

Facility Performance Evaluation (FPE)
Guidance Document
for Public Facilities

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Preface:

This guidance document was written in partnership with NASFA (National Association of State Facilities Administrators) and the AIA (American Institute of Architects) with contributions from the USGBC (US Green Building Council). There are several NASFA member states currently engaged in performing Facility Performance Evaluations (FPE) of their facilities. This guidance document is the result of ongoing discussions among members of the NASFA / AIA community related to sharing FPE methodology, tools, resources and findings. The creation of this guidance document reflects the work of a NASFA / AIA sub-committee that was formed out of mutual interest in this topic.

History of the NASFA / AIA Sub-committee:

In 2005, the AIA Public Architects Knowledge Community had an open discussion at their National Convention workshop in which a topic of interest to the membership was the pursuit of some type of post completion evaluation of sustainable building projects to determine how they were actually performing.

Bruce Bockstael, the Vice Chair of the AIA Advisory Board during that time, formed several search committees to find resources or contacts regarding the topics of interest. Following a six month research project on post occupancy evaluation studies, Bruce found a number of academic studies by various universities, but nothing designed to guide public organizations in conducting a post occupancy evaluation.

The closest actual study available at the time was a report from the Cascadia Region Green Building Council in Washington State that undertook an evaluation on several recently constructed LEED® buildings. Bruce developed a report back to the AIA membership the following year and suggested to the attendees that an opportunity existed to put together something meaningful on this topic. Upon the suggestion of David Hart, a member of the Advisory Group, the report was developed into a presentation for the NASFA Convention with the intent that this type of work could be the basis of a mutual program shared by AIA and NASFA.

Since that time, NASFA has facilitated development of a joint subcommittee with the AIA and including participation by the USGBC. The subcommittee, comprised of representatives having varying degrees of experience with Facility Performance Evaluations, has been meeting regularly via conference call throughout 2009 to develop this guidance document as a resource for members of the AIA / NASFA / USGBC communities and others involved in public building projects. Involvement in the sub-committee has provided members with the opportunity to share knowledge, to learn from one another and to capture the collective experience of the group.

Objectives of this document:

This is a guidance document for NASFA members and others involved in the planning, design, construction and operation of public facilities. It is intended to provide information on the use of Facility Performance Evaluation (FPE) as a tool for determining building performance including, but not limited to, the effectiveness of sustainable design and energy efficiency in public facilities.

Primarily, this guidance document will address the following topics:

- Why / when to conduct a FPE
- What kind of information is found when conducting a FPE
- Who is currently utilizing FPEs
- How to conduct a FPE
- Resources for conducting FPEs

This guidance document consists of three parts:

- Overview of FPE
- Conducting an FPE
- Recommended Resources

The information is presented in a summary format with links to sample documents and recommended resources for further reference.

Section 1. Overview

Introduction to Facility Performance Evaluations (FPE)

This section provides a brief overview of the what, why, how, and who of Facility Performance Evaluations (FPE) along with information about the relevance of FPE to sustainable design and LEED®. Section 2 provides more information about conducting an FPE and Section 3 provides recommended resources and sample documents.

What is a Facility Performance Evaluation (FPE)?

- FPE is a quality assurance tool to evaluate building performance, provide feedback to the design process, and identify opportunities to improve building performance.
- FPE may also be known as Post-Occupancy Evaluation (POE) or Building Performance Evaluations (BPE)
- FPE is an assessment of how well the mission, goals, and performance criteria for a building project have been met as well as the degree to which the built environment meets the needs of the owner and occupants.
- Techniques for conducting FPEs include site visits, collecting performance data (e.g. utility bills), data analysis, surveys, interviews, observation and photography to document as-built conditions, facility operations and user feedback.
- FPEs are often performed one to five years after a building is occupied, but can be performed at any time and can be repeated to measure progress in meeting building performance goals.

Interested in learning more?

A thorough and in-depth explanation of FPE can be found in the WBDG (Whole Building Design Guide) or in resources such as "Learning From Our Buildings: A State-of-the-Practice Summary of Post Occupancy Evaluations" publication (2002) available from The National Academies Press.

Links to these References can be found in Section 3 of this document

Why should public building owners consider conducting FPEs?

- FPEs enable owners to assess building performance to determine the value of their investment and the choices that were made during planning, design and construction of the facility. Evaluation can provide information about how these choices affected building quality.
- FPEs leverage the knowledge of users in existing buildings, providing lessons learned and valuable feedback to the owner and project teams. This feedback can improve decision making for new projects.
- Information gathered during FPE can demonstrate how well the built environment addresses needs related to:
 - Operational efficiency (e.g., adjacencies, spatial qualities and functionality)
 - Durability / maintainability
 - Sustainability
 - Flexibility over time
 - Cost effectiveness of the owner's investment
 - Occupant comfort (e.g., lighting, thermal comfort, acoustics, indoor air quality, etc.)

- Data gathered during FPE can be used to:
 - create a baseline for benchmarking building performance;
 - support and inform the development of recommendations, policies, and design guidelines for high performance buildings;
 - identify opportunities for fine-tuning facility operations to improve building performance, operational practices and policies, leading to increased occupant satisfaction;
 - develop capital master planning or capital improvement planning for the facility being evaluated;
 - report to management, funding providers, or elected officials regarding the effective use of capital investments, the level of performance achieved by the facility and the progress made towards sustainability goals; and/or
 - help building owners or portfolio managers determine the effectiveness of improvements made to the facility.

KEY CONCEPT:

Facility Performance Evaluation promotes the use of a “feedback loop” in the planning, design, construction and operation of buildings. Data gathered during FPE can provide public owners with useful information for a variety of purposes.

What are the key features of Facility Performance Evaluations?

The FPE approach an organization uses depends on its goals and needs (what they want to find out), the rigor required, and the time and resources available. The steps in the process consist of a preparation/planning phase, data collection and reporting (includes analysis).

Detailed information is provided in Section 2 of this guidance document, which describes the methodology and steps for conducting a Facility Performance Evaluation.

A brief summary of each phase is as follows:

- **Preparation/planning:**
Define FPE scope and methods, schedule activities including meetings and site visit(s), and prepare for data collection, develop or gather forms, surveys or other tools.
- **Data collection:**
Conduct the site visit; collect building performance data, experiential data and occupant feedback, and obtain information about maintenance and operations.
- **Reporting:**
Analyze data collected and summarize in a report. (Facility Performance Evaluations are generally presented in the form of a graphic report including photo documentation). There are a variety of reporting formats currently in use within public and private sectors. Although the layout and level of detail varies, the reports are generally somewhat consistent in terms of key features and typical information provided. Reports include basic building information, occupant feedback, building performance analysis, building maintenance and operation issues, and often offer recommendations for improving building performance.

- **Take action:**
Determine how the information gathered during the Facility Performance Evaluation will be applied and follow through with action. If the information is to be used to improve the facility being evaluated, the resulting action may include staffing adjustments and/or training for operators of the facility. An impact assessment of the information gathered can help identify appropriate actions and methods of implementation. If the information is to be used to improve planning of future facilities, the resulting action may include development of guidelines, recommendations, planning / design review questions or presentations to stakeholders involved in the planning, design, construction and operations of new facilities.

Who are the current users of FPE?

There are a number of public and private organizations currently conducting Facility Performance Evaluations. The types of organizations utilizing FPE are often public owner agencies or other organizations with large building portfolios because they can realize the following benefits:

- a. Facility Performance Evaluation findings can be applied to a number of facilities.
 - b. Changes implemented can result in operational efficiencies and/or operational savings to the owner.
- State and Federal Government Agencies currently conducting FPEs include the following:
 - California
 - Connecticut
 - Massachusetts
 - Minnesota
 - New York
 - Ohio
 - Washington
 - Federal General Services Administration (GSA)
 - U.S. Postal Service

Interested in learning more?

Links to References, such as contact information for current users of FPE where available, are provided in Section 3 of this document

Other entities conducting Facility Performance Evaluations include architectural planning and design firms. Since design teams are seldom involved in the operational aspects of built projects, FPEs can provide valuable feedback to inform and improve decision making by the design team.

FPE and the Sustainable Design / “Green” Building Movement

Using Facility Performance Evaluation to optimize the effectiveness of sustainable design and high-performance buildings:

With a growing emphasis on “green design” and the utilization of third party rating systems, such as LEED[®], many building owners are selecting and installing cutting-edge building materials and systems with the goals of optimizing performance and reducing environmental impact. The effectiveness of these measures, many of which may be unfamiliar to facility staff, depends on proper operation and maintenance over time. A facility performance evaluation provides valuable feedback to fine-tune operations and maintenance procedures and to improve decision making for future projects.

Examples of building features and strategies to evaluate may include, but are not limited to, the following:

- Energy efficient systems: high efficiency boilers and chillers, co-generation or tri-generation systems, heat recovery systems
- Water conservation measures: waterless urinals, dual flush toilets, composting toilets, rainwater harvesting
- Renewable energy: solar photovoltaic array, solar thermal system, wind turbine, biomass
- Sustainable materials: recycled content finishes, bamboo, cork, certified wood
- Indoor Environmental Controls: daylight and air quality sensors, thermostats, and lighting controls
- Operational measures: coordination and scheduling of natural ventilation and daylight harvesting, “green” housekeeping, recycling
- Building site features: landscaping, stormwater infiltration, parking and commuting measures

How do I know if a “high-performance” building project was successful?

When evaluating building systems and/or materials to determine performance, it is important to develop **performance measures**. These may be based upon the goals, objectives or specifications that were developed during planning and design. Energy modeling, life cycle cost analysis or other decision making tools that were employed during new building design or during existing building retrofit or renovation can provide a baseline for comparison against as-built conditions. Performance measures may also be determined by benchmarking key metrics against the performance of other similar buildings (e.g. energy and water consumption, maintenance costs, occupant satisfaction, etc).

Quantitative data, such as energy usage and operations or maintenance logs can be gathered and analyzed to determine how well a system or material is functioning in comparison to specifications, modeling predictions, or benchmarks. In addition, qualitative or anecdotal data can be gathered from facility maintenance personnel and/or building occupants to determine how well a system or material is meeting user needs. If evaluating renewable energy systems, production data can be compared to planned output or modeling data to determine how well the system is performing.

Evaluating LEED® buildings

The “Leadership in Energy & Environmental Design” (LEED) Rating System recognizes that ongoing performance measurement, verification, and optimization are core elements of high-performance *green* buildings. LEED rating systems for design and construction or tenant improvement projects encourage putting systems and processes in place to monitor ongoing system performance. LEED rating systems for operations and maintenance are built around a process of continually evaluating and improving the performance of building systems and processes.

Interested in learning more?

Complete information on the LEED® rating system and criteria can be found at www.usgbc.org

Does LEED require facility performance evaluations? Do I earn credits in LEED for conducting FPEs?

Although there are no LEED requirements or LEED credits directly awarded for conducting Facility Performance Evaluations, there are several areas within the LEED rating system that relate to or are supported by the data gathered during FPE.

Tables 1 and 2 in Appendix A summarize the credits in LEED for New Construction (LEED-NC) and LEED for Existing Buildings: Operations & Maintenance (LEED-EB: O&M) that may be achieved in conjunction with an FPE, those that contribute to the measurement & verification infrastructure needed to conduct an FPE, and those that create a baseline that may be used for an FPE performance measure.

Which credits in LEED-NC most closely relate to FPE?

Many of the credits in LEED-NC require the use of a design-case baseline for system performance. These baselines provide solid *performance measures* that enable a future FPE to determine if a building is performing up to its design potential and to diagnose any problems. LEED-NC also encourages installing devices and creating plans for continuous monitoring of energy consumption and ventilation performance- measures which enable an accurate analysis of facility performance over time. The two credits in LEED-NC that are most directly related with conducting an FPE are Thermal Comfort: Verification (EQ credit 7.2) and Enhanced Commissioning (EA credit 3). As described below, the requirements of these two credits can be fulfilled by the use of Facility Performance Evaluations.

