


The Building Performance Tracking Handbook

CONTINUOUS IMPROVEMENT FOR EVERY BUILDING

Continuous Improvement for Every Building. *That is the promise of building performance tracking. It is a strategy to improve the operation of facilities at any stage of performance.*

It encompasses tools and practices that enable every building to boost value without breaking the bank. It is flexible and forgiving in recognizing that buildings exist to serve occupants first. And, it is practical in that it champions existing tools, low-cost tools, and intuitive tools foremost.

At the core of building performance tracking is a single principle: while tools are the enabling force for improved performance, people represent the guiding hand that leads to results. Recognizing this is the first step to seeing operating costs fall, asset values grow, and market differentiation improve for your buildings.

The future of building performance tracking is being shaped every day by the decisions of forward-looking building owners, property managers, and energy managers. With this handbook, become a part of the growing push for more responsible and effective strategies for building energy management.

About the California Energy Commission (CEC): Created by the California Legislature in 1974, the California Energy Commission is the state's primary energy policy and planning agency. The Energy Commission has five major responsibilities: forecasting future energy needs and keeping historical energy data; licensing thermal power plants 50 megawatts or larger; promoting energy efficiency through appliance and building standards; developing energy technologies and supporting renewable energy; and planning for and directing state response to energy emergency.

About the California Commissioning Collaborative (CCC): The California Commissioning Collaborative is a non-profit organization committed to improving the performance of buildings and their systems. The CCC is made up of utility, real estate, and building services organizations and professionals who have come together to create a viable market for building commissioning in California. For more information, visit www.cacx.org.

LEGAL NOTICE

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The California Energy Committee of the Building Owners and Managers Association (BOMA) is pleased to endorse *The Building Performance Tracking Handbook* developed by the California Commissioning Collaborative.

The handbook describes the process for monitoring and improving the energy and system performance of commercial buildings. It puts the technical tools and concepts into understandable terms and provides direction to improve building performance tracking.

The reason for our endorsement is simple: the handbook presents a comprehensive process for choosing a performance tracking strategy and evaluating tools on the market. It guides building owners at every stage in this process, whether they are benchmarking with ENERGY STAR® Portfolio Manager or investing in fault detection and diagnostic tools. This handbook is also a valuable tool in supporting BOMA's 7-Point Challenge, the BOMA 360 Performance Program, and the BOMA Energy Efficiency Program (BEEP).

The mission of BOMA California is to preserve and promote the interests of California commercial real estate professionals through legislative and regulatory advocacy. Building performance tracking will become a routine part of building management in California. By endorsing this handbook, we are helping building owners identify best practice, advance their facilities, and keep pace with the commercial building industry.

Joy C. Cole

Joy Cole
Chairman
BOMA California Energy Committee

BOMA
California

About the Handbook

This handbook was created to introduce the basic concepts behind building performance tracking for commercial buildings. While geared toward medium to large buildings or portfolios of buildings, many of these same concepts apply to smaller commercial buildings.

Building performance tracking is a strategy to help building owners ensure that mechanical and electrical systems operate as intended and that energy use is not higher than necessary. The handbook content was developed through a California Commissioning Collaborative research project, which discovered several key findings about building performance tracking today:

- Building performance tracking is typically an informal process that varies considerably among building owners and managers
- Sophisticated software and hardware tools are available, but it's not always clear how to compare the wide variety and select the most suitable option

Most building owners have begun elements of their building performance tracking strategy. However, there is notable uncertainty in the industry regarding the specific steps and tools to achieve success. Understanding this, the handbook has three goals:

1. Describe the steps needed to continually manage building performance
2. Introduce the complex array of building performance tracking tools available
3. Provide guidance for choosing the right strategy based on business needs and resources

The handbook is *not* intended to comprehensively list all available tools in a "consumer report," nor is it a technical manual for using tools. Instead, it provides a basic framework for owners and energy managers to understand building performance tracking and ask the right questions of tool vendors, operators, and contractors about their facilities.

Who Is the Handbook For?

The handbook is primarily intended for property managers, energy managers, and facility engineers. It may also benefit facilities services contractors and building operators.

How Do I Use It?

The handbook has four main sections that build upon each other.

- *Introduction* gives an overview of building performance tracking and the basis for making a solid business case.
- *The Basics* outlines the three basic tools that form the foundation for building performance tracking: energy benchmarking, utility bill analysis, and using the building automation system (BAS) for troubleshooting.
- *Beyond the Basics* introduces the four tools that can take owners to higher levels of performance: energy information systems (EIS), advanced EIS, BAS metrics, and fault detection and diagnostics (FDD).
- *What's Next?* provides a framework to help decision-makers determine which tools fit their business needs, as well as a list of helpful resources.

This handbook is intended to inspire action around building performance tracking, whether owners are enhancing existing strategies or establishing new strategies for the first time. Above all, this handbook was created to show readers that building performance tracking strategies are not just for high performance buildings, but for every building.

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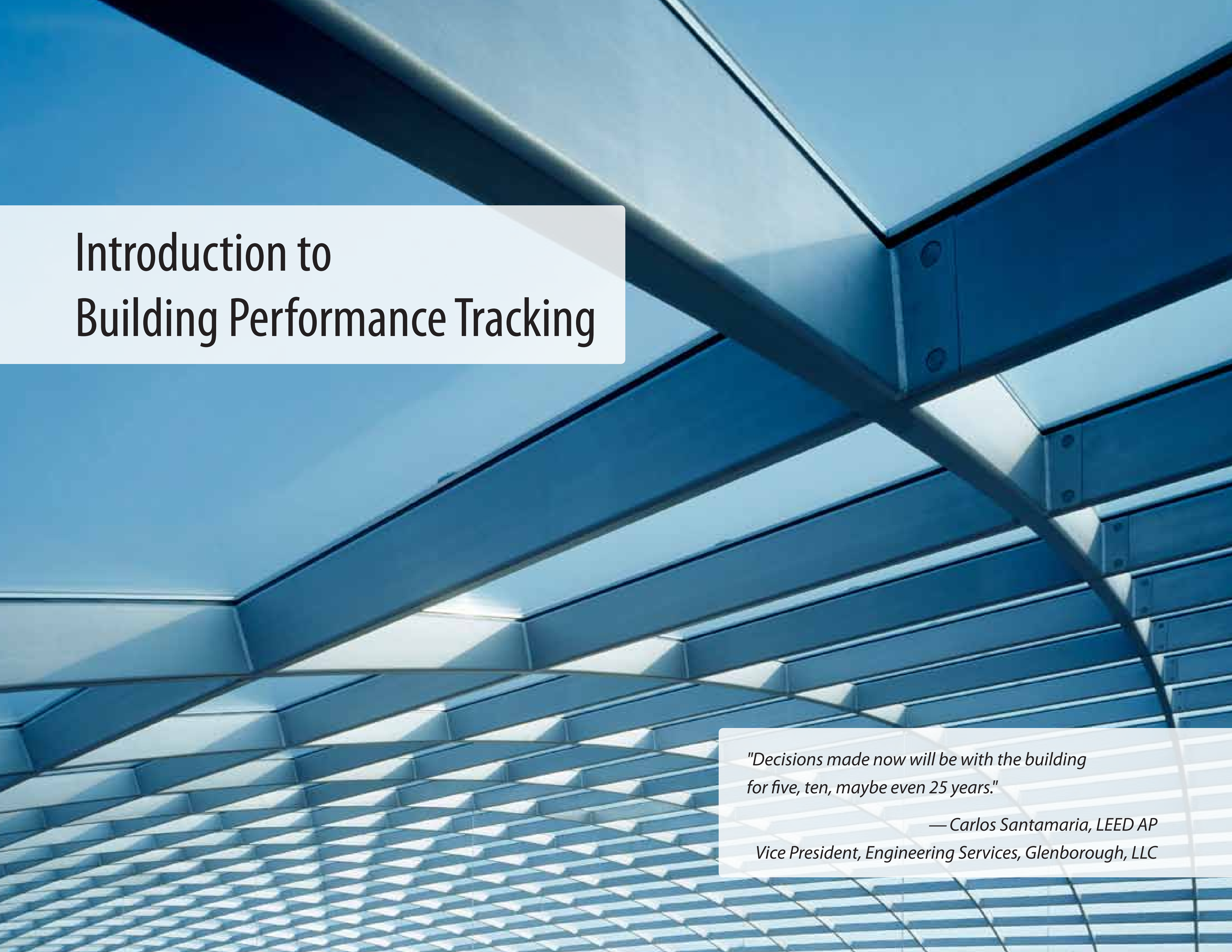


Introduction to Building Performance Tracking

"Decisions made now will be with the building for five, ten, maybe even 25 years."

— Carlos Santamaria, LEED AP
Vice President, Engineering Services, Glenborough, LLC

Introduction to Building Performance Tracking

What is building performance tracking? This section introduces building performance tracking concepts and their relationship to existing building commissioning. It provides the foundation for readers to understand the tools and strategies described in The Basics and the advanced tools described in Beyond the Basics.

This section is comprised of two chapters that will help answer the following questions:

What Is Building Performance Tracking?

- What does the term "building performance tracking" mean?
- What are the reasons for heightened awareness around building performance tracking?
- What are the essential elements of a building performance tracking strategy?

The Business Case

- What are the strategic business and financial reasons for tracking building performance?
- How might ownership and leasing arrangements affect the costs and benefits of building performance tracking strategies?

Building Performance Tracking: A Process of Continuous Improvement

Building performance tracking is a process of continuous improvement. The four steps in Figure 1 show the fundamental process for tracking, analyzing, diagnosing, and resolving issues with heating, ventilation, and air conditioning (HVAC) and lighting systems. Building performance is tracked on an ongoing basis and incorporated as part of standard processes.

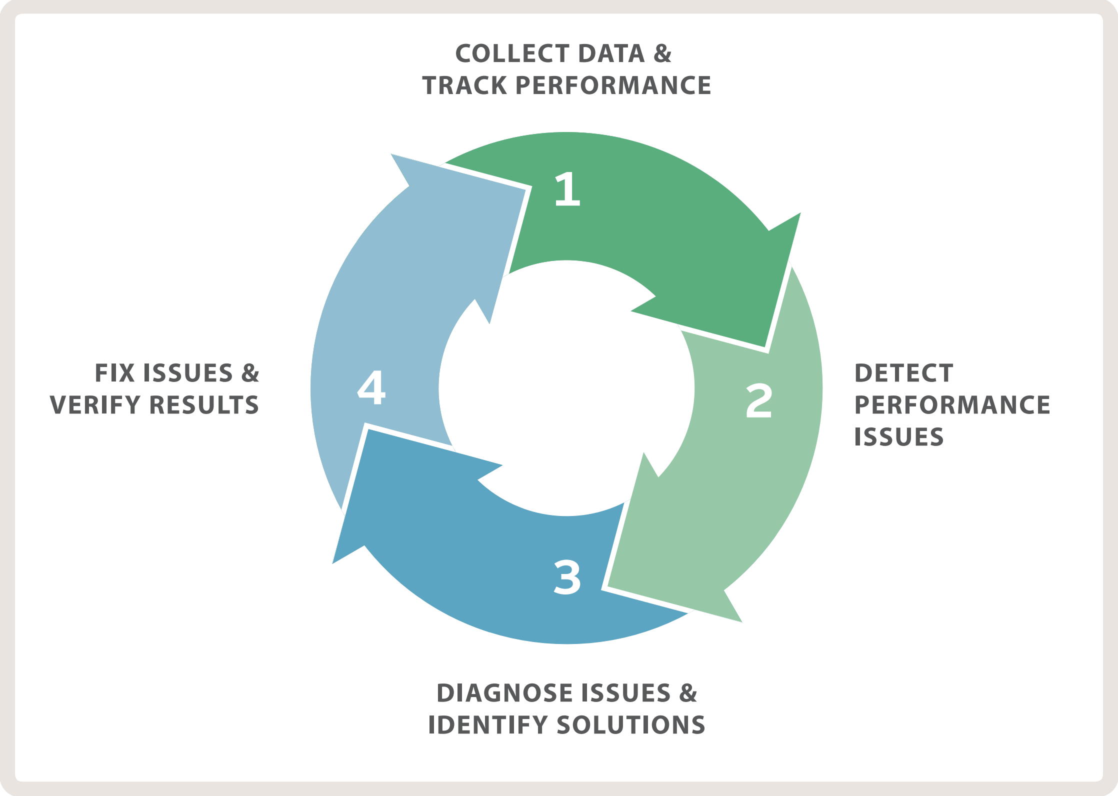


Figure 1: The Four Steps of Building Performance Tracking

What Is Building Performance Tracking?

Buildings are investments with significant profit potential. In today's commercial building market, buildings need to be comfortable for occupants and must operate efficiently to remain competitive. Building owners who achieve this balance benefit from deep cost savings and market leadership.

Introducing Building Performance Tracking

Building performance tracking is a long-term strategy for supporting the continuous improvement of building systems. It is fueled by the hardware, software, people, and processes that make optimization a regular part of building management.

At its core, building performance tracking is a process that monitors how efficiently a building meets its occupants' needs, which includes maintaining:

- Comfortable temperatures and humidity
- Ventilation requirements
- Lighting requirements

Modern building HVAC and lighting systems are interactive and complex. Over time, many building systems begin to operate inefficiently and may require frequent attention to ensure they are optimized. For example, sensors may drift out of calibration, building use could change, and adjustments in control sequences might affect how well systems work together. This can result in occupant complaints and increased energy costs. Building performance tracking is a proactive strategy for achieving occupant comfort without jeopardizing energy performance.

Today's building systems also generate huge amounts of data. This data is highly valuable, as system faults are often invisible to building operators without it. Building performance tracking helps operators gather and analyze data to diagnose problems and identify solutions.

Lastly, to become an industry leader in today's market, owners of income-producing properties must attract and retain tenants by boosting building performance. Building performance tracking is a strategy to help owners enhance property value and net operating income (NOI) through lower operating costs and better information about how a building performs compared to its peers.

Success Story: University of California, Davis

Eight years ago, energy management at the University of California, Davis was a limited, manual process. There were few meters available across the campus, so energy use was simply not monitored at the building level. Fast forward eight years, and UC Davis has made tremendous strides in its building performance tracking strategy.

Tracking energy performance at UC Davis is no small feat. The 5,000 acre campus operates on the scale of a small city, with 1,200 buildings totaling 14 million square feet and a wide variety of HVAC and lighting control systems.

Fortunately, UC Davis has tools and management strategies to help overcome these challenges, including an energy information system for continuous monitoring of building energy meters, and the HVAC central plant's control system. Tool features include:

- Electricity and gas usage data collection
- Data aggregation and analysis
- Reporting and data storage
- Web-based dashboard

To see the full UC Davis success story, visit www.cacx.org/PIER.

The goal of building operation is to achieve optimal occupant comfort with the least amount of energy consumption. Buildings that achieve this balance do so by addressing the two main elements of building performance: 1) **System Tracking** for HVAC and lighting systems, and 2) **Energy Tracking** for the whole building and wherever submeters are in place.

Building owners should address both sides of the coin to reap the full rewards of tracking building performance, since each side can answer different questions about building operation. Figure 2 shows how meters and controls gather data on system or energy performance for HVAC, lighting, and plug load systems.

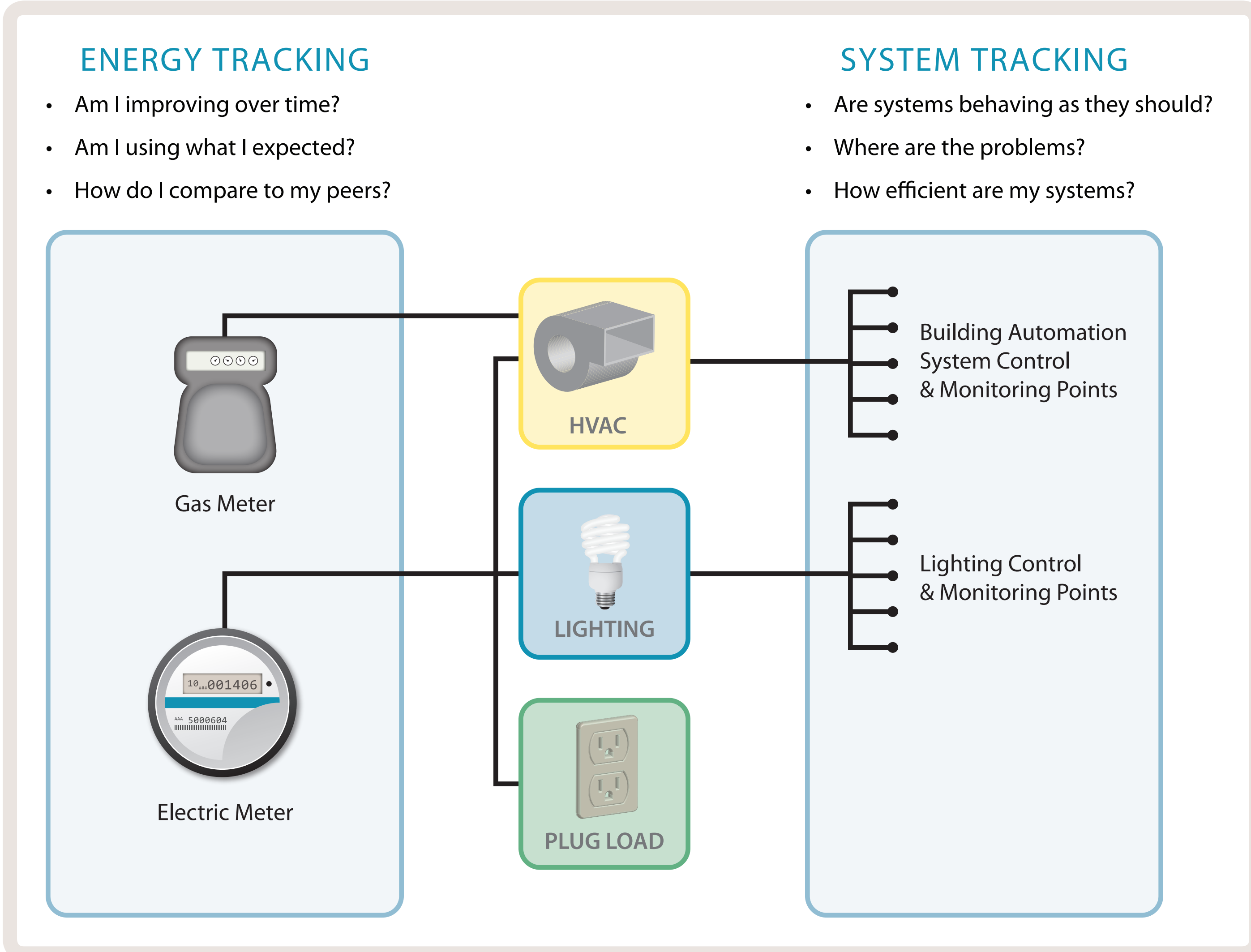


Figure 2: Energy Tracking and System Tracking: The Two Sides of Building Performance Tracking

Building Performance Tracking and Commissioning

Building performance tracking can serve as an ideal complement to existing building commissioning (EBCx) – also referred to as retrocommissioning (RCx) or recommissioning (ReCx). Building performance tracking helps verify the energy savings achieved through EBCx and ensures that occupant comfort and financial benefits last.

