A Market-Friendly Post-Occupancy Evaluation: Building Performance Report

Final Report – Contract C 10091

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EXECUTIVE SUMMARY

Post-occupancy evaluation (POE) is the general term for a broad range of activities aimed at understanding how buildings perform once they are built and how satisfied building users are with the environment that has been created. Much of the development and work on POE to date has been supported within academic institutions, resulting in protocols which tend to be detailed and specific to research purposes.

The purpose of the research and development tasks documented in this report was the identification of market interests and perceived value of a POE, and development of a low-cost, market-responsive post-occupancy evaluation protocol based on those findings. Project tasks included a detailed literature review and interviews with key market actors. Development tasks were guided by a technical advisory committee.

Key research findings include:

- Owners, not design teams, are the primary audience for a POE (although designers can benefit).
- Few owners collect information regarding occupant satisfaction. Most rely on informal communications and complaints.
- Owners and design team members seem interested in the concept of a standard building performance or evaluation tool, with most stating they would take advantage of such a tool if it were available and affordable.
- Energy use and occupant satisfaction were at the top of the list of important elements to include in an evaluation, followed by interviewing facility managers and reviewing system controls/operations.
- Cost of the evaluation was cited as the largest barrier to use, followed by logistical or time constraints. While portions of the market may support costs of $5,000 or above, some key markets may require much lower costs, e.g. $2,000.
- The term “Post Occupancy Evaluation” is itself a market barrier.

Based on the findings, advice from the technical advisory committee, and communications with others performing POEs, a low-cost Building Performance Report (BPR) protocol was developed. Though the protocol has not yet been field tested, a related project conducted by the Cascadia Region Green Building Council (Cascadia) informed its development.

To respond to market price sensitivities, the BPR is broken into three levels. Level One is a performance review consisting of a simple set of basic indicators (occupant survey, energy bill analysis and facility manager interview) reflecting whether the building is performing to the desired level. The conclusion of a Level One Performance review will be a four-page, graphic intensive report which:

- Describes the building and its basic operational elements.
- Benchmarks the Occupant Survey information in graphic form.
- Summarizes, indexes and benchmarks energy use (and water use, if desired).
- Provides a limited set of findings and recommendations regarding issues in building performance and how they might be improved, or whether additional diagnostics are recommended to better understand the issue.

Level Two includes a series of optional diagnostics tools for use if building performance issues were identified during the Level One performance review but their underlying causes were not immediately evident. Several diagnostic tools are identified; additional tools may be available in the market.

Level Three is a pathway leading to improved performance, through referrals to available guidelines, training and market-based services, and/or re-engagement of members of the building design and construction team.

A remaining question is who should support the BPR process, and possibly some of the diagnostic services. A central organization should define the basic elements of the product (and protect it with a brand name), maintain a central database to improve benchmarking over time, maintain product consistency and quality assurance, and provide training. This organization could be an energy-related nonprofit or a trade association.

There appears to be sufficient market interest to warrant further development of the framework and tools detailed in this report. While the Level One performance review process, tools and report exist at a sufficient level to support field testing, additional development is required. This report recommends the following tasks:

- Complete the initial development of the BPR through a field test of Level One.
- Continue development of an improved pathway into the Second (diagnostic tools) and Third (resources) Levels.
- Enter into a partnership with a key owners group or trade association for final development tasks. Such a partnership could influence key elements of the BPR to better address market needs, build initial support for implementation, and expedite market adoption.

1. Introduction

Purpose

This report documents the activities undertaken by New Buildings Institute (NBI) under contract with the Northwest Energy Efficiency Alliance (Alliance) to research, package and test a simple and inexpensive post-occupancy evaluation protocol. The general purpose of the research was to identify and/or develop a post-occupancy evaluation protocol that provided value to the market and met market needs, as the majority of work on POEs has been related to research rather than focused on market interests.

The project consisted of the following tasks:

- Establish and coordinate a technical review panel
- Conduct a literature review of post-occupancy evaluations and related strategies
- Interview key market actors to establish the value proposition
- Identify and assess a low-cost POE
- Field test the draft protocol
- Summarize findings

The investigation of current approaches to post-occupancy evaluation, market interviews and development of a market-responsive protocol were the final focus of this project period. Field testing of the draft protocol did not occur. However, the Cascadia Region Green Building Council did conduct POEs in a series of buildings in the Northwest in 2005, and their experience, while using different tools and with a somewhat different purpose, did inform the findings and recommendations of this report.

Background

Post-occupancy evaluation (POE) is the general term for a broad range of activities aimed at understanding how buildings perform once they are built and how satisfied building users are with the environment that has been created. There is no industry accepted definition of POE and many different terms in use, such as environmental design audits, building-in-use evaluations, post-occupancy assessment, facility assessment and building performance evaluations.

While the POE field is limited at this point, it is also very diverse, and interest is increasing. Much of the development and work on POEs has been supported within academic institutions, resulting in protocols which tend to be detailed and specific to research purposes. There is no well-defined protocol in general use, although there are several occupant surveys which have been used across multiple buildings.

The best known protocols are related to the PROBE (Post-Occupancy Review of Buildings and their Engineering) work in Great Britain (which has expanded to several other locations) and survey tools developed and supported by the Center for the Built Environment at UC- Berkeley. It appears that even these better known products have been used perhaps on a few hundred buildings at most over 20 years.

There is also a range of possible purposes and benefits for POEs, including:

- Support for the development of design and planning guides
- Provision of information to the building industry
- Testing of new concepts
- Justification of major expenditures
- Education of decision makers (owners and designers) to avoid repeating past mistakes
- Improvement of building performance over time; e.g. remedy problems or adapt the facility to changing organizational needs
- Accountability of design professionals and owners for building performance
- Better communication among designers, clients, facility managers, end-users

Report Organization

Section 2 of this report focuses on key findings from the literature review.

Section 3 reports on findings from interviews with key market actors[1].

Section 4 of the report presents the recommended structure and content of a post-occupancy evaluation protocol. The POE protocol has been given a more market friendly name: Building Performance Report, or BPR. The recommendations are given in several stages. First, findings from the literature survey, interviews, the Cascadia survey work and comments from the technical advisory committee are integrated into a series of general recommendations of what the market desires and how the services might be provided. Second, a framework for the BPR is presented which discusses the content and structure of the BPR service. Third, two specific aspects of the BPR tool are presented – a suggested report format and an occupant survey.

Section 5 of the report suggests additional development work which may be useful to prove the value of BPR, refine the tools and integrate BPR with current market-oriented processes.

Appendices are included which contain additional useful background material to this report and as support for future work. These include process findings from the Cascadia POEs, a detailed look at two relatively similar survey protocols and some additional operational issues associated with the BPR.

[1] The **Appendix** also contains the full literature review with references, as well as the protocol used for the market actor interviews.

2. Key Findings from the Literature Review

An extensive literature review was undertaken in the early stages of this project. The full literature review is included as Appendix D; key barriers, opportunities and findings are outlined below.

Barriers and Opportunities

Key researchers and product developers of POEs have documented the educational value of their evaluations but wondered aloud why POEs find such a limited audience. A number of barriers to the use of POEs are well documented. Among the more substantial are:

- Funding for POEs is not included in design budgets, and it is unclear who has responsibility to conduct POEs.
- Interest in the end product can be limited, as it is perceived to come too late in the process. The design team has moved on to the next project. The owner may not be planning similar projects or considers the lessons learned to be unique to one project.
- There can be significant technical and logistical difficulties in obtaining data.
- The POE report may uncover problems, possibly leading to awkward questions or even liability. At the very least, design professionals don't welcome other professionals reviewing their work with a critical eye.
- The timeframe for conducting the evaluation is well beyond the traditional scope of work for design and construction contracts (i.e., one year after occupancy).
- Perhaps the key barrier to actual integration of POEs within organizational practice is contained in the following paragraph (Zimring and Rosenheck in *Learning from Our Buildings*, 2001).

> "Structured organizational learning is difficult. It requires the will to collect data about performance and the time to interpret and draw conclusions from the data. More fundamentally, learning involves risk and change. Learning exposes mistakes that allow improvement but most organizations do not allow shortcomings. Learning brings change and organizations are usually better at trying to ensure stability than at supporting change."

Despite the barriers, there is ample evidence of current renewed interest in POEs. One of the drivers is the appeal of sustainable construction. POEs can accelerate the learning period about positive and negative changes created by sustainable buildings and help demonstrate the market value of such projects. For example, sustainable buildings typically include elements to reduce resource use, and many claim to better support human health and productivity. A simple POE can determine to what extent benefits are actually being realized, and at a deeper level of analysis, which building elements are responsible for these benefits. There are multiple recent or current studies on the benefits of green buildings.

A second driver is the recent increase in energy prices. So far, business-driven applications have been few, but this issue has business managers again reviewing their options for reducing operating costs, with a focus on energy. Much of the impetus behind POEs thus far has come not from business but from research, with the exception of large government owners of buildings. The literature confirms this, with references to asset management, space planning and the Balanced Scorecard Approach (which looks at financial, business process, customer relations and learning and growth).

Information is most likely to be used when it's been asked for. Several efforts are currently being made to link POE research findings back to business decisions, with an emphasis on the pre-design programming process for new construction or space renovation in existing buildings. There is definitely a growing interest and opportunity in the market for targeted information on actual building performance and occupant feedback.

Key Conclusions

The primary conclusions resulting from the literature review are:

- There are a wide variety of POE protocols, but most are related to research agendas rather than market needs
- No one protocol exists which accomplishes the goals of this project in terms of budget, scope and ease of implementation.
- There are elements of several different protocols which appear to be useful and relatively simple to implement.
- A series of critical market barriers must be addressed for the end results of this project to be useful and repeatable.

For this project to meet market needs, the major questions to be resolved to scope and scale the draft POE protocol are:

- What data are the market most interested in?
- What types of data development processes will the market support?
- How much money is the market willing to pay for this information?
- How can building reports be educational without finding fault?
- What is the right intervention point(s) for a POE, and who is involved from the building (owner) side?

This project relied on two primary processes to develop the answers to these questions: a technical advisory committee and a series of interviews with key market actors. Results from those processes are reported in following sections.

3. Findings from Market Interviews

Process

Interviews were conducted with key market actors to better understand four key aspects of building performance evaluations:

- Current practices regarding feedback on building performance and occupant satisfaction
- The most intriguing elements of a potential POE tool
- Potential value of a POE
- Key barriers to increased use of POEs generally

An interview protocol was developed and ten fairly detailed telephone interviews were conducted, lasting from 20 to 40 minutes. Selected interviewees represented three different market perspectives: private developers/owners, public building owners and design team members. Three interviews were conducted with the private developers/owners, four with public owners and three with architects or engineers. All but one of the respondents were actively engaged in new construction projects, and five continue to have responsibility for managing buildings over time. Buildings included a wide range of new features, such as daylighting, natural ventilation and newer mechanical system options (e.g., underfloor air and ground source heat pumps).

Current Practices

When asked, *"What are your key measures for judging the success of a new building project after the project is completed and occupied?,"* respondents gave a range of answers, but primarily referenced informal feedback and client communications. One public owner had initiated a post-occupancy survey of their own design, one specifically mentioned the warranty review process, and one reviewed energy use compared to model results. Two design team members had initiated post-occupancy reviews on selected projects in recent months.

Most respondents referenced some form of functional follow-up of building performance, such as commissioning, reviewing the energy management system, warranty reviews or reviewing energy use. While almost all respondents cited informal interactions regarding occupant satisfaction, only two respondents completed any type of systematic review of occupant satisfaction.

Only one respondent was able to name evaluation tools available to use for reviewing building performance, occupant comfort and/or occupant satisfaction. Six respondents have used LEED on projects, three had heard of the Energy Star tools, and one was using Energy Star Portfolio Manager.

Respondents were asked to rate aspects of the interior environment of buildings for occupant health and comfort. The ratings were simply "very important, somewhat important, or not important". The elements are listed below in order of the rated importance, with a numeric score where 3 equals "very important" and 1 equals "not important."

Access to windows	*3.00*
Individual occupant control of lighting within a space	*2.90*

Ability of the mechanical system design to provide fresh air	*2.90*
Provision of daylighting deep into a space	*2.70*
Overall quality of the electric lighting	*2.65*
Openable windows	*2.40*
Individual occupant control of temperature within a space	*2.40*
Ability of occupant to control the amount of fresh air	*1.95*

Respondents were also asked to judge the frequency of complaints received. Temperature-related complaints were the most common, with complaints about ventilation and lighting issues rated as "occasional."