As a prerequisite to LEED certification under any rating system, a project must include a fundamental level of commissioning for major building systems (the one-time measurement of how systems perform and how they coordinate with each other). Enhanced Commissioning involves a return visit by the commissioning agent within 10 months of occupancy. Information gathered during early Facility Performance Evaluation activities can be shared with the commissioning agent to provide indicators of problem areas within a building.

The requirements of the Thermal Comfort: Verification credit include implementation of an anonymous thermal comfort survey of building occupants within a period of six to eighteen months after occupancy with an agreement to develop a corrective action plan if survey results indicate dissatisfaction of greater than 20% of occupants.

In relation to the Enhanced Commissioning activities, the Thermal Comfort: Verification survey can be distributed as an early FPE activity in coordination with the commissioning evaluation within 10 months of occupancy. This approach enables the building owner to discuss and troubleshoot thermal comfort issues with the commissioning agent and apply corrective action in a coordinated manner.

Since a Facility Performance Evaluation is generally conducted after at least a year of occupancy, the survey would be considered an early pre-FPE activity, which is described in Section 2 of this document under “Quick Response Surveys”. In addition to informing the Commissioning follow-up activities, the information gathered during a “Quick Response Survey” can also provide a benchmark for the full Facility Performance Evaluation to be conducted at a later date.

Interested in learning more?

The Massachusetts Division of Capital Asset Management (DCAM) has developed a thermal comfort verification survey to be distributed by the FPE team between 6 to 9 months after occupancy. A link to this survey is provided in Section 3: Recommended resources.

How does LEED-EB: O&M relate to FPE?

LEED-EB: O&M has many synergies with FPE because it initiates a process of continual assessment and improvement of facility performance. Nearly all of the credits within this rating system require establishing a performance benchmark and assessing current performance. Many of the credits require the creation of processes or installation of systems for measurement and verification of performance over time. (See Appendix A, Table 2)

The LEED-EB:O&M rating system can be a valuable tool for those planning an FPE, as it describes methods for setting benchmarks and performance goals in many areas and address several additional areas of facilities performance that may not be included in a typical FPE. Likewise, an FPE program may be an ideal way to initiate greening an existing building portfolio. When implementing LEED-EB: O&M in conjunction with, or in addition to an FPE program, building owners should take careful consideration of the schedule and documentation needs for their LEED certification goal.

A building is not eligible to apply for LEED-EB: O&M certification until it has been occupied for at least 12 months. This corresponds to the length of utility history needed to receive a benchmark score through ENERGY STAR Portfolio Manager- a prerequisite for LEED-EB: O&M certification. Additionally LEED-EB: O&M requires that sustainable operations performance is verified and monitored over a *performance period* of at least 3 months and no more than 24 months. Ideally, a building owner would set a target date to apply for LEED certification and would work backward from that date to schedule complementary activities from their FPE program. In a situation where the FPE is initiated before a LEED goal is set, the FPE creates the foundation for ongoing performance monitoring and provides preliminary information to assist in LEED goal-setting.

Interested in learning more?

Information on Energy Star Portfolio Manager can be found in Section 3 Recommended resources

One example of this is the LEED-EB O&M prerequisite for Minimum Energy Efficiency Performance (EA prerequisite 2). This prerequisite requires eligible buildings to achieve an ENERGY STAR Portfolio Manager score of 69 or higher. During an FPE, a building profile is created in Portfolio Manager including details on occupancy, space types, plug loads, etc. and an initial score is obtained. The building owner can then pursue improvements to improve this score to reach their LEED goal. All that is required for LEED documentation is to continue to upload monthly utility data and to generate an updated score when it is time to apply for LEED-EB: O&M certification. Many other credits in this rating system can be achieved in a similar fashion, where the “heavy lifting” is conducted at one point in time and performance is monitored throughout the rest of the performance period.

Interested in learning more?

Additional information outlining the relationship between the LEED NC and LEED EB rating systems and Facility Performance Evaluations are provided in table format in Appendix A of this document.

KEY CONCEPTS:

Many facilities utilize the LEED® rating system, which involves third party verification, to optimize success related to sustainable, high performance building design and operations.

Many of the objectives of Facility Performance Evaluations are aligned with the goals of the LEED® rating system and vice versa. Some FPE activities may contribute to meeting LEED® criteria.

Section 2. Conducting a Facility Performance Evaluation

This section describes how to conduct an FPE. It describes the planning / preparation, data collection, and reporting phases of the FPE process. Sample documents and recommendations are contained in Section 3: Recommended resources.

Planning and Preparation

Prior to conducting a Facility Performance Evaluation (FPE), there are several necessary steps to complete, as outlined below. The main purpose of the FPE is to learn from the built environment. These steps will help the team identify and employ the appropriate methodology and tools to maximize success.

Establish a Strategy

Develop the plan... What is the scope and level of effort for the FPE? Who will conduct it and when? Who needs to be involved at the facility? How will data be gathered? How will the FPE be coordinated with the Enhanced Commissioning or other LEED related activities?

- **Identify goals of the FPE**
 - What are you trying to learn and why? What will be done with the information gathered?
 - Are you intending to make changes to the existing building based upon information gathered?
 - Are you gathering data to inform decision making on new projects?
 - Are you collecting measurable data and performance feedback for reporting or tracking purposes?
 - Will the FPE activities be fulfilling a LEED requirement, such as Thermal Comfort Verification?

- **Identify types of data to be collected and reported**
 - The purpose of the FPE determines the data to be collected and reported, which will therefore inform the appropriate tools to use.
 - Information collected may be subjective, such as user feedback, or objective, such as utility meter data. Highly successful evaluations often involve gathering both types of information.
 - Determine the types of systems, materials or building features that will be evaluated and how best to gather the data needed.
 - Identify performance measures for determining success of systems, materials and features to be evaluated.
 - Identify the original goals of the building project; this may inform performance measures for the building as a whole or for specific items being evaluated.
 - Types of data to be collected and reported often include the following:
 - User feedback (subjective information gathered from building users)- Subjective data is often used as an indicator of areas that are problematic, which may require additional investigation through objective means. For example, chronic user complaints about temperature or air quality may indicate a problem with the HVAC

system. Subsequent review of system data in such situations may lead to discovery of necessary repairs or adjustments.

- Observation - Photo documentation of spaces, systems and materials to illustrate context or current conditions at the time of the FPE.
- Systems performance data such as energy and/or water usage, and maintenance logs – may also involve specific monitoring of some systems.
- Information regarding changes in occupancy, functions or use of the facility since its original construction can be gathered through a combination of feedback, observation and comparative analysis against performance criteria and/or as-built documentation.

- **Determine who will conduct the FPE**

- Building evaluations are best conducted by objective individuals who were not directly involved in the building project. There are several reasons for this, including the following:
 - Users may be uncomfortable providing constructive or critical feedback to those who were involved in decision making for the project.
 - Project team members may be defensive in response to constructive or critical feedback about the building or project.
 - Project team members may be so familiar with the facility that they inadvertently overlook items when collecting data.
- Evaluations are often best conducted by a pair or team of evaluators. There is a lot of information involved in FPEs for one person to collect and analyze. In addition, when conducting interviews or site visits and facility tours, it is helpful to have one person ask questions while one person takes notes, although team members may take turns doing so rather than strictly taking one role or the other.
- Evaluations are best conducted by those who have astute observation, interviewing and listening skills. For public building owners, this may be internal staff or an outside consultant.

- **Identify types of user groups involved**

- Identify key contacts at facility and establish communication protocol for scheduling site visit, interviews, access to back of house spaces, and access to building information including energy and water utility data.
 - FPE site visits often include user surveys as well as group or individual interviews with facility occupants including staff, maintenance personnel and decision makers at various levels. Individuals providing feedback may or may not have been involved with the building project and decision making.
 - A well rounded FPE report will include feedback from a variety of building users with different perspectives.
 - Facility directors or other key operations and maintenance personnel are often the primary contact for the FPE team since they have intimate knowledge of the facility's performance and access to the necessary spaces within the building.

- **Discuss occupant survey process, contacts, approvals, etc.**

- Standard occupant surveys are available from a variety of sources, including the New Buildings Institute (NBI) and the Center for the Built Environment

(CBE). A list of resources is provided in Section 3 of this guide for handy reference.

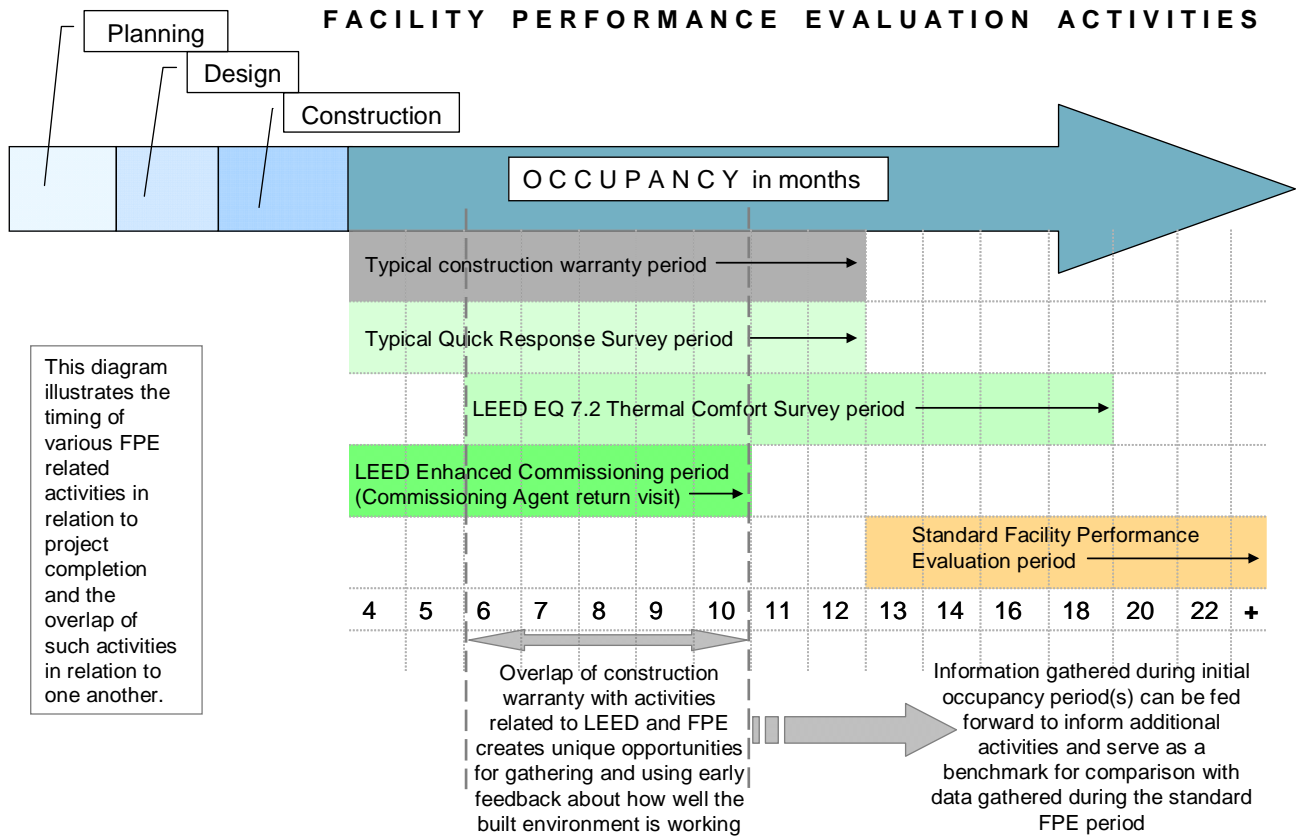
- Surveys may be collected on-line via the internet, in person using a portable computer or pen and paper, through hardcopy mailings or any combination of these options. Some organizations administering surveys choose to collect and compile their own data, using tools they have created or those built into online survey programs such as Survey Monkey or Zoomerang. Others utilize member based organizations or consultants to compile the data for them.
 - Understand your audience when determining which type of survey to use. Facility maintenance personnel, for example, may have limited access to computers. Some users may not be aware of an online survey or may not take the time to complete it. Your key contacts at the facility should be able to provide insight into the culture of the organization and preferences of your target audience to help with the selection of appropriate survey tools.
 - Any survey to be conducted will have some rate of non-response, regardless of the method chosen to administer the survey. Surveys are often most successful if participants can be assured of anonymity.
 - Prior to conducting a survey, the FPE team should get approval from the appropriate authority within the administration of the facility.
 - Some organizations choose not to utilize surveys at all. Some organizations prefer to gather feedback through the use of individual and group interviews rather than surveys.
- **Identify timing of FPE activities in relation to building occupancy and goals**
 - Define when the FPE activities should be conducted and identify appropriate timelines for the work. FPE may be conducted on an individual facility, on a defined group of facilities, or FPE might be an ongoing process for all new buildings.
 - Ideally an FPE is conducted sometime during the first several years of occupancy.
 - With the exception of a targeted “Quick Response Survey”, it is preferable to wait at least a year after initial occupancy for to allow the systems and users to experience the full range of seasons and conditions in the building. There is almost always an adjustment period when a building is first occupied. Evaluations conducted too early during the “shake out” process may have inaccuracies due to the adjustment period needed by building systems and occupants. Occupants that have recently moved into a new facility may be overly negative or positive, depending upon how they handle change.
 - If the goal of the evaluation is to conduct a “Quick Response Survey” (QRS), it will be necessary to conduct an evaluation prior to the first year of occupancy. The purpose of a QRS is to determine if there are issues with a newly occupied project that should be resolved during the warranty period. In buildings occupied upon substantial completion through a temporary certificate of occupancy, the contractor and sub-contractors may still be present to address problems if identified by a QRS.
 - QRS may also be used to inform Enhanced Commissioning activities or to verify thermal comfort in a building as part of LEED certification.