EBCx is a systematic process for investigating, analyzing, and optimizing the performance of building systems by improving their operation and maintenance. EBCx helps ensure that building systems are well-integrated and meet current facility requirements. In practice, EBCx has been shown to reduce energy costs by an average of 16 percent, and provide non-energy benefits such as improved occupant comfort and reduced maintenance costs[1]. Ongoing commissioning extends the EBCx process by incorporating building performance tracking, training, and updated documentation so that energy savings persist.

Figure 3 shows the role that building performance tracking could play at each phase of EBCx, however performance tracking strategies are not a prerequisite for EBCx.

Fix the Building or Install Performance Tracking Tools: Which Comes First?

There are two potential paths for tracking building performance and commissioning a facility:

1. Install the performance tracking system and use it to help identify problems and quantify savings.
2. Implement improvements through existing building commissioning first, then invest in the performance tracking system to preserve the savings.

The path forward depends on a combination of staff availability and expertise, and the tools selected to support performance tracking.

While not a cut-and-dry rule, it is generally recommended to commission prior to, or during, implementation of building performance tracking tools and strategies. This way, building systems are optimized from day one, and performance can be maintained at that level going forward.

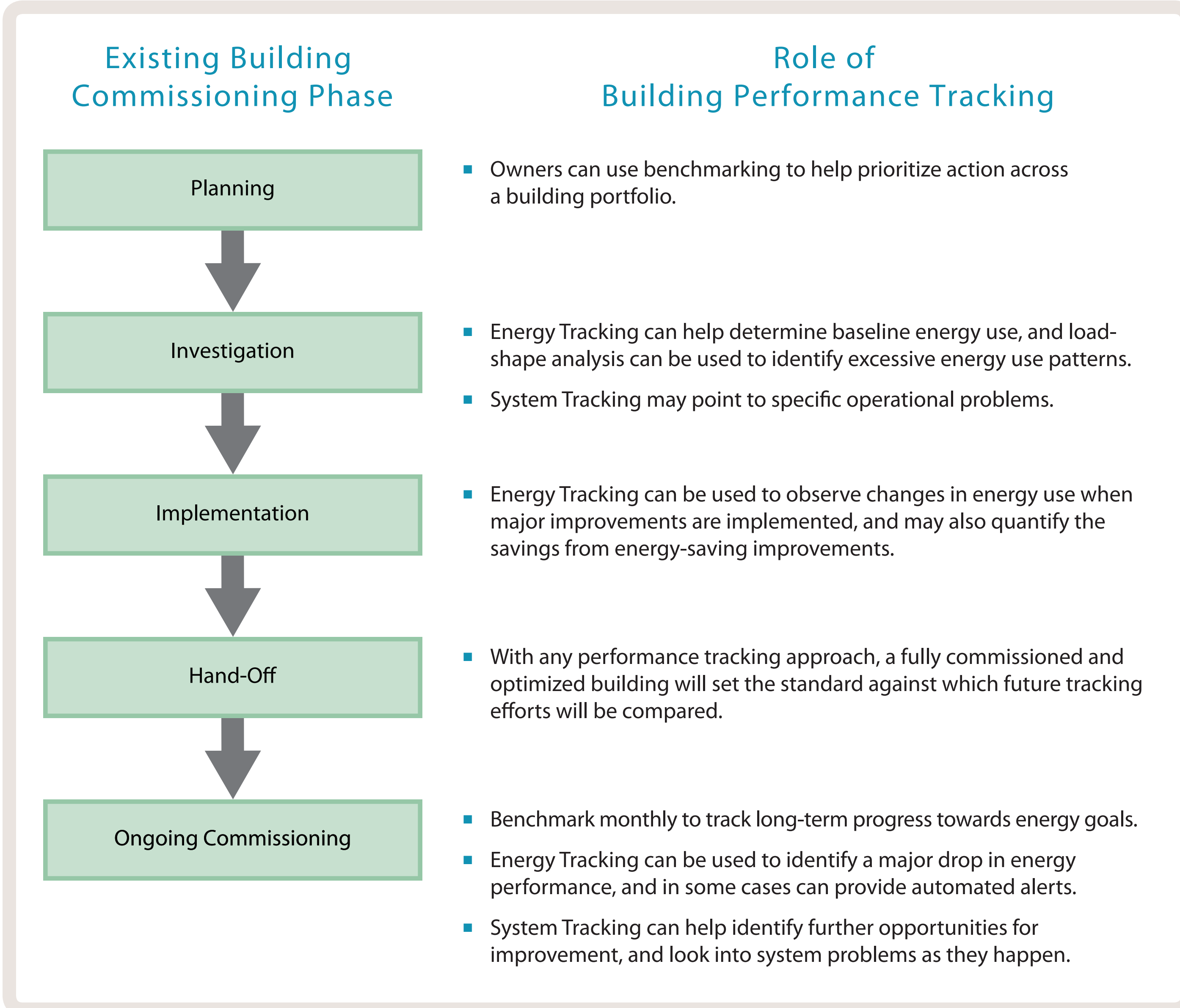


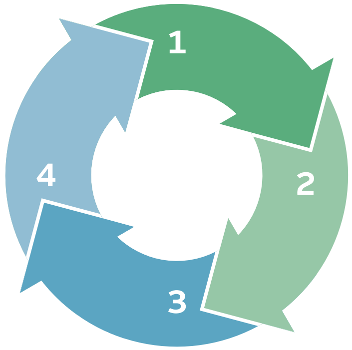
Figure 3: The Relationship of Existing Building Commissioning and Building Performance Tracking

How Does Building Performance Tracking Work?

As noted in Figure 1, there are four key elements to building performance tracking:

1. **Collect data and track performance.** HVAC and lighting performance data is tracked along with energy consumption data. A variety of tools are available to support tracking, and typically multiple tools will be used as part of an overall management strategy.
2. **Detect performance issues.** This process may be automated through the use of tools, or the tools may present information in a way that makes it easier for users to identify problems manually.
3. **Diagnose issues and identify solutions.** The skill, knowledge, and training of building operators or service contractors are key factors in diagnosing issues successfully and identifying the right solutions.
4. **Fix issues and verify results.** This is the most critical step to achieving the benefits of building performance tracking.

By repeating these steps, building owners can ensure the continued persistence of improvements.



People + Processes + Performance Tracking Tools

Building performance tracking requires the three Ps: **P**eople, **P**rocesses, and **P**erformance tracking tools. If one of these elements is missing, the benefits will be reduced.

The First 'P': People

Commitment from all building management stakeholders, from the board room to the mechanical room, is essential for building performance tracking. Its success hinges on approval from all levels of an organization. Without people instituting goals and rewards, and managing day-to-day performance, tools may fall into disuse and success becomes difficult.

Each stakeholder group is motivated by different needs and will benefit from different types of tools. Table 1 outlines the major distinctions among stakeholders.

Table 1: The Stakeholders of Building Performance Tracking

	FROM THE BOARD ROOM…	…TO THE MECHANICAL ROOM
Who?	Building owners, property managers, and energy managers	Building engineers and operators
Interested in…	Building or portfolio-level view	System or equipment-level view
Driven by…	Financial value of the building, budget forecasting, occupant comfort, company brand strategy, and energy and sustainability goals	Comfort complaints, daily load requirements, equipment downtime, and equipment lifecycle
Benefits from…	Context: How will building performance influence tenant retention, asset value, carbon regulations, and marketing? This group needs tools to prioritize capital investments, compare the performance of a building or portfolio, and increase NOI.	Specifics: When is a change in performance a problem, and what are the root causes of problems? How is equipment functioning at a given time? This group needs tools to understand the status and efficiency of equipment.

To learn more about the best practice roles and responsibilities for people, visit the Management Framework chapter.

The Second 'P': Processes
Processes are the key to embedding best practices in the daily management of commercial buildings. Processes define the framework in which people use performance tracking tools, and are critical to ensuring that owners and operators interpret performance data, take follow-up action, and see a boost in energy cost savings. If formal management processes are not in place, utilization of tools will be vulnerable to staff turnover.

Management processes that support building performance tracking include:

- Allocation of the financial and labor resources
- Well-defined reporting and accountability
- Specific language to support building performance tracking in contracts with tenants and service providers
- Incentives for building performance tracking job execution

To learn more about creating sound processes, visit the Management Framework chapter.

The Third 'P': Performance Tracking Tools
Software tools, and the associated hardware, are the backbone of building performance tracking. Performance tracking tools range from free online

USAA Real Estate and ENERGY STAR Portfolio Manager

USAA Real Estate Company offers a prime example of how an inexpensive, simple performance tracking tool can create significant results. With ENERGY STAR Portfolio Manager, a free online energy benchmarking tool, and in conjunction with internal tracking tools, USAA Real Estate tracks the cost savings gained from energy upgrades across its portfolio. The company's dedication to energy improvement led to $2.8 million in energy savings in 2009.

benchmarking tools to sophisticated portfolio management tools. At their core, all of these tools track information about building performance and relay it to building owners and operators. There is a wide range in the quality and depth of this information, the extent to which tools function automatically or manually, and the upfront and ongoing costs of tools.

The primary functions of building performance tracking tools include:

- Tracking progress towards sustainability goals
- Prioritizing areas for action, for example across a portfolio of properties
- Identifying system problems or other negative energy impacts
- Diagnosing the root cause of system problems
- Demonstrating that a system fix has been successful, or that a new piece of equipment is operating correctly
- Ensuring that optimized building systems remain optimized
- Measurement and Verification (M&V) of energy savings achieved or the persistence of savings under EBCx or ongoing commissioning programs

To learn more about tools, visit Basic Tools and Beyond the Basics.

The next chapter describes the benefits of building performance tracking and provides the information needed for building owners to build the business case.

The Business Case

This chapter describes the strategic business and financial benefits of building performance tracking, and gives building owners, property managers, and energy managers the facts to help obtain buy-in within their organizations.

Business Reasons for Building Performance Tracking

As a cornerstone strategy for continuous improvement, building performance tracking is a necessary step to meet the challenges of the commercial building industry. One of these challenges is a greater focus of tenants and the public on the sustainability of buildings, requiring more compelling tenant attraction and retention strategies. In addition, owners face the continual need to increase market presence, cost savings, and asset value to maintain a competitive edge. The upward trend in energy costs is another challenge; nationwide electric costs increased by 43% on average between 1999 and 2008[2]. Lastly, legislation on energy disclosure and carbon emissions for commercial buildings is an ongoing challenge for owners.

Why is building performance tracking necessary to meet these challenges? This chapter answers that question by describing the direct and indirect financial benefits of building performance tracking. Some of the direct financial benefits include:

- Electric and gas cost savings
- Higher net operating income (NOI), profit, and asset value
- Increased occupant satisfaction and tenant attraction
- Elevated market presence as a leader on sustainability issues

Building performance tracking has many indirect financial benefits because of the powerful knowledge it provides. With building performance tracking, owners and energy managers can:

- Understand how a single building compares to other buildings within a portfolio, and how it compares to its own historical use as well as to industry peers. Higher performing buildings have a competitive advantage.
- Support sustainability efforts, for instance those with more accurate energy savings and rebate calculations under programs like EBCx, and by tracking progress toward energy or sustainability goals.

Be Prepared for Greenhouse Gas Reporting

On October 29, 2009, the Environmental Protection Agency (EPA) issued its **Greenhouse Gas Mandatory Reporting Rule**, which requires facilities that emit 25,000 metric tons per year of carbon dioxide equivalent (CO_2e) or more to collect and report their emissions to the EPA. While this excludes the vast majority of commercial facilities, which typically emit far less CO_2e, it indicates where federal emissions reporting requirements may be heading.

Building performance tracking helps facilities stay on top of emerging federal requirements that may mean stricter standards for tracking, reporting, and accounting for electricity and gas use in the building industry.

- Provide better reporting mechanisms to all stakeholders, including operators, occupants, property managers, and investors, on the energy profile of a building or portfolio.
- Provide a platform for occupants to see and understand their energy use.

A more detailed discussion of the key benefits is included below in order to give building owners the relevant information to make the business case for building performance tracking at their organizations.

Reduce energy costs and enhance property value

Utility bills typically constitute 30 percent of a building's operating expenses. Lower energy consumption equates to lower operating expenses, which for owner-occupied properties is a direct financial gain. For income-producing properties, a reduction in operating expenses translates into higher net operating income (NOI). NOI is calculated as:

NOI = Annual Gross Income - Operating Expenses

Assuming that all energy savings flow through to the bottom line, annual net operating income will increase by a value equal to the total annual savings. The increase in NOI contributes to higher asset value. Using the Income Approach, the most common way to value income-producing buildings, the increase in asset value is calculated as:

Asset Value Increase = Increase in Net Operating Income / Capitalization Rate

Higher asset value is beneficial when a building is sold, but also when building owners want to leverage the property's accumulated equity.

Maintain occupant satisfaction

Building performance tracking tools allow operators to identify spikes or dips in energy use more quickly, diagnose root causes, and in some cases preempt comfort complaints. A higher performing building can be a competitive advantage in attracting tenants, and a comfortable building will help retain tenants and boost occupant productivity.

Be positioned as an industry leader

Building performance tracking helps building owners improve their sustainability credentials through certification programs, including the Environmental Protection Agency's ENERGY STAR® rating and the U.S. Green Building Council's Leadership in Energy and Environmental Design® (LEED) program.

Link Between Sustainability and Profits

Research that links sustainable buildings to higher rents and increased building value is growing.[3,4] As this link becomes clearer, a greater emphasis will be placed on tracking building performance to maintain these benefits.

Protect against liability

Gas leaks, poor indoor air quality, and non-compliant ventilation rates are examples of liability risks relating to building operation. Building performance tracking can help identify and address such system performance or safety problems more quickly, before they turn into liabilities.

Insurance for energy efficiency investments

Improvements to building systems do not always achieve the expected benefits. For example, operational control improvements may be overridden in response to a temporary event, or more efficient equipment may be installed but not optimized to reap the savings. Building performance tracking provides a window into the operation of a building, increasing the confidence in the long-term savings from energy projects.

Impact of Ownership and Leasing Types

Building ownership and leasing structures are critical factors in determining how the financial cost and benefit of building performance tracking and other energy-saving investments will affect owners, occupants, and investors. This section briefly describes the primary ownership and lease structures and their effect on stakeholder motivation.

Building ownership

With owner-occupied properties, building owners typically enjoy the full benefit of energy cost savings from capital and operational improvements, while owners of income-producing properties realize benefits differently, depending on the lease structure.[5]

For income-producing properties, there are three major office leasing structures in the U.S.: fixed-base, net, and gross. The true value of a performance tracking tool, retrofit or operational improvement for a building owner will depend on the lease structure.

Under gross, single net, and double net leases, the same party (building owner) pays for both the capital or operational improvements and utility costs, and therefore obtains the full financial benefit of the improvements. Under triple net leases, the building owner pays for capital or operational improvements, while the tenant pays for utility costs, which may lead to the 'split incentive' problem. Under fixed-base leases, utility costs are shared among tenants and owners, so the benefits are shared and both parties are motivated to save energy.

Reducing Liability at UC Davis

At the University of California, Davis, an energy information system (EIS) tool alerted staff to a spike in natural gas consumption at student housing, which they quickly attributed to a gas leak in the laundry space. Fixing the leak avoided a major safety issue and produced immediate gas savings.

Energy Efficiency Economics

To learn more about leases and the financial costs and benefits of energy-saving investments, consider reading "Energy-Efficiency Economics: What You Need to Know," HPAC Engineering.[6]

The "Split Incentive" Problem

Split incentives happen when those responsible for paying energy bills and those making capital investment decisions are separate entities.

When owners pay utility bills, tenants are detached from their energy use and lack the financial incentive to use energy responsibly. When tenants pay utility bills, building owners are discouraged from making capital or operational improvements because tenants benefit from the energy cost savings.

Split incentives are a typical characteristic of tenant lease agreements, such as the triple net lease structure where tenants pay for utilities. Removing the split incentive problem is a key part of structuring leases to maximize energy performance.

In short, the ownership and leasing structure of commercial buildings, whether they are owner-occupied or income-producing, triple-net or gross, will influence the building owner's monetary gain from capital and operational improvements.

'Green leases' for commercial buildings

The commercial building community has recognized the challenges of each lease structure and has begun to develop tools and templates to make the leasing process more energy conscious. Many options are available; two examples are listed below:

- **BOMA International Commercial Lease: Guide to Sustainable and Energy-Efficient Leasing for High-Performance Buildings**[7] is a guide to writing commercial real estate leases for high-performance green buildings. It offers an alternative structure to the triple net lease, in which owners have the right to pass through to tenants any capital costs that lower operating costs, including through maintenance, commissioning and green certification or rating programs.
- **The Green Leases Toolkit**[8], which was developed by the California Sustainability Alliance, contains a suite of leasing guidelines and templates to facilitate dialogue between owners and tenants, define each party's goals and objectives around sustainability, and create more transparency throughout the process.

