Building Performance: Design through Operations

Setting the Framework for Energy Data and Design Continuity in High Performance Buildings

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NASEO National Association of State Energy Officials

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NBI is a nonprofit organization working to improve the energy performance of commercial buildings. It works collaboratively with commercial building market players—governments, utilities, energy efficiency advocates and building professionals—to remove barriers to energy efficiency, including promoting advanced design practices, improved technologies, public policies and programs that improve energy efficiency. More information about NBI is available at www.newbuildings.org.

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Executive Summary

Since 2008, state and federal policies, building energy code improvements, and efforts of leading design professionals have driven improvements in design strategies, processes, and system selection to achieve ever-increasing levels of energy efficiency; however, efforts to improve a building's design as modeled are not necessarily realized in its actual performance. Previous studies by New Buildings Institute (NBI) and others highlight the need to shift the attention of the design team, building occupants, and facilities managers to the link between modeled design and building operation and use.

A common adage, oft repeated in the energy efficiency field, is that "you cannot manage what you do not measure." Building performance monitoring has become commonplace as states and cities have enacted energy monitoring, benchmarking, and disclosure laws, and measured performance data is now available in a variety of formats on various platforms. Nevertheless, systems available in the market today that capture data on a real-time basis often do not present the data in terms of performance indicators that are readily understood and accessed by building managers and occupants. A 2008 study[1] by NBI looking at energy performance in Leadership in Energy and Environmental Design (LEED) buildings found that actual Energy Use Intensity (EUI) for over half the projects deviated by more than 25% from design projections, with 30% significantly better and 25% significantly worse. This finding underscores a pressing need to more effectively bridge the divide between the modeled and actual performance of buildings, thus reducing the range of energy performance variability and increasing certainty about the operational performance of buildings post-occupancy.

The design community, building owners and operators, facility managers, and other parties should use real-world building performance data to measure and track energy usage in the built environment. Measured performance analytics can empower architects and designers to improve future building design and enable occupants to improve the performance of their buildings over time.

This report examines various sources of building performance data, identifies Key Performance Indicators (KPIs) that support the analysis of building performance data, and discusses how to establish a feedback loop among designers, managers, and tenants. Three especially important KPIs for measured performance are the EUI, the annual energy usage, and the ENERGY STAR Score.

A wide variety of measured performance data sources were investigated as part of this effort; the characteristics of these data sources and the KPIs they include are evaluated in detail. A total of 44 data sources are examined in spreadsheet form in Appendix A; these data sources are summarized in the body of the report.

Three key needs have been identified as a result of this analysis, including: increasing the quantity of measured performance data available in current data sources; improving access to and transparency of measured performance data in current data sources; and enhancing engagement between various stakeholders, including the design community, the building industry, government entities, nonprofits, building owners, operators, and tenants.

To further this effort, three follow-on activities are crucial. First, there is a need to investigate trends and practices in performance feedback models and practices to determine what changes are occurring in the relationship between predicted and actual energy performance. This may involve gathering a broad set of high performance buildings with participation by the operator, owner and design team; obtaining detailed data on selected key performance indicators and their as-modeled analogues (i.e. predicted EUI) to refine empirical data on modeled versus measured performance; and analyzing building measured performance data within

[1] Energy Performance of LEED® for New Construction Buildings, New Buildings Institute, 2008; available at: http://newbuildings.org/sites/default/files/Energy_Performance_of_LEED-NC_Buildings-Final_3-4-08b.pdf

this dataset to evaluate the effect of specific design and operations strategies on actual energy performance as compared to anticipated design performance. Second, there is a need to partner with municipalities and states that are implementing disclosure ordinances to make sure that data is accessible and transparent, as in Washington, D.C. Finally, there is a need to pilot new models for the use of measured performance data and to engage stakeholders to help improve the existing models.[2]

By performing in-depth analysis of the real-world effects of various measured performance efforts, a final report could provide valuable information for design and operations teams, including specific recommendations to improve design and operating practices.

[2] NBI's *2014 Getting to Zero Status Update* includes a publicly available catalog of new construction and major renovation projects which may form a potential sample of buildings through which to pilot innovative data gathering methodologies. See http://newbuildings.org/sites/default/files/2014_Getting_to_Zero_Update.pdf.

Introduction

In early 2008, New Buildings Institute (NBI) concluded a year-long study for the U.S. Green Building Council (USGBC) to examine the post-occupancy performance of Leadership in Energy and Environmental Design (LEED) buildings. The study was the first review of its kind, providing a critical link between design intention and actual performance outcomes for LEED New Construction (LEED-NC) projects.

On average, the study found that LEED buildings deliver anticipated savings through a variety of measures and achieve, on average, energy performance that is 25 to 30% more efficient than that of conventional buildings. As the level of LEED certification increases, average performance improves, with Gold and Platinum buildings using about 24% less energy than LEED-certified buildings. However, individual building performance results displayed a high degree of variance, with some performing much better than anticipated, and others much worse.

Actual Energy Use Intensity (EUI)[3] for over half the projects deviated by more than 25% from design projections, with 30% significantly better and 25% significantly worse. These and other results from this exploratory study suggest a need for improved feedback tools, follow-up research on performance factors and improved modeling guidelines.

Since 2008, state and federal policies, building energy code improvements and efforts of leading design professionals have driven improvements in design strategies and processes as well as system selection to achieve ever-increasing levels of energy efficiency; however, efforts to improve a building's design as modeled are not necessarily realized in its actual performance. Previous studies by NBI, the National Association of State Energy Officials (NASEO)[4], and others highlight the need to shift the attention of the design team, building occupants, and facilities managers to the link between modeled design and building operation and use. The most critical components for a successful low-energy building now reside in post-occupancy through operations and occupant energy use.