KEY CONCEPTS:

Depending upon the goals of the FPE, evaluation activities may be conducted at different times in relation to the occupancy of a facility, as illustrated in the diagram below.

A Quick Response survey, conducted during the typical construction warranty period, may be used to gather information in coordination with LEED Credits for Thermal Comfort Verification and Enhanced Commissioning.

A full Facility Performance Evaluation is generally conducted after at least a year of occupancy.



Note: after 12 months of occupancy Energy Star score can be obtained and project can apply for LEED-EB certification

Identify scheduling constraints and other logistical considerations

- Operating hours, academic year or other constraints
- Coordinate any FPE efforts with the key contacts at the facility, who can help identify constraints such as operating hours or low occupancy periods. Evaluation teams often observe facilities in use as part of the FPE process. Depending upon their purpose, some buildings have high and low occupancy times, days, or seasons.
 - Buildings on college campuses, for example, may have limited use in the summer months and those using the building in the off season may not be typical year round users. Feedback gathered in off peak times may certainly be valuable, but should be evaluated in the proper context.
- Depending upon the purpose of the evaluation, FPE teams may choose to visit the facility multiple times during different operating scenarios.

Pre-FPE Tasks: preparing for the FPE site visit

Define the analysis approach, develop the tools, and collect background information.

- **Establish a baseline for performance analysis:**
 - When collecting objective data, such as energy or water usage, it is helpful to establish a baseline for comparison. Depending upon the purpose of the FPE, you may wish to compare facility performance to other buildings of similar type, size, geographical location, etc. or to planned performance for the project or both.
 - Available / recommended industry benchmarks for comparison of energy usage and building performance against other buildings are as follows:
 - Energy Star / CBECS
 - The Energy Information Administration (EIA) maintains a database called the Commercial Building Energy Consumption Survey (CBECS) database consisting of actual energy usage of existing buildings nationwide based upon surveys conducted and published every four years. This data is the basis for the Energy Star Benchmark and Energy Star rating system.
 - Using a reporting tool called Portfolio Manager, building owners can upload information about their building and receive a rating in comparison to buildings of similar type, size, usage and location. Building owners can use Energy Star Portfolio Manager to benchmark the building performance for comparison in the FPE. (See Section 3 of this document for a link to this resource).
 - New Buildings Institute (NBI)
 - NBI conducted a study of measured energy performance of LEED buildings called the “Energy Performance of LEED for New Construction Buildings.” Based upon whole building energy data gathered from 121 LEED certified buildings across the U.S., the report examines actual performance levels using benchmarks including initial energy modeling and ENERGY STAR ratings.

- Center for the Built Environment (CBE)
 - CBE is a research organization that operates under the National Science Foundation (NSF) Industry/University Cooperative Research Center (I/UCRC) program. CBE is a membership based organization that conducts building evaluations and maintains a database of completed surveys, which can be utilized by members as a benchmarking tool.
 - Recommended tools for comparison of existing building performance vs. planned building performance include the following:
 - Energy and water usage / utility data
 - If the FPE is evaluating performance after a construction project or energy efficiency project on an already existing building, the comparison may be against the buildings actual energy use measured pre and post project.
 - If the FPE is evaluating performance after a new construction project, the comparison may be against the building's planned energy and water use as predicted by energy modeling vs. the actual energy and water use as reported by meters or utility data.
 - CO2 levels (Indoor Air Quality & carbon footprint)
 - The FPE can include comparison of CO2 targets related to indoor air quality and carbon footprint against benchmark data for similar buildings or against goals that were set during design.
- **Prepare for site visits, surveys, and/or user interviews**
 - Gather data collection forms, templates or other tools and tailor to meet the needs for the specific facility if necessary.
 - See References in Section 3 for a list of available tools and templates
 - Determine the types of users that will be interviewed or surveyed.
 - Review survey or interview tools and questions; customize as necessary for different users. If surveying widely different groups (e.g. students and facility managers), it may be advisable to administer different surveys to each group. Electronic surveys can be customized to filter questions to participants according to parameters set by the FPE team, such as user type.
 - Arrange site visits and interviews. If developing a survey, determine who will be surveyed, how surveys will be administered and coordinate with facility.
 - Ensure the survey or interview questions reflect the goals of the FPE. (see below for more info on occupant surveys).
 - Provide information about the FPE to building staff, etc. ahead of time so that they will understand the purpose and schedule. This will enable them to provide appropriate time and access to the facility and occupants.
 - Ask your key contacts for logistical information such as parking, meeting room accommodations, building and participants schedule and constraints, etc.

- **Gather background information and data on the facility to be evaluated**
Some of the information listed below may be readily available and collected prior to the FPE. Some may need to be collected during the FPE site visit or in conversations with key facility contacts. During the prep phase, the FPE team can fill in the available info, making note of missing or incomplete data to expedite the data collection process in subsequent phases.

Building facility personnel and occupants may have limited time to spend during on-site visits, so gathering information ahead of time will enable the FPE team to maximize use of their time to gather feedback and data on issues not readily available elsewhere. For public facilities, much of this information may be readily available in public records, facility websites, or from the building “owner” or public office responsible for the building project. Prior to spending time at the facility with the occupants, a pre-FPE conversation with the Design and Construction project manager is often helpful to gather the background information and context of the project.

- Gather plans, program, goals, objectives, background data and as-built drawings, depending upon the scope and goals of the FPE.
- Gather facility data, if available:
 - Building Name
 - Address
 - Substantial Completion Construction Date
 - Occupancy Date
 - Building Size (square footage)
 - Building Description: basic construction type, floors, orientation/configuration, percent glazing, etc.
 - Construction Cost
 - Occupancy: number of occupants (typical values and max) and use schedule
 - Use / Program: how is the building used (e.g. offices, labs, data center, classrooms, etc.); include approximate square footage or percentage breakdown for multi-functional facilities.
 - Building Description: basic construction type, square feet, floors, orientation, percent glazing, etc.
 - Building System Descriptions: HVAC, controls, lighting, hot water, equipment, other energy using devices.
 - LEED® Descriptors: sustainable site, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality – strategies and points (provide LEED® scorecard or Washington Sustainable School Protocol (WSSP) scorecard)
 - Design and Construction Team: architect, engineers, contractor, public project manager, owners representative.

KEY CONCEPTS:

Establishing baseline data, gathering background information and customizing tools as necessary in advance will facilitate a smooth and productive on-site FPE visit.

Data Collection

As discussed previously, the components of post occupancy evaluation (FPE) generally include: energy and water consumption measurements, occupant surveys, and a site visit and facility manager/staff interviews.

Once the goals of the FPE and the team have been identified, background information has been gathered, and surveys, interview questions and site visit agendas have been developed, the FPE team is ready to begin collecting data on-site.

Methodology (how and by whom data is collected)

As noted in the planning and preparation section above, there is a variety of data collected during the FPE site visits, depending upon the scope and goals of the FPE. The descriptions below provide detailed information and guidance for collecting facility data:

- Energy and Water Use: cost and performance data
 - Meters and utility data: Based upon the planning / prep stage outlined above, use existing data to identify existing utility data. Utilize the site visit to collect / complete energy and water use information; meter information, etc.
 - Collect at least a year of energy data for all fuels. Ideally, collect more than a year of data to allow for start-up issues that typically occur in the first months of operation. Collect water consumption information if it is readily available.
 - It is best to request this information from the facility prior to the site visit since it will take staff time to gather this data. As an alternative, obtain permission to contact utilities directly to obtain this information.
- Experiential data / user feedback
 - Occupant Survey: Consider using an existing survey that has been tested, is simple to apply, and allows for comparison of results – for example, the Center for Built (CBE) Environment survey or the New Buildings Institute (NBI) survey. These web-based surveys are easy to conduct and provide the opportunity to compare data. The CBE survey is a little longer and includes some more detailed follow up questions (depending on the response), while the NBI survey is shorter and simpler. See available tools below for links.
 - Occupant Interviews / feedback: In addition to or in lieu of surveys, some organizations conduct group or individual user interviews of occupants who work in or visit the building on a regular basis. In some cases, occupants may provide feedback or comments via email; this may occur when occupants cannot attend interviews or as a follow up when they think of additional comments after the interview has ended.
- Information from facility staff on process, maintenance and operations
 - Below are some samples of specific questions for staff. These may be applicable for the facility director and O&M staff working in the

Interested in learning more?

See Section 3: Resources for available survey and benchmarking tools from:

- ***New Buildings Institute (NBI)***
- ***Center for the Built Environment (CBE)***
- ***Usable Buildings Trust***
- ***Energy Information Administration / CBECs / Energy Star***

building, or other occupants that were involved in the project planning process:

- Building design and construction: Did this process go smoothly? What issues came up? Was facility staff involved? In what ways?
 - Building commissioning: What was your experience with the commissioning process and the building start-up? Was facility staff involved?
 - Building Performance: How is the building working? Is it performing as expected (meeting owner needs and design requirements)? Have there been any problems?
 - Identify specific (unique, innovative, important) building features. Which ones are working well? Which ones are not working well? Explain. It is also recommended to gather specific information regarding MEP/FP and roofing systems.
 - Building Operation & Maintenance: Who maintains and operates the building (in-house, contracted)? What kind of operation and maintenance program is in place (or how would you describe the O&M program)? Are there maintenance manuals and construction documents? Is any building performance/operation information tracked? Describe.
 - From an operations and maintenance standpoint, what do you like about the building? What don't you like? Which features make your job easier / more difficult?
 - Occupants: How have occupants responded to the building? Are you hearing any specific complaints or any specific positive comments? If so, about what?
- Building walk-through
 - Conduct a simple walk-through of the building. Find out what is working well and not so well. Identify opportunities for improvement. Complete any gaps in the background information collected on the building during the FPE prep phase. Consider the following during your observations of the facility:
 - Are there obvious signs of energy waste?
 - (i.e. lights on in unoccupied spaces, personal fans or space heaters, etc.)
 - Occupant comfort
 - (lighting, glare, temperature, air flow, noise)
 - Occupancy and building use
 - Appearance
 - Quality of maintenance
 - Overall building environment
 - Changes to the building over time
 - Measurements (i.e. indoor air quality, lighting levels, temperature)

KEY CONCEPTS:

Facility Performance Evaluation data may be gathered through a combination of user interviews, surveys, observations and measured data.

Selection of the appropriate data collection tool depends upon the goals of the FPE and how the findings will be used. A well rounded FPE generally utilizes several data collection methods in order to capture comprehensive information.

