
- Whole building issues
- Specific system issues
- Need to reduce energy consumption
- Utility rebate programs
- Energy Star
- LEED EBOM

Do you have any specific goals you want to accomplish?

II. General Building Information

Can you tell me about the building?

- Square footage?
- Age?
- Occupant types and locations?
- Sources of heating and cooling?

Does the building have an Energy Star Score?
Do you know the building's Energy Use Index?
Do you have copies of your utility bills?
Do you have a floor plan or plans of the building?

III. Project-Specific Information

Are there major concerns or problems with building operations?

- Excessive hot or cold calls
- Ventilation or air movement issues
- Energy costs seem too high
- Problems with BAS

IV. Building Systems

Can you tell me about specific systems?

- Cooling
- Heating
- Main AHUs
- Terminal units
- BAS

Have you done any energy-related improvements to equipment?

- Efficient lighting upgrades
- Installation of VFD
- High-efficiency equipment

Client Consultation Agenda

DURATION: 1.5 hours
ATTENDEES: Facility Manager, Chief Engineer, EMP
PURPOSE: To establish goals and gather building information to inform and develop a successful energy management project.

I. Project Goals and Objectives

- Meeting purpose
- Specific project goals

II. General Building Information

- Information gathering
- Energy Star and EUI
- Utility data
- Floor plans and drawings

III. Project-Specific Information

- Major concerns or problems with building operations
- Whole-building and/or specific system issues

IV. Building Systems

- Gathering systems information
- Previous energy-related improvements

Appendix B | SAMPLE PRELIMINARY ASSESSMENT OUTLINE

During the preliminary site assessment, the EMP performs a walk-through of the building, preferably accompanied by a member of building staff, to ask questions and gather basic information about how the building's systems currently operate. The EMP should develop an outline of the assessment that can be used to guide the process and help the EMP prepare for the visit.

Preliminary Assessment Outline

Duration: 7.5 hours

Participants: Building Engineer or Facility Manager; EMP

Items needed:

- Proper protective equipment, if necessary
- Notebook
- Camera
- Thermometer/Humidity sensor
- Light meter
- Multi-meter
- Flash Drive / portable memory drive
- Data loggers: temperature/humidity/light/current

I. BAS Review (~ 1.5 hours)

Use this time to review the BAS and all equipment that is controlled by the BAS. This will be a good time to take notes about specific pieces of equipment to help determine what you will look for when you visit that piece of equipment. If there is a computer interface, review each operating screen. Take screenshots and save on your flash drive.

Possible questions:

- Do you have an as-built set of BAS drawings?
- Do you have a copy of the sequence of operations for the equipment?
- What equipment do you control with the BAS?
- What are the major concerns with the BAS?
- Do you have schedules the automatically start and stop equipment?
- What are the typical setpoints for spaces and discharges?
- What sequences do you use? Economizer? Optimum start/stop? Temperature reset? Demand control ventilation?

- Are you able to make adjustment to setpoints or schedules?
- Can you trend data with the system?
- Is the system accessible via the internet?

II. Central Plant: Chiller Review (~1.5 hours)

Take pictures and record measurements of supply and return temperatures. Record information such as the time, outside air temperature, and humidity. Record the position of any bypass valves.

Possible questions:

- What is the age, size, efficiency of the chillers?
- Are there problems meeting loads?
- Do you feel it is over/under sized?
- What are your typical supply and return temperatures?
- Are VFD's used?
- Have building loads changed since the systems were installed?
- When was the last time the water flows were rebalanced?
- Does the building utilize primary, secondary, tertiary pumping?
- Are any electricity meters or submeters dedicated to serving the central chilled water plant?

Take pictures of the following:

- Chiller
- Chiller nameplate
- Chilled water supply and return temperatures at the thermometers
- Chiller water piping configurations.
- Pumping configurations
- Note which pumps are operating.

Also take video and narrate what you are looking at to reference later.

III. Central Plant: Boiler Review (~1 hour)

Take pictures of the system. Visually inspect the boiler and steam vents. Inspect insulation on the boiler, piping, and ancillary systems and valves.