Elements of Interest in a POE Tool

The remainder of the interview focused on opinions regarding potentially valuable aspects of a benchmarking or assessment tool for buildings, the perceived value of such a tool and key barriers to its use.

Respondents were asked to rate the importance of various elements of a potential POE system. They are listed below in order of the rated importance, with a numeric score where 3 equals "very important" and 1 equals "not important." Elements listed in the first group were rated "very important" by all but one or two respondents. Elements in the second group were listed as "very important" by a majority of respondents. Elements listed in the final group were generally considered "somewhat important."

Most Important Elements

Measurement of energy use per occupant or square foot	*2.90*
Review of the key mechanical system controls	*2.90*
Detailed interview with facility manager	*2.90*
Occupant satisfaction with lighting	*2.80*

Very Important to a Majority of Respondents

Comparison of energy use with other similar buildings	*2.70*
Comparison of energy use against preset targets	*2.65*
Occupant satisfaction with temperature control	*2.60*
Occupant perception of productivity	*2.60*

Generally Rated "Somewhat Important"

Measurement of water use	*2.45*
Physical measurement of indoor air quality, such as CO2 concentrations or the presence of volatile organic compounds	*2.30*
Health statistics of occupants, such as sick days used	*2.30*
Measurement of water use per square foot or occupant	*2.10*

Respondents were encouraged to suggest additions to the list of elements. Two respondents strongly recommended acoustic satisfaction/comfort, two recommended a review of maintenance costs, and one recommended a general observation of building operations.

Value and Barriers

When asked , "*Do you believe that benchmarking aspects of building performance could improve building value, occupant satisfaction, or the ability to rent space more rapidly?,*" seven of ten responded "yes," and two said it could have value.

Seven out of ten also responded "yes" when asked, "*If there were a reliable benchmarking or assessment system for building performance, would you be interested in using it on your buildings?*" The remaining three said "possibly" or "probably."

Respondents were also asked to name a fair price to benchmark a 100,000 square foot building. Nine responded, ranging from $2,000 to $20,000, with an average value of $6,800. Two respondents said $2,000, one said $5,000, and three said $10,000. Three others offered a range as a response, citing either $5,000 to $8,000, $5,000 to $10,000, or $10,000 to $20,000. The remaining respondent suggested that as an annual service, the private property management market would pay $500 per building for any information that helped them manage their property better and improve financial returns.

Finally, respondents were asked, "*Who do you think would be the primary audience for a report on overall building performance and what are the two or three most important aspects of building performance that should be covered in that report?*" Nine respondents suggested the property owners (including school boards for school districts) were the primary audience for the report. Design teams were mentioned by two respondents, and property management or maintenance were mentioned by two people.

The key aspects of building performance which respondents felt should be covered in a report spread across a broader range. Five respondents mentioned some aspect of operating costs or financial savings, such as comparing to best practice costs or identifying operating costs. Three respondents mentioned energy performance and three mentioned general occupant satisfaction. Two respondents noted potential improvements to the property as an important element of the report, and one suggested indoor air quality.

Finally, respondents generally agreed that cost was the largest barrier, mentioned by seven respondents. Four mentioned logistical or time constraints, three noted some aspect of value (deep enough, proven), two mentioned liability concerns, and only one respondent mentioned limited market interest.

Several respondents had specific comments about the potential value of the evaluation tool:

> *"Just to know the building is nice is not enough, I'd want to see things where I can improve and save money. As a small building owner I am pretty in touch with my tenants. I can see it would have a wider range of uses for larger owners."*
>
> *"This goes in hand with some of our publications on preventative maintenance. We are hearing more about how we can maximize the maintenance and energy use to improve ROI. The rising cost of energy is on the radar, definitely."*
>
> *"Managing for optimal lease amounts means catering to the tenant. More and more that means dealing with tenant concerns about health concerns that were not part of the picture ten years ago."*

"The management is tuned to what the tenants value. This by definition means that those buildings are well run mechanically. Mechanical has the biggest impact. Cleaning is next."

In response to whether a one would use benchmarking.

"We would be interested in it, and we would promote it to the owner. I think future bids could just have it be an inherent part of the proposal. The design team would perform it, but it needs to be bought into by the owner, and the price needs to be within the overall project budget."

Summary of Interview Findings

While some of the respondents currently measure aspects of a building's physical performance, only two have a systematic way of collecting information regarding occupant satisfaction. Most rely on informal communications and complaints.

Respondents generally seemed interested in the concept of a standard building performance or evaluation tool, with most saying they would use such a tool if available. While those questioned had a reasonably long list of elements that should be included in such a tool, their initial impression of a fair price averaged only $6,800 for a 100,000 sq. ft. building.

While energy use and occupant satisfaction were (as expected) at the top of the list of important elements, they were joined by interviews of the facility manager and review of system controls.

Owners are the clear audience for the report on building performance. While energy performance was a priority, anything that reflected operating costs or savings opportunities also ranked very high.

Cost of the evaluation was listed as the largest barrier to use, followed by logistical or time constraints.

4. Recommendations

This section of the report contains several recommendations to develop and deliver a market-friendly POE protocol. One suggestion was that the protocol have a name more attuned to market values. The recommended name for the specific POE protocol being developed is Building Performance Report (BPR), and this specific name is used in the remainder of this report when referring to the specific POE protocol under development.

The recommendations are broken into several sections. General recommendations are included immediately below, followed by a recommended framework for the BPR. Substantial thought was given to specific aspects of the BORP, such as the occupant survey, other data collection instruments and the report to the client. These additional elements are included in the Appendix.

General Recommendations

NBI staff developed the following recommendations by synthesizing and integrating findings from the research elements of the project, Cascadia's experience with its POE project and the direction and advice provided by the Technical Advisory Committee.

1. **Focus the BPR on the needs of the owner.** From both a sales and results perspective, the owner is the client. While elements of POEs are of interest to design teams, it's owners who have the more compelling interest and greater ability to fund. Owners can create a feedback loop to influence design teams for future projects.
2. **Break the BPR into at least two elements, with the first being as simple and low-cost as possible.** If a building has no significant operational problems, any effort focused on documenting or diagnosing problems is wasted. A low-cost protocol could be repeated every year or two and would also enable owners to compare a range of buildings within their portfolio. While the interviews indicated that the market might be willing to pay $5,000 or more for useful data, cost of the first element of the BPR should not exceed $2,000 in order to increase market acceptance.
3. **The BPR should include information that focuses the attention of the owner on improving building operations.** For buildings requiring attention, the focus should be on taking actions that improve comfort and/or reduce operating costs and not end with simply documenting conditions. Create a pathway to action.
4. **The BPR should not include specific critiques of design elements (e.g., a daylighting design or unusual HVAC system design) but instead rely on occupant feedback, energy bills and facility manager knowledge to identify potential problem areas.** While a potential value of POEs is assessment of the value of specific design elements, there is not a market for such criticism and there would likely be considerable resistance, or even the potential for legal action, from design team members and/or owner's representatives. Other performance measurements can serve to review the overall success of the building.
5. **Consider an initial focus on institutional /public buildings.** Public and institutional owners hold their buildings for a long time, and the split incentive present in many private markets is not a barrier for public owners. Schools and public office buildings may be good initial markets. Large corporate owners that operate their own buildings may also be an attractive early market.

6. **Given the focus on owner needs and building operations, the BPR may be just as useful for existing buildings as for new buildings.** Inclusion of existing buildings enables owners to compare performance across a range of buildings, an assessment which generally meets their needs better. Many operators of portfolios of buildings are most interested in comparing across their portfolio rather than to national or regional benchmarks. Use in existing buildings also substantially increases the potential market for BPR services.
7. **There is a likely market for BPR services, and continued development and testing of the BPR should prove worthwhile.** There may be unique partnerships that can support the implementation of the BPR over time, including potential relationships to the EPA Energy Star program, the Alliance's Buildings Performance Services, BOMA or organizations concerned with facility management and sustainability, e.g., the Cascadia Region Green Building Council.

Framework for BPR

The following framework provides a structure for the various levels of services provided by the BPR. A draft report is contained in Appendix A.

Level One – Performance Review

A simple set of basic indicators regarding whether the building is performing to the desired level is collected in this review. Information would be collected to answer three fundamental questions:

- **Are the occupants satisfied with the way the building is performing?** This information will be obtained through an Occupant Survey of approximately two pages. Survey would be on paper and could be self-administered, then submitted to a vendor for analysis and benchmarking, The Occupant Survey would cover the following areas, although it could be customized beyond a set of core questions to include other customer needs (a draft survey, based on a public domain survey developed by Jacqueline Vischer, University of Montreal is included as Appendix C):
    - Lighting comfort
    - Temperature comfort
    - Acoustical comfort
    - Ventilation comfort
    - Daylighting/views comfort
    - Perceived productivity

- **Are the resource costs of the building reasonable?** This would focus on energy use, corrected and indexed for square footage. Occupant density and weather corrections would be included in the corrections, as would the presence of major computer rooms or other unusual usage. Customer may need to supply utility billing data to keep costs low; corrections would be performed by the vendor. The basic protocol to calculate energy use would be the Energy Star Portfolio Manager. Outcomes would include:
    - Summary of energy costs and summary of water costs (optional)
    - Energy Use Index per square foot
    - Energy Star rating (0-100)
    - Comparison to performance targets established in design
    - Carbon score if desired

- **Are there areas of building operation that may need additional attention?** Given the "reasonable price" estimates provided by interviews with representative market actors, this review will need to be general rather than detailed. Also, this element will result in a brief summary of key issues and potential savings opportunities, not a detailed report, as that would add to the costs. Elements could include:
    - Interview facility manager.
    - Review of areas of concern noted in the Occupant Survey.

The elements below are optional, as they substantially impact the cost of the basic service. It is possible that these elements could be provided by a peer network (e.g. facility managers association) with the BPR providing a format for the collection and review of data.

- Building walk-through with facility manager and possibly others
- Discussion with facility manager and others regarding potential savings opportunities and/or performance enhancements, focused on O&M

Buildings Operations and Performance Report The conclusion of a Level One performance review will be a four-page, graphic-intensive report that:

- Describes the building and its basic operational elements
- Benchmarks the Occupant Survey information in graphic form
- Summarizes, indexes, and benchmarks the energy use
- Provides a limited set of findings and recommendations regarding issues in building performance and how they might be improved, or whether additional diagnostics are recommended to better understand the issue

A sample report mock-up is included as Appendix A.

Level Two – Diagnostics

Additional tools may be useful if some building performance issues have been identified but their underlying causes not determined during the Performance Review. While this area is still being researched and developed, in many cases an energy services provider may readily be able to provide diagnostic services or recommendations. A few newer tools that may be beneficial are:

- For lighting comfort – a LightRight Consortium web survey can help define the problems from a lighting design/technology perspective. See Appendix J for further information.
- Temperature/ventilation issues – A short-term testing protocol similar to one developed as part of Vital Signs or the Advanced Building Systems Integration Consortium.
- Energy use high – variety of possible approaches. Some of the procedures outlined in the Alliance's Building Performance Services would be useful, as would an EZ Sim analysis (see a brief synopsis in the Appendix I).

Level Three – Guidance or Services

No new options are included here. There are a variety of services, training and written guidance available in the marketplace for use by clients. A list of some useful options would be provided to clients.

Operational Issues

A remaining question is who should complete the BPR and possibly some of the diagnostic services. A central organization should define the basic elements of the BPR (and protect it with a brand name, etc.), maintain a central database to improve benchmarking over time, maintain product consistency and quality assurance and provide training. This could be an energy-related nonprofit or a trade association.

Either the building staff or the BPR service provider can distribute and collect occupant surveys. In most cases building staff will provide the energy and water bills to the BPR service provider. If the building staff does not want to provide this information, additional time on the part of the BPR service provider to obtain this data will result in increased cost.

If detailed on-site review is needed, the primary provider of these services should be someone with a broad energy-related technical background, covering lighting as well as mechanical systems. Examples might be an experienced facility manager or energy auditor. The review could be provided by:

- Utilities or DSM program administrators (probably on a fee basis)
- Commissioning agents
- A peer process established through facility managers
- Alternatively, owners of portfolio of buildings could implement the performance review on their own, or energy service companies could provide it as part of a service package.

5. Options and Recommendations for Further Development

From a new construction perspective it is useful to note that the NW Alliance, NBI and EPA all support a building process that emphasizes buildings' performance. This differs from the standard definition of energy efficiency in new construction (documented in ASHRAE, proven by modeling, and still adhered to by the U.S. Green Building Council, for example) that an efficient new building is one that contains certain types of equipment that are projected to perform at a certain level. Buildings need to be operated and maintained properly to achieve both high levels of energy efficiency and high levels of occupant comfort.