FPE Reporting

Once the data has been gathered during the Facility Performance Evaluation activities, it must be analyzed and organized into a meaningful report. The format and degree of formality of the report will be informed by the goals of the FPE, the intended audience for the results, and the type of data gathered.

Methodology (how data is being reported)

If the purpose of the Facility Performance Evaluation is to inform the decision making process for future facilities, the FPE report should focus on information that can be fed forward in a generalized way. For instance, conclusions that apply to a building type or that can be useful to the planning, design, construction and/or operation of facilities in general may be more useful than very specific examples particular to an existing facility. The report may, however, contain illustrative examples based on the specific facility to support general conclusions or recommendations.

If the purpose of the FPE is to make improvements in the facility being evaluated, the report should contain specific examples with recommended actions for that particular facility.

In some cases, the purpose of the FPE may be to improve the existing facility and to feed forward information to new projects. In this case, the report may be structured to serve both purposes.

Reports for internal use by the owner's project team(s) might be less formal than reports shared with outside entities. In either case, the FPE team should take care to present information on facility performance in an objective and diplomatic manner since project teams may feel a sense of personal responsibility towards the success of the completed facility.

Report Format (Existing templates, databases, reports)

- Information collected from the site visit, facility staff interviews, utility data, and occupant survey(s) is generally summarized in a brief report with graphs and tables. The following is an example of how FPE report content may be structured:

Interested in learning more?

See Appendix C for a sample report format from (NBI) the New Buildings Institute

FPE Report Content

- Introduction: Objective, motivation, purpose
- Building Description: Basic building information, occupancy characteristics, building systems, green/LEED features
- Occupant Survey: How well does the building meet the needs of the occupants? Present results of the occupant survey. (Note: the building may meet the needs of some occupants but not others.)
- Energy Performance: Does the building use resources efficiently? Present the results of the Energy Star Benchmarking, comparison of planned versus actual energy use, or both if applicable. If available, also include energy modeling results (if modeling results are presented, it is important to provide an explanation so the information is interpreted properly).

- Operations and Maintenance: How well is the building working? Are there areas that warrant further investigation or action? Summarize the results of the building walk-through and facility staff interviews.
- Key Conclusions and Recommendations: How well is the building meeting owner/occupant needs? Is it meeting its design and performance goals? What is working well? What opportunities exist for improvement? What steps, if any, are recommended to be taken as a result of the post-occupancy evaluation?
- Feed-forward for new projects: In addition to informing potential improvements for the building evaluated, many organizations use FPE to improve future projects. When gathering and reporting information during FPE it may be helpful to think about how decision making on new projects can be informed by the data gathered during this process.
- Backup documentation for additional reference: may include photographs, site visit notes or reports, interview notes, and details of occupant surveys.

KEY CONCEPTS:

Facility Performance Evaluation data is typically analyzed and summarized in a standardized report format so that the information gathered may be clearly understood.

FPE data is generally used to make improvements in the facility that was evaluated and/or to feed information forward into the planning, design and construction of new facilities.

Section 3. Recommended Resources / Reference Materials

The following is an annotated collection of resources corresponding to the various sections of the FPE Guidance Document. Resources in this section have been provided by the members of the NASFA / AIA Facility Performance Evaluation sub-committee and USGBC participants. It is not necessarily a comprehensive resource list, but rather represents tools and reference materials developed or utilized by the sub-committee or its members. This Section is intended to be a “living document”. It has been created with the acknowledgement that references and resources may change over time. This is especially true for website links and other electronic references. As such, the sub-committee has provided an annotated description of each reference to give users of this document an overview of why the specific references are useful. It is our intent that this will serve two purposes:

1. It will enable others to understand the intent and relevance of the reference, should the specific tool or resource become unavailable or obsolete.
2. It will also provide the appropriate context so that users of this document can decide for themselves whether the specific tools and resources provided will fit their needs.

Recommended resources are organized on the following pages according to the applicable sections of the FPE Guidance Document. You can also check out the “quick links” below for popular reference topics. For those users viewing this document electronically, each topic heading is hyperlinked to the appropriate place within this Section. For those utilizing a hard copy version of this document, the pages numbers have also been provided for reference.

Interested in learning more?

***Find available resources by topic using this handy reference guide
(electronic version is hyperlinked to each section):***

What would you like to know more about?Refer to:

- ❖ *Facility Performance Evaluations, in generalSection 1 resources (page 22)*
- ❖ *Current users of FPE in public facilities.....Section 1 resources (pgs. 22-23)*
- ❖ *FPE and Sustainable Design.....Section 1 resources (page 24)*
 - ❖ *Relationship of FPE to LEED credit requirements.....Appendix A, Tables 1 & 2*
 - ❖ *LEED EQ7.2 Thermal Comfort survey sampleAppendix B*
- ❖ *Establishing benchmarks for Energy Performance.....Section 2 resources (page 25)*
- ❖ *Sample tools, templates & surveys for FPE data collection....Section 2 resources (pgs 25 -27)*
- ❖ *FPE reporting format.....Section 2 resources (page 27)
and Appendix C*
- ❖ *Sample FPEs (public and private facilities).....Section 2 resources (page 27)
and Appendix D*
- ❖ *Websites and info about NASFA, AIA and USGBC.....General resources (page 28)*

Section 1 Resources

- ❖ **Overview / Introduction to FPE:** these resources provide additional information and a more in-depth look at Facility Performance Evaluations

1. Whole Building Design Guide chapter on FPE - Facility Performance Evaluation (POE): <http://www.wbdg.org/resources/fpe.php>

The Whole Building Design Guide is a web-based resource from the National Institute of Building Sciences aimed at providing government and industry practitioners with access to current information on a wide range of building-related topics from a 'whole buildings' perspective. In addition to the information on FPE, this is a great overall resource for anyone involved in all phases of building projects.

The Facility Performance Evaluation chapter of the WBDG is written by:

- Craig Zimring, PhD - College of Architecture, Georgia Institute of Technology
- Mahbub Rashid, PhD, AIA - College of Architecture, Georgia Institute of Technology
- Kevin Kampschroer - Public Buildings Service, U.S. General Services Administration

This resource provides information on the origins of FPEs, the various types and phases of FPEs, data collection tools, benefits and barriers to conducting FPEs. This website also includes a list of additional resources related to FPEs.

2. **Assessing Building Performance**, Wolfgang F.E. Preiser, PhD, editor (Professor of Architecture at the University of Cincinnati) and Jacqueline C. Vischer, editor, Elsevier Butterworth-Heinemann, 2005.

This book, based on collaboration by the International Building Performance Evaluation (IBPE) consortium, provides an introduction to methods of building performance assessment including case studies from around the world.

- ❖ **Current users of FPE:** As available at time of publication, information has been provided here to identify organizations that may be able to offer additional information on their experience using Facility Performance Evaluations for public facilities.

Contact Information is provided here for participating members of the NASFA / AIA sub-committee involved in the creation of this guidance document who are involved in FPEs in public facilities.

- California:
 - Department of General Services
- Massachusetts:
 - Division of Capital Asset Management (DCAM)
FPE Contacts:
 - Polly Welch, Registered Architect
Office of Planning, Design & Construction
 - Patricia Chaput, LEED AP, Assoc. AIA
Office of Facilities, Maintenance & Management

Energy Efficiency & Sustainable Buildings Group
617-727-4030 x202
patricia.chaput@state.ma.us

NOTES: The Division of Capital Asset Management in Massachusetts utilizes FPE to assess how well completed projects are performing and to inform decision making through by feeding forward lessons learned to new projects being planned. An example case study can be found in Appendix D of this document.

- New York
- Ohio
 - Department of Administrative Services
State Architect's Office
FPE Contact:
 - Lane Beougher, AIA, FCSI, LEED AP
614-752-0013
lane.beougher@das.state.oh.us

NOTES: Ohio uses an Annual Savings Report evaluation process to determine if the guaranteed savings metrics have been achieved for its Performance Contracting program that received a NASFA Award for Innovation in 2003. Ohio utilizes Portfolio Manager to benchmark the performance of nearly 6,000 state owned and leased buildings. Ohio is also embarking on a process to assess underperforming facilities as part of our efforts to reduce energy consumption by 15% by June 30, 2011.

- Washington
 - Department of General Administration, Engineering and Architectural Services
Energy Section
FPE Contact:
 - Stuart Simpson, CEM, LEED AP
306-902-7199
ssimpso@ga.wa.gov

NOTES: Washington recently performed FPE on four facilities as part of a pilot project. Additional information can be obtained in the Case Study outlined in Appendix D of this document.

- Federal General Services Administration (GSA)
 - Department of General Administration, Public Buildings Service Office of Federal High-Performance Green Buildings
FPE Contact:
 - Lance Davis, AIA, LEED AP
202-208-2038
Lance.davis@gsa.gov
 - Many of the Federal Government Agency FPEs are conducted through Pacific Northwest National Laboratory
 - (Jeremy will check with a contact there for inclusion)

❖ **FPE and Sustainable Design:**

- **Green Building Post Occupancy Evaluations: Learning from Experience**, AIA Best Practices (BP 19.07.01), Revised February 2007, Excerpted and Adapted from an article in the September 2003 issue of Environmental Building News by Nadav Malin with Jessica Boehland, with research support provided by Kristen Johnson,
http://www.aia.org/aiaucmp/groups/ek_members/documents/pdf/aiap016673.pdf

This is a three-page article focusing on the use of post-occupancy building evaluation as a tool for assessing performance of “green” buildings. The article highlights findings from the University of Minnesota’s Center for Sustainable Building Research (CSBR), which has conducted POEs of sustainable design efforts by several state agencies.

- **Procedures for Commercial Building Energy Audits**, ASHRAE Book (90426), Current cost \$58, published in 2004.

This book provides purchasers and providers of energy audit services with a complete definition of good procedures for an energy survey and analysis. It also provides a format for defining buildings and their energy use that will allow data to be shared in meaningful ways.

Available through the bookstore link on ASHRAE’s website:

<http://www.ashrae.org/publications/page/1279>

(search “Books” by the publication name or number provided above)

A direct link to the publication is provided here: <http://tinyurl.com/yhwo6xz>

- **Related information on LEED:** see Appendix A of this document for tables relating LEED NC and LEED EB-O&M to Facility Performance Evaluations

Section 2 Resources

❖ **Establishing benchmarks for Energy Performance:**

Benchmarking Tools

- **Energy Star Portfolio Manager**
http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager

This is an interactive energy management tool designed for tracking and assessing energy and water consumption across a portfolio of buildings in a secure online environment. Portfolio Manager can help set investment priorities, identify under-performing buildings, verify efficiency improvements, and receive EPA recognition for superior energy performance.

Portfolio Manager utilizes energy consumption and cost data to benchmark building energy performance, assess energy management goals over time, and identify strategic opportunities for savings and recognition opportunities. EPA has developed a [Benchmarking Starter Kit](#) (linked here) to help users get started quickly.

- ### ❖ **Sample tools, templates & surveys for FPE data collection:** As available at the time of publication, this section includes resources known to the authors to provide survey tools and data collection services related to FPE. Most, if not all, of these resources are either fee-based membership organizations or paid consultancy service providers. In addition to available fee-based services, however, several of these resources have informative and useful websites with helpful links to additional FPE information.

- **Center for the Built Environment (CBE)**
<http://www.cbe.berkeley.edu/>

CBE's mission is to improve the design, operation, and environmental quality of buildings by providing timely, unbiased information on building technologies and design techniques.

CBE is a membership based research organization operating under the National Science Foundation (NSF) Industry/University Cooperative Research Center (I/UCRC) program.

CBE employs a research team and industry partners that develop ways to evaluate occupied buildings to gather feedback on how people use space, to assess user satisfaction with indoor environment, and to link this information to physical measurements of indoor environmental quality. CBE also studies technologies aimed toward making buildings more environmentally friendly, more productive to work in, and more economical to operate.

CBE's website contains occupant surveys, research tools and findings.

- **New Buildings Institute (NBI)**
www.newbuildings.org

NBI is a nonprofit organization working with national, regional, state and utility groups to promote improved energy performance in commercial new construction. NBI manages projects involving building research, design guidelines and code activities. NBI shares ideas between states and regions, and between researchers and the market.