A common adage, oft repeated in the energy efficiency field, is that "you cannot manage what you do not measure." Building performance monitoring has become commonplace as state and local benchmarking, monitoring, and disclosure efforts spread, and measured performance data is now available in a variety of formats on various platforms. Nevertheless, systems available in the market today that capture data on a real-time basis often do not present the data in terms of performance indicators that are readily understood and accessed by building managers and occupants.

It is essential to establish data definitions and design team continuity, educating the owner, occupants and facility managers on the efficiency of the building. This level of engagement informs design modelers of actual occupancy parameters and helps deliver lower-energy buildings. Feedback mechanisms can help bring performance reality in line with expectations and will inform each of the groups with control over energy use on what to do differently. The feedback can inform and improve future designs. For occupants and operators, it informs activities and drives operational improvements.

The study objective is to lay the groundwork on building performance data and describe ideas to increase the impact of data on actual performance outcomes. This report first reviews existing relevant data sources and defines an ideal set of building performance data and characteristics. Second, it discusses existing data gathering and transfer methodologies that can result in reducing the time and effort in gathering complete

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[3] Energy Use Intensity is a calculation of how much energy a building uses per square foot.

[4] NASEO, as secretariat of the Zero Energy Commercial Buildings Consortium and with support from the U.S. Department of Energy, published *Analysis of Cost and Non-Cost Barriers and Policy Solutions for Commercial Buildings* (2011) and *Next Generation Technologies: Barriers and Recommendations* (2011) and supported NBI's *Getting to Zero 2012 Status Update* (2012), which are available at http://naseo.org/publications.

and detailed set of building performance data that could assist in the effective design and operation of ultra-high performance buildings. Lastly it suggests next steps toward increasing performance feedback and data access.

Existing Data Sources

There are many sources of building performance data, from broad platforms with thousands of buildings to small, privately maintained case study collections and databases. The first step in understanding how to make this data useful for the design community, building occupants, and operators is to identify the measured performance data sources that exist today.

Data Sources Summary Matrix

NBI has identified 44 distinct data sources, summarized in Table 1, below; the list is not comprehensive as new data and formats are being created and identified continuously. A more-detailed version is available in Excel format and is available concurrently with this report; see Appendix A.

Table 1: Data Sources Summary Matrix, Simplified

Organization	Name	Description	Intended User(s)	Searchable	Number of Buildings (Approximate)
American Institute of Architects	2030 Commitment	Architecture and design firms commit to designing more efficient buildings and report design portfolio	Design Community	No	276 architecture and engineering company portfolios, 160 building case studies.
Architecture 2030	2030 Districts	Districts in USA cities coordinate individual buildings for voluntary compliance to Architecture 2030 goals	Building Managers, Developers, Property Owners and Managers	No	Total: 500-1000; across five 2030 Districts: Seattle, Cleveland, Pittsburgh, Los Angeles, Denver
California Energy Commission	CEUS	Action-oriented benchmarking database for California, last updated 2006	Architects/Design Community, General Public, Researchers	Yes	2700, all in California
DOE, Energy Information Administration	CBECS	Benchmarking data from a quadrennial survey of national commercial building stock, last updated 2003	Architects/Design Community, General Public, Researchers	Yes	5000+ in 2003 sample, with weighting factors representing % of total U.S. sf
DOE, Office of Energy Efficiency and Renewable Energy	Buildings Performance Database	Comprehensive database of actual data on buildings across the USA	Public	Yes	750,000 (700,000 residential; 50,000 commercial)

DOE, National Renewable Energy Laboratory	High Performance Building Database	Searchable case studies of private and public sector buildings; various organizations have customized portals to access data	Public, Design Community, Developers, Property Owners and Managers	Yes	150
EPA, ENERGY STAR	Portfolio Manager	Broad web-based building benchmarking tool	Property Owners and Managers	Yes	280,000 (as of 12/2011)
U.S. Green Building Council (USGBC)	Leadership in Energy and Environmental Design (LEED)	LEED building submittals	Design Community, Building Managers, Developers, Property Owners and Managers	Yes	20,000 + buildings completed
Municipal and State Data Disclosure Requirements	Various	Mandatory energy benchmarking requirements	Public, Property Owners and Managers	Sometimes	10,000

Municipal and State Mandatory Disclosure Ordinances

One significant and growing source of data is related to municipal and state mandatory disclosure ordinances. At least eight cities and two states have passed ordinances that require reporting of energy performance data, and similar laws are being considered in more jurisdictions. Table 2 below shows a summary of municipalities and states that have passed mandatory disclosure laws. A more detailed version of the table can be found in Appendix A. Many jurisdictions from towns to states have been benchmarking public buildings including offices, schools, higher education facilities, and more. At the state level, California and Washington have enacted mandatory benchmarking for both public and private buildings.

Table 2: Municipality and State Mandatory Disclosure Ordinances

Municipality or State	Platform	Intended User(s)	Number of Buildings (Approximate)
Austin	EPA Portfolio Manager	General Public	Unknown
Boston	EPA Portfolio Manager	General Public	Unknown
District of Columbia	Proprietary Platform (Excel-based, online)	General Public	Public: 400; Private: 500
Minneapolis	EPA Portfolio Manager	General Public	Public: 100; Private: Unknown
New York City	Proprietary Platform (Excel-based, online)	General Public	Commercial: 4000; Multifamily: 2000
Philadelphia	EPA Portfolio Manager	General Public	Public: 250; Private: Unknown
San Francisco	EPA Portfolio Manager	General Public	Public: 300; Private: Unknown

Seattle	EPA Portfolio Manager	General Public	3000
Chicago	EPA Portfolio Manager	General Public	Zero in 2013
California	EPA Portfolio Manager	CA Energy Commission, parties involved in property transfers and leases	Unknown
Washington	EPA Portfolio Manager	Private sector: parties involved in property transfers and leases; Public sector: General Public	Public: 100s Private: Unknown

State Energy Offices

More and more states are tracking benchmarking information for their public buildings. As a part of this project, NASEO reached out to its members and received responses from the states listed below regarding their building performance data and energy benchmarking efforts. Although other state energy offices are likely to have efforts as well, the following states provided this snapshot of their energy performance tracking for public buildings:

- Kentucky: Some state offices and most school districts; 600-700 buildings.
- Idaho: Some state-owned facilities.
- Iowa: Variety of state-owned facilities; 1800 buildings.
- South Dakota: Variety of state-owned facilities; 100-200 buildings.
- Washington: State owned facilities; hundreds of buildings.