Possible questions:

- What are the age, type, and size of the boiler and ancillary systems?
- For steam boilers, what is the pressure rating?
- Is a boiler maintenance program in place?
- Is a steam trap maintenance program in place?

Take video and narrate what you are looking at to reference later.

IV. Air Handling Units (~1 hour)

Ask staff about AHU maintenance and operations. Identify the areas served by each AHU. Note any VFD's, inlet vanes, or outlet vanes. Inspect economizer controls, damper positions, sensor locations, and safties.

Possible questions:

- Have any repairs or upgrades been made to any AHUs?
- Does the building have any indoor air quality or temperature issues?
- Does each AHU have pre-heat, cooling, or heating cols?
- Are coils steam, hot water, chilled water, or direct expansion heat exchangers?

Take video and narrate what you are looking at to reference later.

V. Occupant Spaces; Terminal units; Lighting (~2 hours)

Look for signs of indoor environmental quality issues. Listen for mechanical noises, and be aware of temperature in occupant spaces. Document terminal air units and terminal heat units. If necessary, take a light fixture count. Note types and locations of motion sensors or daylighting controls.

Possible questions:

- Does the building receive frequent hot or cold calls?
- Have any lamps been removed in occupant spaces?
- What types and quantities of terminal units are installed?
- What is the condition of terminal units?
- What types and quantities of lamps and ballasts are in place?

If possible and appropriate, ask occupants about their comfort and building conditions. Take video and narrate what you are looking at to reference later. Review MEP drawings, floor plans, and other available drawings either before the Assessment if they are provided, or immediately after the Assessment.

VI. Wrap-Up (~30 minutes)

- Collect any last-minute documents and make copies.
- Arrange a meeting to discuss findings and initial thoughts
- Wrap up, and provide a timeline for following up with a call or next meeting.

Appendix C | ENERGY STAR PORTFOLIO MANAGER TOOL

The Energy Star Portfolio Manager tool shows current, baseline, and target scores based on up-to-date energy usage information. The online platform allows for the designation of multiple types of spaces, different pieces of equipment, and unique occupancy profiles within a building. All of these data points are factored into the building's Energy Star score. The tool accommodates monthly energy use data for as many energy sources, accounts, and meters as are necessary to fully describe the building's energy profile.

ENERGY STAR PORTFOLIO MANAGER ACCOUNT INFORMATION

Home > My Portfolio > Sample Facility > **Edit Office Space**

Edit Office Space: office 1

To edit a space attribute, please select the "Edit" link at the far right of each row.

REQUIRED

***Space Name:** office 1 CANCEL SAVE

Current Space Attribute Values What is this?

Space Attribute	Space Attribute Value (Temporary values should only be used if an Actual value is not currently known) What is this?	Use Default Value	Units	Effective Date (when this Attribute Value was first true) What is this? (MM/DD/YYYY)
Gross Floor Area (required for benchmarking)	2000	N/A	Sq. Ft.	01/01/2006
Weekly operating hours (required for benchmarking)	100		Hours	09/01/2006
Workers on Main Shift (required for benchmarking)	10			01/01/2006
Number of PCs (required for benchmarking)	10			01/01/2006
What percent of this space is air-conditioned? (required for benchmarking)	50% or more			09/01/2006
What percent of this space is heated? (required for benchmarking)	50% or more			01/01/2006

The screenshot above is a typical representation of a Portfolio Manager data input page. The tool's appearance is subject to change as improvements are made over time. Visit the Energy Star website (www.energystar.gov) and create a new Portfolio Manager account or log into an existing account to view the current version.

Appendix D | Commercial Building Energy Consumption Survey

Funded by the federal government of the United States, the Commercial Building Energy Consumption Survey (CBECS) provides publicly-accessible data and summary tables of commercial building energy usage by building type, energy source, building systems, and several other variables. Historically, the survey itself has been conducted every four years, and the data has been processed and published two or three years later.