Due to funding constraints, this project stopped short of field testing a POE protocol. However, the project did develop recommendations, a BPR structure, protocol and draft report and other more detailed information that would readily support a move to field testing with limited additional development. There are several ways for project development to continue to evolve, and these are explored briefly below.

1. **Complete initial development through a field test of Level One.** The initial processes, tools and report format need additional development, and that development should be tested through actual field implementation on a limited number of buildings.

2. **Continue development of an improved pathway into Second Level (diagnostic tools) and Third Level (resources).** While several diagnostic tools were explored in this project, more information on project fit and costs is needed. There may also be a need to develop additional Second Level tools, or at least repackage existing tools into the BPR framework. Building Performance Services has some useful tools imbedded in its protocols, as well as a resource guide for training, so better linkages with that effort should be worthwhile.

3. **Locate a potential partner for further development.** The original rationale for the project was to develop a POE protocol that the market might embrace and which had the potential for common use in buildings. Finding an appropriate partner could dramatically escalate the speed of market adoption. Several options are listed below, with implications for what such a partnership might entail. In general, it is probably most useful to pick a particular market or particular partner before investing in much further development. That way, the market or partner could influence the additional development in a positive way - shaping the tools for the particular need, determining an appropriate administrative or support structure and getting partnership buy-in to the success of the BPR as a product and a venture. (Other, more specific, partnerships could be developed for an initial foray into the market; for example, a state or local government or large corporate client.

    a. **Cascadia Region Green Building Council** Cascadia has pursued its own POE evaluation project, which, while successful in that they evaluated a series of buildings, experienced many of the same barriers that POEs typically face – limited market interest, substantial logistical concerns, how to fund (Cascadia funded all of the initial projects POEs). The BPR product may enable Cascadia to resolve some of these difficulties, should they have an interest in pursuing POEs further. Sustainable buildings are a good market for POEs, and Cascadia may be an interested partner.

    b. **State of Washington, Office of the Superintendent of Public Instruction (OSPI).** Washington is launching the Washington Sustainable Schools (WSS) project, with substantial technical and administrative assistance from the Alliance and $6.5 million from the Washington legislature. The legislature has required reporting on schools built to WSS requirements; proven superior performance could lead to additional funding. OSPI may request that some funding be set aside for development of monitoring and reporting protocols. OSPI did participate with five other states to solicit funds from the U.S. Dept. of Energy to develop a school-specific POE, but the project went unfunded.

c. **EPA Energy Star/Consortium for Energy Efficiency.** EPA has achieved only moderate uptake of its energy benchmarking tool, despite having strong general support from the commercial real estate industry. CEE has developed a network of utilities to work with EPA to develop a strategy that links utility support to the EPA program. Development of a specific new tool that provides more compelling information to property owners could be useful to either organization independently or to the linked program effort.

d. **Partner with an Energy or Facility Management Association.** There are a variety of energy management or facility management associations that might be useful partners. Use of the BPR could assist in securing management attention for energy efficiency projects and/or serve as useful benchmarking and education resources. There may also be opportunities for peer network support in performance of some of the BPR elements, such as facility walkthroughs or more detailed diagnostics steps. Associations want to provide value to their members, and offering BPR services may be a unique service they can offer.

4. **Link to Other Alliance Commercial Sector Initiative Efforts.** The BPR may be a useful front end to target market efforts, or to the Alliance's Building Operations efforts. The "dashboard" of the BPR report may help generate management interest in energy efficiency, from both an occupant comfort and financial perspective. Certainly some of the elements of Building Operations program are excellent follow-up steps to a BPR report that finds opportunities to improve energy services or efficiency in a building.

5. **Develop a business plan to provide BPR services to the market.** Assuming positive additional development steps, a business plan should be developed to enable the BPR services to be provided to the marketplace in a sustained manner. The potential partnerships and the relationship with the NW Alliance described in earlier recommendations will be primary drivers of the structure and services of the BPR related business. However, within any structure, the BPR has the potential to be developed into a business enterprise.

APPENDICES

Appendix A - Building Performance Report (BPR)

Level 1 Review Summary for XYZ Building (*Sample*)

BPR Objectives:

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

Topics selected to be covered for this building were:

- ☑ energy use trend
- ☑ energy use compared to external benchmark
- ☐ energy use compared to internal benchmark(s) or productivity measures
- ☐ indoor water use
- ☐ irrigation water use
- ☑ occupant perception of building systems functional comfort
- ☑ occupant perception of workspace design functional comfort

Sources of Information

- Survey of occupants, summarized in **Section I**, covering perceived functionality of building systems and interior space design.
- Compilation and review of energy [and water] usage from utility bills, summarized in **Section II**.
- Interviews with building and facility management, to gather their impressions and clarify information revealed in the first two steps. **Section III** summarizes interview results and suggested future actions.

Building characteristics

Building type	Commercial office
Location	Olympia, Washington
Number of floors	5, plus 1 level underground parking
Conditioned square footage	125,000
Year built	2002
Certifications	Energy Star
Number of occupants	500

THUMBNAIL SUMMARY OF RESULTS

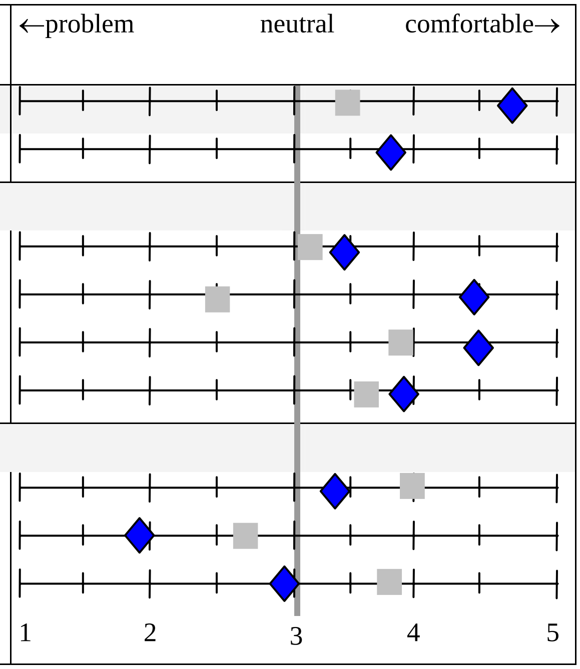
Occupant Assessment of Building Systems:	● Good
Occupant Assessment of Workspace Functionality:	● Not as good as an average building
Energy Efficiency:	● Good

I. Does the Building Meet the Needs of Its Occupants?

A *BPR* survey of occupants was conducted in May of 2005 regarding functional comfort aspects of the building. The building scores (◆) show the average rating of all respondents in the building. The index scores show the difference between this building (◆) and the typical building (■) from the benchmark database.

Summary of Average Survey Responses

Category index sc	Building Score	Index Score
OVERALL BUILDING	**3.5**	**+1.2**
Workspace helps get work done	3.8	
BUILDING SYSTEMS ASSESSMENT		
Temperature	**3.4**	**+0.3**
Air Quality	**4.5**	**+2.0**
Building Noise	**4.5**	**+0.6**
Lighting	**3.8**	**+0.2**
WORKSPACE DESIGN ASSESSMENT		
Spatial Comfort	**3.3**	**-0.7**
Privacy	**1.9**	**-0.8**
Office Noise	**2.9**	**-0.9**



◆ - Average score from this building ■ - Average score from benchmark database

Index score = this building score – typical building score.

Of the 450 occupants present for the survey, 80% responded.

Observations

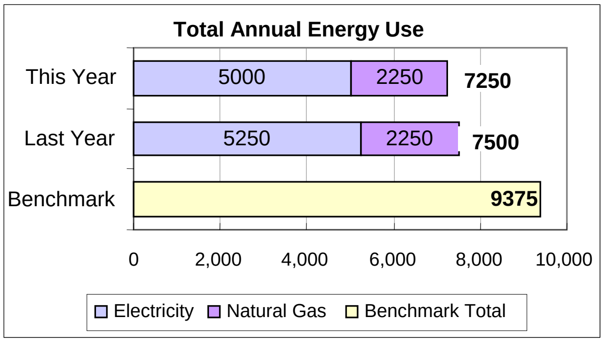
- The functional comfort score for the building overall is very positive and is much better than a typical building.
- All categories of the Building Systems Assessment are positive and above typical building norms. Air quality assessment is exceptionally high.
- Workspace Design category results are all below those for typical buildings.

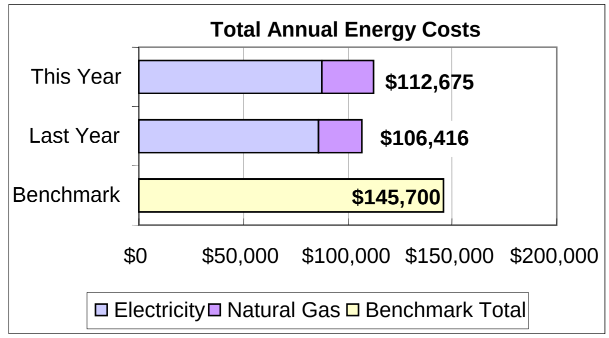
Areas for possible follow-up

- Although overall temperature conditions are rated positively, X% of respondents felt the temperature is sometimes too cold. See **Section III** for follow-up conclusions from the building operation review on the source of this problem.
- The results indicate concerns regarding noise, privacy, and space conditions in the workspaces.

II. Are the Energy Costs for Running the Building Reasonable?

Energy records for the total building were summarized for the current year (4/1/04-5/30/05) and the prior year. This building's results are compared with the Pacific Northwest commercial office benchmark, adjusted for building type, conditioned square footage and actual outdoor temperatures.





This year's energy *use*:	**This year's energy *cost*:**
77% of the Pacific Northwest benchmark	77% of the Pacific Northwest benchmark
Energy star 70th percentile	
97% of last year's use	106% of last year's cost

Observations

- The building's energy use per square foot is good, significantly below the benchmark of other Pacific Northwest office buildings.
- The building is in the 70th percentile for Energy Star, showing that it uses less energy per square foot than 70% of similar buildings in the similar climate conditions.
- Total energy use was slightly below the previous year, while total energy costs increased slightly. The cost increase followed from rate increases of 7% for electricity and 22% for natural gas.

Areas for possible follow-up

- The good energy use level in relation to benchmarks raises no warning flags. However, rising energy costs make additional efficiency measures increasingly valuable. See Section III for suggestions on ways to investigate possible savings.

III. Are there areas of building operation that may need additional attention?

Summary Observations

- ***Good overall efficiency***. Building systems are generally functioning well and performing efficiently.
- ***Source of cold temperature complaints***. Analysis of occupant comments about cold temperatures showed these comments came primarily from the northwest corner of the second floor. Discussions with the facility managers reveal that recent remodeling has affected employee locations and air flow in this area.
- ***Economizer cooling.*** The facility manager interview revealed that the automatic system for natural ventilation during cool nights was not working the previous summer because of difficulty in finding replacements for faulty components. Correction of this situation could potentially save 3 – 5% of electricity use.

Future actions

- Review thermostat locations and cubicle divider locations in the northwest corner of the 2nd floor, to reduce cold air complaints. [Potential sources of assistance include: ___________]
- Investigate repair or replacement of the economizer. [Potential sources of assistance include: ___________]
- Consider further analysis and follow-up on the Workspace Design Assessment comments. This action could result in a improved productivity of the current building occupants, and may also provide useful input to space planning for future remodels or moves. . [Potential sources of assistance include: ___________]

Appendix B - Draft Marketing Brochure

What is a Building Performance Report?

Buildings Performance Report (BPR) is a simple system of determining whether your building is performing the way you want it to. Are the occupants comfortable and productive? Are your energy bills at or below target? How does yours compare to other, similar buildings?

How does BPR work?

BPR offers two levels, depending on your needs. Level One determines the state of building performance. If the building is not meeting your goals, Level Two adds a diagnostic process to determine where you need to focus attention to resolve problems.

Level One uses the best of academic building and environment research along with regional and national benchmarks to determine how well your building is working for its occupants, and whether it is doing so efficiently. Your building is compared to regional and national benchmarks, as well as to your own performance targets.

If you want to better understand or improve your building performance, Level Two includes a set of diagnostic tools that review and measure specific building functions to see where increased attention would create the most benefit.