Key Performance Indicators

On the one hand, it is important to gather as much useful data as possible to track and measure building performance. On the other hand, attempting to gather and track too much data risks turning off potential users and contributors; even committed users can get bogged down from information overload. Certain data points are especially important for tracking and measuring performance. We refer to these as Key Performance Indicators (KPIs). The KPIs identified in this report represent a minimum dataset that can fulfill three critical needs: identify a building within a dataset, define normalized building energy performance, and ensure comparability between buildings and across datasets. These KPIs include information about basic building characteristics as well as information about building performance. The availability of KPIs across 44 measured performance data sources was evaluated; this information can be found in the matrices downloadable through Appendix A.

Table 3, below, shows selected KPIs.

Table 3: Key Performance Indicators

KPIs: Building Characteristics					KPIs: Measured Performance Data		
Location	Date of Construction or Major	Conditioned Square Feet	Principal Building Activity	Occupancy: FTEs and Hours per	Energy Use Intensity (EUI) [5]	Annual Energy Usage	ENERGY STAR Score

[5] EUIs may be expressed in kBtus/sf/yr for the sum of all fuels or in kWh/sf/yr for electric only. Some data sources use source EUI and some use site EUI; the two metrics typically differ by a factor of two to four.

	Renovation			year			

Not every dataset includes all of these KPIs. Table 4 below shows how (if at all) the major data sources include KPIs.

Table 4: Measured Performance Key Performance Indicators by Data Source

Data Source Name	EUI	Energy usage (12 months minimum, all fuels)	ENERGY STAR Score
2030 Commitment	Predicted	No	No
2030 Districts	Some	Yes	Some
USGBC	Measured and Predicted	Some	No
Buildings Performance Database	Measured	No	No
Municipal and State Disclosure Requirements	Some	Some	Some
Portfolio Manager	Some	Yes	Yes
High Performance Building Database	Some	Some	Some

Collecting and tracking KPIs facilitates comparisons between buildings. Comparisons can inform an owner's decision making about undertaking energy efficiency projects and potentially increase the value of the property by showcasing how it performs and operates in comparison to its competitors. Tracking KPI information over multiple years can help a building owner or manager (or a third-party service provider) get an idea of energy use trends over time and determine if their energy conservation efforts are bearing fruit. On a wider scale, tracking this information can help illustrate larger trends in building performance and can enable analyses of the effects of building energy codes, retrofit projects, equipment choices, regional climate differences, and more.

Major Data Sources

While many measured performance data sources exist, not all are created equal. The structure of a data source and its intended audience are important when considering how to apply measured performance data to potential users such as the design community or building owners and occupants. A few major data sources warrant more detailed examination due to their prominence or structure.

Commercial Buildings Energy Consumption Survey (CBECS)[6]

The most robust and detailed source for statistical information about energy use and related building characteristics in the United States is the Commercial Buildings Energy Consumption Survey (CBECS). CBECS was last completed in 2003, but 2012 CBECS data will be published in stages beginning in mid-2014. A fully updated dataset is projected to be released in late 2015. The data includes detailed information about building characteristics (e.g., size, census division, vintage, occupancy, building type, and more) and energy

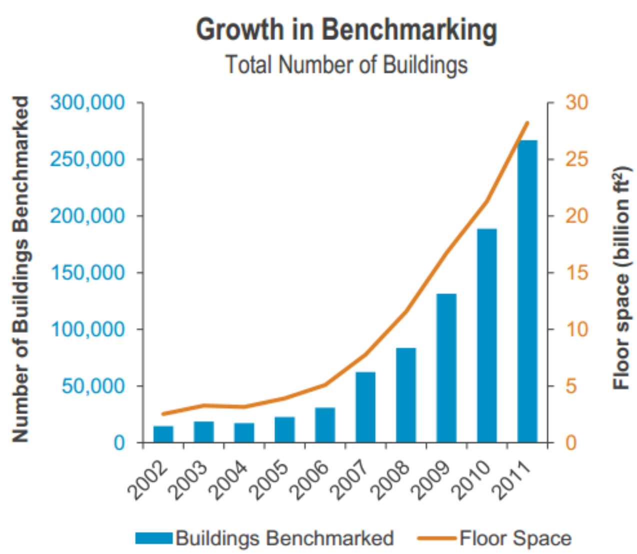
[6] CBECS 2003 is available at http://www.eia.gov/consumption/commercial/data/2003/.

consumption including energy usage by fuel type and end use. The data in CBECS 2003 is derived from about 5,000 buildings across the country and covers 72 billion square feet of building floor space. CBECS is well suited for research and investigation into broad categories like building EUI by building type or more specific questions like electric, gas, or other fuel energy intensity of specific building types within specific size ranges, climate zones, vintages, etc. This data has been and continues to be used extensively to characterize the building stock in the United States and to set baselines for comparison purposes.

