

Building Cost and Performance Measurement Data

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BACKGROUND

A key barrier to widespread adoption of sustainable design is the lack of actual, measured performance information for sustainably designed and operated buildings. Although there have been some quality business case analysis studies performed [e.g., U.S. DOE, 2003; Kats, 2003], there has been an absence of measured building performance data from currently operating sustainably designed buildings [BD&C, 2003; ENSAR, 2003; Carmona & Oreszczyn, 2004]. Additionally, a group of key stakeholders involved with the project described in this paper identified measured performance versus modeled or estimated performance as a more effective tool for the Federal agency sustainable design advocates when they are proposing design budgets.

To address this need, the Building Cost and Performance Data project was initiated in fiscal year 2004 by the Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy's (EERE) Federal Energy Management Program (FEMP). The scope of the project was to develop a relatively simple method for measuring building cost and performance that would generate data that could be used to demonstrate the life cycle benefits of sustainable design to Federal decision makers. To meet this goal, the project

developed a measurement protocol with a set of high-level metrics for identifying cost and performance differences of operating sustainably designed and traditionally designed buildings.

These metrics are intended to be used to document the measurement of the performance and cost of a sustainably designed building and compare it to the performance and cost of a similar traditionally designed building (the pairing of a sustainably designed building with a traditional building will be called a “building set” through the remainder of this paper). The value of the information generated through the use of these metrics will increase as more building sets are measured and the results shared with others. To accomplish this, the project is looking for building sets that are willing to participate in a minimum of 12 months of performance measurement.

METRICS AND PROTOCOL DEVELOPMENT

On this project, building cost and performance metrics were defined and a protocol outlining their use was prepared. The *metrics*, or measurable characteristics, were developed, reviewed and tested to ensure they were technically feasible and defensible. The building cost and performance *protocol* describes the metrics in more detail and provides guidance on how to use them. To accomplish the development of these tools, the project

- Performed an extensive search of building measurement studies,
- Based on the information discovered in the search, developed strawman metrics,
- Formed a Technical Advisory Group to ensure the metrics and protocol were technically defensible and usable by key stakeholders,
- Identified metric selection criteria to keep the number of metrics to a manageable and meaningful set,
- Gained an understanding of the target audience in order to focus the metrics on their key interests,
- Performed a pilot test on the use of the metrics on two building sets, and
- Developed a final set of metrics and protocol incorporating the lessons learned from the pilot test.

During fiscal year 2005, the project will focus on identifying building sets where the metrics and protocol for data collection can be applied.

Over 40 relevant documents were reviewed for guidance on sustainable design cost and performance metrics. This literature search identified that there was not currently a set of metrics, a protocol, and/or measured building cost and performance data that met the goal of this project. However, there were several good resources that offered considerable insight into what to and how to measure building performance [e.g., GBC, 2004; Paladino, 2003a and 2003b; USGBC, 2004].

The Technical Advisory Group has been critical to the success of this project. It is comprised of individuals working in the Federal government and private sector. The current list of members is provided at the beginning of this paper. The Technical Advisory Group has reviewed all of the materials prepared for the project and provided key input on the selection and measurement details for the cost and performance metrics.

The final set of metric selection criteria were refined by the Technical Advisory Group and are provided in Figure 1 [Wallace, 2003]. Many building cost and performance measurements could be taken. These criteria were used to help in identifying and limiting the number of metrics so that the final set met the intent of the project, which is a simple yet technically defensible method of measuring the performance of sustainably designed buildings.

<p><i>Ease of Collection</i></p> <p><u>Availability</u>: Information routinely collected for other purposes or by other entities.</p> <p><u>Obtainability</u>: Available via relatively simple measurement or collection.</p> <p><u>Cost</u>: No cost or minimal cost to collect the data.</p> <p><u>Time</u>: Minimal time investment to collect data.</p> <p><u>Standardization</u>: Frequently measured quantity with well-established collection procedures where feasible.</p> <p><u>Public</u>: Based on data that can be shared with the public.</p> <p><i>Usefulness of Information</i></p> <p><u>Relevance</u>: Representative of sustainability.</p> <p><u>Importance</u>: Having a large sustainability impact potential.</p> <p><u>Comparability</u>: Amenable to normalization for comparisons over varying climates, years, and uses where feasible.</p> <p><u>Utility</u>: Usable for additional purposes where feasible.</p> <p><i>Quality of Data</i></p> <p><u>Quantification</u>: Numeric measurements facilitating both absolute and relative sustainability performance assessments where feasible.</p> <p><u>Accuracy</u>: Reflective of the actual state of the system.</p> <p><u>Precision</u>: Minimal error in metric measurement.</p> <p><u>Clarity</u>: Well-defined, easily communicated, and clearly understood among multiple parties.</p> <p><u>Simplicity</u>: Minimal normalization or manipulation of data.</p>
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Figure 1 – Metric Selection Criteria