According to their website, NBI has completed [the broadest study to-date](#) (linked here) of measured energy performance of LEED buildings called “Energy Performance of LEED for New Construction Buildings.” The purpose of this study is to better quantify actual energy performance levels of green building by gathering whole building energy data from 121 LEED-NC buildings across the country that had been occupied for at least one year. Study results examine relationships of actual performance levels to other benchmarks, including initial modeling and ENERGY STAR ratings.

NBI’s website contains a [sortable list](#) (linked here) of current resources on Measured Performance. Included in the list are brief descriptions and links to the key documents and tools currently available from NBI for measured performance analyses and case studies.

- **Usable Buildings Trust (UBT)**
<http://www.usablebuildings.co.uk/>

The Usable Buildings website is a free resource for practitioners, managers, building owners, developers, students and others interested in making buildings that are more suitable for the people who use them, less damaging to the natural environment and better long-term as a long-term investment.

The Usable Buildings website is run by the Usable Buildings Trust, an independent charity, registered in the United Kingdom. According to their website, “UBT promotes better buildings through the more effective use of feedback on how they actually work.” UBT shares results through its website, through user groups, through collaborative work and by providing input to postgraduate courses.

Usable Buildings website contains a feedback portfolio of techniques for obtaining feedback from occupied buildings as well as a number of publications related to FPE and building performance.

- **Thermal comfort survey (DCAM)**

This is a thermal comfort survey related to LEED credit EQ Credit 7.2 developed by The Division of Capital Asset Management (DCAM) in Massachusetts. The survey is intended to be distributed by the FPE team between 6 to 9 months after occupancy. A link to this survey, located in Appendix B, is provided here: [APPENDIX B: Thermal Comfort Survey sample](#)

❖ **Related Industry tools and requirements:**

- **International Performance Measurement & Verification Protocol (IPMVP)**
http://www.evo-world.org/index.php?option=com_content&task=view&id=272&Itemid=279

- Volume I: Concepts and Practices for Determining Energy and Water Savings
- Volume II: Concepts and Practices for Improving Indoor Environmental Quality
- Volume III: Part I: Concepts and Practices for Determining Energy Savings in New Construction
- Volume III: Part II: Concepts and Practices for Determining Energy Savings in Renewable Energy Technologies Applications

The IPMVP documents provide an overview of current best practice techniques available for verifying results of energy efficiency, water efficiency, and renewable energy projects in commercial and industrial facilities. These resources may also be used by facility operators to assess and improve facility performance.

Energy conservation measures (ECMs) covered in the IPMVP include fuel saving measures, water efficiency measures, load shifting and energy reductions through installation or retrofit of equipment, and/or modification of operating procedures

❖ **Sample Facility Performance Evaluations (public and private facilities):**

This section includes a link to published FPEs. In addition, some sample FPE “case study” information provided by NASFA members can be found in [Appendix D](#) (linked here).

- **Assessing Green Building Performance: A Post Occupancy Evaluation of 12 GSA Buildings**, Pacific Northwest National Laboratory, Kim M. Fowler and Emily M. Rauch, July 2008.
http://www.gsa.gov/gsa/cm_attachments/GSA_DOCUMENT/GSA_WBDG_Report_Final_R2-p-q5Q_0Z5RDZ-i34K-pR.pdf
- **Aronoff Center for Design and Art: A Post-occupancy Evaluation**, AIA Best Practices (BP 19.07.02), June 2008, Excerpted and adapted from an article in the *AIA Journal*.
http://www.aia.org/aiaucmp/groups/ek_public/documents/document/aiap072639.pdf

❖ **Sample Facility Performance Evaluations reporting format for NASFA members:**

Contributing NASFA members suggest a standard reporting template for reporting information to facilitate sharing of findings across states and across agencies. Our proposed format for FPE reports is based on the New Buildings Institute sample report located in [Appendix C](#) (linked here). This is open for discussion and revision; as NASFA members begin collecting and sharing FPE information we can modify this format to best suit the needs of the users.

General Resources

Facility Performance Evaluation (FPE) Guidance Document for Public Facilities “Author Organizations”:

❖ **NASFA: National Association of State Facilities Administrators**
www.nasfa.net

The National Association of State Facilities Administrators (NASFA) is a non-profit professional organization founded in 1987. NASFA's mission is to provide leadership in the development and implementation of state facility administration practices.

NASFA members include facilities professionals from all 50 states, the District of Columbia and the U.S. territories. These professionals are responsible for planning, development, operations and maintenance of state facilities, such as hospitals, prisons, parks, colleges and universities.

NASFA's “Corporate Affiliate Program” facilitates participation by representatives of private sector corporations that provide facilities management products and services to state government agencies.

❖ **AIA: American Institute of Architects**
www.aia.org

The American Institute of Architects (AIA), which consists of nearly 300 state and local chapters, is the leading professional membership association for licensed architects, emerging professionals, and allied partners.

The AIA provides support to the architectural community and promotes design excellence through their efforts including continuing education programs, industry standards for contract documents, professional publications and online resources, market research and awards programs.

Member groups within the AIA that were involved in the creation of the FPE Guidance Document for Public Facilities include the following:

- *Public Architects Knowledge Community*
- *Committee on the Environment*

❖ **USGBC: US Green Building Council**
www.usgbc.org

The U.S. Green Building Council (USGBC) is a non-profit organization with a community comprised of 78 local affiliates, more than 18,000 member companies and organizations, and more than 140,000 LEED Professional Credential holders. Members of the USGBC include builders and environmentalists, corporations and nonprofit organizations, elected officials and concerned citizens, and teachers and students.

The USGBC's mission is to transform the way buildings and communities are designed, built and operated, enabling an environmentally and socially responsible, healthy, and prosperous environment that improves the quality of life.

APPENDIX A: LEED[®] credit tables

TABLE 1: LEED for New Construction (LEED NC¹) and Facility Performance Evaluation (FPE)

For a full list of credits and description of requirements, download the LEED for New Construction rating system at: <http://www.usgbc.org/DisplayPage.aspx?CMSPageID=222>

			Credit Requirements:		
Credit(s)	Title	Summary of Requirements	Establish Baseline for FPE comparison	Create M&V Infrastructure	May be Fulfilled During FPE
SSc4.2- 4.4	Alternative Transportation	Facilities to Encourage Alternative and fuel-efficient transportation	yes		
SSc5.1 - 5.2	Site Development-Habitat & Open Space	Maintain open space vegetated with native or adapted vegetation	yes		
SSc6.1 - 6.2	Stormwater Design	Measures to control quantity and quality of site stormwater runoff	yes		
SSc7.1 - 7.2	Heat Island Effect	Shade and high solar reflectance for roof and site hardscape	yes		
SSc8	Light Pollution Reduction	Measures to control light trespass from building site	yes		
WEp1 & WEc3	Water Use Reduction	Reduce water use and sewage conveyance through reduced flow fixtures, fittings, and appliances	yes		
WEc1	Water Efficient Landscaping	Limit the use of potable or natural water for landscape irrigation	yes		
EAp1	Fundamental Commissioning	Verify that energy-related systems are installed, calibrated, and perform according to the owner's requirements	yes		
EAp2 & EAc1	Energy Performance	Demonstrate level of energy efficiency through whole building energy simulation or prescriptive measures	yes		
EAc2	On-site Renewable Energy	Use renewable energy systems to offset building energy costs	yes		

¹ Table is based on LEED v.3, which is the current version of LEED as of 7/23/09

EAc3	Enhanced Commissioning	Begin the commissioning process early in the design process and conduct post-occupancy training and review of operations	yes		yes
EAc4	Enhanced Refrigerant Management	Use no refrigerants, or use refrigerants with minimum ozone depletion and climate change impact	yes		
EAc5	Measurement and Verification	Develop and implement a plan for ongoing accountability of energy consumption over time		Yes	
EAc6	Green Power	Engage in a contract to purchase a percentage of the building's electricity from renewable sources	Yes		
IEQp1 & IEQc2	Indoor Air Quality Performance	Establish ventilation rates and/or meet prescriptive measures	yes		
IEQc1	Outdoor Air Delivery Monitoring	Install permanent monitoring capacity for ventilation systems		yes	
IEQc3.2	Air Quality Management Plan Before Occupancy	OPTION 2 : Conduct baseline indoor air quality testing after construction, prior to occupancy	yes		
IEQc5	Indoor Chemical and Pollutant Source Control	Achieve sufficient air exhaust and negative pressurization of spaces where hazardous gases or chemicals may be present	Yes		
IEQc7.1	Thermal Comfort Design	Document design and operational procedures taken to promote occupant thermal comfort	Yes		
IEQc7.2	Thermal Comfort Verification	Conduct a post-occupancy thermal comfort survey of building occupants	yes		yes

TABLE 2: LEED for Existing Buildings: Operations & Maintenance (LEED EB: O&M²) and Facility Performance Evaluation (FPE)

For a full list of credits and description of requirements, download the LEED for Existing Buildings: O&M rating system at: <http://www.usgbc.org/DisplayPage.aspx?CMSPageID=222>

Credit(s)	Title	Summary of Requirements	Establishes Baseline	Creates M&V Infrastructure	May be Fulfilled During FPE
SSc4	Alternative Commuting Transportation	Quantify commuting trips made and mode used by regular building occupants and demonstrate use of alternative modes	yes		yes
SSc5	Protect or Restore Open Habitat	Maintain site areas with native or adapted vegetation	yes		yes
SSc6	Stormwater Quantity Control	Implement an annual inspection of all stormwater management measures	yes		yes
SSc8	Light Pollution Reduction	Measurement of light trespass from building site and/or prescriptive control measures	yes		yes
WEp1 & WEc2	Minimum Plumbing Fixture and Fitting Efficiency	Reduce water use and sewage conveyance through reduced flow fixtures, fittings, and appliances	yes		yes
WEc1	Water Performance Measurement	Whole building and/or major system submetering of water consumption		yes	
WEc3	Water Efficient Landscaping	Limit the use of potable or natural water for landscape irrigation	yes		yes
WEc4	Cooling Tower Water Management	Measure chemical management and/or nonpotable water use in cooling towers		yes	

² Table is based on LEED v.3, which is the current version of LEED as of 7/23/09

EAp1	Energy Efficiency BMP's	Planning, documentation, and opportunity assessment for energy-efficient operations	yes	yes	yes
EAp2 & EAc1	Energy Performance	Demonstrate level of energy efficiency through benchmarking or prescriptive measures	yes		yes
EAc2.1-2.3	Existing Building Commissioning	Conduct energy audit; implement identified measures; implement an ongoing commissioning program	yes	yes	yes
EAc3.1 - 3.2	Performance Measurement	Use a building automation system; install system-level meters	yes	yes	yes
EAc4	Renewable Energy	Meet a portion of the building's total energy consumption with on-site or off-site renewable energy	yes		yes
EAc5	Enhanced Refrigerant Management	Use no refrigerants, or use refrigerants with minimum ozone depletion and climate change impact	yes		yes
EAc6	Emissions Reduction Reporting	Quantify and document the emissions reduction benefits of building efficiency measures	yes		yes
Mrc1-5	Sustainable Purchasing	Document purchases of products with reduced environmental and air quality impacts	yes	yes	yes
Mrc6	Waste Stream Audit	Conduct a waste stream audit of the building's ongoing consumables waste stream	yes		yes
Mrc7 - 9	Solid Waste Management	Maintain and document a waste reduction and recycling program	yes	yes	yes
IEQp1 & IEQc1.3	Indoor Air Quality Performance	Demonstrate ventilation rates and/or meet prescriptive measures	yes		yes

IEQc1.2	Outdoor Air Delivery Monitoring	Install permanent continuous ventilation monitoring systems		yes	
IEQc2.1	Occupant Comfort Survey	Implement an occupant comfort survey	yes		yes
IEQc2.3	Thermal Comfort Monitoring	Maintain a system for continuous monitoring, tracking, and optimization of systems that regulate indoor comfort		yes	
IEQc2.4	Daylight and Views	Demonstrate occupant access to daylight and views through simulation or prescriptive measures	yes		yes
IEQc3.2	Custodial Effectiveness Assessment	Conduct an audit of facility appearance	yes		yes
IEQc3.3 - 3.4	Green Cleaning Products and Equipment	Document purchases of products with reduced environmental and air quality impacts	yes	yes	yes
IOc3	Documenting Sustainable Building Cost Impacts	Document overall building operating costs and changes over time	yes		yes

APPENDIX B: Thermal Comfort Survey sample

Note: the sample cover letter and survey provided on the following pages are from the Division of Capital Asset Management in Massachusetts

Insert Date:

Dear Employee:

We appreciate that you are willing to take the time to participate in this survey. DCAM would like to solicit your advice and feedback on (insert name of facility).