What You Learned In This Section: Introduction to Building Performance Tracking

Building performance tracking is a strategy to meet the new age of higher performing buildings. It is a strategy that is gaining attention in the press, and is a workhorse process that creates results. It requires people, processes, and performance tracking tools, and is defined by a four-step process to achieve continuous improvement.

To ensure a successful building performance tracking strategy, it is critical to gain buy-in from decision-makers through a strong business case, and understand how ownership and lease structures will influence costs and benefits.

These concepts provide the foundation for readers to understand the basic tools and strategies described next in The Basics, as well as the advanced tools described in Beyond the Basics.

The Basics of Building Performance Tracking

"The highest aspirations and the most sophisticated tools won't help if you ignore the fundamentals."

— Brenna Walraven, Managing Director
USAA Real Estate Company

The Basics of Building Performance Tracking

Building performance tracking can conjure up images of expensive tools with complex dashboards. While these tools can be powerful, they are far less valuable without a framework to drive their effective use. This section describes the basic strategies of building performance tracking for every building owner. These strategies are comprised of two main components:

- A strong **management framework** to guide the people and processes behind building performance tracking
- The **basic tools** needed to establish a building's baseline and to understand the context for energy and system performance. These tools include energy benchmarking tools, utility bill analysis tools, and the building automation system (BAS).

The two chapters in this section will help answer the following questions:

Management Framework

- Why does a strong management framework matter?
- What are the steps to build a strong management framework?

Basic Tools

- How do I benchmark my building or portfolio?
- What are my options for tracking utility bills?
- How does the building automation system (BAS) fit into performance tracking?

Every commercial building is unique, and there is no single 'right' strategy for building performance tracking. However, the concepts in this chapter describe the fundamental approach every building owner should take, whether they are starting, developing, or enhancing building performance tracking in their buildings.

> "All of our energy management efforts are underpinned by two principles: energy benchmarking, so we more objectively know how we're performing, and action plans, as a specific roadmap of how to execute and drive energy savings. The highest aspirations and the most sophisticated tools won't help if you ignore the fundamentals."
>
> — Brenna Walraven
> Managing Director
> USAA Real Estate Company

Management Framework

A management framework is the structure that guides building performance tracking. It encompasses both the people within the building performance tracking team and the processes that guide action, communication, priorities, needs, incentives, goals, resources, time, and training for the team. This chapter covers the specific steps to achieve a best practice management framework that supports building performance tracking.

Why Does a Strong Management Framework Matter?

Having a best practice management framework is critical to getting the greatest benefit from performance tracking tools. A management framework defines the environment in which building operators and owners use the tools, and it ensures they have the guidance needed to extract, interpret, and act on the data gathered.

Typically, the greatest obstacles to building performance tracking are the lack of necessary staff time and resources to turn data collected from the tools into actions that improve the building. As a result, investment in performance tracking tools can be a net financial loss unless there is the dedicated staff time and protocols for action. Establishing a management framework will support the need for trained staff to make information actionable. Ultimately, it is a more cost-effective, long-term proposition if building owners establish a management framework before investing in sophisticated tools.

"While energy loads arise primarily from buildings and the equipment inside them, success in reducing those loads is very much a function of dealing with people, their respective organizations, and the business realities they face."

— *Embedding Energy Efficiency in the Business of Buildings*[9]

Steps to Build a Management Framework

This section lists some of the steps building owners can take to build a strong management framework for tracking building performance.

While these steps are recommended, it is important for building owners to survey existing management practices in their buildings and work with their staff to build upon them. Rarely is there a need to overhaul current processes; most owners can simply revise them to focus more on energy and system performance.

The following steps are important for implementing a strong a management framework:

1. Carve out resources
2. Identify the champion and team members
3. Set quantifiable performance goals

4. Consider incentives to motivate staff
5. Determine accountability of team members
6. Include performance tracking language in contracts

Below, each of these steps is described in order to lay the foundation for best practices in management of building performance tracking.

Carve out resources

Building owners must allocate resources to invest in performance tracking tools and the labor hours to use the tools. Refer to The Business Case chapter for guidance in making the case for these resources and obtaining management approval of the budget. Building performance tracking is a long-term strategy, so incremental investments year-to-year may be the right approach to getting started.

It is critical that the performance tracking team, especially building operators, have enough time and resources to monitor performance, identify anomalies, and take follow-up action to correct problems. Staff must review and act on performance data on a regular basis, and with adequate training so the full capabilities of the tools are realized. Sufficient time should be budgeted for these needs in order to fix the problems that are uncovered.

> "Information must be actionable. Make the information work for you."
>
> — Carlos Santamaria, LEED AP, Vice President, Engineering Services, Glenborough, LLC

Identify champion and team

Having an internal energy champion and designated team allows building performance tracking to be more intentional, and enables coordinated action from property managers to operators. Clearly defining the roles and responsibilities of each team member works to eliminate confusion and focus each person's efforts. Table 2 illustrates the range of options available when establishing the building performance tracking team.

Table 2: Building Performance Tracking Team Members

INTERNAL SUPPORT	EXTERNAL SUPPORT
In-house energy manager and operations and maintenance (O&M) staff	Third-party service contractor (O&M service contractor, tool vendor)
Property manager, asset manager, or building owner	Existing building commissioning (EBCx) provider
Occupants	Technical consultants

Include both senior management and O&M staff on the building performance tracking team. Management presence will ensure buy-in for the building performance tracking program, while O&M staff provide on-the-ground insights to cement building performance tracking in the realities of building operation. Support from external parties can alleviate the burden of labor from in-house O&M staff while offering valuable expertise.

Set performance goals

If an organization or business has top-down mandates to reduce energy or improve sustainability, building performance tracking can directly support those efforts. If there are no pre-existing targets, then goals should be set based on energy use, cost, or the ENERGY STAR benchmark.

Energy and Sustainability Goals

What are some examples of long-term goals in energy and sustainability from real facility owners? An October 2010 survey by the California Commissioning Collaborative on building performance tracking returned some examples:

- Reduce energy use by 2 percent every year
- Reduce energy use by 10 percent in 2010
- Reduce electrical and fuel use by 20 percent by 2014
- Achieve a building energy use intensity of 50 kWh/sqft/year
- Achieve an EPA ENERGY STAR rating of 75
- Achieve a net zero energy-consuming building by 2030

Consider incentives to motivate staff

Leading building managers have found incentives to be a critical piece of their overall performance tracking strategy. Bonuses and recognition can help motivate best practices. Some examples include:

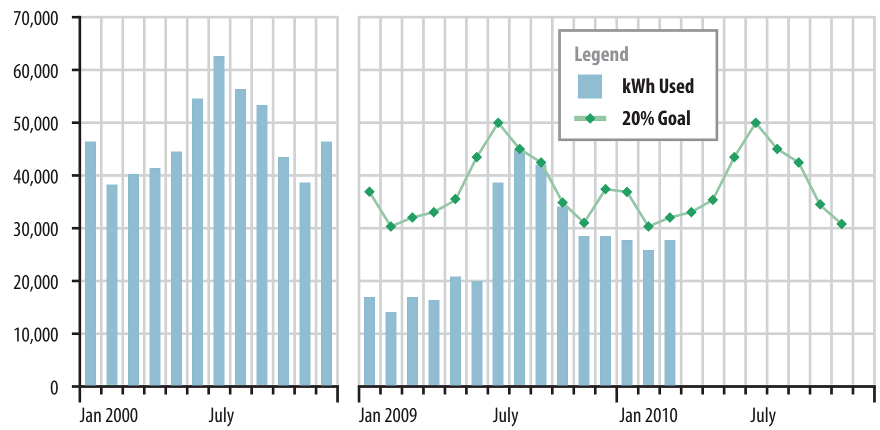
- Tie internal and third-party staff bonus payments to system and energy performance
- Create company-wide recognition for staff and occupant efforts to save energy
- Give occupants web access to energy dashboards, and introduce actions they can take to cut energy use. Display this information in public areas.
- Involve occupants in periodic audits of office space
- Email bulletins or scorecards to employees on building performance

Involving Occupants in Building Performance Tracking

By releasing a monthly scorecard to inform building occupants of energy performance, the Oregon Department of Administrative Services found a unique way to increase involvement in energy saving efforts. The scorecard provided handy tips on how occupants could reduce their energy use, as well as a summary of progress towards its goal of reducing energy use 20 percent from 2000 levels by 2015. The result: the agency reduced its energy use 27 percent from 2000 levels by 2009.

Occupant Scorecard

Electricity Usage Summary (through March 2010)



Quarterly (Jan - Mar '10)

- Usage = 81,112 kWh
- Cost = $6,083

Savings (Jan - Mar '10)

- 43,063 kWh
- 35% over year 2000
- Cost Savings = $3,230
- 61% combined electric and gas savings

The building had a major renovation in 2008-09 that contributed significantly to the reduced energy use.

Determine accountability of team members

Create a flow of information about building performance up and down the chain of command. Operators should report to high-level managers on their successes in finding problems and identifying solutions, while managers should guide operators on what areas to prioritize based on the company's overarching goals.

Well-defined reporting procedures help ensure accountability and drive action. For example, integrating building performance tracking with work order systems will drive issues identified towards resolution. Reporting protocols also provide an avenue for collecting and publishing the positive results of building performance tracking.

The Pew Center on Global Climate Change provides useful material on how to make energy efficiency a core strategy of business. Read the "seven habits of highly efficient companies" in the Center's publication *From Shop Floor to Top Floor: Best Business Practices in Energy Efficiency*.

Include performance tracking language in contracts

When possible, insert specific building performance tracking goals into real estate transaction documents and contracts with O&M service providers.

Property Management Agreements (PMAs) present another opportunity to root building performance best practices in contract language. For example, PMA contracts could require:[10]

- Energy performance benchmarking with ENERGY STAR Portfolio Manager
- Established processes and responsibilities around EBCx
- Training of operators, property managers and other staff on energy management
- Defined expectations for engaging with occupants to unlock additional paths toward energy efficiency

The management framework described in this chapter offers a foundation for using the tools described in later chapters.

Top-Down Support for Building Performance Tracking is Key

The Aventine, a high-performing building in La Jolla, CA, has achieved an ENERGY STAR rating of 100 – the highest possible rating. The property management firm Glenborough's top-down support for energy efficiency helps make it a company best practice. Management promotes energy awareness through competitions, open lines of communication, and creative autonomy for operators to find new savings investments. Glenborough also uses quarterly and annual reports to highlight and prioritize areas for improvement. These reports reinforce accountability and place energy efficiency alongside other traditional business health indicators.

O&M Service Contracts

The U.S. EPA publication ***Operation and Maintenance Service Contracts: Guidelines for Obtaining Best-Practice Contracts for Commercial Buildings*** gives useful guidance on how to structure O&M service contracts to maximize energy performance. The guidelines recommend contracts that link tasks to energy performance, indicate specific energy performance responsibilities, goals, and milestones, and include payment incentives based on energy performance objectives.[11]

Basic Tools

This chapter describes the tools that are recommended best practice in every building. At some facilities these tools may be effective on their own; for others they form the foundation for progressing to the tools in Beyond the Basics. The three fundamental strategies are:

- Energy benchmarking
- Utility bill analysis
- Using the building automation system (BAS) for troubleshooting

These three tools, illustrated in Figure 4, give building owners access to fundamental information, including:

- **Energy performance data** for the whole building, accessed through monthly utility bills and given valuable context through benchmarking.
- **System performance data** such as supply air temperature and pressure, outside air ventilation rate, variable frequency drive speed, and zone temperatures. In a typical large commercial building, this information will be accessible via the BAS.

For energy tracking, benchmarking and utility bill analysis can be characterized as a periodic tracking approach that should be conducted monthly, quarterly, and annually. For system tracking, the BAS can be used to review and improve system operation, and to help pin down the underlying issues driving high energy use or irregular system performance.

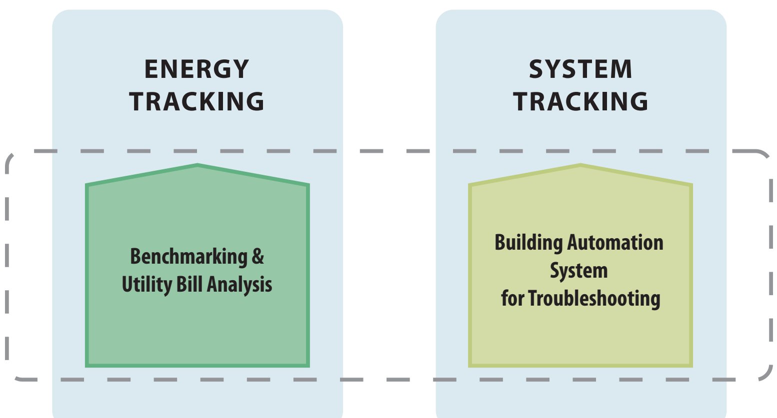


Figure 4: The Basic Tools of Building Performance Tracking

"You can't manage what you don't measure"

Building performance tracking gives property managers and operators greater control over their assets and better access to information. It also provides a platform for occupants to see, understand and become conscious about their energy use, leading to savings. Building performance tracking paves the way toward high performance, similar to the way financial reporting about investments leads to better understanding and management of those investments.

Energy Benchmarking

Energy benchmarking is a strategy for comparing a building's energy performance either to peer groups or to historical performance. Energy benchmarking has increasingly become the norm for commercial building owners, who appreciate the value of the data and ease-of-use of the tools. These tools not only benchmark performance at a point in time, but also indicate when performance improves or degrades over a longer period.

Energy Benchmarking Tools

The most common benchmarking strategies include the following:

- Track normalized energy use with ENERGY STAR Portfolio Manager. This tool uses data normalization to factor in variables such as weather, building operating hours, and building type.
- Track energy use intensity (energy use per square foot) and compare to publicly available data
- Track energy cost per square foot, and compare with industry standards, for example BOMA Experience Exchange Report® (EER) or IREM Income/Expense Analysis® Reports

Each strategy is described in greater detail below, including tips on making the method most effective.

ENERGY STAR Portfolio Manager

ENERGY STAR Portfolio Manager is the most well known and widely adopted benchmarking tool in the U.S. As of June 2010, nearly 130,000 buildings had received an ENERGY STAR rating, representing over 16 billion square feet. Nearly one-third of these buildings were offices.[12] Because ENERGY STAR ratings have become so prevalent, they are now integrated into city and state legislation.

The ENERGY STAR rating indicates a building's performance compared to similar buildings. ENERGY STAR Portfolio Manager converts a building's energy use intensity (energy use per square foot) into a number between 1 and 100, with 100 being the highest possible rating. If a building has a rating of 78, it means that building uses less energy per square foot than 78 percent of similar buildings, and higher energy use per square foot than 22 percent. This number is normalized for factors such as building type, occupancy, and climate. The U.S. Energy Information Administration's Commercial Building Energy Consumption Survey (CBECS) provides the underlying building data, which all ENERGY STAR buildings are benchmarked against.

The ENERGY STAR label is valuable as a marketing tool to help attract tenants. Buildings that earn an ENERGY STAR rating of 75 or higher may qualify for

ENERGY STAR Legislation Update

As of April 2011, policies that mandate the disclosure of a building's ENERGY STAR rating at the time of sale or lease have passed in California, Michigan, Ohio, Washington, and Hawaii, as well as in some major cities such as Denver, Seattle, and New York.

the ENERGY STAR label for that year, and receive press and a lobby plaque. Additionally, buildings can earn up to 15 points in the Leadership in Energy and Environmental Design (LEED) Existing Buildings: Operations & Maintenance rating system through their ENERGY STAR rating.

ENERGY STAR Portfolio Manager does not calculate ratings for all building types. Fire stations, police stations, colleges and universities are some of the excluded building types. However, even if a rating cannot be obtained, all building types can still use ENERGY STAR Portfolio Manager as a tool to normalize energy use based on weather variations.

Energy Use Intensity

Tracking energy use intensity (EUI) is a manual approach to energy benchmarking that can be performed by any building owner with access to utility bills. Energy use intensity is calculated as a building's energy use per square foot per year. Building owners can benchmark EUI in several ways:

- By comparing the EUIs of buildings in a portfolio
- By comparing a single building's EUI to its historical EUI
- By comparing a single building's EUI to its peer group with data gathered from the U.S. Energy Information Administration's Commercial Building Energy Consumption Survey (CBECS)
- By comparing a single building's EUI to its peer group through online energy benchmarking tools CalARCH and EnergyIQ, which are based on California Commercial End Use Survey (CEUS) data. Visit Useful Resources for further information on these tools.

Manually benchmarking EUI may not normalize for weather or other factors that may affect energy use. Nevertheless, benchmarking EUI may be a good approach if a building type or size is not covered by ENERGY STAR Portfolio Manager.

Energy Cost per Square Foot

Benchmarking the cost of electricity and gas use can be a useful strategy for owners driven by cost per square foot data. Through this approach, building owners compare a building's utility costs either to historical performance or to regional peers. The BOMA Experience Exchange Report (EER)[13] and the Institute of Real Estate Management's (IREM) Income/Expense Analysis Reports[14] are the main sources of regional peer data for the commercial office building industry. Published annually, the reports provide statistical data and analysis on financial income, expenses, and operations for offices in hundreds of cities in North America.

The information gained from these reports fits into established financial reporting processes and helps drive discussion on how to allocate capital and operational budgets. Benchmarking energy cost is also a useful tool for goal-

CBECS and ENERGY STAR

The Commercial Building Energy Consumption Survey (CBECS) is a national survey that collects data on the energy use, energy costs, and energy-related characteristics of commercial buildings every four years. EPA's Portfolio Manager compares each facility's performance to the CBECS data to generate the ENERGY STAR rating, and not to other ENERGY STAR buildings.