***Why is BPR important*?**

In the broadest sense, the reason we build buildings is to create a better environment for people, so they can work, shop, relax, or learn in comfort and with few distractions. A wide range of scientific studies show that the energy-using systems in a building, that is the lighting, ventilation, heating and cooling systems, can impact human comfort, health and productivity. The energy systems in buildings can deliver these services for better and worse, and in terms of their efficiency, for richer or poorer. You want better and richer. Therefore, you need building energy systems that work for people, and at the lowest energy cost.

Most contemporary buildings have very complex energy systems. Buildings designed using benchmarks such as LEED are making a conscious effort to improve both the environment of the building itself and the impact of the building on the environment. In order to perform at their best for occupants and the energy bill, buildings need efficient systems that are well controlled and maintained.

What's included in BPR?

Level One consists of a survey of building occupants and a review of energy and water bills. The survey is relatively brief, about 30 questions, but covers key aspects of the occupants' comfort and ability to complete their work with minimum distractions. The energy and water bills are corrected for specific building parameters and weather. Both results can be compared to regional and national benchmarks, as well as your company's internal goals. If your company occupies multiple spaces, they can be compared to each other.

Level Two consists of more detailed reviews, using a variety of tools, depending on the issues raised in Level One. A fundamental part of Level Two is detailed review of the facility in conjunction with the facility manager. This may be supplemented by instrumented analysis of ventilation effectiveness or a more detailed review of lighting quality.

How Much Does BPR cost?

There are several options to keep costs low. Level One can be completed for $1,500 for most buildings. Costs can be substantially reduced for companies that have more than one building or want to conduct this review annually to track improvements.

Level Two costs range from $3,000 to $6,000, depending on building size and complexity and the type of analysis tools included. Most buildings cost $3,000 to $4,000 and complete the process with a punchlist of how to improve building performance and an understanding of the potential financial benefits, from resources savings and potentially from productivity improvements.

Appendix C - Draft Occupant Survey

1	**Temperature Comfort:**	1	2	3	4	5
		Uncomfortable				Comfortable
2	**How Cold it Gets:**	1	2	3	4	5
		Uncomfortable				Comfortable
3	**How Warm it Gets:**	1	2	3	4	5
		Uncomfortable				Comfortable
4	**Temperature Shifts:**	1	2	3	4	5
		Too Frequent				Comfortable
5	**Ventilation Comfort:**	1	2	3	4	5
		Uncomfortable				Comfortable
6	**Air Freshness:**	1	2	3	4	5
		Stale Air				Fresh Air
7	**Air Movement:**	1	2	3	4	5
		Stagnant Air				Good Circulation
8	**Noise Distractions:**	1	2	3	4	5
		Too Distracting				Comfortable
9	**Background Noise Levels:**	1	2	3	4	5
		Too Much Noise				Comfortable
10	**Specific Noises (voices, equipment):**	1	2	3	4	5
		Too Noisy				Comfortable
11	**Noise from Ventilation Systems:**	1	2	3	4	5
		Too Noisy				Comfortable

12	**Noise from Lights:**	1	2	3	4	5
		Buzzing Lights				Comfortable
13	**Noise from Outside the Building:**	1	2	3	4	5
		Too Noisy				Comfortable
14	**Visual Privacy:**	1	2	3	4	5
		Uncomfortable				Comfortable
15	**Conversation Privacy:**	1	2	3	4	5
		Uncomfortable				Comfortable
16	**Telephone Privacy:**	1	2	3	4	5
		Uncomfortable				Comfortable
17	**Electric Lighting Comfort:**	1	2	3	4	5
		Uncomfortable				Comfortable
18	**How Bright it Gets:**	1	2	3	4	5
		Uncomfortable				Comfortable
19	**Glare from Lights:**	1	2	3	4	5
		Uncomfortable				No Glare
20	**Glare from Windows:**	1	2	3	4	5
		Uncomfortable				No Glare
21	**Access to Daylight:**	1	2	3	4	5
		Inadequate				Adequate
22	**OVERALL WOULD YOU SAY YOUR WORKSPACE HELPS OR HINDERS YOU IN YOUR WORK?**					
		1	2	3	4	5
		Makes work more difficult				Makes work easier
23	**GENERALLY, HOW SATISFIED ARE YOU WITH THE PHYSICAL ENVIRONMENT IN WHICH YOU WORK?**					
		1	2	3	4	5
		Dissatisfied				Satisfied

Appendix D - A Review of Post-Occupancy Evaluation Literature

Purpose and Process

This review of post-occupancy evaluation (POE) protocols was undertaken to inform a project funded by the Northwest Energy Efficiency Alliance (NW Alliance). The overall goal of the project is to compile and test a relatively simple and low-cost POE protocol that may have market appeal.

The literature review undertaken by New Buildings Institute (NBI) and summarized in this paper has three specific purposes:

- Determine the state-of-the-art in POEs.
- Determine key lessons learned that could inform the general development and implementation of the protocol for this test.
- Locate elements of protocols that might be useful to include in the project test.

The literature was assembled based on internet searches, document reviews and contacts with individuals who are working in the field. The scope reached to Great Britain, Australia, New Zealand and Canada, as well as the United States.

Post-occupancy evaluation is the general term for a broad range of activities aimed at understanding how buildings perform once they are built and how satisfied building users are with the environment that has been created. There is no industry-accepted definition of POE, and there are many different terms in use: environmental design audits, building-in-use assessments, facility assessment and building performance evaluations. (Learning From Our Buildings, 2001)

Because of the wide range of purposes for POE use, with many related to in-depth research of the built environment and human health and productivity, the literature was quickly separated into two groups. The first group was articles, papers, projects and reviews referencing simple, low-cost POEs with possible appeal to a broader market that were most related to the purposes of this test project; that is, representing relatively simple, low-cost POEs, with possible appeal to a broader market. The second group included papers and projects that generally were more detailed, research-oriented, and/or comprehensive in their scope. The bulk of the information summarized in this report is from the first group.

There are also two recent books on the field which have brought together many of the key lessons learned to date in a series of articles from major authors in the field. The first book is *Learning From Our Buildings: A State-of-the-Practice Summary of Post-Occupancy Evaluation*, that was compiled by the Federal Facilities Council. The Federal Facilities Council is a cooperative association of 21 federal agencies with large inventories of buildings, such as the General Services Administration, Naval Facilities Engineering Command and the U.S. Postal Service. The second book, *Assessing Building Performance*, was edited and partially written by Jacqueline Vischer of the University of Montreal, and published in early 2005. Both books succeed in summarizing key concepts and lessons learned and are referenced frequently in this summary.

General Findings

A wide range of methods and techniques have been developed, and delivery costs reflect this variation. The costs per building reported to conduct POEs range from $1,800 for a simple standard questionnaire to $90,000 for an in-depth analysis including interviews, site visits, and multi-disciplinary teams. (*Learning From Our Buildings*, 2001)

Learning From Our Buildings suggests a list of possible purposes and benefits for POEs:

- Support for the development of design and planning guides
- Provision of information to the building industry
- Testing of new concepts
- Justification of major expenditures
- Educate decision makers (owners and designers) - avoid repeating past mistakes
- Improve building performance over time; e.g. remedy problems or adapt the facility to changing organizational needs
- Make design professionals and owners accountable for building performance
- Aid communication among stakeholders – designers, clients, facility managers, end-users

The best known protocols are related to the PROBE (Post-Occupancy Review of Buildings and their Engineering) work in Great Britain (which has expanded to several other locations) and survey tools developed and supported by the Center for the Built Environment at UC- Berkeley. It appears that even these better known products have been used perhaps on a few hundred buildings at most over 20 years. And, with the exception of the Disney theme parks (which use POEs to help plan future additions and changes), most of the ongoing work is associated with large, government-related property owners and developers, such as the General Services Administration and Public Works Canada.

Barriers

Some of the key researchers and product developers have wondered aloud why POE has found such a limited audience. There are a number of barriers to the use of POEs that are well documented. Among the more substantial are:

- Funding for POEs is not included in design budgets, and it is not clear who has responsibility to conduct POEs.
- Interest in the end product is limited, as it is perceived as being too late in the process. The design team has moved on to the next project, the owner may not be planning any similar projects, or considers the lessons learned to be unique to one project.
- Technical and logistical difficulty obtaining data.
- The POE report may uncover problems, possibly leading to awkward questions or even liability. At the very least, professionals are not that interested in other professionals reviewing their work.
- The timeframe for conducting the assessment is well beyond the traditional scope of work for design and construction contracts (i.e. one year after occupancy).

Perhaps the key barrier to the actual integration of POEs within organizational practice is contained in the following paragraph (Zimring and Rosenheck in *Learning from Our Buildings*, 2001).

> "Structured organizational learning is difficult. It requires the will to collect data about performance and the time to interpret and draw conclusions from the data. More fundamentally, learning involves risk and change. Learning exposes mistakes that allow improvement but most organizations do not allow shortcomings. Learning brings change and organizations are usually better at trying to ensure stability than at supporting change."

Opportunities

The report just quoted above also provides some additional reasons for the renewed interest in POEs at the current time, noting that;

> "Issues such as sustainability, which are undergoing rapid change, are particular candidates for "double loop" learning where both goals and methods for achieving them are being developed..."

One comment on making POEs more relevant is the simple observation that information is most likely to be used when asked for. With the exception of the large government owners of buildings noted earlier, much of the driving force behind POEs has been research rather than business. The literature contains references to asset management, space planning and the Balanced Scorecard Approach (which looks at financial, business process, customer relations and learning and growth), but examples of business driven applications appear to be limited.

Vischer (2005) notes the importance of process, in particular how to include the views and concerns of stakeholders and users. In particular, she emphasizes clarifying who the information consumers are at the project outset, selecting a limited number of key indicators, and deciding on a reporting framework in the POE planning process.

Finally, the literature indicates that there are several efforts being made to link POE research findings back to business decisions, with an emphasis on the pre-design programming process for new construction or space renovation in existing buildings. Examples of this are the publications of the Advanced Buildings System Integration Consortium of the Center for Building Performance and Diagnostics at Carnegie Mellon University. Their Guidelines for High Performance Buildings 2004 summarizes research results on a particular topic (for example high performance lighting systems) and provides simple design guidance and average costs and benefits, including health and productivity benefits that are drawn from a cross-section of POE related research..

There is definitely a growing interest and opportunity in the market for targeted information on actual building performance and occupant feedback.

Detailed Methodologies

Most POEs look at some combination of occupant surveys, building observations, and billing data for utilities. In this section of the literature summary, the protocols for data collection and reporting from various sources are considered.

Occupant Surveys

Occupant surveys are a staple of POE. A primary benefit they provide to the process is their ability to secure quantitative data from a variety of occupants. Having worked with a variety of approaches for many years, the developers of PROBE believe that surveys can be used to ascertain a number of difficulties with building performance that might be more expensive to find in other ways. (Presentation by Adrian Leaman.) As with other elements of POE, there are various tools available.

PROBE-style questionnaires have been used on a variety of buildings. While initially the PROBE questionnaires were quite complex, they have been streamlined over time to two pages of questions (20+ questions), and now take occupants between 4 and 10 minutes to complete. Surveys are paper based with a 7 point scale for most questions. Responses are entered into an Excel spreadsheet and analyzed. One PROBE user recently completed occupant surveys in 5 buildings, and found that the process and results met expectations, although different survey distribution and collection techniques were needed in different types of buildings. (Baird and Jackson, 2004) PROBE maintains a database of responses on more than 100 buildings, so individual building results can be compared to other results.

The Center for the Built Environment at UC-Berkeley (CBE) has developed a survey tool that is available for use, and is being used in Canada for work being completed by R. Hyde of Keen Engineering, and is proposed for use in a project sponsored by the Cascadia Region Green Building Council. This survey is web based, and has about 150 questions for occupants. Estimated completion time is 10 minutes for the core survey, as not all questions are required for any given responder. Core questions cover office layout, furnishings and cleanliness as well as thermal comfort, air quality, lighting and acoustics. Additional survey areas have been developed. Ms Hyde estimated a cost of about $5,000 per building to organize, facilitate and process the results of this survey. As with any occupant survey instrument, there can be substantial costs to getting the information.

Vischer has developed a paper survey for the Buildings-In-Use program that she developed which is about 30 questions long, and a variant of the survey is in the public domain. (Vischer, 2005) Similar to the other surveys noted above, there is a history of use, and the ability to compare results across multiple buildings and with historic data.