ENERGY STAR Portfolio Manager[7]

The industry-leading broad-based platform for building benchmarking is the U.S. Environmental Protection Agency's (EPA) ENERGY STAR Portfolio Manager (PM) tool. PM is a web-based tool focused on building occupants and managers that is used to measure and track energy and water consumption in buildings. Approximately 40% of U.S. commercial building space, totaling about 30 billion square feet, is already benchmarked in PM[8], and the tool is used by hundreds of municipalities and states as well as the federal governments of the United States and Canada. The majority of jurisdictions with mandatory disclosure laws in this country use PM as the data reporting platform. Figure 1 shows the growth in popularity of PM through 2011. PM is intended for and used by building owners as opposed to being used for broader research. Therefore, despite the fact that PM has the largest dataset in North America, that information is generally not available to the public or for research (outside of ENERGY STAR) to help establish national benchmarking trends.

Figure 1: ENERGY STAR Portfolio Manager Benchmarking Trends[9]



Various software platforms integrate with PM in ways that can make reporting easier and more useful. For example, the USGBC has since 2009 required energy reporting for LEED-certified buildings and mainly uses the PM platform for that reporting. Several utility companies have integrated software tools with PM to automate

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[7] Available at http://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager

[8] According to EPA: http://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager.

[9] Image from Energy Star DataTrends Factsheet on Energy Use Benchmarking, available at http://www.energystar.gov/buildings/sites/default/uploads/tools/DataTrends_Energy_20121002.pdf?e497-01bf.

the direct upload of energy data. Customers of the Sacramento Municipal Utility District, for instance, may enter their building data into PM and the utility will automatically and continuously upload energy usage data. Many third-party energy performance benchmarking and tracking software providers incorporate PM into their product offerings. Despite its prominence, much of the data in PM is private, and gathering data from this source is complicated by the need to respect the privacy of building owners, occupants, builders, designers, and other parties involved in the project.

High Performance Buildings Database[10]

The U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) built and maintains the High Performance Buildings Database (HPBD). This database is a searchable repository of individual high performance building case studies across North America (and beyond). The information in the database is intended to improve the design and construction of high performance buildings by showcasing building details and lessons learned from individual building projects. The database is searchable, but because it is structured around individual building case studies it is not intended for analysis of broad segments of the built environment.

Various entities have built and maintain portals to access data stored in the High Performance Buildings Database through proprietary interfaces. These groups are listed in Table 5 below.

Table 5: High Performance Building Database Access Portals

Organization	Portal Focus
U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy	Primary database home site
New Buildings Institute	Zero Net Energy Verified and Capable buildings
BuildingGreen	Examples of green design products and practices described by BuildingGreen
American Institute of Architects	Buildings selected through AIA's annual Top Ten Green Projects competition
USGBC	Buildings certified through LEED building rating system
Federal Energy Management Program	Federal building projects
Massachusetts Technology Collaborative	Building projects that have benefited from grants provided by MTC
USGBC Cascadia Chapter	Building projects located in British Columbia, Washington, and Oregon
Efficiency Vermont	Building projects located in Vermont
Enterprise Community Partners	Low-income housing projects that have received funding through the Green Communities program

Buildings Performance Database[11]

DOE's Buildings Performance Database (BPD) includes data about buildings across the United States. Intended to be as comprehensive as possible, the database includes information on over 750,000 buildings. While the dataset contains primarily residential records – about 90% of the buildings in the database – it still represents

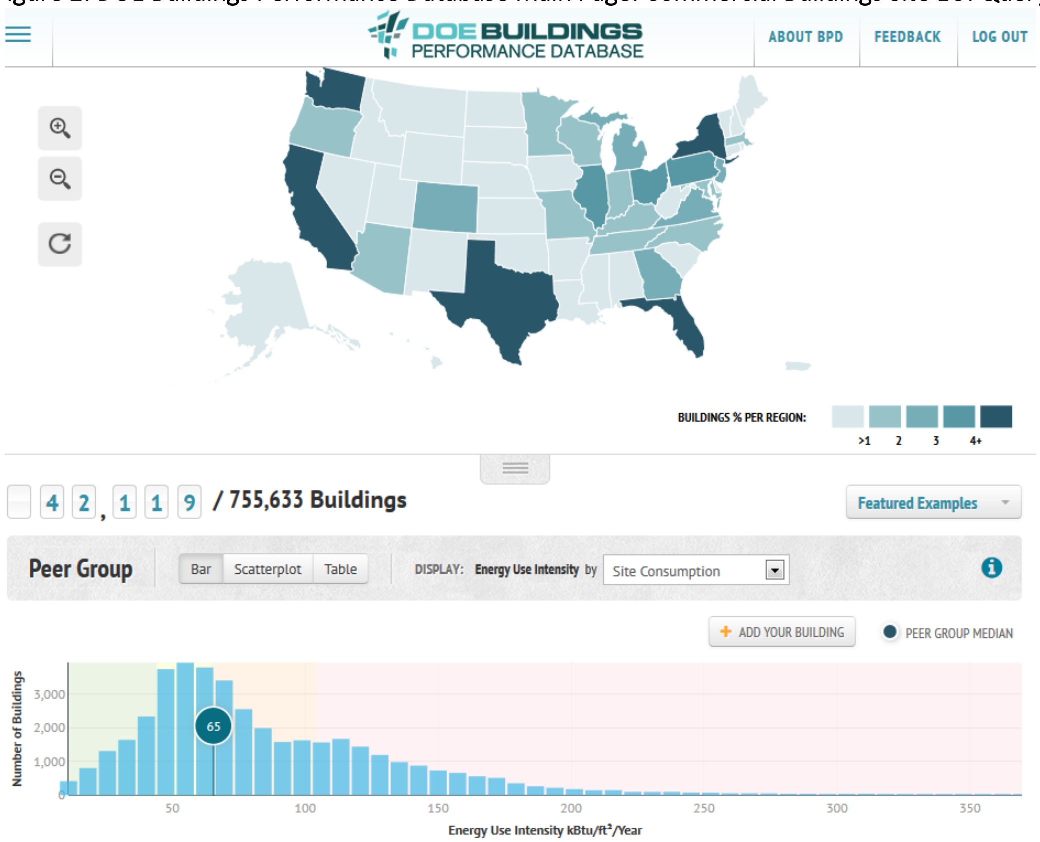
[10] Available at https://buildingdata.energy.gov/.