If a building type is not covered in ENERGY STAR, using CBECS data to benchmark can be a helpful alternative.

setting as it speaks to the bottom line. When benchmarking energy cost against peers, is important to keep the peer group regional since utility rates will vary region-to-region and may skew the perception of a building's performance.

Benchmarking Best Practice Tips

Regardless of the benchmarking methods used, follow these best practice tips:

- Benchmark a portfolio and look for the top and bottom performers. Best practices from the highest performers can be transferred throughout the portfolio.
- Achieving an ENERGY STAR rating of 75 and earning the plaque is an achievement, but it doesn't have to stop there. The difference between a rating of 75 and 100 can be a 20 percent energy reduction, and it's worth chasing that additional prestige and boost in net operating income (NOI).
- Set goals and track progress. Commercial building energy competitions have been cropping up around the country. Enter one to get motivated and earn publicity.
- Accurately determining square footage for EUI calculations is not always easy. BOMA's floor measurement standards are one source of guidance on this topic.[16]
- Having at least one electric meter and one gas meter per building is best practice for benchmarking. One meter per tenant is an even more powerful strategy for multi-tenant buildings.
- It may be challenging to secure data from all floors in multi-tenant properties due to data confidentiality. Consider integrating language into lease contracts that guarantees access.

Benchmarking is a powerful strategy for driving continuous improvement and tracking progress towards goals. Taking additional performance tracking steps, including detecting, diagnosing, and fixing issues, is often necessary to identify specific opportunities for improvement or highlight system faults.

Utility Bill Analysis

Utility bill analysis helps facility managers and building operators understand the building's energy use patterns over time and detect and investigate high energy use. Utility bill analysis offers a more precise look at the energy use of buildings because it provides information at the meter level, as opposed to simply the whole-building level with energy benchmarking.

Utility Bill Analysis Tools

To analyze utility bills, building owners can manually compare a single building's data to a portfolio or to historical performance. This practice helps owners

Success Story: ABM Industries

ABM Industries, a facility services company, leveraged EPA's Portfolio Manager to receive recognition for its environmental achievements with USAA Real Estate Company. An EPA success story highlighted ABM's use of Portfolio Manager in its FBI Chicago office building, which reached a rating of 78 after one year.

While this was enough to earn the building the ENERGY STAR, the improvements didn't stop there. In 2008 the building reached a rating of 95, representing an additional 20% improvement that translated into annual cost savings of $90,000.[15]

understand what typical energy use looks like for their buildings, and when a spike or drop in energy use or costs might indicate a performance issue.

There are several options for building owners interested in utility bill analysis:

- Manual, in-house analysis of bills provided monthly by the utility
- More sophisticated in-house spreadsheet analysis of bills through purchased software
- Free or low-cost utility bill analysis software from the utility
- Third party provides software-as-a-service for building owners to analyze data
- Third party provides utility bill analysis service

Many building owners purchase a tool or contract with a service provider to help automate the utility bill analysis process. The typical features and additional features that utility bill analysis tools and service providers offer are described in Table 3.

Table 3: Core Characteristics and Additional Features of Utility Bill Analysis Tools

CORE CHARACTERISTICS AVAILABLE THROUGH MOST UTILITY BILL ANALYSIS TOOLS
▪ Reports electricity and natural gas use and cost data over time, such as monthly, quarterly, year-to-date, and annually
▪ Automatic audit of bills to identify billing anomalies. For example, when two months have identical costs, it may point to an error.
▪ Benchmarking of utility costs against a pre-defined budget
▪ Benchmarking of energy use against pre-defined savings targets, a portfolio, or through ENERGY STAR
▪ Portfolio-wide comparisons to identify facilities with the highest savings potential
▪ Error checking of billing and data entry
▪ Greenhouse gas emissions reporting
ADDITIONAL FEATURES AVAILABLE THROUGH SOME UTILITY BILL ANALYSIS TOOLS
▪ Cost and usage reports of additional utilities, including oil, propane, water, sewer, irrigation, refuse
▪ Ability to import interval meter data and create detailed analysis and graphical representation of daily energy load profiles
▪ Processing of bills, budgets, and forecasts and interfacing with accounting systems
▪ Utility rate analysis to determine when a more beneficial rate structure might be available
▪ Online access; multiple levels of access
▪ Weather normalization of energy use data
▪ Cost avoided from energy upgrades

Utility Consumption Analysis Tool

The CCC provides a free Excel-based tool that calculates actual daily energy use based on monthly bills, along with a host of other useful data analysis features. Download the Utility Consumption Analysis Tool at www.cacx.org.

Figure 5 is a screenshot of a utility bill analysis tool, which includes an energy use report, cost comparison, and peer and historical benchmarking features.

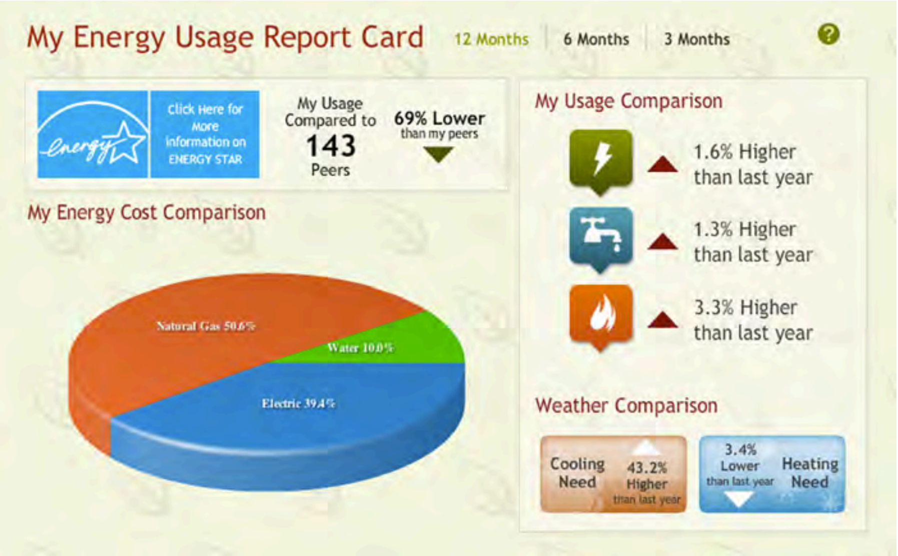


Figure 5: An example of a utility bill analysis software interface (EnergyCap)

Utility bill analysis provides a portfolio-wide snapshot of performance and a view into operating expenses. Energy cost data can be meaningful to the CFO and useful in gaining buy-in for energy upgrades. Additionally, this analysis offers some assurance that utility costs are fair and accurate through automatic error checking and identification of data anomalies. Detecting specific operational problems can be difficult, especially if energy waste is not large enough to appear in the monthly utility bill, however utility bill analysis is a fundamental practice for sound energy management that can help bring attention to major energy changes.

Building Automation System for Troubleshooting

This section gives a brief overview of how to use building automation systems (BAS) for troubleshooting system performance issues. Most large buildings use a BAS to control a building's HVAC and lighting systems. BAS can vary widely in capabilities and configuration, but on the basic level they contain an instantaneous display of the building's current operation, including data

"We track monthly bills across our portfolio using EnergyCAP. The software sends an alert if energy use is ±10% compared to the same month of the prior year, and then we'll contact the building engineers to find the root cause."

— Richard Dishman, Chief Portfolio Engineer, The Irvine Company readings from hundreds or thousands of data points from HVAC and lighting systems, along with the programming necessary to control system operation.

The BAS plays a key role in all building performance tracking strategies because it can be used for troubleshooting system performance problems. There are three steps associated with troubleshooting:

1. Set up the BAS as a performance tracking tool using trend logging and alarms
2. Use the BAS to investigate performance issues, such as system faults or spikes in energy use
3. Verify system fixes and improvements

The BAS can be a low-cost strategy when it is already in place at a building. However, building owners must be prepared to allocate resources for staff time to actively track performance through the BAS and fix the issues they find.

BAS are also commonly referred to as Energy Management Systems (EMS), Energy Management Control Systems (EMCS), and Direct Digital Controls (DDC). For operators who seek to add a more sophisticated approach to using the BAS for performance tracking, see the chapter BAS Metrics.

“When we are notified by our real-time energy monitoring system of energy use anomalies in the buildings we operate, first we check to see if there are any non-typical events such as weekend meetings or system maintenance. If that doesn't provide any clues we'll use the BAS trend logs to review equipment run schedules and use of manual overrides.”

— Al Pipkin, Director, Facilities Integrated Resource Management (FIRM), Jorgensen Facility Services

Setting up the BAS as a performance tracking tool

Using the BAS as a performance tracking tool begins with trend logging to record the performance of systems under various modes and operating conditions over time. Even if operators don't actively monitor trends, trends can be used for tracing back historical operation when a system problem occurs. Archiving the trended data is a key step in making sure the data is preserved.

BAS interfaces may slow when large quantities of trends are running. Consulting with the control contractor may be necessary to clarify system capabilities. To trend the most useful points, refer to Table 4.

In addition to trends, BAS alarms can be configured to expose a system fault, a problem relating to occupant comfort, or an occupant-driven change with a damaging impact on energy. Typical BAS alarms will signal when a data point is outside of a predetermined threshold. For example, the temperature in a zone may exceed the setpoint temperature by a certain amount, or the chiller may have higher pressure than is tolerable. When the threshold is exceeded, the alarm may send an email to key personnel, or flash an icon on the BAS user interface. More sophisticated 'smart alarms' are also possible, which are covered in the chapter BAS Metrics.

Table 4: Suggested Points to Monitor in the Building Automation System[17]

SYSTEM PERFORMANCE ISSUE	SUGGESTED POINTS TO MONITOR	SUGGESTED SAMPLING INTERVAL
Identify unnecessary equipment operation (chillers, pumps, air handlers, exhaust fans, lights, plug loads, etc.)	Equipment current (this may be taken at motor control centers, electric panels, motor electric disconnects, etc.)	15 minutes
Identify short cycling of equipment	Equipment current	2 minutes
Chiller start	Chiller current, cooling coil valve position, outside air temperature (OAT), etc.	10 – 15 minutes
Chiller loading	Chiller current or power in killowatt (kW), OAT	10 – 15 minutes
Reset schedules	Chilled water supply temperature, reset parameter (OAT, valve position, etc.)	5 – 10 minutes
Cooling tower operation and capacity strategies (fans, mixing valve and entering condenser water temperature reset)	Current for all cooling tower fans, valve position, tower sump, entering and leaving condenser water temperature, reset parameter (OAT, wet bulb, dry bulb), fan stage parameter	5 minutes
Equipment staging (compressors, chillers, cooling towers, boilers)	Stage, controlling parameter, OAT, return air temperature (RAT), supply air temperature (SAT)	2 minutes
Variable speed drives (chilled water pumps, fans, etc.)	RPM or Hertz, speed controlling parameter value and setpoint (pressure, temp., etc.), related load parameters (OAT, chilled water temp., supply air temp., etc.)	2 minutes
Economizers	Mixed air temperature (MAT), RAT, and OAT	5 minutes
Valve leakage (chilled water or hot water)	Heating element enable or valve position, SAT, cooling coil valve position, hot and cold deck temperatures	2 minutes

All BAS have inherent alarm capabilities that do not require custom programming by a controls contractor. The most effective approach is to limit BAS alarms to only the most significant alarms. Otherwise, operators may become inundated with meaningless alarms that are easy to ignore.

Use the BAS to investigate performance problems

After discovering performance problems, either through trend logs and BAS alarms or any other performance tracking tool, the next step is to find the specific problem, including its root cause. All performance tracking tools require operators to use the BAS to *diagnose* problems, even if those tools can automatically *detect* faults.

Verify improvements

After fixing performance issues, the BAS can be used to verify that performance has improved by observing data at the operator workstation and reviewing trends. This step assures operators that the problem has been fixed and often involves tweaking operating parameters to optimize the improvements rather than overriding them entirely. Also, BAS alarm thresholds may need to be revised based on the new operating conditions of the equipment.

Troubleshooting Guidance

BetterBricks' Symptom-Diagnosis Tool is a great free resource for systematically investigating problems using a BAS. This tool is just one of many useful tools and guidelines that are available free at www.betterbricks.com.

What You Learned: The Basics of Building Performance Tracking

This section described the basic strategies of building performance tracking for every building owner, comprised of two main components:

- A *strong management framework* to guide the people and processes behind building performance tracking, and to see the full benefit of tools.
- The *basic tools* needed to monitor both the system and energy performance of commercial buildings. Benchmarking, utility bill analysis, and the BAS are the three basic tool strategies that can be easily implemented in every building.

This section provided the groundwork for building owners to move beyond the fundamentals and adopt a continuous tracking approach, covered next in Beyond the Basics.

Beyond the Basics

“We used to track energy use month to month — now we can track minute to minute.”

— Karen Jawl, Director of Operations, Jawl Properties

Beyond the Basics

There is broad consensus on what constitutes the basics of building performance tracking. However, for the building owner looking to move beyond the basics and take greater control of performance, the picture becomes more complicated. The number of available tools is ever-increasing, and a lack of naming conventions makes it difficult to compare them.

This section introduces the types of tools available to any owner wanting to move beyond the basics of building performance tracking. Figure 6 illustrates the six major categories of tool functionality, two of which have already been covered. These six categories are split between energy and system tracking, and there are three levels of sophistication offered:

- **Basic Tools:** This category of tool is used to track monthly energy use and to support system troubleshooting in cases where problems occur. These tools were covered in the previous chapter, and are recommended as the foundation for any building performance tracking strategy.
- **Performance Data and Metrics:** This category of tool collects and displays energy and building system data in real-time. This enables users to manually analyze building performance, track metrics, and respond when they see data that indicates a potential problem.
- **Automated Alerts:** This category of tool also collects real-time performance data, and in addition uses sophisticated software to automatically alert users when problems occur.

Figure 6 is organized to distinguish tool *functionality* – in practice, a particular tool may incorporate multiple functions. For example, some energy information systems incorporate benchmarking and BAS metrics.

One challenge facing an owner looking for a building performance tracking tool is the lack of standardized terminology within the industry. The tool names and descriptions used in this section will not necessarily be used by tool vendors. The primary purpose of this handbook is to describe the major features and their benefits, so that building owners can engage in productive dialogue with vendors and find the tool that will meet their unique needs.

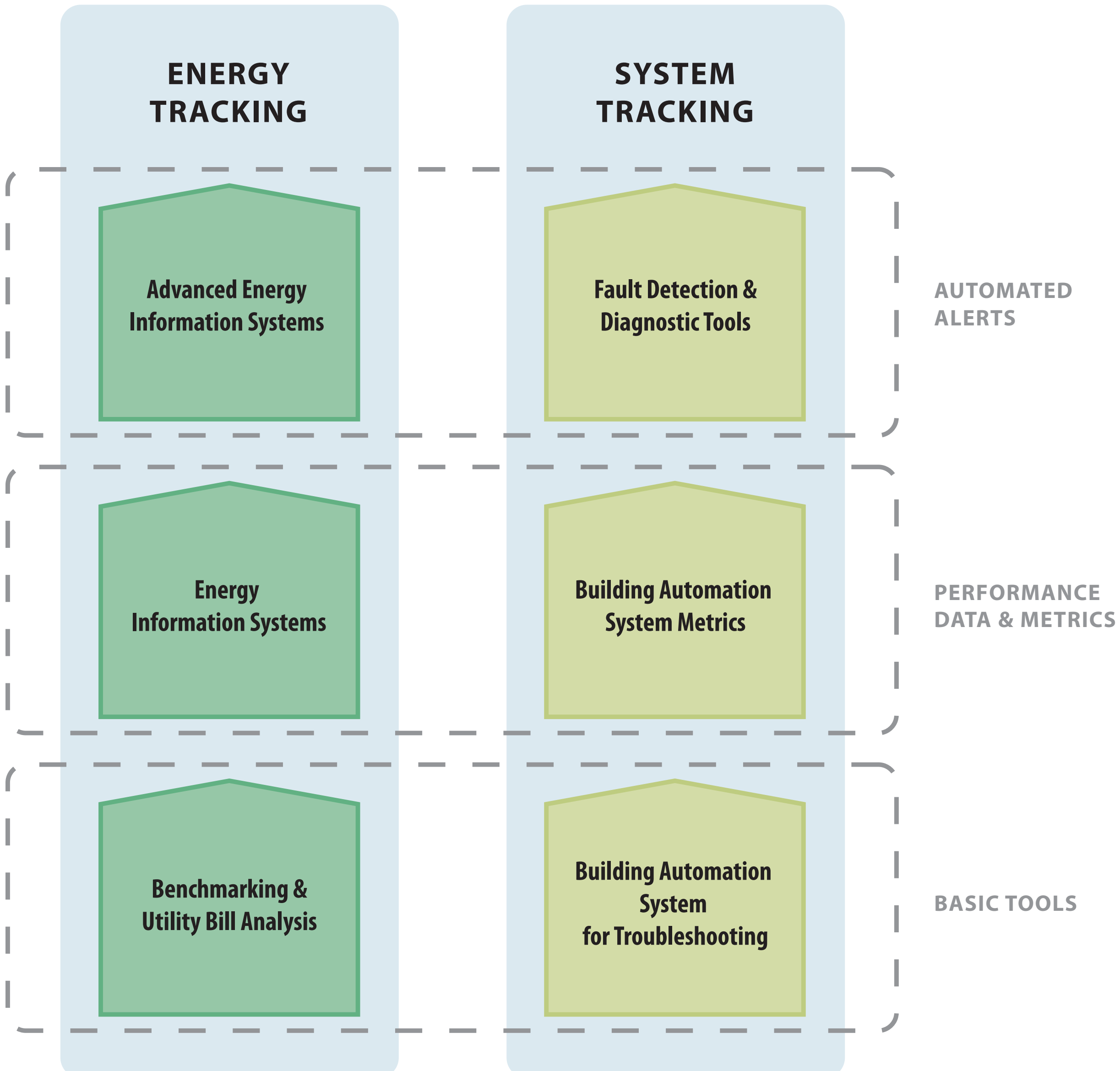


Figure 6: The Six Categories of Building Performance Tracking Tool Functionality

Energy Tracking

The greatest growth in building performance tracking tools is happening in the area of energy tracking. A wide variety of tools are available, and the features and underlying data analysis capabilities can vary considerably among tools.