The LightRight Consortium completed an extensive research project in 2003 that developed and tested a web-based survey that is both rich in detail and easy to respond to. The survey results relate lighting comfort and satisfaction to elements of the built environment. At this stage, the survey is limited to lighting related issues and is designed for the office sector. (Conversation with Carol Jones).

Kaplan (2001) found that cyber surveys have quicker response times compared to mail surveys (5 to 10 days versus 10 to 15 days). However, he notes the e-surveys may only get half of the response rates of mail or phone surveys. The CBE survey targets at least 50% respondents, but some projects have difficulty in meeting that standard. (McCarry and Hyde, 2002) The developers of PROBE attempt to reach 80% to 90% of occupants. (Bordass and Leaman, 2005)

BOMA completes surveys related to occupant satisfaction with buildings approximately ever other year. While using their survey format has not been explored at this time, the BOMA surveys could provide a useful benchmark that is valued by building owners.

Energy and Water Use

As with other aspects of POEs, there is no defined protocol for energy and water use analysis. Some POEs compare actual energy and water use to modeled results (Turner, 2005; McCarry and Hyde, 2002) While comparing actual to anticipated energy use has some value, experience has shown that modeled and actual energy savings are frequently not well correlated (Johnson, 2002) due to differences in occupancy hours, microclimatic effects, unanticipated occupant behavior, operational problems associated with the buildings start-up, efficiency measures in the model but not the building, or assumptions or methodology problems with the simulation. The simulation and actual experience can be trued up (and operational problems identified and resolved), but usually at a significant cost.

EPA has promoted for many years a benchmarking approach based on the (corrected) actual energy use of buildings, and assigns a score of 1 to 100 compared to other commercial buildings, with 100 being the most efficient buildings. Buildings with a score of 75 or better can earn an Energy Star Building label. EPA's Target Finder tool converts a modeled result to an anticipated actual result. Approximately 2,000 buildings have received the Energy Star label, and thousands more have taken the first step of completing the benchmarking analysis.

The authors of PROBE have proposed a unique approach that may be adopted in Europe. It gives a building two scores; a projected score based on the energy efficiency features of the building and an "as operated" score based on energy use over time. Again, reconciliation of these scores may not be easy and obvious, although receiving an "as operated" score substantially below the "as built" score would certainly put pressure on the facility manager to find the reason why. Combined with commissioning results and interviews with the building operator, the results may at least be explainable.

NBI (EPA, 2005) has postulated that there are four elements that define the efficiency of a building:

1. Efficiency measures are a central element of a performing building,
2. Design strategies and controls build performance into the building structure,
3. Installation, operation and maintenance assure performance translates to the meter over the life of the building, and
4. As-built performance is tracked and measured against targets set in design.

All four elements need to be in place to assure that a building operates with optimum efficiency. POEs on buildings that adopt these practices will be more cost effective to perform and interpret.

Detailed Building Reviews

More detailed building reviews fall into three general categories: 1) expert walk-throughs of buildings to detect operational problems, 2) interviews with facility management staff, and 3) instrumented analysis of some building features.

Walk through reviews usually need to happen at some level, simply to familiarize the person or persons completing the report with the building. Walk throughs can detect certain types of problems very readily, such as glare problems with sunlight or occupants defeating control systems or adding fans, heaters, or lighting to their work area. However, occupant surveys can also be designed to detect these same problems.

Interviews with facility management staff are included in several of the protocols or examples studied. CBE has a very detailed survey instrument, while other projects appear to gather information from facility managers in a more informal way. The Northwest Alliance has developed a survey instrument within their Building Performance Services project that attempts to gain perspective from facility staff on operational problems within a building.

Instrumented analysis was an important part of the PROBE series of buildings, but others caution that costs can be high, data inconclusive, and occupant surveys may detect many of the same issues. Agents of Change, a multi-university program headed at the University of Oregon, use some short-term instrumentation as part of an educational process for students in how buildings really operate, and some of their methodologies may be useful for POE purposes. The Center for Buildings Performance and Diagnostics has developed a toolkit that includes instrumented analysis. (Loftness, 2002)

U.S. DOE (2002) notes that "Peak or time average carbon dioxide concentration are useful indicators of how effectively occupant-generated bioeffluents are controlled by ventilation and may be a fair indicator for other pollutants associated with occupancy." They also suggest other specific alternatives for measuring a variety of indoor environmental quality indicators.

Reporting

As with other elements of POEs, there is no standard reporting protocol. Many of the more extensive protocols result in reports of 100 pages or more, some are as little as 10 pages.

The more recent PROBE series projects generated published summary reports of about six pages, largely narrative discussions about the building and its specific features, but with standardized reporting on energy use and carbon dioxide emissions, occupant survey results, key design lessons, and a "Designer's Response to the Feedback Study" section. PROBE also pressure tested most building to determine air leakage rates, and benchmarked those results.

Conclusions, Questions, and Recommendations

While the POE field is quite limited at this point in its development, it is also very diverse and interest is increasing. Much of the development and work on POE has been supported within academic institutions, and therefore the protocols tend to be detailed and specific to research purposes. There is not a well-defined protocol that is in general use, although there are several occupant surveys that have been used across multiple buildings.

The potential educational value of POEs has gone unchallenged, but the organizational environment must be amenable to the lessons. Very few private businesses have adopted POEs as a strategy to offer more value to their clients, and few of the more research- oriented POE projects have focused on values that might be of interest to businesses.

Going forward, several authors have noted that the increasing popularity of sustainable building and the changes created by the sustainable building process have created an opportunity for the use of POE. POEs can shorten the learning time about the positive and negative changes that sustainable buildings may create, and they can help demonstrate the value of sustainable buildings to the market. For example, sustainable buildings typically include elements to reduce resource use, and many claim to better support human health and productivity. A simple POE can determine to what extent these benefits are actually being realized, and at a deeper level of analysis, to what building elements can these benefits be attributed.

Based on this review of the literature, a series of findings and remaining key questions has been made for this test project, as well as some recommendations to guide further project development.

Key findings include:

- There are a wide variety of POE protocols, but most are related to research agendas rather than market needs
- There is currently no protocol that appears to meet the needs of this project in terms of budget, scope and ease of implementation.
- There are elements of several different protocols that appear to be useful and relatively simple to implement.
- There are a series of critical market barriers that this project must address for the end results of this project to be useful and repeatable.

For this project, the major question to be resolved is:

Are owners, developers, and design teams interested in obtaining a set of data from recently completed, sustainable buildings to better inform both operational and future design decisions? This question was anticipated from early project development work, and the project includes an advisory committee representing these interests as well as additional survey work with key groups. Getting clear guidance on the market interest will perhaps help this pilot develop a protocol with more value and staying power in the private market. Key sub-questions include:

- What data are the market most interested in?
- What types of processes to develop that data will the market support?
- How much money might the market be willing to pay for this information?
- How can building reports be educational without finding fault?
- What is the right intervention point(s) for a POE and who is involved from the building side?

Recommendations

This review of the literature, while limited, suggests some directions for this project to pursue.

- Most importantly, the project needs to determine the market interest in the types of information that POEs can generate, as well as other key parameters that define how that information is developed and reported.
- The project should develop or use consistent benchmarks to the extent possible to create comparative data for key indicators such as energy use, water use, indoor air quality, and comfort. Use of Energy Star benchmarking and using all or a subset of the questions from one of the more common occupant survey protocols are recommended.
- Given the interests and position of the Northwest Alliance and the New Buildings Institute, consideration should be given to establishing additional benchmarks that meet market needs, as well as a standardized reporting format. Implementation of this recommendation may not be possible within the constraints of the current project, but useful experience can be gained.
- Examination of the "organizational learning" barrier (i.e. learning exposes mistakes) should be carefully considered, especially with regard to innovators and market leaders. Specifically, the project should examine how to present information in a way that overcomes this barrier in reporting on projects.

References

Baird, G. (2004), *Probe-Style Questionnaire Surveys of Building Users – An International Comparison of their Application to Large-Scale Passive and Mixed-Mode Teaching and Research Facilities*. Wellington, NZ: Centre for Building Performance Research.

Bordass, W., Leaman, A. (2005), *Productivity in Buildings: The Killer Variables*. London, UK.

Bordass, W. (2004), *A "How To" Guide to Feedback*. London, UK: William Bordass Associates.

Bordass, W., Leaman, A., *Selected Probe Reports 1 through 23*. London, UK: William Bordass Associates.

Carmody, J. et al. (2004), Post Occupancy Evaluation – Law Enforcement Center Ramsey County. Minneapolis, MN: Center for Sustainable Building Research, Univ. of Minnesota.

Heerwagen, J., *Do Green Buildings Enhance the Well Being of Workers?* Environmental Design & Construction Magazine.

Hyde, R. and McCarry, B. (2002), Operating Experiences at the CK Choi and LIU Centre Buildings at the University of British Columbia. Vancouver, BC, Canada: Keen Engineering.

Johnson, J. (2002), *Is What they Want What they Get? - Examining Field Evidence for Links between Design Intent and As-built Energy Performance of Commercial Buildings.* Report to the Environmental Protection Agency

Kampschroer, K. (2003), Green Spotlight on Post-Occupancy Evaluation. *The Cornerstone*, Fall 2003.

Learning From Our Buildings – A State-of-the-Practice Summary of Post-Occupancy Evaluation. (2001), Washington, DC: National Academy Press.

Leaman, A., *Building Performance Measurement*. London, UK: PowerPoint Presentation.

Loftness, V., et al. (2003), *Productivity Protocol Development: The Role of Real Estate and Facilities in Individual and Organizational Effectiveness.* Pittsburgh, PA: CMU Center for Building Performance and Diagnostics.

Loftness, V. et al. (2002) *Creating a National Environmental Assessment Toolkit.* Pittsburgh, PA: CMU Center for Buildings Performance and Diagnostics

Lighting Satisfaction Survey Tool. Light Right Consortium.

New Buildings Institute (2005), *The Road to Performance: Commercial New Construction Programs*

NSF/IUCRC Center for Building Performance (2004), Guidelines for High Performance Buildings 2004. Pittsburgh, PA: Advanced Building Systems Integration Consortium, Carnegie Mellon University.

Occupant IEQ Survey. Berkeley, CA: Center for the Built Environment.

Stanley, L., *Learning from Our Buildings, A State-of-the-Practice Summary of Post-Occupancy Evaluation*. Washington DC, National Academy Press.

Sanders, P.A., Collins, B.L. (1995), *Post-Occupancy Evaluation of the Forrestal Building, January 1993-December 1994*. Washington, DC: U.S. Department of Commerce.

Turner, C (2005), A First Year Evaluation of the Energy and Water Conservation of Epler Hall: Direct and Societal Savings. Portland, OR: Portland State University.

US EPA (2003), Professional Engineer's Guide to the ENERGY STAR Label for Buildings. Washington, DC: United States Environmental Protection Agency.

Vischer, J. (2005), *Assessing Building Performance*. Burlington, MA: Elsevier Butterworth-Heinemann.

Vischer, J. (____), Revaluing Construction: Building Users' Perspective. Montreal, Quebec, Canada: School of Industrial Design, Univ. of Montreal.

Wade, J., Pett, J., Ramsay, L. (2003), *Energy Efficiency in Offices: Assessing the Situation*. London, UK: The Association for the Conservation of Energy.

Zimring, C., Rashid, M. and Kampschroer, K. (2005), Facility Performance Evaluation (FPE). Washington, DC: National Institute of Building Sciences.

Appendix E - Survey Tool Reviews

While many have used ad hoc surveys of building occupants, there are few readily available survey tools currently in the market. Surveys mentioned in this report include the following:

Building Use Studies, Adrian Leaman http://www.usablebuildings.co.uk/

This U.K. survey tool that grew out of the PROBE studies is available for license. See additional description below.

Buildings in Use, Jacqueline Vischer, University of Montreal http://www.gret.umontreal.ca/an/activities.htm

A new survey tool is being developed from Vischer's earlier Buildings In Use survey base. The questions for this survey are in the public domain. See additional description below.

Center for Building Performance and Diagnostics, Vivian Loftness, Carnegie Mellon University http://www.arc.cmu.edu/cbpd/index.html

Developmental work on post-occupancy building performance analysis, including the National Environmental Assessment Toolkit.

Lighting Satisfaction Survey Tool, Light Right Consortium http://www.lightright.org

Free survey tool limited to lighting performance can be used for diagnostic use or before and after measurements.