Released: Dec 2006
Next CBECS will be conducted in 2007

Table C10. Consumption and Gross Energy Intensity by Climate Zone[a] for Non-Mall Buildings, 2003

	Sum of Major Fuel Consumption (trillion Btu)					Total Floorspace of Buildings (million square feet)					Energy Intensity for Sum of Major Fuels (thousand Btu/ square foot)				
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
All Buildings*	990	1,761	1,134	1,213	724	10,622	17,335	11,504	15,739	9,584	93.2	101.6	98.5	77.0	75.5
Building Floorspace (Square Feet)															
1,001 to 5,000	143	187	90	170	95	1,313	1,709	1,010	1,915	975	108.7	109.6	88.8	89.0	97.9
5,001 to 10,000	110	137	91	156	69	1,248	1,725	1,077	2,024	959	88.1	79.3	84.6	77.1	71.7
10,001 to 25,000	183	286	146	166	118	2,406	3,506	1,498	3,176	2,073	75.9	81.6	97.6	52.3	56.9
25,001 to 50,000	146	212	125	152	107	1,547	2,424	1,382	2,381	1,647	94.4	87.6	90.3	63.7	64.8
50,001 to 100,000	149	273	183	191	118	1,480	2,780	2,011	2,352	1,668	100.8	98.0	90.8	81.2	70.6
100,001 to 200,000	117	336	187	283	141	1,311	2,889	1,881	2,597	1,538	89.4	116.3	99.2	109.1	91.7
200,001 to 500,000	129	226	168	136	94	1,150	2,007	1,678	1,612	1,047	111.8	112.5	99.8	84.1	89.6
Over 500,000	Q	272	254	132	Q	1,073	1,766	1,966	1,573	1,282	Q	153.8	129.4	83.9	Q
Principal Building Activity															
Education	141	238	131	186	123	1,537	2,800	1,403	2,435	1,698	91.6	85.2	93.5	76.6	72.6
Food Sales	Q	Q	Q	Q	Q	271	368	Q	273	Q	Q	Q	Q	Q	Q
Food Service	52	96	Q	134	Q	227	400	219	440	366	230.1	238.7	Q	305.4	Q
Health Care	96	161	108	145	83	475	784	564	844	496	202.4	205.8	191.4	171.9	167.7

The screenshot above depicts an excerpt of Table C10 from a recent CBECS survey. This table lists average energy intensity according to climate zone and building characteristics such as floor space, activity, year of construction, number of floors, and weekly operating hours. The figures in this table were released in 2006 and are based on the CBECS survey conducted in 2003. Visit the CBECS website (www.eia.gov/emeu/cbecs/contents.html) to view many additional tables and future updates.

Appendix E | Energy Units and Conversion Factors

There are numerous units used throughout the energy industry to describe consumption. The following tables are intended to be representative but not exhaustive. The conversion factors are drawn from reputable sources such as the U.S. Department of Energy. The EMP should be familiar with the common energy units and be comfortable converting from one to another. A best practice for the EMP to follow is to always list the descriptive unit next to any figure.

Energy Unit	Standard Abbreviation	Common Uses	Conversions
British thermal unit	Btu	Multiple Fuels Calculations	1 Btu = 1,055 J 1 Btu = 1.055 kJ 1 Btu = 1.055 × 10^{-3} MJ 1 Btu = 252 cal 1 Btu = 0.252 kcal 1 Btu = 2.93 × 10^{-4} kWh 1 Btu = 10^{-5} therm 1 Btu = 10^{-3} kBtu 1 Btu = 10^{-6} MMBtu
calorie	cal	Calculations	1 cal = 3.966 × 10^{-3} Btu 1 cal = 4.184 J 1 cal = 10^{-3} kcal 1 cal = 1.162 kWh
dekatherm		Natural Gas	1 dekatherm = 10 therms 1 dekatherm = 10^{6} Btu
erg (CGS Unit)		Calculations	1 erg = 1 g cm^2 / s^2 1 erg = 10^{-7} J
gigajoule	GJ	Calculations	1 GJ = 1,000 MJ 1 GJ = 10^{6} kJ
gigawatt-hour	GWh	Electricity	1 GWh = 1,000 MWh 1 GWh = 10^{6} kWh
joule (SI Unit)	J	Calculations	1 J = 1 kg m^2 / s^2 1 J = 9.48 × 10^{-4} Btu 1 J = 0.948 kBtu 1 J = 948 MMBtu 1 J = 10^{-3} kJ 1 J = 10^{-6} MJ 1 J = 10^{-9} GJ 1 J = 2.78 × 10^{-7} kWh 1 J = 0.239 cal 1 J = 2.39 × 10^{-4} kcal