This section of the handbook describes two generic groups of energy tracking tools, and highlights the one key difference between the two groups in terms of functionality: energy modeling. For each of these tool categories, the benefits, considerations, technical requirements, and best practice tips are covered in this section.

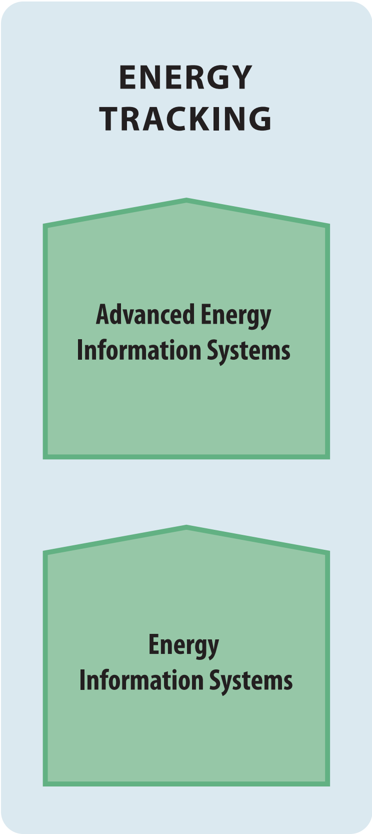
The chapters covered in this section include the following:

Energy Information Systems

Energy information system (EIS) are used to store, analyze and display current and historical energy use, typically displaying hour-by-hour data for each meter. EIS provide the capability for the user to analyze energy consumption patterns using a variety of graphical formats. This hourly tracking enables system improvements to be viewed at the meter level and problems to be more easily and quickly identified.

Advanced Energy Information Systems

Advanced EIS include tracking and graphical display of hourly energy use inherent with an EIS. In addition, these systems incorporate sophisticated energy modeling functionality that can predict expected energy use based on a number of variables, and alert the user if energy use exceeds that prediction. Advanced EIS have the additional benefit of being able to track ongoing building performance in comparison with historical baseline models.



Energy Information Systems

Monthly utility bill analysis and benchmarking are powerful tools for assessing progress toward goals, prioritizing action, and observing long term trends as part of a high-level performance tracking strategy. However, it is important to understand the limitations of tracking energy use on a monthly basis and to consider what is possible when using tools that can track and display energy use at a higher resolution.

Energy information systems (EIS) are used to store, analyze and display current and historical energy use, typically displaying hour-by-hour data for each meter. EIS provide the capability for the user to analyze energy consumption patterns using a variety of graphical formats. This hourly tracking enables system improvements to be viewed at the meter level, and problems to be more easily and quickly identified.

How do energy information systems work?

Energy information systems are predominantly offered as "Software as a Service" (SaaS) and comprise three main elements:

- **Energy meter and communications:** Data is collected at intervals of between one minute and one hour. These measurements are taken primarily from electric and gas meters, but can also include water use and other system-related data. Tracking whole building consumption is typical, and in some cases submeters may be installed for specific systems. A data acquisition system in the building typically collects information and transmits it to the EIS server.
- **EIS server:** Commonly managed by the EIS service provider, the host server is the central data storage and analysis tool. Data is aggregated, filtered for errors, analyzed, and archived.
- **Web interface:** Users can view data in a variety of formats, including graphical dashboard displays that are typically customizable. The web interface can be used for viewing data from an individual building or a portfolio of buildings.

These elements are represented in Figure7, which provides a generic overview of EIS architecture. These elements are also covered in more detail in "EIS Technical Requirements".

For More Details on EIS

Much of the technical content in this chapter is adapted from ***Building Energy Information Systems: State of the Technology and User Case Studies***. Granderson, Jessica, M.A. Piette, G. Ghatikar, P. Price. LBNL-2899E. Lawrence Berkeley National Laboratory, Nov. 2009.

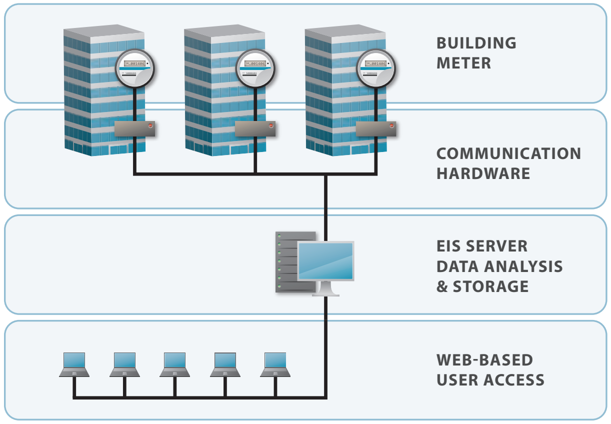


Figure 7: Typical EIS Architecture

The information available to users through an EIS varies from system to system, but a core set of characteristics can be generally expected, as shown in Table 5.

Table 5: Core Characteristics and Additional Features of EIS

CORE CHARACTERISTICS AVAILABLE THROUGH MOST ENERGY INFORMATION SYSTEMS	
Benchmarking	■ Comparison of energy use across a portfolio of buildings
Data Quality Assurance	■ Flagging (and in some cases resolution) of corrupt or missing data downloaded from meters
Data Visualization	■ Time-series plots based on user-defined time intervals, including the ability to trend multiple points on the same chart ■ Daily load shape plotting, including minimum / maximum / average demand ■ Overlay plots from before and after improvements to view impact on energy use
Analysis	■ Simplified calculation of energy cost based on average unit cost per kWh or therm ■ Greenhouse gas emissions estimation
ADDITIONAL FEATURES AVAILABLE THROUGH SOME EIS SYSTEMS	
Benchmarking	■ Ability to pull ENERGY STAR rating from EPA's Portfolio Manager
Energy Analysis	■ Scatter plots (enable users to see energy use patterns that may not be apparent in time-series plots) ■ Calculation of energy cost based on actual utility tariffs ■ Simple weather normalization of energy use based on heating degree days (HDD) and cooling degree days (CDD) ■ Simplified forecasting of near-future loads, calculated based on recent loads and forecasted temperatures

Figure 8 shows high energy consumption in a Texas Walmart store displayed via their EIS. This issue was traced back to a failed dimming control module. Walmart's energy analyst identified the problem, corrected it, and avoided $35,000 per year of additional energy costs, as reported in Granderson, 2009.

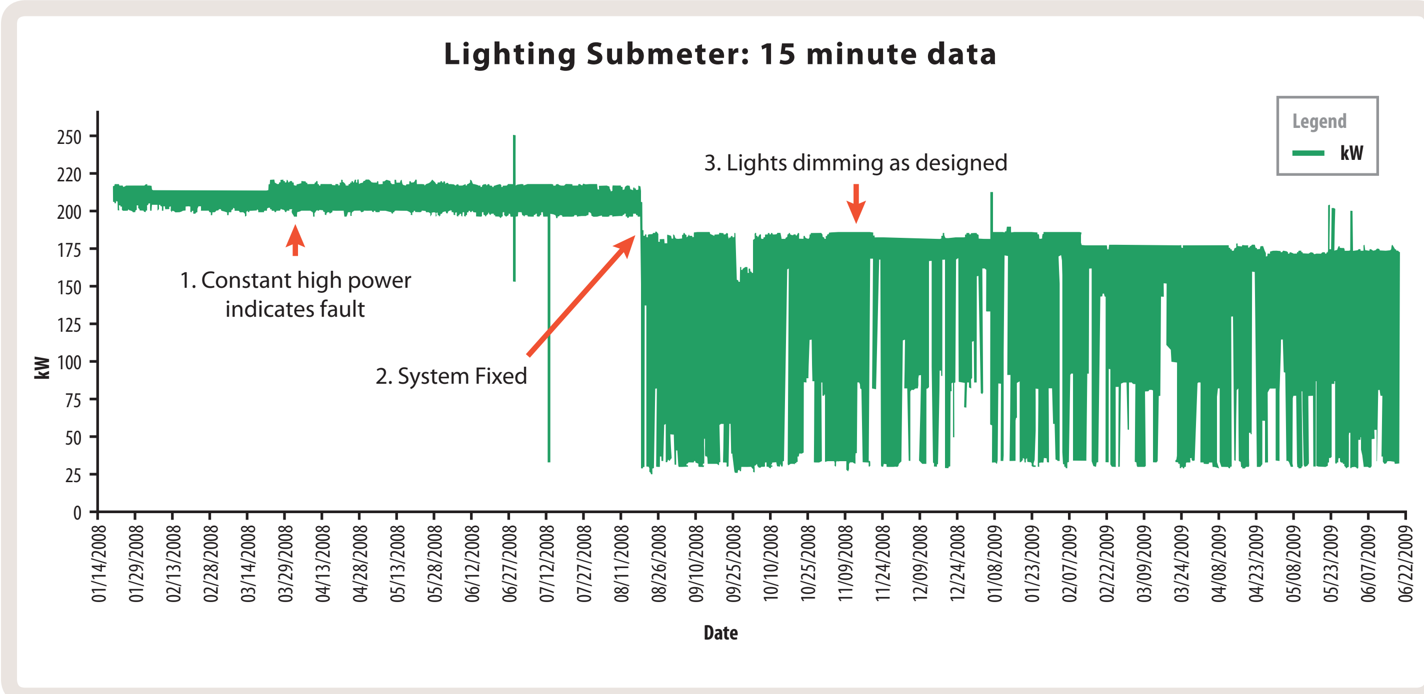


Figure 8: EIS indicates a lighting control problem and verifies that the problem has been fixed. Graphic adapted from Granderson, 2009.

Tracking Energy Metrics Using An EIS

Tracking energy metrics is one key benefit offered by an EIS. Figure 9 provides guidance on the range and type of metrics that could be applied. Which options are selected to track depends on the metering available and building attributes. For instance, in a leased building where occupancy rates have changed over the years, it may be important to normalize for building occupancy through whole building kWh / occupant / year.

Example: **Whole Building kWh / sq ft / year**

Metering Scope
- Whole building
- End use (HVAC, lighting, plug loads, etc.)
- Specific system (chilled water, air handlers, etc.)

Units Tracked
- Electricity (kWh)
- Demand (kW)
- Gas (therms)
- Combined electric and gas (kBtu)
- Cost ($)

Normalization
- Square feet
- Cooling degree days
- Heating degree days
- Occupancy

Time Frame
- Per year
- Per month
- Per day

Figure 9: Options for Tracking Energy Metrics

EIS Benefits

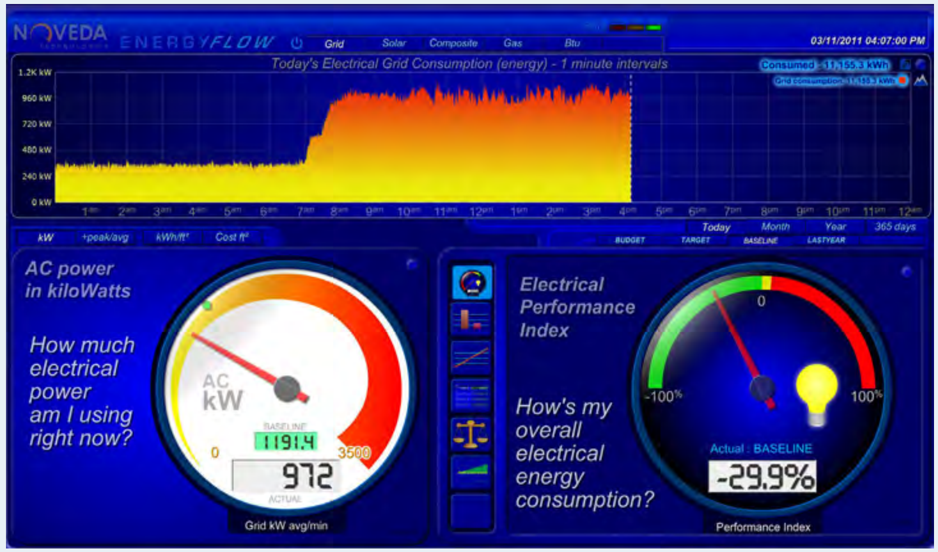
The capability of EIS to track energy use in hourly increments results in the following energy and non-energy benefits:

Find and fix problems quickly: EIS provide the ability to see jumps in energy use in near real-time so action can be taken quickly to address problems. While the tools do not diagnose the *cause* of problems, they can provide clues by identifying the timing and magnitude of energy impacts. If, for example, an energy increase is observed to coincide with maintenance on a particular air handler, it can become the first stop for the root cause investigation. Figure 9 is an example EIS dashboard with features to help viewers understand energy performance in real-time.

Help ensure that efficiency investments pay off: Not only do users get a clearer picture when things go wrong, they also have a better view when things go right. Typically, when major energy efficiency improvements are implemented, there should be a resultant drop in energy use. If that is not the case, it may point to a scenario in which the improvement has not been commissioned properly.

Persistence of improvements: Once an efficiency improvement has been implemented through EBCx or other efficiency upgrades, EIS are powerful tools for ensuring the continued high performance of the building.

Energy use patterns can hint at potential improvements: EIS allow users to assess patterns of energy use over time and gain an intuitive feel for how this relates to actual building operation. For example, a user might ask, *"Why does energy use start creeping up three hours before the building is occupied?"* or *"If the office is closed on Sundays, why is the energy use profile similar to Saturday?"* Getting a deeper understanding of building operations often translates into significant savings and comfort improvements over time.



Getting to Know Your Building Better

A building operator decided that the best way to understand his systems was to walk around the facility while watching instantaneous energy use on a laptop via Noveda's Energy Flow Monitor EIS software. As he physically observed systems switching on and off, he was able to isolate the impact of specific assets on the building's energy use. This helped the company prioritize their energy efficiency efforts.

Figure 9: An example EIS dashboard from Noveda's Energy Flow Monitor

The 'one-stop shop': Most EIS have the capability to compare the energy use intensity (EUI) benchmark across a portfolio of buildings. While this is not radically different than the capabilities of utility billing analysis or benchmarking tools such as the ENERGY STAR Portfolio Manager, there is benefit to having all of the information accessible through a single web-based program that streamlines the management process. This feature will allow the user to view information at the portfolio level and to drill down to the hourly level without needing to switch between different applications.

Flexibility: Current EIS on the market include a variety of dashboard displays with varying levels of user-customization. This flexibility is critical for avoiding information overload, and it enables users to adapt the tool to suit their own needs and priorities.

EIS Considerations

A fundamental feature of EIS is that they are great for viewing *changes* in energy use patterns. As a result, the ability of EIS to help identify ongoing problems that existed *before* the EIS was installed is very limited. For this reason, it is recommended that this approach be combined with more methodical analysis of building systems through EBCx or energy audits.

While EIS can display current and historical energy use, these tools have three key limitations:

1. EIS have a limited ability to estimate what the energy use *should* be on an hourly basis. It is up to the user to develop a feel for energy use patterns over time. This limitation is overcome through the addition of energy modeling functionality, which is covered in the next chapter: Advanced EIS.
2. The ability of an EIS to calculate energy savings over time is also limited. For example, a system may show a comparison of the current and prior week, or the corresponding week of the prior year, but that will not account for changes in key variables such as weather and occupancy. The next chapter covers advanced EIS which can perform this function.
3. While EIS can indicate magnitude and timing of changes in energy use, they cannot pinpoint the sources of those changes. This requires manual investigation, use of the BAS for troubleshooting, and/or automated fault detection and diagnostic tools.

The challenge of getting energy use data from meters can be significant. Meter type, data language, and company IT security are examples of hurdles that need to be overcome. These challenges are covered in "EIS Technical Requirements".

Staff availability and turnover needs to be considered when implementing EIS as a tracking tool. The EIS software automatically generates high-impact visual displays of energy use, but operators will need to allocate time for viewing and interpreting the data, and to gain a feel for the building's normal energy use characteristics.

EIS Technical Requirements

An overview of the technical requirements for installing EIS is described below.

Metering: EIS systems have the capability to track a broad range of data streams. Electric and gas use are most common, but EIS could track steam or water use so long as the data is compatible. The primary requirement is that the meter must be capable of providing pulse outputs; this may require a meter upgrade and/or the addition of a secondary device. EIS vendors may provide this service as part

Success Story: UC Merced

UC Merced's energy manager used web-EMCS, a web-based interface for their building automation system, to identify significant gas use at night when the system was not intended to operate. The subsequent simple fix resulted in a 30% reduction in daily average gas consumption at the steam plant, and an estimated $2,500 in monthly savings.

— Adapted from *Building Energy Information Systems: State of the Technology and User Case Studies*[18] of their installation, or they may have a recommended market partner who installs and configures metering.

Submetering: Installing submetering for specific systems such as lighting or HVAC will add to the precision of EIS data analysis. Submetering can increase the benefit of the EIS because it enables users to see changes in energy use patterns that are too small to show up in whole-building analysis. Submetering can also reduce the time and effort needed to pinpoint the location of those problems.

Additional Data Points: Points from the building automation system (using existing sensors for temperatures, pressures, flows, etc.) or other systems such as lighting and occupancy controls can generally be brought into the EIS. The complexity of point mapping and communications will affect the cost of integrating these points. Providing a single dashboard for operators that includes both meter data and system control, and monitoring points can facilitate detection of problems and troubleshooting solutions, however most EIS functionality is focused on tracking meter data.

Communications: Be aware that numerous forms of communication are possible and vary between vendors. Direct wired options may be suitable when relatively few meters are in close proximity. Various wireless options may be suitable when there are numerous meters scattered throughout the building and no easy means for wired communication is present.

Data Storage: Servers are usually offsite and may require an ongoing fee. It's important to ensure that storage capacity will meet requirements, and onsite backup storage should be considered to ensure data continuity if there is a communication problem with the external server. When it comes to storage, more is better, as EIS are ideal for tracking progress towards long-term energy goals.