[11] Available at https://bpd.lbl.gov/

0.9% of the U.S. commercial building stock (EIA 2003) and 0.6% of the U.S. residential building stock (EIA 2009). Information about building systems as well as measured performance information is available. The purpose of the database is to enable users to perform statistical analysis on buildings, including both high performance and ordinary buildings. According to DOE, the database helps users to "compare performance trends among similar buildings to identify and prioritize cost-saving energy efficiency improvements and assess the range of likely savings from these improvements." The graphically oriented and data-driven user interface of this database is particularly well-suited for finding data about narrowly defined peer groups within the built environment.

Figure **2** shows the BPD's main page, in this case filtering for commercial building site EUI.

Figure 2: DOE Buildings Performance Database Main Page: Commercial Buildings Site EUI Query



International Portals and Examples

There are several good examples of databases and portals with building performance data outside of North America. The European Union has established an open data hub [12] to disseminate and analyze information about Europe's building stock and energy use. The data hub is similar in intent and user interface to DOE's Buildings Performance Database and is administered by the Buildings Performance Institute Europe (BPIE). Australia has established the National Australian Built Environment Rating System (NABERS)[13] to measure environmental impacts of buildings. NABERS incorporates measured performance data, building characteristics, waste management, and indoor environmental quality information to provide a holistic building rating. China has developed a rating system under the Ministry of Housing and Urban and Rural

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[12] The EU BPIE data hub is available at http://www.buildingsdata.eu/.

[13] NABERS is available at http://www.nabers.gov.au/public/WebPages/Home.aspx.

Development (MOHURD)[14] that includes all nonresidential buildings (private and state-owned). Rating through the MOHURD system is mandatory for all large office buildings, buildings labeled as green buildings, and buildings undergoing publicly-funded retrofit projects. More rating and benchmarking systems exist in countries throughout the world. The Institute for Market Transformation (IMT) has developed an interactive policy map[15] to explore building energy performance data and policy across the world.

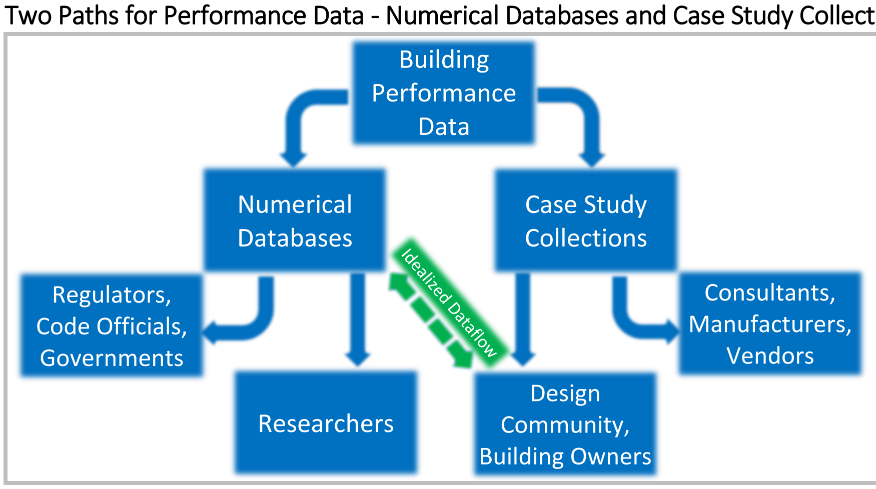
The Nature of the Data: Structures and Characteristics

Building performance data exists in many locations and in many formats. However, that very diversity can be confusing if efforts are not made to ensure the information remains accessible and well organized.

Data Source Structures

Most data sources are built on one of two basic structures, depending on the purpose of the dataset. A collection of case studies generally is intended for designers, contractors, policy makers, and others to view examples of individual buildings. That information may be used to build from lessons learned in other projects or may be used to disseminate information about cutting-edge technology or practices. On the other hand, a numerically-driven database is generally intended for research and investigation into the current state of adoption and use of various technologies, to find comparison data for building related projects, and for other statistical information gathering. Figure 3 shows how building performance information can be organized in these two ways and some of the end users. The arrows represent the predominant data pathways but are not meant to be exclusive: a numerical database may be used by consultants, designers, building owners, etc., while case study collections may be used by researchers or regulators. The green dashed arrow shows how measured performance information sharing can fit into this framework as a two-way data flow between numerical databases (where the data is collected and stored) and data end users such as building owners and designers.

Figure 3: Typical Two Paths for Performance Data - Numerical Databases and Case Study Collections



A good example of the difference between these two structures is illustrated by examining two of the data sources discussed above: the BPD and the HPBD. The BPD has information about commercial and residential buildings and can predict estimated changes in whole-building EUI for measure-level building retrofits based on statistical analysis of the dataset. However, to find information about the experiences of particular buildings the HPBD is a more useful tool, with individual project information and much granular, measure-level detail.

[14] The MOHURD website (in Chinese) is available at http://www.mohurd.gov.cn/.

[15] The IMT's Building Rating Policy map is available at http://www.buildingrating.org/ammap.