Energy Unit	Standard Abbreviation	Common Uses	Conversions
kilocalorie	kcal or Cal	Calculations	1 kcal = 3.966 Btu 1 kcal = 4.184 × 10^{-3} J 1 kcal = 1,162 kWh 1 kcal = 1,000 cal
kilojoule	kJ	Calculations	1 kJ = 1,000 J 1 kJ = 10^{-3} MJ
kilowatt-hour	kWh	Electricity	1 kWh = 3,412 Btu 1 kWh = 3.412 kBtu 1 kWh = 3.412 × 10^{-3} MMBtu 1 kWh = 3.6 × 10^{6} J 1 kWh = 3.6 × 10^{3} kJ 1 kWh = 3.6 MJ 1 kWh = 860.4 kcal 1 kWh = 0.8604 cal 1 kWh = 0.03412 therm
megajoule	MJ	Calculations	1 MJ = 947.8 Btu 1 MJ = 238.8 kcal 1 MJ = 0.278 kWh
megawatt-hour	MWh	Electricity	1 MWh = 1,000 kWh 1 MWh = 10^{-3} GWh
million British thermal units	MMBtu	Multiple Fuels Calculations	1 MMBtu = 10^{6} Btu 1 MMBtu = 1,000 kBtu 1 MMBtu = 1,055 MJ 1 MMBtu = 293.1 kWh 1 MMBtu = 10 therms 1 MMBtu = 1.0545 GJ
quad		Calculations	1 quad = 10^{15} Btu
therm		Natural Gas	1 therm = 10^{5} Btu 1 therm = 1.055 × 10^{8} J 1 therm = 28.83 kWh
thousand British thermal units	kBtu	Multiple Fuels Calculations	1 kBtu = 1,000 Btu 1 kBtu = 10^{-3} MMBtu

The purest way to describe energy is in terms of heat content (e.g., J or Btu). For practical reasons, however, it is helpful to speak of masses and volumes of physical fuel types such as oil, coal, and natural gas. The particular formulation and quality of liquid and solid fuels such as oil and coal will determine the actual heat content. Similarly, the specific pressure and composition of gaseous fuels such as natural gas will determine the actual heat content.

Some of the most common volumetric measurements for fuel use in the U.S. include:

1 barrel (42 gallons) of crude oil = 5,800,000 Btu
1 gallon of gasoline = 124,238 Btu*
1 gallon of diesel fuel = 138,690 Btu
1 gallon of heating oil = 138,690 Btu

1 barrel of residual fuel oil = 6,287,000 Btu
1 cubic foot of natural gas = 1,025 Btu*
1 gallon of propane = 91,333 Btu
1 short ton of coal = 19,858,000 Btu*

* *Conversion factors of these sources are based on the U.S. average from a recent year.*

Natural gas is a particularly common energy source in buildings, but a variety of common energy units are used to describe consumption. Since the actual heat content of a given volume of natural gas is highly dependent on both its pressure and temperature, utility bills will often list specific conversion factors, which may change from one month to the next.

Besides Btus and therms, common units for expressing the amount of natural gas include:

1 cf = 1 cubic foot
1 ccf = 100 cubic feet
1 mcf = 1,000 cubic feet

Using the factor above equating 1 cubic foot with 1,025 Btu, additional factors include:

1 ccf = 102,500 Btu
1 mcf = 1,025,000 Btu
1 ccf = 1.025 therm
1 mcf = 10.25 therm
1 therm = 0.9756 ccf
1 therm = 0.09756 mcf

In addition to these energy units, the EMP should be familiar with units for measuring various equipment parameters, lighting fixtures ,greenhouse gas emissions, water consumption, and possibly other physical properties.