Legacy Data: If interval meter capability already exists, some EIS vendors can enter data from previous years at the time of installation so that historical trends are available from day one. This is especially useful if the company has goals relative to past energy use (eg. *By 2015 we will achieve savings 20% below use in 2005*).

EIS Cost

EIS costs typically break out into three elements:

- Installation of metering and communications hardware
- EIS setup and configuration
- Monthly subscription costs, which may be on a per-meter basis or some other multiplier

There are currently no established rules of thumb for EIS cost. Costs will vary depending on building data availability, tool functionality, number of data points, and the need for submetering. In some cases, multiple vendors or installation subcontractors may be involved.

EIS Best Practice Tips

An EIS is a step beyond benchmarking in terms of sophistication, and that sophistication requires a greater level of commitment to management, training, and documented processes. Research has shown the benefits of having an energy champion to ensure best return from investment in tools such as EIS. Without a formalized process the tool can fall into disuse, especially if the champion leaves the company. Refer to the Management Framework chapter for more details.

All stakeholders should be involved from the start; an EIS can provide benefits to management, operators, and occupants, so taking a team approach to specifying and installing the EIS is ideal. Allow sufficient time to hone the daily management processes, and set up periodic team meetings (eg. quarterly/annually) to review how the processes are working.

An EIS can be a useful tool for supporting an EBCx project. It will help the commissioning provider understand the building's energy use characteristics, enable impacts of improvements to be readily viewed, and help ensure the improvements persist after the project ends.

The next chapter describes Advanced EIS with modeling capabilities, which can more accurately determine if energy use is excessive, and automatically generate alarms.

Get the EIS Habit

It is recommended that operators incorporate EIS review into their daily routine. As little as ten minutes per day will speed the process of learning the building's energy use characteristics, and provide more immediate warning if the prior day's energy use looks abnormal.

Advanced Energy Information Systems

As described in the previous chapter, energy information systems (EIS) are proving to be effective in supporting building performance tracking through hourly energy use analysis and visualization. They allow users to view, assess, and respond to energy use patterns in a timely manner.

Advanced energy information systems go beyond those capabilities. These systems incorporate sophisticated energy modeling functionality that can predict typical energy use based on a number of variables, and alert the user if energy use exceeds that prediction.

How do Advanced EIS Work?

Advanced EIS tools may encompass all the same features as the EIS. This chapter only covers the key distinguishing feature of advanced EIS: their energy modeling capability.

Advanced EIS will track energy use at the building's main energy meters or submeters. Additional driving variables that affect energy use are also tracked and analyzed. Outside air temperature, day type (weekend/weekday or day of the week), and hour-of-day are typical, but other variables such as building occupancy levels may also be used.

Over a period of many months to one year, the advanced EIS develops a model to predict typical energy use based on historical energy use data, normalized for the driving variables mentioned above. A comparison of 'typical vs. actual' energy use can then be used to automatically generate alerts when differences occur.

Depending on the specific system, alerts may be issued instantly or incorporated into regular reports (eg. a daily report may be emailed to users). Along with the ongoing comparison of expected and actual energy use, advanced EIS can also calculate energy savings relative to a historical baseline and have simple cost-savings estimation capabilities.

It is important to distinguish between the two primary models that can be created using advanced EIS:

- **Expected Energy Use:** These models use recent energy use (generally the last 6-12 months) and current operating conditions (weather, occupancy, etc.) to develop an ongoing prediction of expected energy use. Expected energy use is then compared to actual energy use to flag instances when use is unexpectedly low or high. Figure 10 shows how an advanced EIS might indicate variations in actual energy use from expected energy use.

Developing a Good Baseline

The length of time required for advanced EIS to develop an accurate baseline model is based on many variables, such as the time of year and the stability of building operations. A broader range of weather conditions and operating characteristics will produce a more accurate predictive model.

- **Historical Baseline Energy Use:** These models use historical energy use data from a fixed window of time to document the way a building has used energy in the past. This historical baseline can then be compared to current energy use. For example, a baseline period might be the year preceding an EBCx project. Once the project is complete, the historical baseline model can use current weather conditions to calculate what the energy use ***would have been*** if the improvements had not been made. When the current energy use is less than the historical baseline model, this is an indication of the amount of energy the EBCx project is saving. In many cases, this level of rigor in modeling and analysis can be described as measurement and verification (M&V).

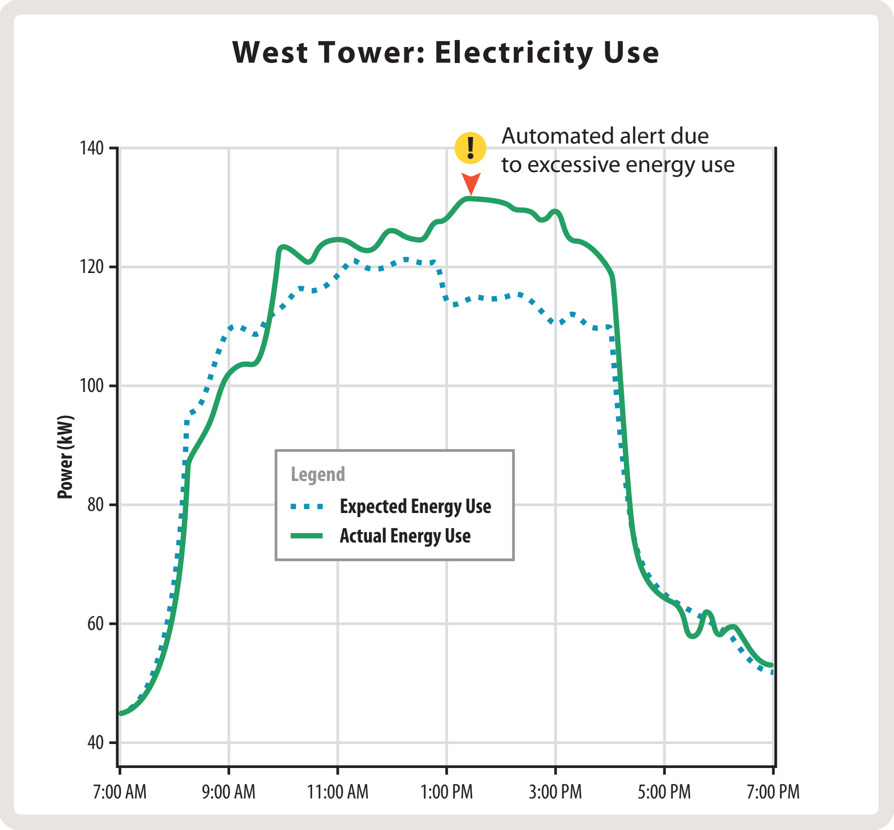


Figure 10: Example of predictive model display adapted from Pulse Energy screenshot

"We utilize the Public Dashboard functionality of the Pulse software, so that our tenants can view energy use in real time. This has proven to be very popular, and helps us generate tenant buy-in for our sustainability efforts."

— Karen Jawl, Director of Operations, Jawl Properties

Advanced EIS Benefits

The key benefit of advanced EIS is that the software automatically generates energy alerts. This feature overcomes three limitations of standard EIS:

- A user may not have time to monitor EIS data regularly
- Staff turnover can result in new operators taking time to re-learn the building's energy use characteristics in order to review the EIS data
- Staff may miss problems using an EIS because they are too subtle to be identified through visual analysis of energy use

The modeling capabilities of advanced EIS can more accurately forecast near-future loads in support of demand response efforts, and also provide improved estimation of energy savings from energy efficiency projects. Advanced EIS capabilities are built around weather-normalized models so that they can compensate for year-to-year fluctuations and give a better assessment of true building performance.

Advanced EIS Considerations

It is common to focus on comparing 'expected' to 'actual' energy use. For example, an alert may be generated if actual use is greater than 10 percent above expected. However, since the expected energy use is updated continuously, users may miss long-term performance degradation using this approach alone. For this reason it is best to also set triggers based on historical baselines – this is covered in the section "Advanced EIS Best Practice Tips" below.

Stability of building operation is a significant factor when developing the initial baseline model for advanced EIS. For example, major equipment replacements, remodeling, and changes in occupancy during the months following EIS installation will negatively impact the predictive accuracy of the model. The result is that the advanced EIS will need a longer baseline period before it can reliably generate automatic alerts.

Some considerations with standard EIS are also relevant to advanced EIS:

- These tools identify *changes* in energy use patterns, so problems that existed prior to installation may not be picked up by the tool. As with standard EIS, it is recommended to pair advanced EIS installation with EBCx.
- It is essential to ensure that operations staff has time to review the results and to follow up on alerts.
- Obtaining data from meters and for variables that affect energy use, such as occupancy rates, can be challenging.
- Reported costs and savings are typically based on simple, average per-unit energy costs rather than on true utility rate structures.

Success Story: Sysco

Sysco employs Northwrite's Energy WorkSite advanced EIS in collaboration with site tune-ups, supported by continuous communication between corporate managers, on-site energy champions, and Cascade Energy Engineering. This integrated approach of tools, processes, and management framework has enabled Sysco to achieve 18 million kWh savings per month, representing an 18% overall reduction in energy use.

— Adapted from *Building Energy Information Systems: State of the Technology and User Case Studies*[19]

Advanced EIS Technical Requirements

System architecture and configuration for advanced EIS are essentially the same as for standard EIS tools. Also, as with standard EIS, submetering can provide greater precision for identifying problems, but should be considered relative to complexity and cost.

Advanced EIS Best Practice Tips

The same recommendations discussed in the previous chapter for EIS apply to advanced EIS, along with some additional recommendations described here. Advanced EIS can continuously compare actual energy use with expected use and multiple baselines. It is important for users to understand the differences in the energy models and to set alerts accordingly. Table 6 provides some general guidance.

Table 6: Advanced EIS Model Applications

MODEL	VIEW	ALERTS
Expected Energy Use	Continuously track actual vs. expected energy use to identify problems as they occur	A good starting point is to alert if actual use is >10% above expected. This can be adjusted to tighter tolerances over time.
Historical Baseline	**Maintain Savings from EBCx:** Continuously track actual energy use vs. an optimized baseline to identify long term performance drift.	A good starting point is to alert if actual use is >10% above the post-project baseline. This can be adjusted to tighter tolerances over time.
	Periodic Progress Measurement: Track actual vs. baseline energy use on an annual basis to report on progress towards corporate energy savings goals.	Alerts may be set *below* the baseline (assuming energy use is decreasing over time). For example, if a project results in 10% whole building electric savings, an alert might be set to ensure that savings do not degrade.
	Project Savings Measurement: Set a new baseline before each major energy efficiency improvement so that measurement and verification can be performed.	

Energy use is not smooth; spikes in energy use may occur for legitimate reasons (eg. when a large air handler starts up). To avoid false alarms, alerts should be based on exceeding a certain threshold for a continued period (eg. thirty minutes). Regular, repeated spikes may indicate excessive cycling of equipment, however, so users should look for that in their daily routine checks.

What You Learned: Energy Tracking

Beyond the basics of benchmarking and utility bill analysis, owners have two available options for energy tracking: energy information systems and advanced energy information systems.

Energy information systems allow users to track energy use at the hourly level, supported by powerful data visualization capabilities. Hourly tracking offers a number of benefits over tracking monthly energy use that can translate into cost savings and greater assurance for efficiency investments.

Advanced EIS use sophisticated modeling to continuously compare energy use to expected and historical baselines and are weather-normalized to account for changes year-to-year. The ability of advanced EIS to automatically generate alerts based on building-specific models takes them beyond the realm of standard EIS. Advanced EIS are powerful tools for alerting users to building performance problems, and also for ensuring that the savings from energy efficiency improvements persist over time.

System Tracking

For the building owner wanting to move beyond the basics of system tracking, there are two contrasting options. Using the building automation system (BAS) to track metrics utilizes a tool already familiar to building operators to provide a summary of BAS data. Installing a fault detection and diagnostic (FDD) tool offers higher levels of sophistication to help operators automatically pinpoint problems with HVAC systems.

The chapters covered in this section include the following:

Building Automation System (BAS) Metrics

Using the BAS to track key performance metrics is an effective and inexpensive way to manage system performance using a tool that is already installed in most large buildings. Tracking metrics enables users to respond to potential problems quickly and observe long-term improvements gained through energy efficiency projects.

Fault Detection and Diagnostic (FDD) Tools

FDD tools automatically generate reports that highlight system problems and help diagnose the root cause or pinpoint the actual location of the problem. The automatic analysis provides end-users with a means to quickly address performance issues, which helps achieve and subsequently maintain building performance.

Building Automation System Metrics

The earlier section on Basic Tools described how the BAS can be used to establish trend logs and simple alarms and to troubleshoot issues in response to those alarms.

A typical BAS has capabilities far beyond troubleshooting and simple alarms, however. Using the BAS to track key performance metrics can be an effective and inexpensive way to boil down the thousands of data points that may be tracked into digestible information. This minimizes daily labor resources required and provides a way to track long term building performance improvements.

What is a metric?

A metric is a key performance indicator which may be compared to historical or expected values to describe building performance. A metric may indicate the energy cost per unit of service provided, indicate energy use during a period of time, or characterize system operation. The BAS can track thousands of points within a building; the distinction with a metric is that it combines data from multiple points to provide deeper meaning. For example:

- Tracking the kW for a cooling plant gives some indication of performance, but this will vary considerably based on load and outside temperature. However, tracking the kW *per ton of cooling* delivered provides a measure of how efficiently the plant is operating (see Figure 12).
- Tracking zone temperatures is important for ensuring comfort, but reviewing temperatures in every zone is difficult to manage long-term. Tracking a metric such as the percent of time when zones are within setpoint can be useful for assessing performance at a glance and for tracking improvement or degradation over time.

Most BAS have the capability to track energy-related metrics, so long as meter data can be input to the BAS. This approach may be preferred if the BAS is being used as the sole tracking tool, although data visualization is typically better with an EIS.

The most common energy metrics are energy use or cost per square foot per year, both of which can be applied to the whole building or to specific systems if submetering is available. Refer the EIS chapter for guidance on developing energy metrics, as well as additional system tracking resources in Useful Resources.

How does metrics tracking work?

There are two complementary ways in which metrics can be tracked using the BAS

- Trends may be plotted to show daily/weekly/monthly/annual patterns (Figure 11 gives an example)

- Average, minimum/maximum, and percentage values may be calculated within the BAS and reported periodically (eg. a daily or weekly summary)

Trending enables the user to see patterns over time and gain an instinctive feel for how values are affected by variables such as occupancy and weather. The user can then look for abnormal changes in metric values that might indicate problems, and observe longer term patterns to increase confidence that energy efficiency improvements are paying off. Ideally, each tracked metric will have a target value. Many metrics are building-specific so it may take time to establish reliable targets.

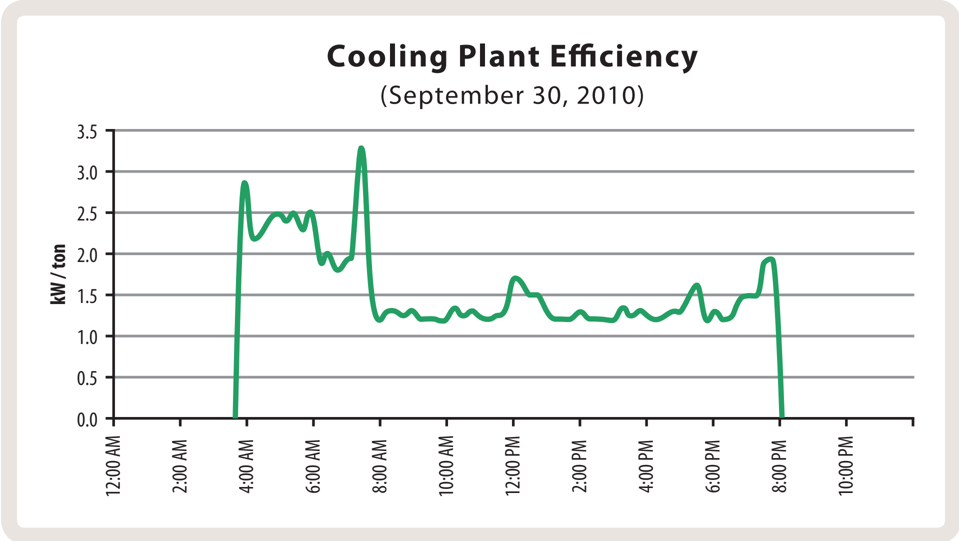


Figure 11: An example of metric tracking: kilowatt per ton trends shows cooling plant efficiency over time

Recommended BAS Metrics

There are many options for selecting suitable metrics to track, and Table 7 provides some recommendations.

Table 7: Recommended HVAC System Metrics

METRIC	DEFINITION	NOTES
Occupant Comfort Index (%)	% of operating hours spent within zone target temperature	■ Measure for each zone; in addition, can group by floor or other collection of zones ■ Track average, minimum, and maximum values for the building ■ Target is 100%
Cooling Plant Efficiency (kW/ton)	kW per ton of cooling	■ kW of entire plant preferred, but pump metering is not always available ■ Will vary based on load (eg. weather, occupancy) — Operator learns over time what to expect ■ Comparing plots for multiple consecutive days may help to identify changes in performance
Heating Plant Efficiency (%)	$\frac{\text{Btu per hour (out)}}{\text{Btu per hour (in)}}$	■ Will vary based on load - Operator learns over time what to expect ■ Btu per hour (out) can be provided by a custom Btu meter, or calculated based on water temperature and flow rate; Btu per hour (in) is a conversion from therms supplied ■ Metering not always available
Fan System Efficiency (kW/cfm)	kW per cubic foot per meter of air flow	■ For each air handler: kW of supply/return/exhaust fans combined, cfm of supply air ■ Look for variance between air handlers or changes over time that may indicate problems
Outside Air Ventilation (OA cfm/person)	Cubic feet per minute of outside air per person	■ Average OA cfm / person, during occupied hours operating at minimum outside air (non-airside economizer mode). ■ Air flow meters required. ■ Number of occupants will be manually entered, and should be updated at least once per year

BAS Metrics Tracking Benefits

Metrics tracking is a strategy for boiling down the thousands of data points that can be tracked into information that can be understood and acted upon. Metrics tracking minimizes daily labor resources required and provides an easy way to track long term improvements on a monthly or annual basis. Building operators already review the BAS regularly, so adding this functionality to an already-familiar tool should minimize the additional effort required for operators to track metrics.