The Division of Capital Asset Management (DCAM) is responsible for the design and construction of most of the Commonwealth's new buildings as well as major renovations. We are conducting this survey to gather information that will help DCAM. First and foremost, your response will help us fine-tune this building to be sure we are providing pleasant and productive workplaces for the Commonwealth employees and the public. Additionally, DCAM uses your response to feed forward to the design and construction of future buildings.

Instructions:

This web-based questionnaire has been designed to gather a lot of important information with the least possible time burden for you. If at any time you wish to stop, you may do so. The format may not provide sufficient opportunity for you to give us detailed answers to questions. If you would like to provide more information or an opinion on any specific issue, you may provide comments in the box at the end of the survey.

All responses will be kept strictly confidential and cannot be linked to an individual's identity.

If you need any assistance in completing this form or need the survey supplied in a different format, please contact (insert DCAM contact info here).

Thank you for your time and assistance.

DCAM Survey Team

Background

1.1 For which department do you work?

Personal Workspace

2.1 Which of the following best describes your personal workspace?

3.1 (Check one)

Office spaces:

- ₁ Private office with floor to ceiling walls and a door
- ₂ Shared office (with other people) with floor to ceiling walls
- ₃ Open area with cubicles
- ₄ Other, please specify: _____

Non-Office Spaces:

- ₅ Teaching spaces
- ₈ Other, please specify: _____

2.1 On which floor is your workspace located? _____

Comfort at your Personal Workspace

3.1 How satisfied are you with the following aspects of air quality / thermal comfort:

	Satisfied	Somewhat Satisfied	Somewhat Dissatisfied	Dissatisfied	Not Applicable
a) Temperature	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄	<input type="checkbox"/> ₅
b) Level of humidity	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄	<input type="checkbox"/> ₅
c) Air movement	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄	<input type="checkbox"/> ₅
d) Air freshness	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄	<input type="checkbox"/> ₅

If you indicated any dissatisfaction with the air quality / thermal comfort in your workspace, which of the following contribute to your dissatisfaction?

(check all that apply)

- ₁ Air is stuffy / stale
- ₂ Air seems dirty
- ₃ Air has odor
- ₄ Insufficient air flow
- ₅ Too much air flow
- ₆ Noisy air flow
- ₇ Air is too cold in summer
- ₈ Air is too hot in winter
- ₉ Other, please specify: _____

3.2 Which of the following do you personally control in your workspace?

(check all that apply)

- ₁ Thermostat
- ₂ Opening a window
- ₃ Lighting
- ₃ Portable heater
- ₄ Portable fan
- ₅ Other, please specify _____

3.3 Which of the following, if any, have you added to your workspace?

(check all that apply)

- ₁ Portable heater
- ₂ Portable fan
- ₃ Desk lamp
- ₄ Window covering
- ₅ Other, please specify _____

3.4 In general, how would you describe the thermal conditions of your workspace?

(check all that apply)

- ₁ Hot
- ₂ Warm
- ₃ Slightly warm
- ₄ Neutral
- ₅ Slightly cool
- ₆ Cool
- ₇ Cold

3.4 In general, how would you describe the thermal conditions of the building's common spaces?

(check all that apply)

- ₁ Hot
- ₂ Warm
- ₃ Slightly warm
- ₄ Neutral
- ₅ Slightly cool
- ₆ Cool
- ₇ Cold

Academic Spaces

4.1 If your job involves teaching, how satisfied are you with the following aspects of your teaching space:

	Satisfied	Somewhat Satisfied	Somewhat Dissatisfied	Dissatisfied	Not Applicable
a) Air quality	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄	<input type="checkbox"/> ₅
b) Temperature	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄	<input type="checkbox"/> ₅

If you indicated any *dissatisfaction* with the air quality / thermal comfort in academic spaces, which of the following contribute to your dissatisfaction?

(check all that apply)

- ₁ Air is stuffy / stale
- ₂ Air seems dirty
- ₃ Air has odor
- ₄ Insufficient air flow
- ₅ Too much air flow
- ₆ Noisy air flow
- ₇ Air is too cold in summer
- ₈ Air is too hot in winter
- ₉ Other, please specify: _____

Additional Information

5.1 Please feel free to provide any additional comments or specific details related to the thermal comfort of your workspace or common spaces within the building.

***** End of survey *****

APPENDIX C: Sample FPE Reporting format

Provided on the pages that follow is a sample reporting document, developed by the New Buildings Institute. It is included here as an industry reference for consideration by users of this FPE Guidance Document for Public Facilities.

Further information about the New Buildings Institute can be found in Section 3: Recommended Resources / Reference Materials on page 28.

BUILDING PERFORMANCE REVIEW FOR XYZ SCHOOL DISTRICT ABC Elementary School June 30, 2006

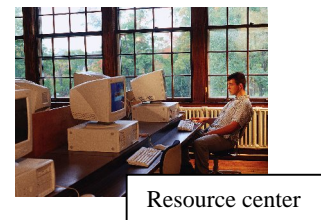
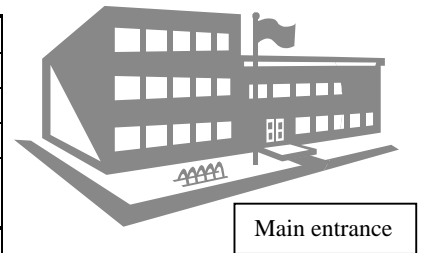
BPR OBJECTIVE

To determine whether the ABC Elementary School building is performing efficiently and in a way that meets the needs of its occupants.

BUILDING DESCRIPTION

ABC Elementary opened in the fall of 2005 with 500 students. The new building replaced the previous structure on the same site, an all-electric school built in 1960.

Building	ABC Elementary (K-6)			
Address	1234 6 th St, Anytown, WA 98000			
Constructed	2005			
Size	50,000 square feet. 2 floors.			
Cost	\$7.5 million [\$150/sq ft] construction \$9.0 million [\$180/sq ft] total budget			
Occupancy	Students	Teachers	Other Staff	PC's
10/2005	500	25	12	250
Hours of use	Class day: 9 a.m. – 3:30 p.m.			
- school year	Community uses: to 9 p.m. many week days			
- summer	M – F for at least one month			
Systems				
HVAC	Hot water heat, premium efficiency boiler No mechanical cooling CO ₂ sensors for ventilation control			
Lighting	Daylighting, sun shelves, occupancy and light sensor controls in classrooms			



REPORT CONTENTS

Section I: Survey

Does the building meet the needs of the occupants?

Section II: Energy Performance

Does the building use resources efficiently?

Section III: Operations and Maintenance

Are there areas that warrant further investigation or actions?

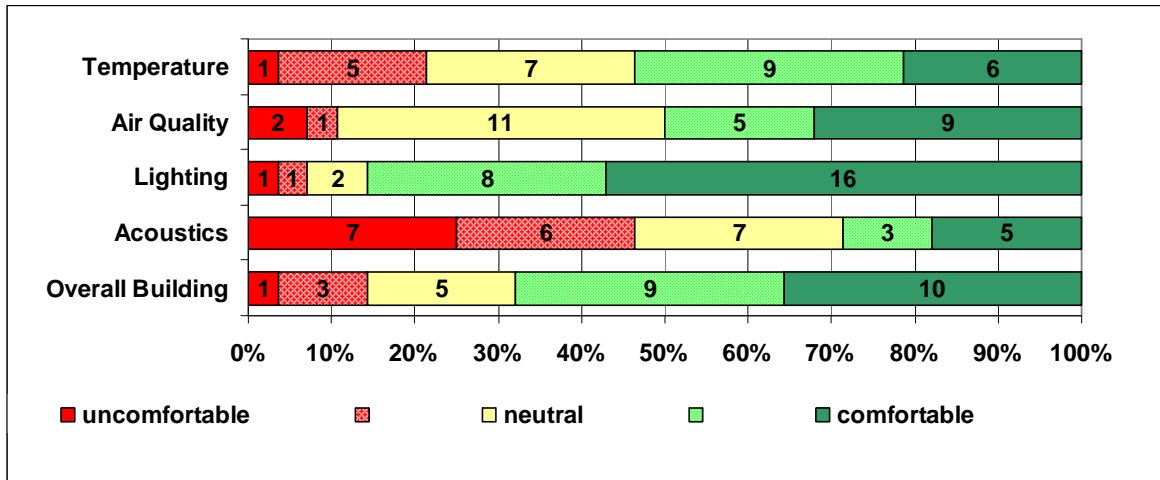
Section IV: Key Conclusions and Recommendations

I. OCCUPANT COMFORT

ABC Elementary Occupant Survey Conducted May 8-12, 2006

37 building teachers and staff
 28 respondents
 76% response rate

Number of respondents, and percentage of total respondents, by comfort level



Temperature comfort was relatively high, but with a few localized concerns.

- Some rooms with south or west-facing windows appear to have uncomfortable solar heat gains.

Sample survey comment:

- *In the warm weather, my room gets uncomfortably hot. I use the shades, turn off lights, open windows but can't control the temperature*

- Although there were a few comments regarding cold drafts, the facilities staff have recently adjusted classroom radiators, which may have addressed these concerns.

Lighting comfort rates very good.

- There are particularly strong positive contributions from the building daylighting

Sample survey comments:

- *I love the natural light and big windows*
- *Airy, light and cheerful*

Acoustics represent the only area with significant negative comments.

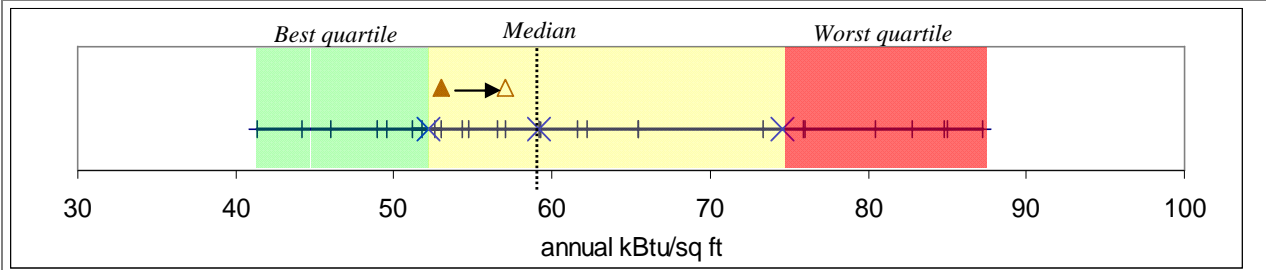
- The most common area noted as needing improvement was for noise disturbance from the common areas and hallways

Sample survey comments:

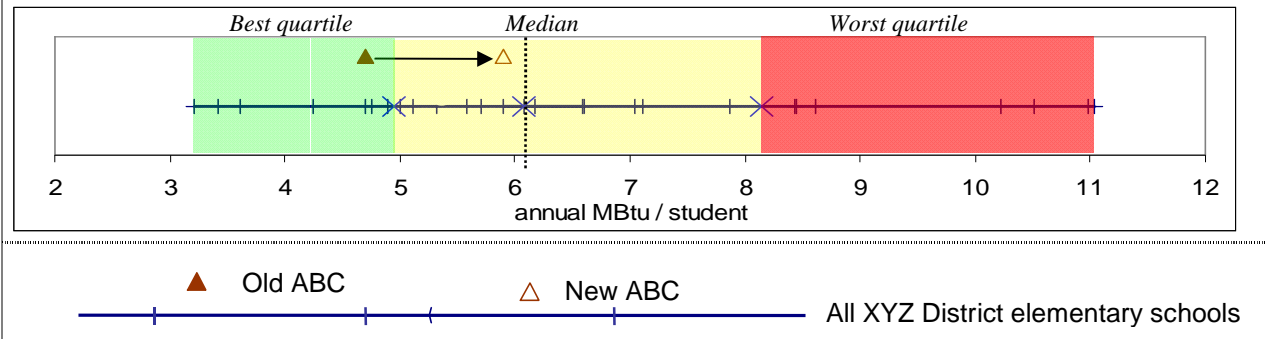
- *Noise from activities in the shared space interferes with classroom teaching.*
- *I would like softer surfaces in the shared spaces to reduce noise.*

II. ENERGY PERFORMANCE

Energy Use / Square Foot



Energy Use / Student



Energy use/sq ft in the new building is just below the median for all XYZ District elementary schools, 8% higher than for the old ABC.