Appendix F | Sample Detailed ECM Description

The following tables present a variety of information pertaining to an ECM involving the installation of CO_2 sensors in the entranceway and lobby of a building. The ECM has already been implemented. The form serves as documentation. The EMP has provided a summary of the measure, savings calculations, methodology, implementation plan, cost calculations, and evidence of verification.

GENERAL INFORMATION	
EMP Firm	Sieben Energy Associates
EMP Name	Adam B.
Project Name & Address	1 N. Energy Avenue
Date of ECM Finding	April 21

MEASURE SUMMARY	
ECM Description	Incorporate Demand Control Ventilation on AHU-3.
Impacted System(s)	AHU-3
Impacted Sub System(s)	EF -3, Chiller 1, and BAS
ECM Narrative	AHU-3 is a 40,000 cfm constant-volume AHU that serves the main building entranceway and lobby. The unit provides conditioned air and is controlled by multiple zone sensors throughout the space. Fresh air is mixed with return air and then conditioned to maintain a space temperature of 67°F during the heating season and 72°F during the cooling season. Conditioned areas include the primary building entrance and public lobby, which features a vaulted ceiling. CO_2 measurements indicate that levels never exceed 500 ppm even during high traffic times, which are typically between 9:00 am and 5:00 pm. The installation of CO_2 monitors will help control the amount of fresh outside air that is conditioned by AHU-3. When CO_2 levels are below the code requirement of 900 ppm, the outside air dampers can be closed and the quantity of outside air can be reduced. Should CO_2 levels rise above minimum requirements, the outside air dampers will be allowed to open until CO_2 levels have once again reached an acceptable level.

Appendices

SAVINGS CALCULATIONS	
Savings Calculation Process	1. Review energy and cost savings calculations. 2. Using existing spreadsheet tools, update the calculations based on the results of the Focused Assessment and Data Acquisition Summary. Enter setpoints, temperatures, airflows, run times, schedules, efficiencies, etc. 3. Provide values of energy and cost savings.
Monthly Average Demand Savings (kW)	0
Annual Energy Savings (kWh)	149,226
Annual Electric Cost Savings ($)	$11,386
In-house Labor (hrs)	5
Electrician Time (hrs)	14
BMS Programmer Time (hrs)	8
BMS Tech Time (hrs)	16
In-house Labor Hourly Rate ($)	$70
Electrician Hourly Rate ($)	$85
BMS Programmer Hourly Rate ($)	$150
BMS Tech Hourly Rate ($)	$125
Material Cost ($)	$2,700
Total Implementation Cost ($)	$7,440
Rebate/ Incentive Value ($)	$0
Simple Payback (yrs)	0.65

SAVINGS CALCULATION METHODOLOGY	
Summary	1. Measure CO_2 values and record outside air damper positions and air volumes. 2. Calculate typical energy use for one full year based on average daily temperatures, outside air volumes, and heating and cooling load values. 2. Calculate projected energy use as a result of reduced outside air volumes if achieved through demand control ventilation. 3. Subtract pre-ECM energy usage from post-ECM energy usage.
Trending and Data Collection	Trend data collected and analyzed: • CO_2 levels in the entranceway and lobby • Discharge air temperature from AHU-3 • Mixed air temperature from AHU-3 • Outside air temperature • Outside air damper position • Chilled water cooling valve positions on AHU-3
Supporting Graphs	Supporting pictures, software screenshots, and necessary graphs are separately provided.

IMPLEMENTATION PLAN	
Scope of work	Incorporate a Demand Control Ventilation sequence on AHU-3. This will require the installation of two CO_2 sensors in the entranceway and lobby area. The sensors will signal modulation of outside air damper positions to maintain the CO_2 level below the code threshold of 900 ppm. Outside air dampers on AHU-3 will open and close to maintain a CO_2 level in the space below a setpoint of 900 ppm. The dampers will modulate to meet the sensor with the highest CO_2 level. Should levels exceed the setpoint of 900 ppm for more than 15 minutes, an alarm at the operators' workstation will be triggered.
Material	Two wall-mounted CO_2 sensors with accuracy of +/- 5%.
Third-Party Labor	Electrician BAS programmer Temperature control contractor
Major Hurdles	Routing of sensor wire back to the control panel in basement.