Tracking a comfort-related metric is particularly useful, and can provide an opportunity to identify and respond to problems *before* any occupant complaints are reported. Archiving trends for metrics, along with the data from which they were created, presents a valuable resource for troubleshooting and diagnostics. Trend data will also be beneficial in supporting an EBCx project.

More data is better when it comes to archiving trends; one year of data provides an excellent view of building performance across all seasons.

BAS Metrics Tracking Considerations

Older BAS have limited functionality to configure attractive dashboard-style displays for tracking metrics. For example, it may not be possible to create a screen that shows plots of all key metrics over the last month. When a BAS has these limitations, it can be more effective to pull data from the BAS into an EIS and report system metrics through the EIS dashboard.

It should be understood that in most cases metrics are building-specific. Some rules of thumb may be applied across all buildings, including maintaining cooling plant efficiency around 1 kW per ton or better, and outside air ventilation rates at 15 - 20 cfm per person for large offices. However, it typically takes time for operators to learn what is normal for their buildings and what indicates a potential problem. This issue supports the concept of implementing EBCx before tracking building performance, so that users learn what metrics look like during efficient operation.

What is a Smart Alarm?

Typical BAS alarms are based on setpoint limits; for example, supply air temperature having a defined setpoint plus or minus an acceptable range. This simple approach may be insufficient in some cases; smart alarms can identify problems that would otherwise go undetected through simple alarms.

For example, a cooling coil may be compensating for a leaky valve on the hot water coil in order to maintain correct supply air temperature, which would result in excess energy use. In that situation, a more sophisticated approach is necessary. One solution would be to trigger an alarm if a temperature difference was recorded across a coil and that coil's valve was commanded shut. This is defined as a 'smart alarm.'

In most cases, smart alarms need to be programmed by a controls contractor, and the support of an EBCx provider may also be beneficial. Fault detection & diagnostic tools (see next chapter) incorporate multiple smart alarms and have the capability to handle even more complex algorithms that are generally beyond the capabilities of a BAS.

BAS Metrics Tracking Technical Requirements

Depending on how the BAS is configured, metrics tracking may require the addition of new sensors so the system can collect the data needed to report on the chosen metrics. Also, BAS programming will be necessary, and will typically require a controls contractor if site engineering staff do not have the training.

If setting up multiple trends, it may be necessary to add extra storage capability, and some older BAS will need to be upgraded if data access is impractical. If users want to track statistics such as average, minimum, and maximum over a period of time, a stable database such as an SQL server will be required.

BAS Metrics Tracking Best Practice Tips

As mentioned earlier, most metrics don't have hard limits; users must learn what to expect from their building over time. For that reason, it is recommended that metrics be checked at least once a day. Plotting multiple consecutive days can be a useful way to identify changes in performance, although users should factor in temperature fluctuations before jumping to conclusions that there is problem.

Fault Detection and Diagnostics

The previous chapter described how using a building's BAS to track performance metrics provides a useful high-level view of system performance. Performance metric tracking requires the end-user to manually determine when metrics drift outside normal expectations through periodic evaluation of the data.

Fault detection and diagnostic (FDD) software tools provide a capability beyond the manual judgment required of performance metric tracking. FDD tools utilize system-level performance data to automatically detect problems. Some tools additionally provide diagnostics to help determine the root cause of the problem. Figure 12 is an example interface from an FDD tool, showing the top 10 faults identified by cost and time, as well as an excerpt from the detailed list of identified faults.

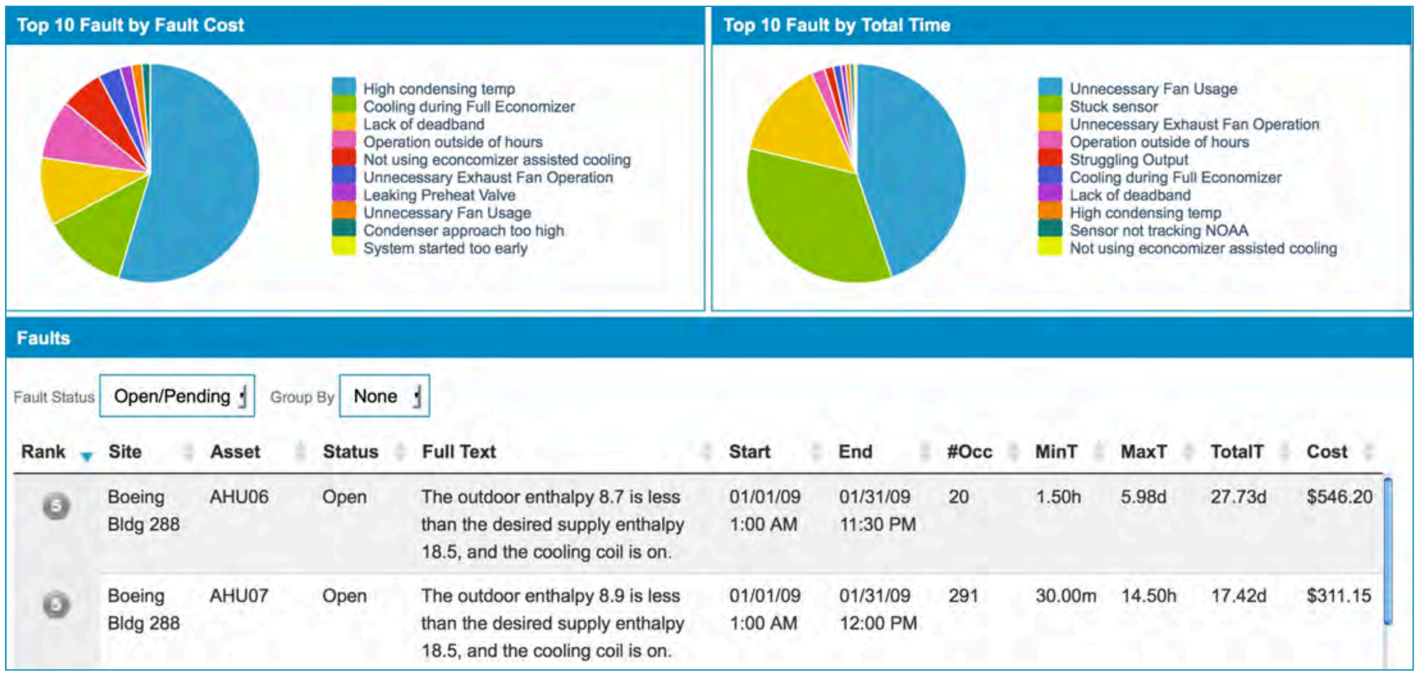


Figure 12: Example FDD tool interface (Scientific Conservation, Inc.)

How do FDD tools work?

FDD tools typically rely on performance data from existing BAS points with a few tools requiring the installation of dedicated sensors external to the BAS. Fault detection algorithms can be implemented through publically available BAS programming code or, more typically, in proprietary code built into commercially available tools. FDD tools typically use the following methods to detect problems:

1. **Expert rules** mimic the thinking done by a systems expert through the use of programming logic ("rules") that compare multiple data points. Expert rules can be used to automatically detect common issues such as leaking valves, inoperable dampers, and even sensors out of calibration.
2. **Performance data comparisons** evaluate monitored BAS data against certain parameters, such as design intent, manufacturers' equipment ratings, and historical trend data. Various calculation techniques are used to create a model of *expected* performance which is then compared to the *actual* performance values.

In addition to indicating problems, expert rules can include another layer of sophistication that accounts for the duration or cumulative cost impact of a particular problem, and they may assign a priority level.

The level to which FDD tools are able to diagnose the root cause of problems varies significantly. Some tools pinpoint the location of the fault without providing specific causes, while others provide the user with a number of potential causes. In either case, additional manual inspection or further analysis may be required to verify the fault and determine its exact cause.

FDD Definitions

Fault Detection: An automated alert indicating a specific system problem, eg. excess outside air is being brought into the building

Diagnostics: Description of what might be causing the problem, eg. outside air damper is stuck open

Expert Rules Examples

Simple Expert Rule: *IF* the AHU-1 supply fan status is on for 2 minutes *AND* the command to the fan is off, *THEN* generate an alarm.

Complex Expert Rule: *IF* the difference between the leaving and entering temperature of a hot water coil taken at 3 minute intervals over 15 minutes exceeds 125 *AND* the signal to the hot water valve is zero, *THEN* generate a "leaking hot water valve" alarm.

FDD Vendor Business Models

Current FDD vendors offer tools that follow a variety of business models. This variety provides the end-user with flexibility to select the option best suited for their particular requirements, as described in Table 8.

Table 8: FDD Tool Business Models

BUSINESS MODEL	DESCRIPTION
Licensed Software	▪ Software is purchased and locally installed on-site ▪ Ongoing license fees may be incurred
Software as a Service	▪ BAS trend data is transmitted, stored, and analyzed with software housed on the vendor's server ▪ Reports and fault data are web-accessible ▪ In-house staff are typically responsible for accessing and reviewing the fault reports ▪ Ongoing service fees are customary
Service-Based	▪ Service provider links to the BAS and downloads performance data to an offsite database ▪ Service provider reviews the faults detected by their FDD software and investigates further by remotely accessing the BAS ▪ Reports are sent to the end-user in defined intervals (weekly, monthly, quarterly, etc.) ▪ Higher ongoing service fees than with other options
BAS Programming	▪ Expert rules are programmed directly into the BAS ▪ Reports are typically run on demand ▪ No ongoing service fees

The current trend is for more tools being offered through the Software as a Service (SaaS) model, since users are seeking greater assistance in implementing their FDD strategy on an ongoing basis.

FDD Benefits

The capability of FDD tools to quickly and automatically identify system problems results in the following benefits:

- **Reduction of analysis time:** Automatic detection of specific faults and assisting in diagnosis of solutions may significantly reduce the time burden on in-house staff. Less time analyzing data leaves more time to respond to the identified faults and tend to other needs in the building.
- **Identification of new savings opportunities:** FDD tools should help with the identification of underlying issues with performance that often go unnoticed. The diagnostic reports generated by these tools can help focus and prioritize improvement efforts to areas that require the most attention.

- **Persistence assurance:** The continuous tracking function of FDD tools is a platform for ensuring ongoing persistence of benefits once building performance is optimized. Any new problems should be identified as they occur and can be addressed quickly to prevent drift in building performance.
- **Work order management:** Some FDD tools have the capability to integrate with computerized maintenance management systems (CMMS) and automatically dispatch work orders for the identified faults, thus streamlining workload allocation and ensuring accountability for resolving problems.

Of all the available building performance tracking tool strategies, implementing FDD typically requires the greatest upfront investment of time and money. However, the benefits are significant, especially as buildings become ever more complex and operating budgets continue to be stretched.

FDD Considerations

It is worth noting that while fault detection capabilities are increasingly available, only a few tools actually have the ability to *diagnose* the causes of faults. Tools that fit the full definition of FDD must include a "diagnostic" feature that recommends possible causes of the fault. However, even without the diagnostic feature, the detection capabilities inherent to tools of this class can save significant amounts of time analyzing data.

Many buildings operate with a number of relatively minor hidden problems, so expect to receive a large number of alerts initially. False alarms may also be high initially until the tool is calibrated to the specific attributes of the building. Working closely with the tool vendor can help establish appropriate alarm limits and minimize false alarms.

While many FDD tools provide estimates of cost avoidance for identified problems, these savings estimates tend to be general approximations and may not be based on exact utility tariffs. Estimates can be useful as a means of prioritizing a list of problems, but should not be relied upon as an energy savings determination.

The considerations listed above will vary considerably depending on the tool, so ask the FDD vendor to explain how the tool addresses these limitations.

FDD Technical Requirements

Technical requirements vary greatly across the spectrum of FDD, which will affect both the cost and the effort required to get the tool up and running. Factors to consider include:

- **BAS Compatibility:** FDD installation typically requires a fairly modern BAS. The complexity of communications with BAS data also varies widely by FDD

FDD Success Story: Santa Clara County

"Most BAS will not notify operators for sensors or actuators that are out of calibration until they actually fail – we could go on for years operating our buildings based on false readings. With SCIwatch FDD, you can monitor accuracy and drift in relation to other system devices to identify abnormalities, enabling us to achieve significant energy efficiency improvements."

— Lin Ortega, Utilities Engineer Program Manager, Santa Clara County tool and BAS vendor, which can result in increased installation timeframes for some systems. If the communication protocol required by the tool (e.g. Lon, BACnet, ModBus, or other) is not compatible with the existing BAS, a system upgrade may be necessary.

- **System Sensors:** Reliable fault detection generally requires reliable sensor inputs. Existing sensors used by the FDD tool should be calibrated and maintained. Be aware that some FDD tools may require dedicated sensors beyond those included in the existing BAS, or that additional sensors be added to the BAS.
- **Tool Scope:** A few FDD tools currently available to the market analyze the performance of a single system type, such as a chiller, VAV terminal boxes, or packaged HVAC equipment. Other tools are more inclusive and span multiple systems across the building. Tools that span multiple systems may include customizable detection options that should be matched to a particular building's systems.
- **Data Storage:** Data may be stored internally in the BAS, on a local network, or in an offsite database maintained by an external party. Data ownership and storage capacity should be carefully considered.
- **Technician Support:** Programming expert rules directly into the BAS requires a controls contractor with extensive knowledge of the existing system configuration for a timely installation.

To ensure successful FDD implementation, all of these technical requirements should be considered as early as possible so they can be included in the vendor's initial specifications and pricing.

FDD Best Practice Tips

While FDD tools can locate problems and provide suggestions of root cause, human intervention is required to be sure of the cause and to implement the fix. To ensure full benefits from FDD tools, it is recommended that tool users develop a process to link the information from FDD reports to a building's maintenance management system or to work planning processes.

Given the complexity of modern buildings and FDD technology, it is important to work closely with the FDD tool vendor. The vendor must take the time to understand the configuration of the building and its BAS to anticipate technical challenges. The level of training and support that is provided after installation will also impact the long-term success of the tool.

FDD Tool Vendors

With new commercially available products coming onto the market, providing a list of FDD tool vendors is likely to become outdated. However, the detailed results of the FDD research that contributed to this handbook is available, including specific information on nine tool vendors.

Characterization of FDD and Advanced EIS Tools. California Commissioning Collaborative, Sept. 2010.

Users should consider two general approaches to their initial implementation of FDD tools and determine what will work best for them:

- **Tight tolerances capture the most problems:** With tight tolerances on when faults are flagged, there will likely be a high number of alerts initially that decrease as problems are fixed.
- **Wider tolerances focus only on major problems:** Wider tolerances means that fewer problems will be flagged. Tolerance may be tightened later to capture additional issues. It may be useful to limit the scope of the FDD tool to systems with known problems, then implement FDD for the remaining systems after improvements are made.

It is useful to keep track of the savings achieved through use of the FDD tool. Savings may be projected on an annual basis or based on an estimate of when the problem may have been found without the FDD tool. Tracking cumulative savings is useful when estimating the overall cost-effectiveness of tool implementation. The most successful FDD installations have found quick return on investment even with relatively high tool implementation costs.

FDD Tools: Not just for large HVAC systems anymore

Fault detection for packaged rooftop units is a quickly emerging product in the market. Several vendors already offer packaged rooftop unit (RTU) FDD solutions and many more products are nearing market readiness. Current RTU FDD packages are capable of detecting faults related to mechanical components, improper refrigerant charge and air-side systems.[20]

Beyond FDD: Automated System Optimization

All of the performance tracking strategies covered in this handbook share a common feature: improvements in savings and comfort can only be achieved if operators act upon the information provided to them.

Automated system optimization is a different category of tool that automatically optimizes HVAC system performance. These tools use sophisticated and often proprietary software algorithms to determine the most efficient control parameters for HVAC systems, including temperature and pressure setpoints and equipment staging. The software communicates directly with the building's BAS to gather system data and uploads the optimal control parameters back to the BAS. The software continually adjusts these parameters to satisfy the varying loads in the most efficient manner possible.

Automated system optimization tools are currently available for central plant and primary air distribution equipment with a focus on variable flow systems. This solution can be expensive if the building is not already equipped with variable frequency drives on pumps, fans and even chillers. As a result, automated system optimization may be cost-effective only for larger facilities with high energy costs and for building owners who are seeking the highest performance possible.

Automated system optimization software does not cover all aspects of system operation, since it can only optimize for issues that relate to the control sequences. Generally, these tools do not currently include FDD algorithms to detect problems that cannot be remedied by controls modifications. However, FDD or other performance tracking tools may be used simultaneously with automated system optimization to help automate all aspects of fault detection.

While this approach is gaining momentum with innovative owners, there are currently only a few vendors with market-ready products available. One such owner is Glenborough, who uses an automated optimization tool at their Aventine building in San Diego. Glenborough combines automated system optimization with measurement and verification, Portfolio Manager benchmarking data, and utility bill analysis to reach and maintain an ENERGY STAR rating of 100 and LEED Platinum certification status.

"Our biggest lesson was learning to trust that the system would automate itself. This leaves me more time to work on my most important task – keeping tenants happy and comfortable."