- New building results are based on just a partial year of experience, while the new heating system was being commissioned. The 2006/07 school year may have better results.

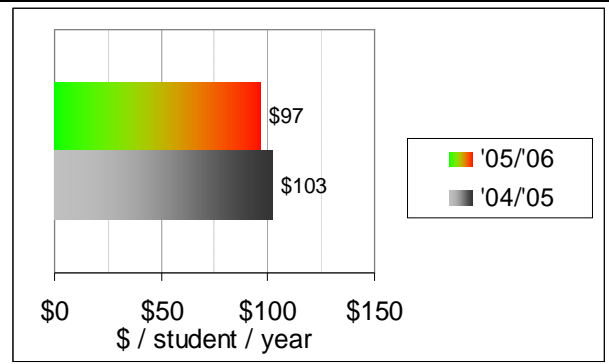
Energy use/student in the new building energy is slightly above the district-wide elementary school median, 26% higher than for the old ABC.

- This increase reflects the small energy use increase per square foot plus the new building's larger square footage per student.

Energy Star Rating

[available after completing at least one full year of results in the new building]

Energy Cost / Student



Energy cost/student decreased slightly, despite the increase in energy use/student. The change from electric to gas heating reduced the school's overall average cost per unit of energy.

III. OPERATIONS AND MAINTENANCE

These observations and suggestions are drawn from interviews with Facilities and Custodial staff, combined with the energy and survey results.

- New building commissioning was still occurring during the period covered by this report. Monitor second year energy usage and occupant comfort to determine whether HVAC commissioning succeeded in bringing down energy costs and reducing localized temperature discomfort.
- Several south and west classrooms appear to have excessive solar gain. Exterior shading is generally the most effective means of controlling this problem, and does not appear to be consistently provided for all rooms. Night ventilation to thoroughly cool the building mass may help increase the portion of the day during which rooms stay cool.
- While the newly commissioned building appears to have adequate ventilation, the facilities staff have not recorded hand-over information from the contractors including design ventilation rates and how “percent-open” damper settings relate to these rates. Periodic calibration of outside airflow rates to these design settings is important to maintaining good air quality over time.
- Building signage could increase occupant comfort and potentially decrease energy usage.
 - Electric light levels in several classrooms appeared to be set unnecessarily high, not taking full advantage of daylighting and light sensor controls. Unneeded lights were observed on in some areas without occupancy sensors.
 - Consider posting simple directions near controls for lighting and for classroom night-heat.
- The no-wax flooring materials used throughout this building are seen as a significant maintenance benefit by the custodian staff, reducing both time and supply needs.

IV. CONCLUSIONS

ABC Elementary generally received high marks from a comfort perspective, which should enhance the learning environment. Noise control in hallways and common areas could benefit from additional attention. Some classrooms need better solar control to reduce overheating.

Energy bills have some room for further improvement. Consider night flushing in warmer weather to cool the building mass and maintain comfort.

Energy bills may also be reduced by turning off unneeded lighting in areas without sensors, and by training and signage for the teachers on how to use classroom lighting controls effectively.

APPENDIX D: Sample Facility Performance Evaluation

The case study documents listed below are provided on the pages that follow:

- Washington State Post Occupancy Evaluation Case Study: Pilot program
- Massachusetts DCAM Facility Performance Evaluation Case Study: LEED™ Gold Academic Building

Washington State Post Occupancy Evaluation Case Study

Introduction

Washington State's High Performance Public Buildings Law (RCW 39.35D) requires all state facilities to be designed, built, and certified to the LEED™ (Leadership in Energy and Environmental Design) Silver standard. The Washington State Department of General Administration is the lead agency for implementing this law. Among its responsibilities, General Administration submits a biennial report to the legislature on implementation of the law including documentation of ongoing operational savings and recommendations regarding implementation. To supplement the reporting and quality assurance requirements in this law, General Administration worked with the Washington State University Energy Program to conduct a pilot project to test the use of Post Occupancy Evaluation (POE) in high performance and LEED public buildings in Washington.

The intent of this pilot project was to develop a simple POE approach that could be used to evaluate state buildings in Washington. Conducting a POE on new state buildings would help document the benefits of Washington's High Performance Public Buildings Law, identify opportunities for improving building performance, and provide feedback that could be used to improve the design and performance of future buildings.

The POE pilot project consisted of three parts. First, we conducted background research on POE. We identified nine organizations involved with POE, conducted web research and interviews, reviewed reports and materials collected in our research, and produced a summary report³.

Next we developed a POE approach that could be tested in recently constructed state buildings. Our goal was to develop a POE approach that could be conducted with a minimal level of effort.

In the third part of our pilot project, we tested the POE approach. We conducted four pilot POE studies in recently completed state buildings. The approach, results, and lessons learned from these pilot POE studies are summarized in this case study.

Approach

The simple POE approach used in our pilot project consisted of three elements:

- site visit and facility manager/staff interviews
- energy consumption analysis⁴
- occupant surveys

The approach we developed relied on POE work by others that we identified in our POE research and on existing tools like Energy Star Portfolio Manager (U.S. Environmental Protection Agency) for energy and water analysis and an occupant survey developed by the New Buildings Institute. During the pilot study, each participating facility was asked to complete a building site visit and information forms, an occupant survey, and provide at least the most recent 12 months of energy (and water) data. In return the facility received a 3-5 page report summarizing the results of the evaluation along with key conclusions and

³ Kunkle, Rick, 2007. *Post Occupancy Evaluation Assessment: Background Research Summary*, Prepared for the Washington State Department of General Administration, WSUEEP08-008.

⁴ We did not analyze water use in the pilot study, but this should be considered for POE projects.

recommendations. A POE Agent with a background in facility analysis facilitated the POE process. The following text briefly summarizes the POE approach that resulted from our pilot project. It includes improvements made to the process as we conducted the four pilot studies.

Facility Site Visit

This is the first step in the POE process. It provides an opportunity to collect information about the building and building performance. The POE Agent visits the building. Facility staff provides a tour of the building, highlighting unique features of the building and discussing how the building is operating. The POE Agent asks about what is working well and not so well and why the building may or may not be meeting performance expectations.

During the site visit the POE Agent goes through the POE process forms with facility staff, answers questions, and helps complete the forms. The **Building Information** and **Facility Management and Operations Staff Questions** forms should be completed as part of the site visit process (or soon after the visit). If possible, facility staff should provide the POE Agent with energy and water use information at the site visit.

Energy and Water Consumption Analysis and Benchmarking

This analysis uses utility data to rate building performance relative to comparable buildings. It requires at least the most recent 12 months of energy data for all fuels and water data. More than 12 months of data is beneficial to allow for start-up issues that typically occur in the first months of building operation. The POE Agent enters the energy (and water) consumption information into Energy Star Portfolio Manager for analysis. Information from the **Energy Star Portfolio Manager Benchmarking** form is also needed to conduct the analysis. Many types of buildings, but not all, can be rated (benchmarked) using Portfolio Manager. If facility staff has already entered energy and water information into Portfolio Manager, the POE Agent may only need to review this.

Occupant Survey

The occupant survey asks building occupants to rate building comfort. The occupant survey was developed by the New Buildings Institute and used in a recent U.S. Green Building Council study of LEED buildings. This is a web-based survey that takes less than 10 minutes to complete. It asks building occupants a series of questions to rate their comfort in four major categories: lighting, acoustics, temperature, and air quality as well as overall building comfort. The process used by the New Buildings Institute for conducting the survey is described in the **Occupant Survey** form, which includes information that needs to be provided to set up the occupant survey for each building.

Results

The four buildings for the POE pilot included:

- a new elementary school that was a Washington Sustainable Schools project
- a state office/warehouse building that received a LEED Silver rating
- a university building with a mix of uses that received a LEED Silver rating
- a community college building with classrooms, offices, and an auditorium that received a LEED Silver rating

The results of the pilot POE studies for these buildings were mixed (Table 1). Two buildings had very good energy performance while the other two were well below average. Energy use intensity (EUI) is a common measure of energy performance (energy use per square foot). Energy Star provides ratings (benchmarks) for common building types based on comparisons with the energy use of similar buildings. Note that an average Energy Star

score is 50. A building with a score above 50 is better than average, while a score below 50 is worse than average. Some building types, like university/college buildings, are not among the common building types rated by Energy Star. Thus for buildings C and D, we used a national average EUI for these buildings for comparison.

Table 1. Energy and Comfort Performance Ratings

	Bldg A	Bldg B	Bldg C	Bldg D
Type	k-12 school	Office/Warehouse	University	Co. College
Square Feet	64,926	60,323	26,585	20,027
Energy Performance				
EUI (kBtu/sqft)	34.5	91	174	72
Energy Star Rating	77	22	~50% worse than avg.	~40% better than avg.
Occupant Survey Comfort Ratings				
Overall	0.9	0.4	1.0	0.8
Lighting (0.6)	1.3	0.9	1.3	1.1
Acoustics (0.0)	0.9	0.0	0.6	1.3
Air Quality (-0.2)	0.6	0.2	0.6	1.0
Temperature (0.1)	0.1	-0.2	0.7	0.4

* Energy Star does not offer a rating for University/College Buildings

The occupant surveys indicated that building occupants were satisfied. Scores of '0' are neutral and normative scores are shown in parentheses for each category. All the scores are equal to or above the norm, except for building B, which had a below average rating for temperature comfort. Comments by the occupants confirmed this low rating. The temperature comfort area had the lowest occupant satisfaction ratings and had the most negative occupant comments across all the buildings. There were lots of too hot/too cold complaints and related concerns about temperature fluctuations.

All the buildings had problems with building operations. Start up problems are not unusual in new buildings, but since these buildings were commissioned there is an expectation these problems would be minimal. It seems that commissioning and the turnover of building operations to buildings staff in some of these buildings was less than adequate. Some of the problems identified in the POE studies included control systems functioning improperly, poor installation and failures of sensors, water leaks in roofs, walls and pipes (likely installation issues), issues with waterless urinals and plumbing design, an oversized chiller, issues with an actively and passively ventilated building, and noise transmission problems. Some of these problems have been corrected, but two buildings continue to have significant problems that are adversely affecting energy performance (and energy cost) and occupant comfort. The POE report recommended re-commissioning in these two buildings.

Lessons Learned

The results of the POE studies at the four pilot buildings confirmed the value of this kind of follow up in new buildings. There were opportunities to improve performance in some of the buildings. The studies highlighted the need for better building commissioning and a better hand off to the facility staff operating the buildings. A number of design issues were highlighted and if POE studies are conducted across a number of buildings, this information could positively influence the design of future buildings.

We learned some things in the process of conducting the pilot POE studies that helped us improve the POE approach. Participation in the pilot was voluntary and in a few cases we had trouble engaging facility staff in the process and it took longer to complete the POE study than we would have liked. In these cases we had trouble obtaining the information we needed from facility staff to conduct the POE study. Because facility responsibilities were shared, it was difficult to identify the person who had the information we needed or that could make things happen. Staff was busy and did not have a lot of time to deal with extra things like a POE study.

We also received very little feedback from facility staff about the POE studies for their buildings. Some were appreciative because the study affirmed what they were doing. For the buildings not performing well, we did not get any feedback on what they intended to do to address the concerns raised in the POE study. We did not meet with facility staff to discuss the results of the POE and this might have been a valuable thing to do.