COST CALCULATIONS	
Material	\$500 per CO_2 sensor. Online pricing from ACME Controls.
Third-Party Labor	14 hours of electrical installation work from J&J Electrical Co. Hourly rate: \$85/hour 24 hours of controls work from ACME Controls (8 hours for the programmer, 8 hours for the technician, and 8 hours of testing and trending). Hourly rate: \$125-\$150/hour
In-House Labor	5 hours of the building engineer's time.

VERIFICATION	
Summary of Completed work	CO_2 sensors were installed on the north and south walls of the lobby. DCV sequence was installed and tested. See attached graphs and pictures.
Changes to Measure or Scope	An additional control board was needed to accommodate the CO_2 sensors. Total ECM cost increased by \$1,700.
Changes to Savings Calculation	None.
Functional Testing	CO_2 level setpoints are raised and lowered to show dampers modulating to meet setpoint and trigger alarms.
Trending	Identified points in the calculation section are trended.
Persistence	The measure is tracked continuously to confirm that CO_2 levels and damper positions meet test results.
Training	Bob S., Building Engineer, was last trained on this measure on June 27.

Appendix G | Sample ECM Matrix and Sample FIM List

The following sample ECM Matrix, which is split across two pages, provides detailed financial analysis of nine different ECMs for a project. The FIM List further below provides examples of FIMs that were developed for the same project.

ECM #	Measure Description	Annual Electric Energy Savings (kWh/yr)	Avg. Monthly Electric Demand Savings (kW/mo)	Annual Electric Cost Savings ($/yr)	Annual Natural Gas Savings (therms/yr)	Annual Natural Gas Cost Savings ($/yr)	Implement-ation Cost ($)	Simple Payback (years)
1	Turn Off Air Handling Units Serving New Event Center during Unoccupied Hours	36,420	0	$2,667	0	$0	$2,280	0.85
2	Operate AS-21 Only When Laundry Is Being Used	7,159	0	$524	5,122	$4,393	$8,650	1.76
3	Coordinate Operation Schedules of Kitchen Exhaust Fans and MAUs with Kitchen Use	51,068	0	$3,740	26,300	$22,556	$6,890	0.26
4	Repair Electric Radiant Floor Heating Controls	62,458	0	$4,574	0	$0	$6,600	1.44
5	Repair Base Board Heating Controls	485,682	0	$34,304	44,446	$0	$1	0.00
6	Optimize Chilled Water Pump Freeze Protection	245,286	0	$19,272	0	$0	$0	0.00

This ECM Matrix includes both no-cost/low-cost and capital measures, although none of the ECMs are particularly expensive. It is clear that most of the nine ECMs have a simple payback of fewer than two years. ECM #8 has a slightly longer payback, and ECM #9 has an extremely long payback. In fact, the repair or replacement of faulty dampers may be recommended as an FIM instead of an ECM, given the significant cost and minimal energy savings.

ECM #	Measure Description	Annual Electric Energy Savings (kWh/yr)	Avg. Monthly Electric Demand Savings (kW/mo)	Annual Electric Cost Savings ($/yr)	Annual Natural Gas Savings (therms/yr)	Annual Natural Gas Cost Savings ($/yr)	Implement-ation Cost ($)	Simple Payback (years)
7	Implement Optimum Start on AHU Fans	173,964	0	$12,287	7,890	$0	$1	
8	Manage Water Flow through Coils to Achieve Design Heat Transfer	253,477	28.94	$20,545	0	$0	$44,730	2.18
9	Repair or Replace Dampers and Turn Off Return Air Fans used for Freeze Protection	15,829	0	$1,159	0	$0	$80,000	69.03
	Total	**1,331,343**	**29**	**$99,072**	**83,758**	**$26,949**	**149,152**	**1.18**

Appendices

The FIMs in the table below are listed in order of their likely potential to improve operational efficiency. Some of these measures might be expected to provide a reduction in energy consumption as well, but they are FIMs in the sense that payback is primarily not energy-related. As discussed above, ECM #9 may just as well be labeled as a FIM and added to this list because of the minimal energy savings and extremely long payback period.