The primary audiences for the cost and performance data are financial personnel responsible for submitting budgets for design projects, technical personnel responsible for designing the new buildings, and management responsible for approving design concepts and budgets. The questions the metrics focus on answering for these audiences include

- How do the life cycle costs of sustainable design compare to life cycle costs of traditional design?
- Do sustainable design strategies translate into improved building performance?

Fort Lewis in Tacoma, Washington offered to be the pilot test location for the metrics. Over a 4 month period PNNL tested the application of the metrics using two Fort Lewis

Battalion Headquarters facilities to determine the ease of collection as well as to identify potential challenges with comparability, data accuracy, and availability. These two buildings serve the same function (office building) for two different active military groups. The size of the buildings was very similar and they were located within a half mile of each other. One of the buildings was built in the 1990s with no intentional thought to sustainable design, while the second building was completed in 2004 and is expected to reach either “certified” or “silver” level using the U.S. Green Building Council Leadership in Energy and Environmental Design (LEED) rating system.

The Social Security Administration Woodlawn facilities near Baltimore, Maryland also provided pilot test feedback on the metrics offering a different perspective from the experience of data collection at Fort Lewis. The Woodlawn facilities were larger, were owned and operated by two different entities, and the buildings had different fuel sources for heating energy.

The information from the pilot test building sets was used to clarify the metrics data collection protocol and to aid in addressing potential data collection challenges identified by the two sites. Examples of lessons learned during the pilot study include:

- Engage building managers early in the process and keep them as leaders throughout the measurement process;
- Consider forming a building team to assist in the data collection effort;
- If buildings are not individually metered, assess whether the cost and effort to meter the buildings fit within the project budget and time constraints;
- Hold teleconference(s) with each building team or point of contact to gather as much information as possible prior to the site visit;
- Bring a digital camera, measuring tape, and a trundle wheel on the site visit;
- For collection of waste and purchasing data, request that appropriate staff participate in teleconferences and the site visit; and
- For collection of productivity and transportation data, recognize that there may be a need to address union officials, management, and/or senior organization officials.

It is expected that as the metrics are applied for longer periods of time and to different building types there may be additional issues that arise.

METRICS

The building cost and performance metrics were developed to offer an ‘easy’ means of data collection for key areas of sustainability. The information that needs to be collected for each building has been broken into two groups:

- 1) Building and Site Characteristics and
- 2) Building Performance Metrics.

The building and site characteristics are used to provide a valid comparison between buildings. The building performance metrics are used to measure the actual performance of the building over time. The performance of the individual buildings will be measured with a minimum of 12 months of data.

As mentioned previously, these metrics are intended to be used to document and compare the measurement of the performance and cost of a sustainably designed building to a

Metric	Collection Units
Key Policies (e.g., sick leave, transportation, purchasing, etc.)	Summary of key policies
First Costs	
Design Cost	\$ $\frac{\$}{ft^2}$
Construction Cost	\$ $\frac{\$}{ft^2}$
Unusual Cost Elements	$\$/activity$

Building Performance Metrics

Building performance metrics provide quantitative measures of building operations over a minimum of 12 months. Most of these data will be collected monthly and summarized into annual performance data (units shown in italics are for an annual summary). One of the considerations for the metrics and units that were chosen was the ability to easily translate the data into performance, environmental, and cost impacts. For each of the following categories of metrics, the specific data points that will be collected are described in Table 2:

- Water
- Energy
- Maintenance and Operations
- Waste Generation
- Purchasing
- Indoor Environmental Quality and
- Transportation.

Most of the metrics in the table are required in order for the analysis of the building performance to be representative of sustainability. However, some of the metrics, for example storm water sewer output, are considered optional because they may be difficult and/or costly to measure, but have the potential of significant environmental, social, and economic impact. It is left to the discretion of those performing the analysis to determine whether the effort to collect those data is worthwhile.