Occupant Indoor Environmental Quality Survey (IEQ), Center for the Built Environment, UC Berkeley http://www.cbe.berkeley.edu/research/survey.htm

This online survey tool is available to CBE members or for a single use fee. A fairly detailed building information form must be completed before completing the survey, consistent with the CBE objective of developing a database sufficient to assess typical performance of specific building features.

Contrasting Buildings-In-Use (Vischer) and Buildings Use Studies (Leaman)

BIU (and successor DiConFon) from GRET	**BUS from Usable Buildings**
North American database, primarily US	International database, primarily UK
Survey questions in the public domain	Survey questions available only after licensing
Currently evolving from support and services through the BIU company (no longer active) to GRET (still in development phase)	Fairly established tool, with variety of services available and being actively marketed
Emphasis leans toward the interior space-planning aspects of employee functional comfort	More interest in integrating occupant ratings with building systems evaluation

Buildings Use Studies (BUS) Occupant Survey

Contact Adrian Leaman, Building Use Studies, Ltd.
44.1904.671280
adrianleaman@usablebuildings.co.uk

Building and Occupant Categories Covered

Commercial buildings with "permanent user populations." In their experience, only about half of these buildings are offices. Remainder primarily schools, libraries, courthouses, med centers.

Separate versions (same core questions) are available for schools, libraries, and museums.

Shorter "transient user" surveys are also available. For schools, they are aimed primarily at university students, not young grades.

Users typically rate buildings better than permanent occupants.

Target Audience for Results

Any of the potential interested parties: owner, facility manager, designer, construction contractor, researcher (about 40% of total use), etc.

Have Building Owners Taken Action Based on Survey Results?

Often, they don't hear how the results are used, but do have anecdotal info, e.g.:

- Small office conducted survey when planning to upgrade windows. But learned that needed to do some basic building modification first.
- Large manufacturer decided to sell building and move to other quarters after evaluating responses

How Widely Used

23 Probe studies

10+ countries, several languages

Over 500 buildings total have used, about ½ in UK

About 10 so far in N. America. Beginning discussions w/ Boston Society of Architects.

(e-mail "7 US and Canadian;" phone call notes "5 US, 10 Canadian")

Question Categories

Temperature
Air quality
Lighting
Noise
Comfort
Design
Space
Image to visitors
Perceived health impact
Perceived productivity impact
Open-ended questions – several, by category for automatic sorting

Survey Flexibility

The core set of questions must always be used. Others may be added or deleted.

Questionnaire Length

1, 2, and 3 page versions. The 2-pager is usually about right.

Benchmarks

3 sets currently: UK (roughly the most recent 50 buildings surveyed), Australia (20+ buildings), international

Need at least 10 buildings in a country to do a local benchmark. Benchmarks are for the variety of building types combined. Don't see significant differences by type.

Can also do a tailored benchmark for an additional fee: e.g. if an institutional owner wanted comparisons among many buildings they owned.

Detailed reports show building response and benchmark for each variable. Licensee can quote one or two individual benchmarks in a published report, but can't share the entire benchmark table.

All licensed surveys are analyzed by BUS and become part of their database (anonymously unless ID permission granted)

How Administered

BUS strongly recommends a paper survey, handed out in the morning and collected in the afternoon. They believe that generates more credible results from:

- a higher response rate (they target 80% of those in the building at the time of the survey)
- more complete coverage (reaches those without PCs)
- less biased results (concern that those who choose to do an online survey are not representative)
- better write-in information (more concise and better written)

Being on-site to administer the survey also gives the ability to gather additional data: general observations on occupant behavior, survey context (e.g. did something occur that day to upset everyone, was the weather unusually warm), etc.

An internet version of the 1 and 2 page surveys is also available where the client insists on that format.

Initial Building Data Required

Some basic characteristics, but not a lengthy form.

License Availability & Cost

Typically license on a one-time basis, for one or several buildings.

- £1000 (about $1750) for the 1st building, £750 for the 2nd, £500 for each additional during the license period.
- An organization like NBI could also become a licensing agent, with fees negotiated based on volume.

This basic fee provides the survey, instructions for administration, a spreadsheet in which to enter results (which are then sent to BUS), and the reports listed above.

Other internal costs to the surveying organization:

- administration and data entry time if using the recommended paper survey;
- cover report preparation.

Report and Analysis Availability / Turnaround Time

License includes statistical analysis and reports, done at BUS (software not normally available for licensee use):

- Data and benchmarks for each variable
- Categorized list of comments (with “duty of care” comments flagged)
- Graphics for up to 65 variables (color-coded averages and benchmarks by variable)

1-2 week turnaround *(? check)*

BUS will write a cover report for an additional fee (the “expensive bit”) or the licensee can write their own.

Information Sources

- 12/8/2005 conversation with Adrian Leaman
- The BUS Occupant Survey: Details for Licensees, http://www.usablebuildings.co.uk/WebGuideOSM/Index.html
- BUS Occupant Survey and Reporting Method, http://www.usablebuildings.co.uk/fp/index.html
- Building Use Studies sample summary charts, http://www.usablebuildings.co.uk/627Charts/index.html
- Probe Strategic Review 1999 Report 3: Occupant Surveys

Buildings Use Studies (BIU) Occupant Survey

Contact Jacqueline Vischer, University of Montreal
(514) 343-6684
jacqueline.vischer@umontreal.ca

The Buildings-In-Use company, founded by Vischer to administer and interpret the BIU survey, is no longer active. However, Jacqueline Vischer, now full time at the University of Montreal, has founded GRET (Groupe de Recherche sur les Environnements de Travail, or Work Environments Research Group) at the university, which is carrying the general work forward and developing on-line alternatives. The GRET software, currently under development, is called DiConFon (Functional Comfort Diagnosis).

Building and Occupant Categories Covered

Primarily office buildings.

Covers staff, not visitors.

Target Audience for Results

- Owner-occupiers, corporate employers & governmental departments – to determine baseline building comfort level, track trends, strategic space planning
- Facilities managers – for operating decisions
- Design professionals – for before and after move/remodel assessments

In general, it's a diagnostic and action-planning tool, not a research tool

Have Building Owners Taken Action Based on Survey Results?

This is the whole point of the BIU survey. The major examples have been for companies timing the survey for input at the beginning of a planned move or remodel. For example:

- World Bank links results to computerized floorplans, and considers them when preparing to reconfigure an area.
- A prototype design for State Police stations throughout Massachusetts was modified based in part on results of BIU surveys.
- A law firm installed a completely new lighting system, and extended an alternative office layout from one floor to all floors in their building.
- Hypertherm established employee teams to be involved in follow-up space design process.

How Widely Used

Developed for Canadian government, extended to private sector and other countries. Used by over 1000 buildings. Past user list includes: Reuters, Boston Financial Group, GTE Government Systems, Bell Canada, World Bank

Question Categories

Building Systems Dimensions

Temperature

Air quality: this was the primary concern originally, much less today

Building Noise

Lighting

Interior Space Planning Dimensions

Office Noise

Space, functionality: primary concerns today focus more on ergonomics

Privacy

Open-ended questions – one or two general ones at the end, which they manually categorize by type for summaries. Find these are typically answered with building convenience topics, e.g. phone system, elevators, sometimes also safety or security concerns.

Questions focus on "functional comfort," not "satisfaction."

> Believe this gives a much better picture of areas that can result in cost-effective improvements.
>
> "Satisfaction" questions tend to be interpreted as asking for general wishes, as opposed to things that would make the employee more productive.

Survey Flexibility

Survey questions themselves are in public domain (at least from the older BIU version), and may be modified as desired by anyone wishing to use them independently.

Negotiated arrangements possible if want a customized version of DiConFon on-line tool.

Questionnaire Length

2 pages, 30 questions

Benchmarks

Database contains over 1000 cases from the last 20 years, primarily in the US and Canada. Some also from the Netherlands, Australia.

Comparators from a set of about 60 "typical" buildings. Also available with patterns over time.

Have not done much analysis of this database by details of building construction or systems. (Don't necessarily gather all the data to do that.)

How Administered

Historically, a paper survey, returned within 24 hours

More recently, GRET developing an on-line version. Seem to assume this is the wave of the future.

Relative disadvantages of online:

- Requires more effort by the building owner/manager(s) to distribute

- Lower response rates (although they haven't done enough yet to be able to quantify the difference)
- Don't gain the other observational information from being in the building to deliver the survey.

They typically survey all occupants, even in a large building. Sampling is a statistically sound alternative, but raises causes "social dynamic" issues from those who aren't surveyed.

Initial Building Data Required

None other than a floorplan (and possibly HVAC zones), from which they code workspaces. That let's them analyze results very precisely by building location. They use the survey as a first stage diagnostic tool to then identify what type of building information they need, rather than gathering an exhaustive set of data up front.

License Availability & Cost

Negotiable. Depends on level of services desired: data and comparators only; diagnostic analysis; follow-up consulting. The amount of work in the latter two categories depends on who is involved at the client end, what they are looking for, what reports or other messages to be developed for the users.

GRET is still developmental, so not a fixed market price yet. (For example, currently partnering on a joint venture basis with a group in Australia, with a commitment of $10,000/year for 3 years. $30,000 is also the donation level to become a member of the GRET advisory council.)

(Vischer will get back to us on what the general fee level and pricing structure had been for the BIU company.)

Report and Analysis Availability / Turnaround Time

Clean case (theoretical) time frame for basic data summary and comparators – 2 weeks

Data collection: 1 day paper, 1 week on-line

Basic data processing and summary – 1 week

Additional summaries, which vary according to specific client/building focus, currently done individually by GRET staff. Beginning to work on software that would automate this, but that is complicated by the variations in what clients want to look at (difference by department, building region, their own trends over time, before-after differences, normative comparisons, etc.)

Additional interpretation time varies by case. Also need some way of familiarizing with the building, if asking Vischer's group to do this remotely after an on-line survey.

Information Sources

- 12/14/2005 conversation with Jacqueline Vischer
- *Assessing Building Performance*, 2005, Preiser & Vischer, eds, Ch. 1 and Appendix A.3
- *Learning from our Buildings*, 2001, Federal Facilities Council, Ch. 3
- *Workplace Strategies: Environment as a Tool for Work,* 1996, Vischer (more detailed background on the development of the survey and methodology)

Appendix F - Considerations: Process Issues and Lessons from Conducting Post-Occupancy Studies

This outline summarizes some general observations from conducting post-occupancy studies of a variety of commercial buildings in 2005. The studies were primarily basic, whole building reviews covering total energy and water use and an occupant survey.

GENERAL

A motivated client is essential. The ease or difficulty of gathering the needed information is heavily dependent on the importance of the study to the building owner (or other client with access to the needed data).

- Simply identifying "who knows what" is a key challenge. To keep study costs down, it's better to require the client to identify all utility accounts, and to collect and consolidate the information. Requiring the client to do more work, however, lessens the attraction of the product for those with busy schedules, and reduces the likely number of completed reviews.
- Outside property management firms may not feel that it's cost-effective for them to provide requested information from their files.

Clarify deliverables and expectations early, particularly with a limited study. It's important to delineate levels of service at the marketing stage. A sample report that clearly shows the type of information delivered and a list of possible follow-up steps may help clarify expectations.

UTILITY USAGE

Make sure that the building to be studied is separately metered. For example a single building on an institutional campus may not have a separate account at the utility company level and may also not have internal meters that have been regularly monitored. The key decision-maker wanting a survey may not even be aware of lack of individual building metering.

Don't underestimate the difficulty of identifying all the utility accounts or meters that must be included in total building usage.

- This area is particularly important (and difficult) in the case of a building with multiple tenants, which can have any of the following options for utility bills:
  - Part of the building owner's bills (i.e. not a problem): tenants with utilities covered in their rent or utility costs allocated based on square footage;
  - Part of a separate bill: tenants directly billed by the utility for their own area. In some cases, such tenants are actually billed for an area larger than their own, and they then allocate to other tenants. This approach further complicates the question of which billings to add.
- The best way to get assurance of all the relevant meters is often to find a facility manager who knows the physical location and label of each.

Direct access to utility company records for billing history at the account level is easier with both a signed authorization from the customer and a copy of a recent bill.

- Utility companies vary in the amount of information they require with an authorization. A copy of a bill ensures that you will know the owner's name as recorded by the utility company (often not the name that the building or occupying company commonly goes by), billing address, etc.

Where utilities have the information on-line, this can be a more effective means of gathering historic data than going through bill files.

Water meters often combine indoor and irrigation usage, although you really want to look at those separately.

The difference between water and sewer volumes may be used as a proxy for the difference, although sewer volumes are usually estimated rather than measured.