FIM #	Measure Description
1	Upgrade Building Automation System
2	Replace Loose Belt on Parking Garage Exhaust Fan
3	Tune, Insulate, and Recover Heat from Boilers
4	Install Exhaust System on AHUs in South Tower
5	Move MAT Sensor on AHU 2

Appendix H | DETAILED STRATEGIC ENERGY PLAN OUTLINE

Some projects may include the development of a comprehensive Strategic Energy Plan (SEP). This will include detailed information regarding ECMs, FIMs, and EBCx, as well as additional energy-related initiatives undertaken by the client as part of the energy management project. The EMP can adjust the SEP structure depending on the priorities of each project and specific initiatives in place at the building.

1. Executive Summary

The **Executive Summary** outlines the client's short-term and long-term energy goals and how project will help accomplish these objectives.

Objective: *Provide a high-level overview of the project that summarizes objectives, goals, and parties involved.*

Content:

- Describe the client's rationale for pursuing energy management, including energy cost information, operational efficiency, and, when applicable, sustainability objectives.
- Outline project goals and objectives, both short- and long-term.
- Provide a short description of project roles and responsibilities, including who will be responsible for funding the project itself and the implementation of ECMs and FIMs. Include a general statement of the EMP's ongoing role in the project.

2. Introduction

The **Introduction** summarizes the energy management process and describes the facility's energy consumption and cost, both current and historical.

Objective: *Detail the building's current energy usage characteristics and how the project will improve energy usage and operations.*

Content:

- Describe the building's energy-related challenges and how the project addresses those challenges.
- Detail the facility's current and historical energy usage, demand, and costs.
- Include energy-related data such as water use, building performance, undesirable emissions, and any other area(s) the project will address.
- Introduce the energy management process as a systematic and holistic means of minimizing resource use while providing a comfortable and productive environment for occupants.

3. Goals and Objectives

Goals and Objectives defines metrics to measure progress and provides a timeline for project implementation and reporting.

Objective: *Clearly outline what the project aims to achieve and how progress will be measured.*

Content:

- Clarify that the energy management process will involve a variety of goals and measures to reduce energy use. These may include ECMs and FIMs, both low-cost and capital.
- Define a baseline and metrics to measure progress. Create a timeline that outlines the project implementation and reporting schedule.
- Briefly describe the tools and procedures used during the project, including timing of site visits, use of data loggers and other measurement tools, energy modeling software, and/or benchmarking methods such as Energy Star Portfolio Manager.

4. Resource Use Management

Resource Use Management provides a detailed description of project results to date and ECMs/FIMs to be implemented, including the timeline, approach, and benefits of each.

Objective: *Detail the building's current energy usage characteristics and how the project will improve energy usage and operations.*

Content:

- Describe the sources of energy used in the building and how usage is quantified. This includes the facility's metering system. Provide account information when available.
- Outline the value of the energy management process, deliverables produced thus far, and other project processes. These may include building investigation, energy modeling, EBCx, and others.
- Describe the importance of energy management and EBCx as they relate to specific building systems or equipment, such as the BAS or metering systems.
- Introduce EBCx as a means of ensuring existing systems are operating efficiently. Describe the necessity of EBCx as an element of the project.
- Include the ECM matrix and an ECM/FIM implementation strategy as it relates to equipment. Detail the timeline, approach, and benefits of each. Identify systems involved and anticipated energy savings and/or operational improvement.
- If applicable, use case studies or general information from past projects to demonstrate the effectiveness and value of the energy management process.

5. Resource Supply Management

Resource Supply Management summarizes the facility's utility supply and local rate structures and explains how the project will resolve any supply management issues.

Objective: *Characterize the building's current energy supply, as well as how the project will address supply-related issues.*

5. Resource Supply Management – Continued

Content:

- Summarize the facility's utility suppliers and the energy they provide. Explain local rate structures, including demand charges, ratchet clauses, time-of-use, pipeline charges, and other charges as necessary.
- If the project involves one or more buildings in a campus environment, explain the different buildings or zones that are served, as well as how the plan will resolve any supply management issues.
- Describe strategies to reduce rate structure, such as innovative supply options, load shedding, load power structure, and demand reduction. Utility-related issues (energy contracts, rate optimization, incentives, green power) may also be included here.