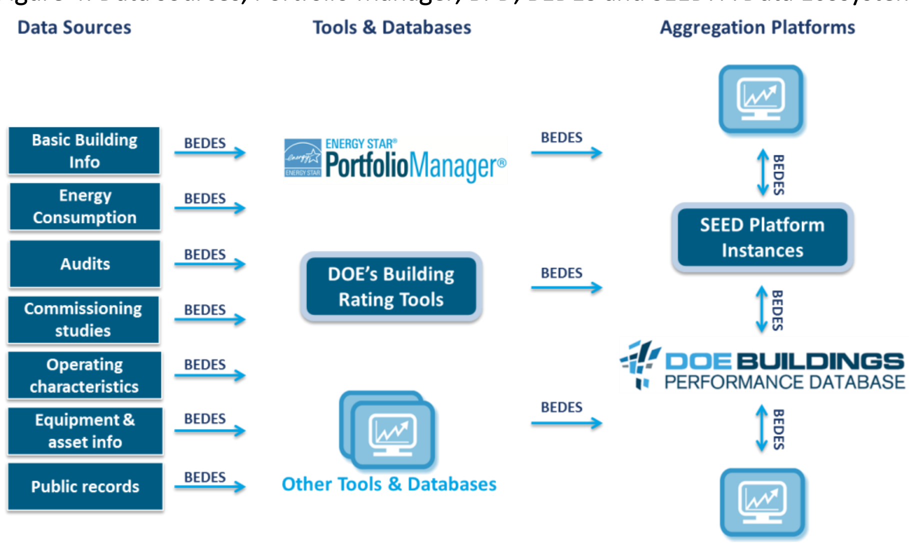
Database Connections and Standardization

Multiple databases may be connected together using an application programming interface (API). This facilitates a connection between different datasets or interfaces and can facilitate information sharing in and out of databases. For example, ENERGY STAR's PM has been designed to allow software from many developers, including utilities, government entities, and third-party software vendors to access data. Data can be imported to PM directly via an API, allowing customers to view up-to-date information without having to import data manually. Conversely, data and metrics can be exported from PM to third-party service providers' tools and software so that customers can view information without directly accessing the PM web interface.

A major challenge in using data from multiple sources is the decentralization and lack of standardization of data sources. The same building may be referred to in various databases as Grocery, Food Sales, Retail-Food, or Retail-Grocery, among other options; some datasets have very granular detail on certain building types but little to no detail on others. A significant push to address this situation is underway under the auspices of the DOE. The Building Energy Data Exchange Specification (BEDES)[16] project establishes data fields, definitions, and units of measure, specifically for building performance data, so that private and public databases can communicate efficiently and effectively.[17] The BPD is fully compliant with the BEDES terminology.

A related project, also under DOE's direction, is the Standard Energy Efficiency Data (SEED) platform[18]. The SEED platform is a free, user-friendly, web-enabled application that helps manage, aggregate, clean, and validate data on the energy performance of large groups of buildings. SEED uses the basic terminology of BEDES. The platform is a good example of interoperability: SEED takes advantage of the BEDES standard definitions to automatically import data from PM (via an open API) and merge that data with other available datasets. Figure 4 shows the relationship between data sources, Portfolio Manager, the BPD, BEDES, and SEED, creating an ecosystem of interoperable private and public data tools.

Figure 4: Data sources, Portfolio Manager, BPD, BEDES and SEED: A Data Ecosystem



[16] More information about BEDES is available at http://energy.gov/eere/buildings/building-energy-data-exchange-specification-bedes.

[17] This project is currently underway and working group meetings are being held monthly through most of 2014.

[18] More information about SEED is available at http://energy.gov/eere/buildings/standard-energy-efficiency-data-platform.

Information Sharing and Privacy Concerns

In some cases a data set may have far more data than is made publicly available. Private parties (building occupants, owners, managers, designers, et al.) use databases to store energy data and provide metrics but often prefer not to share performance data publicly. One reason some building owners do not want to share information is that high performance buildings can confer a competitive advantage: by lowering the company's utility costs, the company may be able to lower prices while maintaining profit margins and thereby gain market share. In some cases building performance data may be available on an anonymous basis; in other cases it is accessible only to the parties that provide that information.

There are several ways to respect privacy rights while still maintaining accessibility of information. The most common is to anonymize the data, which is typically acceptable for most research objectives (broad category analysis, statistical analysis, and comparison set building). To illustrate, the majority of numerically-driven databases (as opposed to collections of case studies) use anonymized data. In data sources that allow the data provider to choose whether to share data, the default data sharing preferences can make a difference. The usefulness of the data may be optimized while respecting privacy rights by ensuring that settings for data sharing are set to "anonymous" rather than "private" (under which setting no data is shared by default). Settings like these must be well organized and clearly posted so that all parties are aware of the choices they are making with their information.

Of course, private data that is stored in a central repository is often only used by parties that share the information (building occupants, owners, managers, designers, el al.). The structure and technical capabilities of the central data repository can add value to the data. Meaningful results, such as energy retrofit guidance, may come from energy performance benchmarking or other analytics even if no one else has access to that information.

Connecting the DOTs (Designers, Operators, and Tenants)

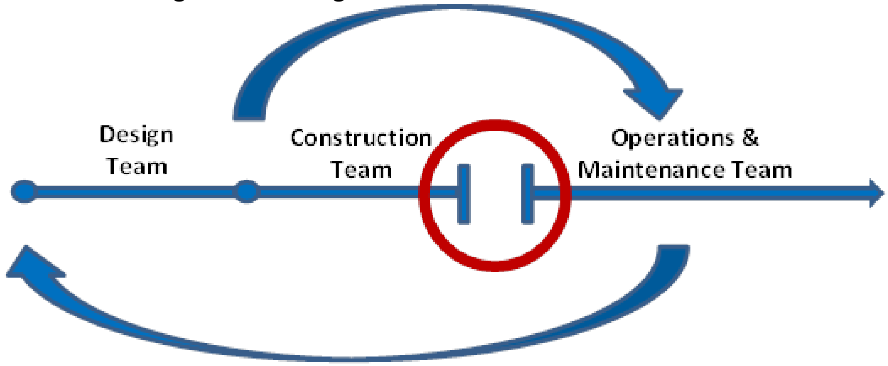
To make a meaningful impact, measured performance data gathered in databases and accessed through software tools must be presented to the right people, at the right time, in the right way. Energy performance data can mean different things to different users: the design community can improve the design of future buildings, building operators can use feedback on current systems to scope and perform retrofits, and tenants can adjust behavior to use less energy.