Over the course of testing our POE approach, we made modifications to the approach to respond to the issues that were coming up. We better defined what we were doing and tried to be more specific about what we wanted from facility staff. This led to developing forms and handouts we could give to facility staff that describe the process and the information we need. We also added a follow-up process to the POE approach to provide a way for facility staff to offer feedback and corrections to their POE study and to indicate how they intend to respond to any issues raised in the POE (this follow up step was not tested in the pilot). We hope to use the results from this POE pilot to develop guidelines for post occupancy evaluation in new state buildings in Washington.

Massachusetts DCAM Facility Performance Evaluation Case Study: LEED™ Gold Academic Building

Introduction

The Commonwealth of Massachusetts' Executive Order No. 484, signed by Governor Deval Patrick on April 18, 2007, requires all state facilities over 20,000 sf to be designed, built, and certified to the "MA LEED Plus" standard. MA LEED Plus utilizes the LEED™ (Leadership in Energy and Environmental Design) rating system with the inclusion of specific pre-requisites deemed important to Massachusetts. As the primary agency responsible for managing state building construction and major renovation projects, the MA Division of Capital Asset Management (DCAM) has a prominent role in implementing this policy. Prior to the requirement of MA LEED+, a number of DCAM's project managers had begun utilizing LEED™ as the benchmark of choice for state building projects. Even prior to its involvement with LEED™, or any kind of "green building" policies, DCAM was utilizing post occupancy evaluation (POE), also known as facility performance evaluation (FPE) to learn from completed projects and create a feedback loop for decision making on new projects. The current emphasis on sustainable design, energy efficiency and water conservation has strengthened the desire of the agency and the building industry to utilize performance analysis to determine whether the decisions being made are bringing operational and life cycle value to state facilities.

DCAM originally performed building evaluations primarily based on occupant feedback regarding building usage, operations and maintenance to gather "lessons learned" to inform new projects. This has proven especially helpful in the area of space planning in which feedback from building occupants about what worked well, what didn't and how user needs changed over time was used to inform decision making for facilities during planning. Sometime in the past several years, the POE program began to focus more heavily on the importance of facility performance. Coincidentally, around this same time, DCAM also began requiring third party commissioning on all major new construction projects. The POE (post occupancy evaluation) program evolved into the FPE (facility performance evaluation) program to better reflect the goals of the analysis. It is now being further expanded to include analysis of planned versus actual energy and water usage in addition to the valuable insights traditionally gained about building planning, materials, operations and maintenance through our FPE visits.

FPEs that incorporate feedback on all aspects of DCAM projects including programming, operations, maintenance, sustainability, as well as energy and water efficiency are expected to help document the benefits and challenges of utilizing the LEED™ rating system, identify opportunities for improving building performance, and provide feedback to improve decision making of future buildings.

The first FPE conducted by DCAM that combined all of these components was for a new academic building that achieved a LEED Gold rating under LEED NC v2.1™. This was the first LEED™ rated project for DCAM, the college, the architect and the general contractor. When this building was completed, Executive Order No.484 was not yet in effect. At that time, DCAM was typically recommending that projects be LEED™ Silver "certifiable", although the state had not yet made the commitment to registering and certifying all building projects. DCAM's client agency, a community college, wanted to achieve a LEED™ rated facility at as high a level possible.

Since this was DCAM's first LEED™ certified facility, it seemed a natural fit to be the first to receive a more comprehensive FPE. There had been a lot of growing pains during the

learning curve while completing the first LEED™ facility and by the time this building was ready for evaluation, Massachusetts was committed to using the rating system for all new construction and major renovation projects. Project managers had a number of questions as to what this entailed; it was also seen by many as adding cost to the projects and some wondered whether it was a valuable investment.

The approach, results, and lessons learned from this facility performance evaluation are summarized in this case study.

Approach

The FPE approach used in our case study consisted of the following elements:

- background data gathering and FPE planning
- site visits and facility manager/staff interviews
- project team interviews
- energy consumption analysis¹

The approach relied heavily on obtaining information from DCAM project personnel and from the facility. During the site visits, staff members met with the FPE team and were very forthcoming with feedback about the facility, which is typical in our experience. The internal DCAM FPE team consisted of three staff members experienced with FPE and a consultant experienced with LEED™. None of the team members had been previously involved in the project, which is DCAM's preferred approach in order to maintain neutrality when conducting the evaluation. The following text briefly summarizes the FPE approach used during this case study project.

Background Data Gathering and FPE Planning:

This was the first step in the FPE process. It provided an initial opportunity for the FPE team to collect overview information and orient themselves to the facility. The FPE team reviewed the certified study program (final planning documentation), all of the LEED™ Gold project certification documentation, and other relevant decision making tools that had been used by the project team during design and construction. The FPE team also reviewed the general facility information found on DCAM and the college's websites.

Facility Site Visit and Interviews:

During the FPE planning phase, the team developed a list of building occupants to interview including members of the College Administration, staff and faculty working in the building, and facilities staff responsible for maintaining the building. Some users interviewed were involved in the planning and design review of the project; others were not. Written feedback was also provided to the FPE team by some users who were unavailable for interviews. The main point of contact at the completed building was the Director of Facilities. In addition to leading the site visit tour, he also made arrangements with all of the building users and college staff the team wished to interview.

During the facility walkthrough tour, the FPE team took photos, documented observations about building performance and conducted interviews of building users. Interviews focused on how the building is operating, what is working well or not so well, what could be learned, what had been changed since occupancy (and why) as well as why the building may or may not be meeting performance expectations.

Feedback and Data Analysis:

Following the site visit, the FPE team organized and analyzed the findings. Information and occupant feedback gathered was organized into the following topics:

1. Feedback from Building Occupants
2. How well the building meets user needs)
3. Commissioning of Building Systems
4. Technical Performance – Operations and Maintenance
5. Energy Performance
6. Key Conclusions and Recommendations

Following the FPE team's site visit and initial data gathering, a consultant was brought on board to fully explore the issues related to the sustainable design process, gather lessons learned and analyze predicted versus actual energy usage.

Energy Analysis

This analysis compared facility meter data to electricity usage predicted by energy modeling in the design phase. It also compared actual production of the building's solar photovoltaic system with predicted energy output. Data from the solar photovoltaic array was readily available from the Massachusetts Technology Collaborative, which had provided grant funding for the array and collects data electronically. Electric meter data was more challenging to acquire. Although meter data was eventually provided by the facility, it was initially unclear how to obtain the necessary information and the formatting of the data was somewhat obscure when first provided. Natural gas data has not yet been acquired for the specific building. Difficulty obtaining the utility data may be attributed in part to the way the campus is billed. The Commonwealth of Massachusetts is currently working with state-owned facilities to make utility data more readily available for analysis.

Results

Feedback and data gathered during the FPE indicate a number of ways in which the building is performing as expected or exceeding expectations. There are also a variety of lessons learned that can be taken from this project in order to inform ongoing and future DCAM projects. A sample of these findings is described below.

Energy Consumption:

The FPE team has begun preliminary comparisons of the energy use intensity (EUI) of the facility to comparable buildings in the 2003 Commercial Buildings Energy Consumption Survey (CBECS) database, maintained by the Energy Information Administration (EIA). EUI is a common measure of energy performance (energy use per square foot). The CBECS data serves as the basis for Energy Star ratings (benchmarks) for common building types based on comparisons with the energy use of similar buildings. The building is consuming less electricity when compared to the CBECS 2003 data, but data for natural gas consumption needs to be gathered to definitively determine the overall energy use index of the building. Additional data is currently being gathered for further analysis.

The actual energy performance of the building was also compared to the energy performance predicted by energy modeling completed for LEED™ project documentation. Metered electricity data, which was only available for one year at the time of the FPE, indicated that electricity usage for the building is very close (within 1.53%) of predicted consumption.

Renewable Energy Production:

The project included a roof mounted solar photovoltaic array and additional solar photovoltaic panels on second and third floor awnings. Based upon two years of data, the solar pv system is exceeding expectations, as demonstrated in the table below.

Table 1: Solar PV - annual electricity production

Predicted	Actual 2007	Actual 2008
27,400 kWh	30,202 kWh	28,921 kWh

Thermal comfort:

Feedback indicated some occupant dissatisfaction issues with thermal comfort. This may have been due to some problems the facility experienced with communication between two critical pieces of mechanical equipment, which affected the ability of the heating and cooling system to function properly. It is our understanding that the manufacturer was involved in the resolution of these issues and provided a warranty period based upon the time needed to develop and successfully implement a solution. DCAM will be following up as the building completes another heating and cooling season to determine if these issues have been fully resolved.

Sustainable features:

Strategies such as the extensive use of daylighting within the building have been met with mixed results. In many spaces, such as lobbies and offices, feedback indicated that the occupants view daylight as a wonderful amenity that enables artificial lighting to be kept off in many locations throughout the day. In computer classrooms, however, the abundance of daylight presents a unique challenge. The layout of the space, particularly the position of individual computer screens and the projector screen in relation to the windows causes a large amount of glare on the screens making it difficult to see the screen during daylight hours. This issue could potentially be mitigated by modifying the furniture arrangement or installing shading devices on the windows.

Facility Operations and Maintenance:

This was the first new building on campus in over 30 years. Feedback indicated that the facilities maintenance team faced some challenges and a steep learning curve in taking ownership of this building, which is not surprising given the changes in technology since the original campus was built. Although experienced facilities maintenance staff on the existing campus are generally very knowledgeable about the buildings systems for which they are responsible, they do not necessarily have the expertise to troubleshoot new and unfamiliar equipment or computerized energy management systems with multiple control points. This has created challenges and frustration for the facility staff, who are trying to maintain the building and optimize operational efficiency.

Commissioning:

This project utilized a commissioning agent hired by the design team to provide enhanced commissioning. The commissioning agent performed site inspections, participated in key job site meetings and was actively involved in operator training exercises, among other things. Feedback indicated there were some areas of the project where the commissioning agent could have been better utilized, such as during review of potential MEP product substitutions. There were also some indications that the commissioning could have been more fully integrated and involved earlier in the design process. DCAM projects are now required to have an independent third party commissioning agent working directly for the owner. Commissioning agent roles and responsibilities continue to more clearly defined.

Lessons Learned

The completion of a new LEED™ Gold building on campus has been very well received. The community college administration and staff members have gone above and beyond the call of duty to share their lessons learned with others by giving presentations, conducting

tours and using the building in a variety of ways as a public venue. In addition, they were extremely generous with their time and knowledge during the FPE process.

Conducted over a period of just under two years, the FPE took much longer to complete than the team would have preferred. This was DCAM's first facility performance evaluation to deliberately focus on LEED™ related issues and energy performance. As a result, it took some time to figure out what was needed and how to proceed. Typically, all FPE activities are completed by DCAM's in-house FPE team. However, for this FPE, personnel changes resulted in delays for the FPE effort and necessitated bringing in additional assistance to complete the FPE data gathering exercise. DCAM has under contract a variety of design professionals, called facility advisors, who can be utilized to assist with specialized scopes of work. Following the initial site visits and interviews with building occupants, DCAM contracted with one of these facility advisors, a local sustainable design professional, to assist with the remainder of the data collection and analysis. Although this outside assistance was helpful to the completion of the FPE project, it may have been more expeditious if the facility advisor was integrated into the FPE activities from the start of the project since some of the FPE team's activities were duplicated in order to get the facility advisor up to speed.

The FPE team also learned that information can be difficult to obtain after the facility is in operation. The Commonwealth is currently working on ways to standardize information and facilitate access to the necessary data. The FPE team is also streamlining its approach to more clearly identify the specific information that needs to be gathered from the client agency.

The aggressive energy efficiency goals of the Commonwealth of Massachusetts, coupled with tough economic times has led to a greater emphasis on building performance since energy savings generally leads to operating savings. DCAM's use of Facility Performance Evaluations can provide valuable knowledge to project staff to improve initial decision making and subsequent building performance. Lessons learned as a result of the evaluation process are shared among the project teams for the specific facility being evaluated as well as to all DCAM project staff in order to continually improve our process and our projects.