6. Resource Data Management

Resource Data Management provides an overview of the benchmarking process and M&V tools to be put in place to collect data on an ongoing basis.

Objective: *Describe how data-gathering has been used as part of the project, as well as any ongoing data management strategies in the building.*

Content:

- Explain how metering provides real-time usage data and ensures a cost-effective approach to achieving the owner's goals. Utility data can be tracked and validated against metered data to identify billing errors.
- Provide an overview of the benchmarking process and address how it can scale expectations to buildings and uses of similar types in the local environment.
- Introduce Portfolio Manager or other benchmarking tools that have been used thus far for the project. If specific accounts or tools have been developed for the building, provide information for the client to access these tools.

7. Financial Analysis

Financial Analysis describes project funding strategies and financial metrics for individual ECMs and FIMs and the project as a whole.

Objective: *Provide detail regarding how project ECMs, FIMs, and EBCx will be funded, as well as the current and projected funding structure of the project itself.*

Content:

- Outline project funding strategies that have been agreed upon by the client and/or building owner. Explain how accumulating energy cost savings can be used to fund future ECMs. Suggest tax incentives or local rebate programs that might apply.
- Describe financial metrics that will be used to measure project success, for example, ROI, simple payback, and/or energy cost savings.
- Establish implementation schedules and detailed analysis about such items as reduction savings, payback, carbon footprint and drawings and schematics involved. At this initial stage, local examples and case studies will help to explain to the owner how the Strategic Energy Plan will evolve.

8. Roles and Responsibilities

Roles and Responsibilities outlines project roles and responsibilities for team members and other stakeholders, including a detailed organization chart to illustrate responsibilities.

Objective: *Define and describe members of the project team, as well as how the client and/or building ownership will have ongoing input into the project.*

Content:

- Stress that the value of the project depends on the dedication and commitment of the project team members to develop and implement an effective energy management project.
- Define project roles and responsibilities for team members and other stakeholders. Develop an organization chart to illustrate responsibilities. Include:
  - EMP
  - Client
  - Building Owner
  - Contractors
  - Building Staff
- Describe in detail each team member's role, anticipated tasks and methods, and deliverables.

9. Measure Results

Measure Results describes how the effectiveness of ECM/FIM implementation will be measured and how project progress and success will be tracked and reported.

Objective: *Describe the metrics that will be used to measure project success and outline a strategy for conveying those results to the client.*

Content:

- Describe how the EMP will measure the results of ECM/FIM implementation.
- Develop a project status report that can be updated on an ongoing basis to convey results to the client. This may include:
  - Up-to-date building energy usage
  - Review of O&M
  - On-going energy supply management
  - Benchmarking updates
  - Updated energy and water consumption
  - Updated savings figures
  - Additional data as needed, such as waste water discharge or emissions reduction.

10. Cost Allocation

Cost Allocation provides a project cost outline that includes schedule, timeline, task cost, and responsibilities.

Objective: *Describe how each project expense relates to the implementation of specific measures and the further development of the project.*

10. Cost Allocation – Continued

Content:

- Provide a schedule, timeline, task cost, and responsibility worksheet. Working examples of these elements up front will prepare an owner for the complexity and value of the process.

11. Resources

The **Resources** section identifies useful references and sources to support the SEP.

Objective: *Provide any resources useful for the project moving forward, both internally-generated and from external organizations.*

Content:

- Include internal reports or strategic documents that provide background on the project objectives.
- Provide academic papers or news items that support project objectives and provide further information and context for the project.
- Produce sample reports or ideas for potential reporting structures to be considered by the client.

12. Appendices

The **Appendices** include additional project documentation and reports, and can be updated with current material as the energy management continues at the building.

Objective: *Provide forms, tables, and figures that reflect the type of information and materials relevant to the project.*

Content:

- Occupancy and Square Footage Chart
- Tenant Comfort Survey
- Utility Analysis
- Energy Model Update Checklist
- Equipment Replacement Checklist
- TAB Report Checklist
- Quarterly Utility Meeting