Actual water meter readings are often missing entirely, for a variety of reasons including: utility sends bills based on estimated volumes; account set up to pay a fixed rate not based on volume; or the building is part of a campus that is not internally submetered.

For doing multiple studies, a good analysis/reporting tool should be both standardized and flexible.

Spreadsheets and one-off adjustments are good for a single case, but rapidly become cumbersome to manage for multiple buildings, particularly if a consistent methodology and appearance of results is required.

A standardized tool that is too limiting results in the user creating side-spreadsheets, which are just as difficult to manage.

A good / ideal tool for analysis and end-report generation would be able to easily handle:

general

Missing data

Billing modes other than monthly

Multiple meters within a building: showing aggregate results and also showing results for each separately.

Summary tables for multiple buildings (e.g. a campus being studied) and automatically update those as individual building values are updated or corrected.

Easy change late in the project to things like building names in *all* reports, graphs

Easily annotation of graphs with actual period over which usage was measured

energy

Different meter read dates: among separately billed tenants in the same building; between electricity and gas; etc.

This matters if you want monthly patterns as opposed to just full year information, and if you want to do temperature-adjusting

In either case, need to either deal with dates exactly or have methodology for determining how actual billing periods line up with each other and with calendar months.

fuels other than electricity and gas.

Ability to do temperature-adjusting, if that’s desired.

water

Different water and sewer volumes.

Harvested water volumes.

Temperature-adjusting is a relatively small refinement for many commercial office buildings.

Important for determining trends and before – after analyses of a single building, where other measurement factors are known to be consistent.

Variation is within the range of general uncertainties for other factors (e.g. square footage, missing and estimated readings, approximated reading dates) for more broad comparison with benchmarks or other buildings.

Complications:

Be consistent about using 24 hr or min/max avg

Min/max not biased overall, but may obscure HDD and CDD in spring / fall swing months

Many of the commonly used weather tables are updated only quarterly or less often. For an up-to-date study, including for example the most recent month's utility usage, you will need to find more recent data to supplement them.

Actual start-stop dates of a billing period can make a difference if you are using this information for building-specific regressions.

SURVEYS

Multiple tenants or departments/bureaus complicate the process, both for initially getting permission and, if the survey is on-line, for distributing an effective invitation (especially if the survey is on-line).

Balance motivating employees with managing expectations

Don't collect comments in an area where no action is likely to be taken, unless the survey is clearly labeled as only for the purpose of gathering data for a larger study.

Don't suggest in the invitation that the employees will see the results of the survey unless the sponsor truly plans to take this step. And, in that latter case, the employer/owner may expect a such a report to occupants to be provided as part of the review package.

Carefully consider the used of open-ended questions.

These questions can provide additional information, but require more time to review and interpret.

Including one fill-in with every main question category may simplify sorting, but answers may not always be on topic.

Comments may sometimes be outside the entire intended scope of the survey.

Know how negative responses will be handled, or else don't include the question. Do the questions provide enough information to diagnose a problem or at least to identify follow-up information to gather?

It's hard to keep a <u>standardized</u> questionnaire short.

Limiting the survey objective to feedback for individual owners permits a much shorter questionnaire. There is no need to gather additional information that might be used for aggregate database analyses, such as occupant characteristics and activities.

Follow-up questions that only apply after negative responses may be useful *if* no other survey follow-up is expected.

It's useful to be able to ask about specific features of interest to the client, but don't clutter the survey with features that aren't in the building in question.

Don't underestimate the software functionality needed to easily evaluate responses. For the most useful survey analysis, you need the ability to easily do the following (or else to purchase/license analysis services from a group with these capabilities).

Summarize and cross-tab results across multiple indicators (e.g. temperature satisfaction for people who sit near windows)

Produce attractive result reports of selected indicators or comparing two buildings.

Concisely summarize response distributions, not just average responses.

Perform statistical tests for the significance of result differences between buildings or between areas in one building.

Categorize and sort fill-in comments.

Don't underestimate the time it takes to thoroughly review survey results. Even with a good summarization tool, it can take several hours in a large building to review results, identify key points, and compare key sub-areas or floors.

Appendix G - Interview Guide

*Contact Person*_____________________ *Phone #* ___________________

Good morning/afternoon. My name is _____ and I am conducting market research for the New Building Institute and the Northwest Energy Efficiency Alliance related to building performance. New Buildings and The Northwest Alliance are developing an assessment or benchmarking tool to help owners and architects determine to what extent buildings are providing energy efficiency, indoor environmental quality and occupant satisfaction benefits, and how these buildings compare with other, similar buildings from a functional and operational costs perspective.

The survey will take 10 to 15 minutes. Is this a good time?

Reschedule if needed. ______________________________

The questions break into two groups. The first set of questions are about your current practices, and the second set are about some key aspects of the benchmarking tool we are designing.

1. *First, what is your job title, and what role do you play in the operation or management of commercial buildings.*

2. *Are you involved in the design and construction of buildings**? If no, skip to question 8***

3. *What are your key measures for judging the success of a new building project after the project is completed and occupied?*

4. *Do you conduct any follow-up on functional aspects of new buildings?*
If Yes Describe

5. *Do you conduct any follow-up on occupant or owner satisfaction?*
If yes, describe

6. *IF NO SPECIFIC ANSWER TO THE PREVIOUS TWO QUESTIONS How do you incorporate experience with previous building projects in determining key aspects of current or future building projects?*

7. *Are there features that have been included in your buildings in the past few years to improve efficiency of building operation, indoor environmental quality and occupant satisfaction?*
If yes, briefly describe

ASK ALL RESPONDENTS

8. *Within a portfolio of buildings, what are your key indicators of how well a building is performing for your business?*

List

9. *What benchmarks or assessment tools are you aware of to measure building performance, occupant comfort, or occupant satisfaction?*

List

10. *Do you use any benchmarks such as LEED or Energy Star?*
    a. *If Yes, what benefits to they provide to your business?*

11. *How important are the following aspects of the interior environment of buildings for occupant health and comfort? Please rate each element as either very important, somewhat important or not important*

Overall quality of the electric lighting	*VI*	*SI*	*Not*
Access to windows	*VI*	*SI*	*Not*
Openable windows	*VI*	*SI*	*Not*
Provision of daylighting deep into a space	*VI*	*SI*	*Not*
Individual occupant control of temperature within a space	*VI*	*SI*	*Not*
Individual occupant control of lighting within a space	*VI*	*SI*	*Not*
Ability of the mechanical system design to provide fresh air	*VI*	*SI*	*Not*
Ability of occupant to control the amount of fresh air	*VI*	*SI*	*Not*

12. *Have you received occupant complaints regarding your buildings. If YES, What are the most common areas of complaints*
    a. *temperature control______ Common/occasional/rare*
    b. *ventilation air _______, Common/occasional/rare*
    c. *other air quality issue______, Common/occasional/rare*
    d. *lighting issues_______ Common/occasional/rare*
    e. *other (list) ________ Common/occasional/rare*

The remainder of the questions are focused on your opinions regarding potentially valuable aspects of a benchmarking or assessment tool for buildings.

13. *If you were to use a system to rate the functional performance of a building, how important are each of the following elements of a assessment system? Please rate each element as either very important, somewhat important or not important*

Occupant satisfaction with lighting	*VI SI Not*
Occupant satisfaction with temperature control	*VI SI Not*
Comparison of energy use against preset targets	*VI SI Not*
Measurement of energy use per occupant or square foot	*VI SI Not*
Comparison of energy use with other similar buildings	*VI SI Not*
Physical measurement of indoor air quality, such as CO2 concentrations or the presence of volatile organic compounds	*VI SI Not*
Review of the key mechanical system controls	*VI SI Not*
Measurement of water use	*VI SI Not*
Measurement of water use per square foot or occupant	*VI SI Not*
Occupant perception of productivity	*VI SI Not*
Health statistics of occupants, such as sick days used	*VI SI Not*
Detailed interview with facility manager	*VI SI Not*
Other (list)	*VI SI Not*
Other (list)	*VI SI Not*

14. *What are the best buildings that you are aware of that serve your market and what are the aspects of these buildings that make them significantly better than average?*

15. *Do you believe that benchmarking aspects of building performance could improve building value, occupant satisfaction, or the ability to rent space more rapidly?*

16. *If there were a reliable benchmarking or assessment system for building performance, would you be interested in using it on your buildings?*
    a. *If Yes, what do you think would be a fair price to benchmark a 100,000 square foot building?*_____________

17. *Who do you think would be the primary audience for a report on overall building performance and what are the two or three most important aspects of building performance that should be covered in that report?*
    *Who*______________________________

*What*_______________________________________

18. What are the most important reasons why you might be interested in using benchmarking of building performance?(DO NOT READ)

____ Support for the development of design and planning guides

____ Provision of information to the building industry

____ Testing of new concepts

____ Justification of major expenditures

____ Educate decision makers (owners and designers) –

_____Avoid repeating past mistakes

____ Improve building performance over time

____ Make design professionals and owners accountable for

____ Aid communication among designers, clients, facility managers

____ Other ______________________________

19. *What is the primary reason or reasons why you would not be interested in benchmarking building performance?* ***DO NOT READ***

_____ Cost

_____ Limited market interest

_____ Liability/Delivering bad news

_____ Logistical problems in data collection

_____ Resistance to change in processes; organizational learning

_____ Other _____________________________________

Thank you for your time. Do you have any questions for me or any further comments?

Appendix H - Procedural Steps

BPR Levels and Options

The following levels are sequential. A client may initially contract for the entire package, or may start just with Level 1 and later decide whether to proceed to additional levels.

Level 1 – Data gathering and simple interpretation: Services include gathering utility and survey data; providing a basic summary of results; conducting phone interview with Facilities Manager to gather general impressions and comments on survey findings; suggesting possible next steps.

Client selects specific topics to be included from the following list:

energy use compared to external benchmark (always included, based on running actual energy information through Portfolio Manager)
energy use trend (two or more years energy experience from the same building)
energy use compared to internal benchmark(s)
Internal benchmarks are either fixed targets provided by the client or developed through the analysis (e.g. if the BPR is done on a group of institutionally owned buildings, which become the internal benchmark)

energy use expressed in relation to client-specified metrics (e.g. energy per customer served, per employee, per dollar of gross revenue, etc.)
indoor water use
irrigation water use
occupant perception of building systems functional comfort
occupant perception of workspace design functional comfort

[There may actually be options within level 1. For the most basic, the client enters all data into spreadsheets, which the BPR team then summarizes.]

Level 2 –Interpretation and analysis: Walk-through building with Facilities Manager, covering items in a standard questionnaire plus specific follow-up items from Level 1. Provides a more detailed report that may include (depending on the specific objectives chosen for the review:

additional analysis by zone, work group, or other building region;
identification of specific building systems problems;
suggested service providers for further follow-up actions;
draft report that could be sent to the building occupants explaining the results of the survey.

Level 3 – Targeted analysis and action plans: This level would typically be provided by an outside consultant, who may have been recommended in the Level 2 report.

Basic steps in conducting a BPR

Sales/Contracting. (Done by the sponsoring organization.)

Identify interested clients.

Determine specific topics to be covered in the potential client's survey

Before agreeing to include water data, have the client confirm that they have actual metered water usage (some utilities don't provide this consistently), and that they have metered results for the specific areas of interest. For example, if irrigation is the focus, determine whether indoor and outdoor water is separately metered.

Level 1 topics include an optional survey section on workspace design functionality, which covers topics such as storage and meeting space, privacy, and noise from other occupants. This option is included because it is a standard part of many occupant surveys and can be useful in planning for overall employee productivity. However, because of the expectations that may be created by asking these questions, the option should be selected *only* if the owner plans to use the results of this portion. Follow-up of negative responses in this area will typically require Level 2 or Level 3 (contracting with the survey sponsor) services.

Sign the service contract, spelling out roles, responsibilities, deliverables. Roles and responsibilities include:

Client responsibility for facilitating the survey: announcing and distributing a paper survey or sending e-mails to all employees with invitations to an online survey. In a building with multiple tenants or governmental departments, many different permissions and distributors may be needed to accomplish this.

Client or BPR responsibility for entering utility data. (Client is always responsible for accurately identifying *all* accounts that must be included for whole-building results.) If the BPR team will be entering the utility data, then either:

Client is responsible for providing that data to BPR, in spreadsheets or via copies of bills, or

Client gives authorization to BPR to get billing data directly from the utility company: signed authorization form and copy of a recent bill. [applicable in areas where the utility will indeed provide such information on request]

Identify primary contacts for information: overall study, utility data, O&M, survey.