Performance Data Feedback Loop

Building designers, including architects and builders, have access to many energy efficiency design strategies and technologies. However, if solid information about the design strategies and energy efficiency measures in a building is not available to the occupants, the building may not live up to expectations. A robust feedback loop between the design community and building operators and tenants is necessary. Measured performance efforts are one important piece of this loop. If measured energy performance does not live up to predicted energy performance, more specific investigations can be launched to determine what building systems should be adjusted or what actions may be taken to improve performance.

Feedback should flow the other way too. Without real-world information on building performance, architects and builders are designing in the dark. Many design and architecture firms across the country (and around the world) are ramping up efforts to track building data in the post-occupancy period to determine what energy efficiency design strategies are living up to expectations and how to improve design. Figure 5 shows this feedback loop and illustrates the common gap between design and construction teams and the building operations and maintenance team.

Figure 5: Building Performance Data Feedback Paths



Gathering the Data

There are many ways of gathering data and there is no one-size-fits-all solution. The data sources matrix, summarized in Table 1, shows many different data sources, each with its own structure and methodologies for collecting data, whether from utilities or the building owners or tenants themselves. Gathering and applying measured performance data will be an ongoing task. For this effort to succeed, all interested parties, from the designers to the tenants, will have to buy into the idea.

Closing the Circle

There is a real challenge in gathering this data and applying it to those who need it. For example, THA Architecture in Portland, Oregon attempts to gather post-occupancy energy usage data on all completed projects as part of the 2030 Challenge (see sidebar). However, "only a few owners have obliged THA's requests" for utility data, according to Isaac Adams, a job captain at THA.[19] This experience is unfortunately all too common among design firms trying to design high performance buildings. One way to avoid this situation is to automate the submission of post-occupancy design data by enabling the upload of energy usage information directly from the utility so that building operators and tenants can "set it and forget it" while ensuring that performance data gets back to the designers. This method of data transfer will allow design teams to improve their products and tenants to download performance indicator metrics like EUI and ENERGY

2030: The Influence of Evidence

The 2030 Challenge is an initiative within the architecture and design community, led by Architecture 2030, which lays out aggressive fossil fuel reduction targets for new buildings and major renovations.

2030 Challenge Targets:

- 70% reduction in 2015
- 80% reduction in 2020
- 90% reduction in 2025
- Carbon-Neutral in 2030

A spreadsheet is provided by Architecture 2030 (the organization behind the Challenge) so that 2030 Challenge participants can plug in utility and energy modeling information to track energy use in their projects.

Measured performance data is critical to the success of the 2030 Challenge. Participants collect post-occupancy building performance data and use that information to determine what design strategies are working and what needs improvement. This feedback drives a continuous improvement process for the architecture and design firms (more than a thousand), governments (local, state, and federal), and professional associations that have signed on to the 2030 Challenge.

[19] http://djcoregon.com/news/2010/10/05/tracking-the-2030-challenge/

STAR scores without having to corral data and perform manual calculations.

There are several common ways building owners can receive assistance from the design team or third parties to improve building performance using measured performance data. The following approaches also represent potential avenues that are available to launch data collection pilot projects and analyze expected versus actual performance data, as these services offer strong data collection practices and evaluation, measurement and verification (EM&V) program components that would be well-suited for data-oriented pilots.

- Energy Savings Performance Contracting (ESPC) enables public and private entities to enter into a contractual agreement with an energy services company (ESCO) to manage an energy efficiency project, offering a turnkey technical and financing package under which the ESCO is responsible for all tasks associated with the project, including identifying and evaluating energy efficiency measures, designing and implementing the project, and conducting EM&V for the project. The agency pays for the services of the ESCO with the energy cost savings that accrue from the project. In turn, the ESCO backs the projected energy savings through a performance guarantee, which provides a high level of security for the agency by ensuring that if the projected savings do not materialize, the ESCO is responsible for shortfalls.
- Bridge Services describes a business arrangement whereby the designer/builder agrees to maintain an ongoing relationship with the building occupants for a set period after occupancy, often one year. This may or may not include a guarantee that the building will perform as expected, as design/build firms are sometimes reluctant to offer such guarantees as occupant choices and vacancy rates can have major impacts on energy use.
- Energy Management (and Control) Systems (EMS/EMCS) and Building Automation Systems (BAS) Support are common in commercial buildings, particularly large office and institutional facilities. A designated energy management team, which may be drawn from the building owner/management company or an ESCO, can automate building operations and track building status, equipment status, and energy consumption over time. As the trend toward cloud-based computing and the 'Internet of Things' continues it may be possible for design teams or ESCOs to access data from these systems to create feedback loops beyond the operators. Recently, the Massachusetts energy office, the Department of Energy Resources (DOER) entered into a $9.7 million dollar contract with EnerNOC to install 1,300 real-time meters in 470 state buildings, covering 25 million square feet, signaling a commitment from the state's state-owned buildings sector to track, analyze, and make project-related decisions based off of EMS data.[20]

Who is using Evidence-Based Design?