Table 2. Building Performance Metrics.

Metric	Collection Units
Water	
<i>Building water consumption will be determined on volume and cost and gathered from utility bills. Storm sewer output will be metered, if feasible.</i>	
Total Building Potable Water Use	$\frac{gal}{month}$ $\frac{\$}{month}$
Indoor Potable Water Use	$\frac{gal}{month}$ $\frac{\$}{month}$
Outdoor Water Use	$\frac{gal}{month}$ $\frac{\$}{month}$

Metric	Collection Units	
Total Storm Sewer Output	$\frac{gal}{day}$	$\frac{\$}{month}$
Energy <i>Building energy consumption values will be gathered from utility bills, utility interviews, and metering [Barley, 2003].</i>		
Total Building Energy Use	$\frac{kWh_{delivered}}{month}$	$\frac{\$}{month}$
	$\frac{Btu}{month}$	
Source Energy	$\frac{kWh_{source}}{month}$	$\frac{kg_{CO_2}}{kWh_{source}}$
Peak Electricity Demand	kW	
Maintenance and Operations <i>Maintenance and operations values will be gathered from maintenance and operations records and discussions with facility staff and occupants [Sullivan, et al., 2004].</i>		
Building Maintenance	\$	hrs
	# requests by type	
	# preventative maintenance	
Grounds Maintenance	\$	hrs
	# requests	
	kg of hazardous chemicals used	
Waste Generation <i>Waste values will be gathered from monthly hazardous waste disposal, solid sanitary waste disposal data, and recycling data. Solid sanitary waste generation data may be estimated using utility bills.</i>		
Churn Cost	$\frac{\$}{churn}$	$\frac{moves_{box}}{occupant \cdot year}$
	$\frac{moves_{furniture}}{occupant \cdot year}$	$\frac{moves_{construction}}{occupant \cdot year}$
Solid Sanitary Waste	$\frac{yd^3}{month}$	$\frac{ton}{month}$
	$\frac{\$}{month}$	

Metric	Collection Units	
Hazardous Waste	$\frac{gal}{year}$	$\frac{kg}{year}$
	$\frac{\$}{year}$	
Recycled Materials	$\frac{ft^3}{month}$	$\frac{ton}{month}$
	$\frac{\$}{month}$	
Purchasing		
<i>Purchasing values will be gathered using the quarterly or annual report data for environmentally preferable purchasing, as directed by Executive Order 13101, if available.</i>		
Environmentally Preferable Purchasing (EPP)	$\frac{\$_{All}}{year}$	$\frac{\$_{EPP}}{year}$
Indoor Environmental Quality (IEQ)		
<i>IEQ values will be gathered using occupancy statistics and survey data. The survey questions are those developed by the Center for the Built Environment (CBE) at University of California-Berkeley [CBE, 2002].</i>		
Occupant Turnover Rate	$\frac{turnover}{year}$	
Absenteeism	$\frac{absentees}{occupant \cdot year}$	
Building Occupant Satisfaction	Survey rating: Very Low to Very High	
Self-Rated Productivity	Survey rating: Very Low to Very High	
Transportation		
<i>Transportation values will be gathered using survey data. The survey questions were developed by CBE and will be distributed to occupants when the occupancy satisfaction survey is distributed.</i>		
Regular Commute	mpg	$\frac{miles}{week}$

PROTOCOL

The protocol is a detailed document that guides the application of the metrics. This document contains the following information for each metric:

- Definition
- Relevance to sustainable design
- Data collection approaches and strategies
- Data calculations, when needed, and
- Lessons learned from the pilot test, when available.

The protocol document also offers an overview of the project, a description of the building set selection guidance, and details on the occupancy and transportation surveys to be used. This document will be used to guide the application of the metrics to available building sets.

NEXT STEPS

Now that the building cost and performance metrics have been identified and the protocol developed, the next step is for full scale application of the metrics. This requires that building sets of sustainably and traditionally designed buildings be identified and the key building personnel agree to measure cost and performance data for a minimum of 12 months. Once building sets have been identified and data have been collected, the compilation and presentation of the results will be the next challenge. The Building Cost and Performance Data project is currently looking for interested parties with building sets where the metrics can be applied. As stated previously, to perform the analysis one sustainably designed building and one traditionally designed building is needed that are closely located, have a similar occupant type, and have been in operation for a minimum of 6 months.

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