Data gathering

Basic info. A short (1-2 page) form with basic information should be gathered at the outset. See a sample draft in Figure 1. It might be a good idea to require this information during the marketing stage, as part of determining the scope of services to be provided. To help ensure that the client is serious about providing data, this basic information should be collected no later than at the time the contract is signed

Energy data. Depends on the level of service being provided by the BPR team.

Provide instructions to the client on entering data into Portfolio Manager, or

Provide client with a spreadsheet on which they can enter the needed data for the BPR team to use, or

Gather the data directly from the utility providers, using previously signed authorizations.

Water data. Use options ii or iii for energy. Gather both sewer and water volumes, where different. Determine (from a billing or the utility company) how sewer volumes are calculated.

Survey data. The actual steps will depend on the survey tool being used. The following assumes that a tool similar to BIU will be used, with paper surveys and with summaries and basic reporting done at BIU (or GRET) with their software. (The organization providing the tools and service is referred to here simply as BIU, but does *not* reflect detailed negotiations of services that Vischer's group could or would provide.)

Client provides a floorplan for BIU to use in coding all workstations. Also specifies any particular subgroups for which results should be reported separately.

Set the survey date with the client, which requires that the primary survey contact verify availability of each independent tenant or department being surveyed.

Provide the client with a written notice that can be given to employees explaining the purpose and importance of the survey. Make sure the notice accurately reflects the client's intended use of results and the way, if any, that results will be reported back to occupants.

Confirm with the client 2-4 days before the survey that all approvals are received and notices have been distributed.

If a BPR representative hands out the survey, the visit to the site can also be used for gathering some building background information, and perhaps a preliminary discussion with the facility manager. Having the client hand out and collect the survey could reduce costs, but may also mean less consistent treatment and possibly lower response rates.

If a paper survey is used, data entry probably done by a BPR representative. Having the client do it potentially risks confidentiality, because workspaces are identified. Having BIU do it may (or may not) be more expensive.

Interpretation and Reporting

Energy data. Standardized spreadsheet or other software should be developed to summarize the Portfolio Manager results in the Level 1 report format.

Survey data. BIU should provide summaries of scores and indices (comparisons to norm) for each of the key dimensions, in a format that will be usable in the Level 1 report. Results from BIU may also include:

Additional summaries by floor, HVAC zone, or other unit specified by the client.

Additional detail for individual questions may be available for appendices

Identification of significant localized problems based on viewing comments by workstation. (This is a BIU capability, but negotiations would be needed to determine how much could be done for the Level 1 fee.)

Facility manager interview. Ideally takes place after the energy and survey data results, so the conversation can include problems revealed there. Alternatively, may have an initial phone conversation gathering general observations (should be a standard interview questionnaire), followed by a specific conversation discussing results.

Reporting. The Level 1 report-writing should be very straightforward, assuming:

tools to put data in a uniform summary format, clear conclusions from the facility manager interview, and

an established template for the types of follow-up options that may be recommended.

Figure 1 - Basic BPR Data Form

General Information

Building name:		
Mo/Yr building opened:		
Mo/Yr of last major renovation		
Renovation / upgrade description		
Mo/Yr of completed commissioning or recommissioning		

Location

Street Address:	
City, state/province Zip	

Ownership and Occupancy

Owner:		
Owner occupied?:		
Multiple tenants?		
	staff	public / visitor
Number of occupants:		
Significant changes in occupancy?		

Building Features

Gross conditioned building area		(ft2)
Number of floors, total:		include basement, parking, service, and mechanical penthouse levels
Number of floors, conditioned:		
Principal activity:	select 1	
Office, general		
Office, bank branch		
Office, bank/financial center		
Office, courthouse		
K-12 School		
Supermarket/Grocery Store		
Hospital		

Hotel, upscale	
Hotel, midscale w/ restaurant	
Hotel, midscale w/out restaurant	
Hotel, budget	
Other	

Certifications

	Rating
LEED	
Energy Star	
Earth Advantage	

Utilities

Provider	elect	gas	water	central steam
Account #(s)				
Tenants and/or usage areas (if multiple accounts)				

Energy Sources

	End Uses		
	HVAC	DHW	Other
standard grid electricity			
natural gas			
fuel oil			
steam			
chilled water			
Solar PV			
Solar HW			

Contact Information

	Primary	Energy	O&M	Survey
Name:				
Phone:				
Email:				

Appendix I - Possible Use of EZ Sim as a Building Performance Report (BPR) Tool

EZ Sim is a spreadsheet-based building energy simulation tool from Stellar Processes Inc. It was designed for simplified whole-building review of existing building operation, and it may be a useful part of the tool-kit for BPR reports.

Description

EZ Sim compares actual whole-building energy use with simulated baselines. The baselines can be generated with minimal building information (location, square footage, type, energy sources). They can also be refined with additional detail about the building, but still much less than is required for a basic DOE-2 model. Actual energy usage is entered by billing period for the entire building. All calculations are adjusted for actual weather and building area.

If actual energy usage differs from the initial baseline, the tool allows the user to very easily tweak some basic building parameters to create a tuned baseline model that better matches actual experience. The tuning adjustments are obviously just one hypothesis for what might be causing the observed actual energy levels. They constitute an informed guess that can create a more targeted list of areas to review with the facility manager.

The Sample Output attachment at the end of this document shows a simple example where tuning adjustments suggest looking for causes of above-average plug loads and above-average air exchange rates.

BPR Use

If sufficient Level 1 budget is available, EZ Sim might be used at that stage. Reviewing the initial tuning adjustments could help refine the list of topics to be covered with the Facility Manager.

The tool might also be used for additional analysis in Level 2. After gathering additional building information, a refined baseline could be generated, followed by further modeling where desired of possible savings from various efficiency measures. The paper referred to under Information Sources provides several examples of this type of analysis.

Advantages

- Relatively quick and simple to use. If the 12 months of energy usage data has already been assembled, the initial data entry and tuning adjustments can probably be done in less than an hour by an experienced user.
- Designed to calibrate against monthly billing data, rather than to require hourly schedules and load patterns.

Personal Observations

- The spreadsheet is fairly straightforward but not totally intuitive. The learning curve would probably be too high for a one-time user. The user should be familiar enough with the tool to know what the “baseline” and “comparison” terms refer to at each stage of the analysis, and to remember the order in which the tuning and description adjustments are made. If recommended as part of a BPR review toolkit that will be used by a large number of individuals, it might be best to provide a custom set of BPR instructions. Those could describe the specific options to use for the initial analysis and translate EZ Sim terminology to that being used in the BPR material (or change/clarify the labels used in a BPR-EZ Sim version of the spreadsheet).

- To make the most use of the available detailed description options, the user should be familiar with building mechanical systems and terminology.
- As with many macro-driven spreadsheets developed several years ago, the tool has the potential for freezing or displaying erratic behavior (at least on my laptop). This seems to be especially true if multiple versions are open simultaneously, as one might have for comparing different buildings.

Sample Output (see next page)

Information Sources

A variety of technical papers by Stellar Processes are available at http://www.ezsim.com.

See, for example,

Robinson, D., "Use of a Billing Simulation Tool for Analysis of Commercial Facilities."

Attachment 1: Sample Output

The extracts below show sample basic information, a performance graph, and tuning adjustment summary from the EZ Sim benchmark report. The graph displays three types of information, for each of electricity and natural gas:

Actual usage (unconnected markers) – the building's actual energy usage over the course of a year, graphed against the actual mean monthly temperature for each billing period.

Comparison usage (dotted lines) – typical energy consumption levels for the basic building characteristics given, before any tuning adjustments to better match actual experience.

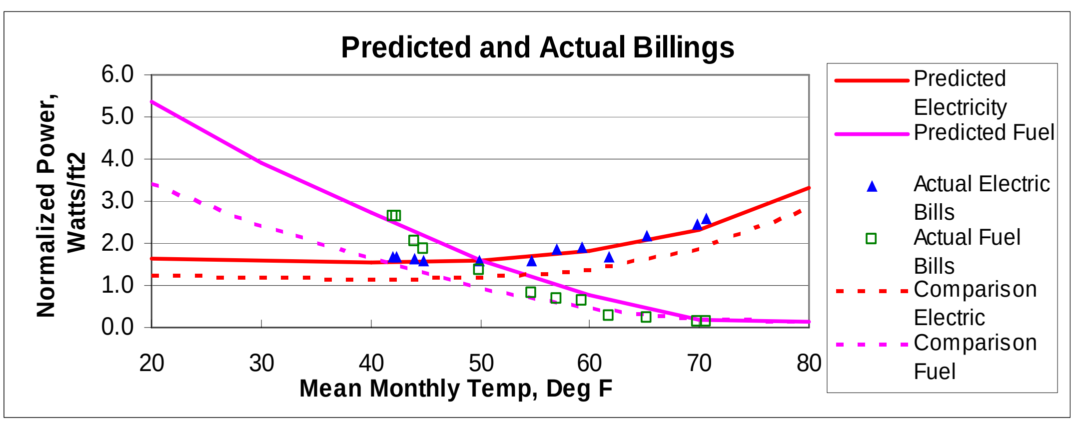
Predicted usage (solid lines) – the energy consumption levels for a "tuned" model that more closely matches actual results.

In this particular example, the building's actual usage was higher than the comparison lines for a typical building. The tuning adjustments made to obtain a better match included increasing the electricity base load and increasing the number of air changes per hour. The Tuning Summary lists the adjustments and suggests possible conditions that might have these effects.

1. BASIC HEATING/COOLING INFORMATION:

Total Square Footage:	12,300
Number of Stories (floors):	1
Building Type:	Cement Block
Energy Code:	New Construction
Business Type:	Office
Space Heat Fuel:	Gas or Other Fuel
Water Heater Fuel:	Gas or Other Fuel
Air Conditioning:	Yes
Economizer:	Yes

2. PERFORMANCE GRAPH



3. TUNING SUMMARY

Modifier:	Look for:
Baseload: Internal gain is greater than usual.	High lighting/plug loads, extra equipment, extended operating hours, extra equipment or process loads, exterior lights (or pumps) left on.
ACH: greater than usual.	Doors open, locked vent dampers, faulty economizer.

Appendix J - LightRight Consortium Web Survey

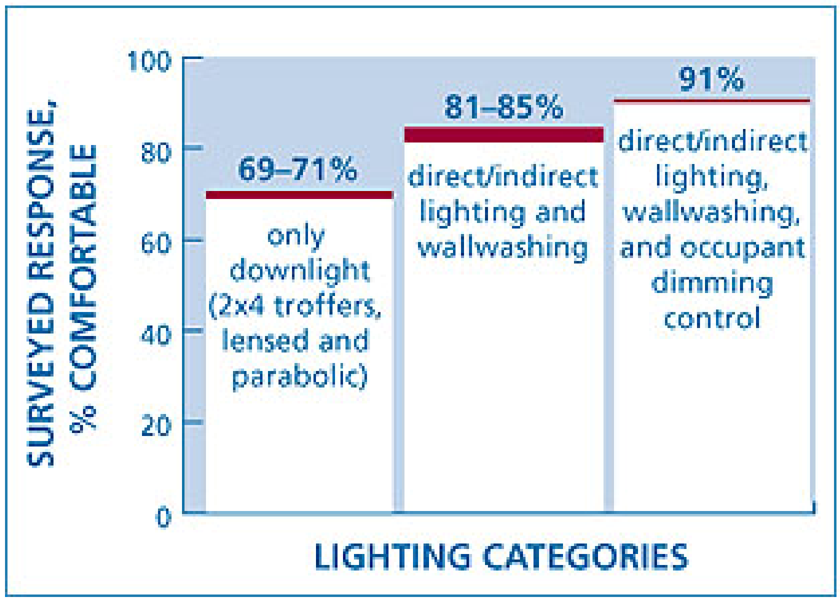
Research shows that a high percentage of office workers—30%— rate the lighting as uncomfortable under the most typical type of lighting (direct-only troffers). Lighting systems that create brightness on the ceilings and walls, and systems that allow personal control of the lighting, are rated significantly higher.

Find out if occupants are comfortable and satisfied with their office lighting using the Light Right Consortium web based survey. Individual occupant responses and company results are held confidential and use of the survey is free.

Use the survey as a before-and-after measurement tool to capture positive results from a lighting improvement project.

Use the survey as a diagnostic tool to determine if lighting changes are needed.

Compare different types of lighting systems to see what creates the highest satisfaction.



Source: Page capture, http://www.lightright.org/surveytool/sign-up.htm