Many organizations have started using the databases and data sources discussed above to improve building performance. Federal, state, and local governments have committed to collecting performance data and using that data to improve energy performance in their building portfolios. For example, several states, including California, Idaho, Iowa, Kentucky, South Dakota, and Washington, are benchmarking state buildings and plan to use the data to reduce energy consumption in their building portfolios. The U.S. General Services Administration (GSA) has established the Office of Federal High-Performance Green Buildings to promote, coordinate, and stimulate green building across the nearly half a million buildings and more than three billion square feet of building space owned or leased by the government. The private sector has also adopted the idea of evidence-based design, with more than a thousand architecture and design firms having signed on to

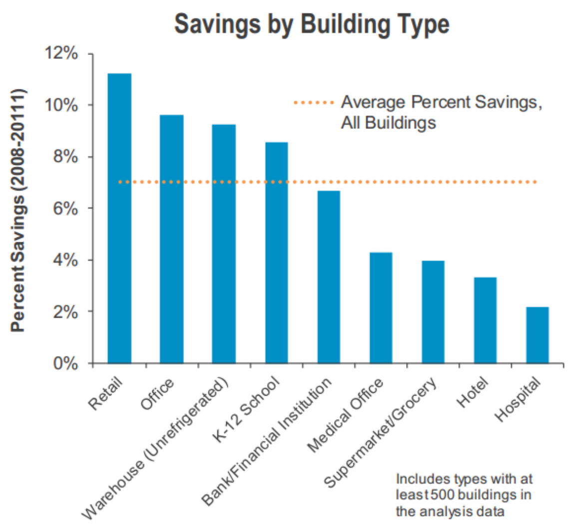
[20] McCarey, M. and Karthik Roa, "Massachusetts Enterprise Energy Management System," February 2014 presentation to NASEO Buildings Committee, http://energyoutlook.naseo.org/Data/Sites/3/presentations/McCarey-Rao.pdf.

the 2030 Challenge and a multitude of ESCOs offering energy performance monitoring services in many incarnations.

Measurement and Improvement

The adage that "you cannot improve what you do not measure" holds true for building energy performance. ENERGY STAR has determined that buildings that benchmark energy usage with PM have achieved average energy savings of 2.4% per year over the four years from 2008 through 2011, versus buildings that do not benchmark their energy usage. Significantly, more than 60% of the 35,000 buildings evaluated achieved 0-10% savings per year, which suggests slow and steady improvements rather than intensive capital projects (about one-quarter of buildings saw energy increases; less than 10% saw more than 10% average annual savings). These slow and steady improvements may be credited, in whole or in part, to behavioral changes of energy managers who are increasingly paying attention to energy performance over time and making adjustments to systems as opportunities arise. Figure 6 illustrates how different building types performed over the four years evaluated.

Figure 6: Benchmarking Savings in Portfolio Manager, 2008-2011[21]



Looking Forward: The Next Stage

Measured performance data is clearly needed, useful, and applicable to the built environment today. This report lays out the current state of building measured performance data collection and use but further work with detailed analysis of measured performance data, trends, and applications is needed.

Measured performance information is not new; nonetheless new data sources continue to emerge and existing data sources are being augmented all the time. As more information becomes available it will be important to take advantage of opportunities to improve the utility of existing data sources. For example, the DOE's Buildings Performance Database currently has data on about 44,000 commercial buildings: about 1% of the total commercial building stock in the United States. The database is well structured with an intuitive user interface and has great potential as a broadly applicable data source but it will become much more useful as more building information becomes available.

[21] Data from ENERGY STAR DataTrends Factsheet on Benchmarking and Energy Savings, available at http://www.energystar.gov/buildings/sites/default/uploads/tools/DataTrends_Savings_20121002.pdf?50b2-cbf3.

The design community has a very important role to play in empowering measured performance data gathering by designing for metering in new construction. Early in the design process it is relatively easy and affordable to incorporate the capacity to easily gather energy usage data. For that capacity to mean anything once the project has been completed, gathered performance data must be accessible to relevant stakeholders including designers and building tenants. There are multiple software options by which measured performance data can automatically be uploaded to a data platform such as SEED or ENERGY STAR Portfolio Manager. By automating this data transfer data gathering can be streamlined, errors can be avoided, time can be saved for all parties, and important feedback can be available to multiple stakeholders.

What various stakeholders can and will actually do with measured performance data is another important consideration. The design community has started paying attention to what happens to their projects after the keys have been handed over to the building tenants. From the design community's perspective, continuous improvement in design can be informed by tracking project performance; the 2030 Challenge is a good example of designers and architects using actual project performance to improve design. From the building owner's, operator's, or tenant's perspective, service offerings like Bridge Services and Energy Savings Performance Contracting are providing pathways for continuous and verifiable improvement in the built environment.

Three key needs have been identified as a result of this research, including: increasing the quantity of measured performance data available in current data sources; improving access to and transparency of measured performance data in current data sources; and enhancing engagement between various stakeholders, including the design community, the building industry, government entities, nonprofits, building owners, operators, and tenants.

To further this effort, three follow-on activities are crucial. First, there is a need to investigate trends and practices in performance feedback models and practices to determine what changes are occurring in the relationship between predicted and actual energy performance. This may involve gathering a broad set of high performance buildings with participation by the operator, owner and design team; obtaining detailed data on selected key performance indicators and their as-modeled analogues (i.e. predicted EUI) to refine empirical data on modeled versus measured performance; and analyzing building measured performance data within this dataset to evaluate the effect of specific design and operations strategies on actual energy performance as compared to anticipated design performance. Second, there is a need to partner with municipalities and states that are implementing disclosure ordinances to make sure that data is accessible and transparent, as in Washington, D.C. Finally, there is a need to pilot new models for the use of measured performance data feedback pathways, such as bridge services, and to engage stakeholders to help improve the existing models.

By performing in-depth analysis of the real-world effects of various measured performance efforts, a final report could provide valuable information for design and operations teams, including specific recommendations to improve design and operating practices.

Appendix A: Measured Performance Data Sources Matrix

As a part of this research NBI created a matrix, in Excel file format, of data sources on commercial building energy performance. The spreadsheet contains two tabs: one listing overall data sources and one tailored specifically to municipal and state sources such as those produced by mandatory disclosure ordinances. The lists in the matrix exceed those presented in this report and are provided to NASEO and DOE as a research product.

The full matrix, in Excel format, is currently available for upload at http://www.naseo.org/data/sites/1/documents/publications/Measured-Performance-Data-Sources--NBI-June-2014.xlsx.