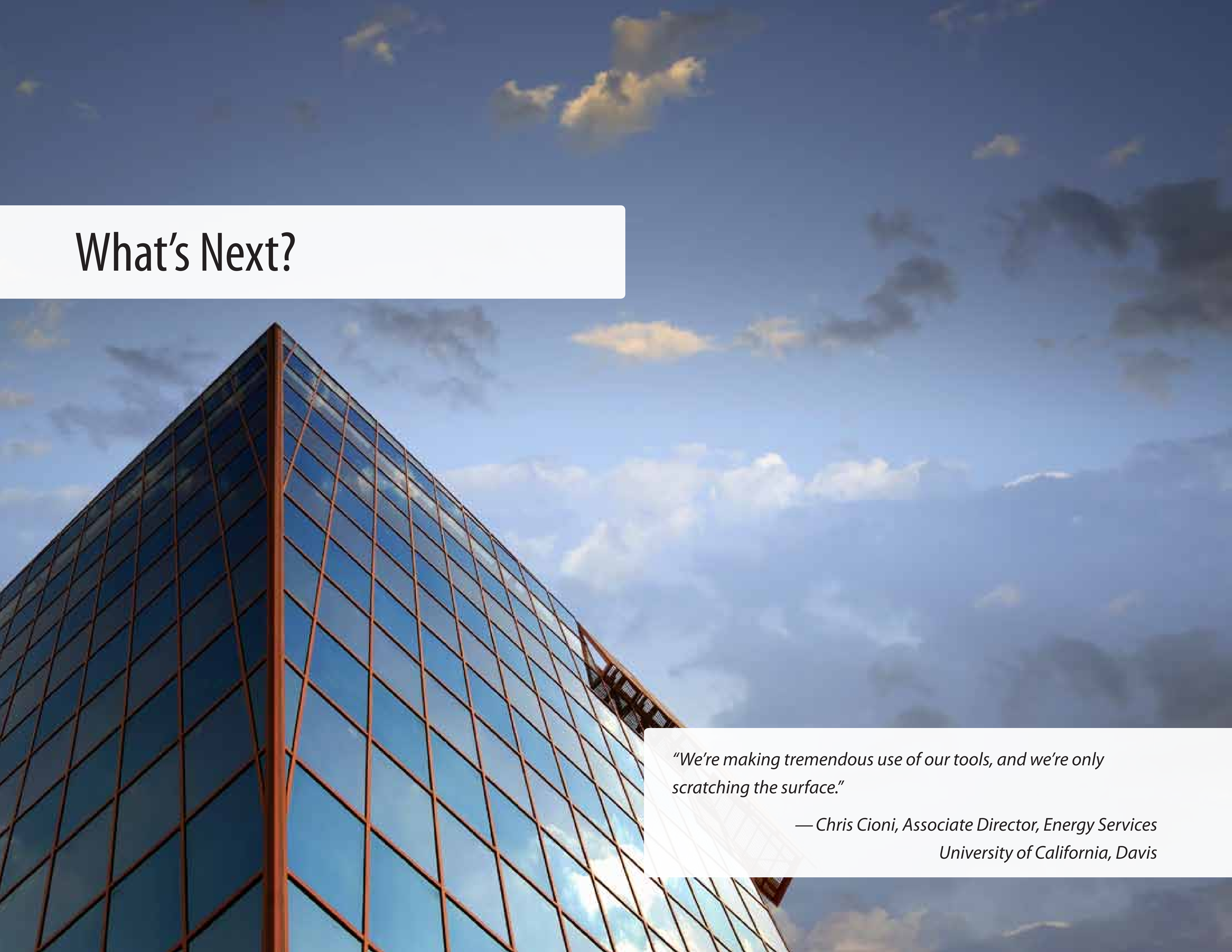
— Doug Eagle, Chief Engineer of the Aventine

What You Learned: System Tracking

Beyond the basic use of the BAS for troubleshooting and trending, users have two options for system tracking: using the BAS to track metrics and installing an FDD tool.

Using the BAS to track key performance metrics is an inexpensive way to manage system performance with a tool that is already installed in most large buildings. Tracking metrics enables users to respond to potential problems quickly and observe long-term improvements gained through energy efficiency projects.

FDD tools automatically generate reports that highlight system problems and attempt to diagnose the root cause or pinpoint the actual location of the problem. The automatic analysis provides users with a means to quickly address performance issues, which should help achieve and subsequently maintain the building's optimal performance.



What's Next?

"We're making tremendous use of our tools, and we're only scratching the surface."

— Chris Cioni, Associate Director, Energy Services
University of California, Davis

What's Next?

I've read the handbook, now how do I choose the right path? Use this chapter to help select an approach and connect with additional useful resources to arrive at an effective plan.

Figure 13 shows a phased process to implementing a building performance tracking strategy. Step 1 is covered in more detail in Management Framework, Step 2 is covered in Basic Tools and Beyond the Basics, and Step 3 is covered throughout the handbook.

Industry leaders are tracking performance and continuously improving their buildings. These leaders recognize that building performance tracking is a key way to get the most out of commissioning investments and continue to identify improvement opportunities over time. This section provides a useful "How-To" resource either to start selecting an approach to building performance tracking or to continue enhancing the tools, people, and processes within an existing approach.

The chapters covered in this section include the following:

Selecting An Approach

- Summary of building performance tracking approaches
- What to consider when selecting a tool
- Benefits and costs
- Selecting the "right" approach

Useful Resources

- Relevant Publications
- Related Organizations
- Acronyms

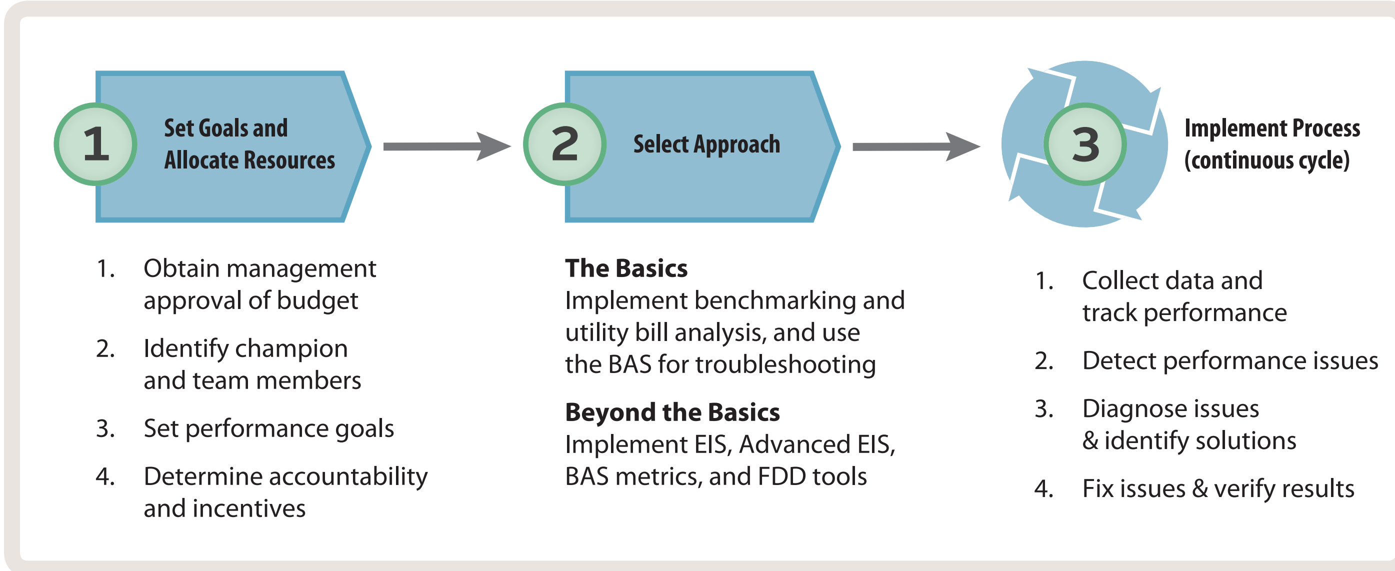


Figure 13: Steps to Implementing a Building Performance Tracking Strategy

Top 5 Ways to Make the Most of Building Performance Tracking

1. A solid performance tracking process includes setting achievable performance goals, well-defined reporting protocols, and specific team member responsibilities, then making sure staff has the time and incentives to execute the plan.
2. Be prepared to act upon the problems found. Don't be surprised to find more problems than expected—they should decrease over time.
3. Integrate tools with other processes and software wherever possible, especially work order management systems.
4. Purchase tools that will be well-utilized. Involve all stakeholders in the selection process to obtain buy-in from the start.
5. Implement building performance tracking along with existing building commissioning (EBCx)

Selecting an Approach

This handbook has emphasized several aspects of building performance tracking related to selecting an approach:

- **Both energy tracking and system tracking can play key roles in building performance tracking.** Energy tracking uses energy data from meters to analyze and reduce the energy needed to operate a building. System tracking uses data from the building automation system and other control systems to answer questions around how equipment is operating.
- **Basic tools come first.** Engaging in benchmarking and utility bill analysis to track energy use and using the building automation system to troubleshoot problems found are prevalent in the industry. These practices are recommended for all facilities, and can be considered the basics of building performance tracking.
- **No single tool will likely meet all needs.** This chapter can be used for selecting a combination of tools that best fit each stakeholder's unique needs and can work well with existing business software, processes, and tools.
- **Building performance tracking and commissioning go hand in hand.** Building performance tracking tools can be well-utilized throughout the EBCx, from helping to identify good candidate buildings to finding and verifying improvements. However, implementing building performance tracking as a persistence tracking strategy after EBCx will allow an optimized baseline to be tracked and maintained over time.
- **The '3Ps'—People, Processes, and Performance tracking tools have to come together.** Since building performance tracking results all hinge on the actions taken as a result of the information or diagnostics, the people and processes are key. Involve a broad range of stakeholders in the tool selection process, and put those tools to good use through sound management.

Table 9 summarizes the key features, benefits, and limitations of the energy and system tracking approaches described in Basic Tools and Beyond the Basics. Users can refer to this table as their performance tracking strategy evolves to meet their expanding needs.

People, Processes, and Tools

Having simple tools, well-trained staff, and effective processes is a far more valuable strategy than implementing sophisticated tools without a solid framework for utilizing them.

Table 9: Features, Benefits, and Limitations of Building Performance Tracking Approaches

	APPROACH	KEY FEATURES	MAJOR BENEFITS	LIMITATIONS
ENERGY TRACKING	Benchmarking and utility bill tracking	Monthly utility bill tracking to compare energy use regularly May include ENERGY STAR Portfolio Manager or other tools	Foundation for all other energy tracking methods Compares data across a portfolio Helps find major energy waste	Need to manually look at the data to find problems Difficult to detect problems early
	Energy Information Systems (EIS)	Interval meter data tracking at the building and often submeter levels Portfolio analysis & benchmarking Data filtering, load shape analysis	Data helps detect problems early Hourly data and submetering to understand potential problems Data analysis features save time	Need to manually look at the data to find problems Limited ability to determine cause of issues Usually not configured to include BAS data
	Advanced EIS	Includes EIS key features Compares interval data to predictive models to detect energy waste at meter level Tracks energy use; compares to normalized baseline	Automated analysis of energy compared to prediction Alerts when energy use outside range Weather and occupancy changes taken into account	Automated alerts don't direct staff on cause of issues Usually not configured to include BAS data
SYSTEM TRACKING	Building Automation System (BAS) for troubleshooting	Primarily HVAC, lighting control Ability to set up trends and alarms Use to troubleshoot problems by observing system operation, trends	Foundation for all other system tracking methods Ability to see details of system operation to pinpoint problems	No data summary for the "big picture" Often not configured to include energy meter data Alarm capability covers only basic faults
	BAS system metrics	HVAC and other system metrics tracked by the BAS and displayed via dashboards	Tracking metrics is a simple way to gauge overall building performance Reduced analysis time compared to using raw BAS data Track metrics for areas of known problems to find problems early	Few BAS packages include metrics (require some programming) Operators require time to learn what is 'normal' vs. a problem. Fewer EIS-like features for data filtering and visualization
	Fault Detection & Diagnostic Tools (FDD)	Automated process for identifying specific equipment or system level faults using BAS data Helps diagnose possible causes	Less time needed for data analysis Can pick up subtle, complex faults otherwise hidden from BAS alarms Prioritize faults based on cost	Directs staff to specific faults but typically only gives a general idea of the cause Installation and sensitivity tuning can be time consuming

What To Consider When Selecting A Tool

Once the basic tools are in place, assess where the biggest pain point is. Comfort? Then choose to enhance system tracking with a focus on comfort metrics and fault detection. Energy management? Then choose to add more effective energy tracking tools. Within both energy tracking and system tracking paths, consider:

- **Is the core data that is required currently accessible or could it be added?** Many larger buildings already have interval meters installed, and this data can be used within the EIS. Other buildings require additional meters or BAS system data improvements.
- **What level of analysis is expected from a tool, and how much time will be available to interact with the tool?** Tools can either provide data and information for manual analysis or automatically detect energy and system issues. Consider how much analysis time you expect to spend with the tool to choose the appropriate level of automation.

Selecting building performance tracking tools that work for a particular facility depends on more than just tool functionality; the management side of the equation is equally important. The questions below are considerations for building performance tracking strategy selection related to people and processes.

- **Does the tool exist as part of a suite that, when combined, is comprehensive?** For instance, some EIS may also include online project management functionality and automated connection to ENERGY STAR benchmarking.
- **Does the tool integrate with something that that already exists?** A BAS upgrade may allow for programming system metrics and smart alarms, which can be useful to minimize the training time required for a new system. In some cases, there are options to overlay a BAS with additional EIS or FDD software modules.
- **If O&M is provided by a service contractor, do they already have experience with particular tools?** With a service contractor, it is possible to avoid the learning curve inherent in any tool.

Table 10 summarizes key decision points related to data required, the desired level of analysis, and applicability.

Table 10: Selection Criteria for Building Performance Tracking Approaches

	APPROACH	CORE DATA REQUIRED	LEVEL OF ANALYSIS	BEST TO USE WHEN:	LESS APPLICABLE WHEN:
ENERGY TRACKING	Benchmarking and utility bill tracking	Monthly utility bills	Provides data to track long term trends and help find major issues	Limited time for detailed analysis – the big picture is sufficient Portfolio of buildings are benchmarked against one another	Desire quick detection of energy waste Utility bill tracking can catch errors in bills, but is not required for tracking energy if building has an EIS
	Energy Information Systems (EIS)	Hourly meter data	Provides data and charts to help find a wide range of energy issues	Sufficient time and expertise exists to review the data to look for trends and anomalies Portfolio of buildings are benchmarked against one another	When buildings are small or there are few in the portfolio, more difficult to make this a cost-effective investment
	Advanced EIS	Hourly meter data, weather data	Automatically detects 'abnormal' energy	Alerts reviewed in a timely manner to identify cause	Frequent changes in building use that are difficult to capture in the baseline model
SYSTEM TRACKING	Building Automation System (BAS) for troubleshooting	HVAC/lighting control and monitoring points	Provide information to help find wide range of system issues	Use trending in conjunction with all other methods to help pinpoint root cause Only include alarms that provide high value information to operators	BAS capability to program alarms or set many trends is limited, or when adding capability is cost prohibitive
	BAS system metrics	HVAC/lighting control and monitoring points	Provides information to help find wide range of system issues	Desire to keep the BAS as a single interface for performance tracking Simple metrics are to be tracked Budget does not allow for larger investments, such as for EIS or FDD	Key monitoring points not in place BAS is not capable of tracking and storing metrics, or when adding capability is cost prohibitive
	Fault Detection & Diagnostics (FDD)	HVAC/lighting control and monitoring points	Automatically detects wide range of system issues	Automated analysis of data is imperative Operators desire more information on the location and severity of the performance issue	Facility has non-standard HVAC system design not covered by the FDD tools Quick tool installation is desired

Costs and Benefits

Many factors will influence the benefits of building performance tracking. While case studies show a good return on investment, there has not yet been definitive research to verify and quantify those costs and benefits.

When considering a building performance tracking investment, it is necessary to take into account the upfront software, hardware, and installation cost of the tool; the ongoing cost of subscriptions and service; and the labor cost to track performance data and address the problems found. For each tool type, here are some general rules of thumb regarding cost:

Energy Tracking:

- **Benchmarking and utility bill analysis:** Low-cost tool strategies with only moderate labor time needed to upload and review utility data and benchmarks. These strategies are most cost-effective when staff has easy access to utility bills or data entry is automated.
- **EIS:** A moderate to expensive tool strategy, since the upfront software investment and the labor required to analyze data is significant. Further, additional meters may be required. The fewer meters tracked, the less expensive this approach will be.
- **Advanced EIS:** Similar to EIS, a moderate to expensive tool strategy that may require additional meters. However, the tool requires less manual data analysis than EIS, so the ongoing labor hours required are less.

System Tracking:

- **BAS for troubleshooting:** A low-cost tool strategy, since typically no extra hardware is required beyond the existing BAS. Labor to set trends and alarms, review data and take follow-up action is required. When the number of trends and alarms are kept to only the most essential points, this strategy is lowest cost; however, when more sophisticated smart alarms are programmed, it can become more expensive.
- **BAS system metrics:** A moderate cost tool strategy, with much of the cost related to programming custom metrics and dashboards. Little additional hardware cost is required except potential BAS memory upgrades and database storage. When the BAS vendor has a packaged solution or experience implementing this approach, cost may be lower.
- **FDD:** A generally higher cost tool type that requires upfront investment and labor for set-up and tuning. If a building's HVAC system design is standard, the tool may be less expensive to install; however, when HVAC systems are uniquely designed, custom rules may be required to be programmed, which will increase cost.

Benefits from implementing building performance tracking vary based on factors such as the amount of time staff can focus on analysis and follow-up, the ability and investment dollars available to act upon the information, and the initial baseline efficiency of the facility. Energy cost savings may result from a combination of operational changes, retrofits, and generally increased awareness, so it can be complicated to separate out the benefits specific to performance tracking activities from other energy efficiency investments.

The recurring message from commercial real estate leaders who have invested in building performance tracking tools is that they quickly pay for themselves, both through reduced energy costs and improved comfort for occupants.

Selecting The "Right" Approach

Leading edge owners have navigated the complex array of resources and tools available and found that a variety of approaches can work well. In summary, there are a few key principles to keep in mind:

- **Purchase tools that will be used frequently.** Involve all stakeholders in the selection process to obtain buy-in from the start. Many sophisticated industry leaders have found success through low-cost and simple tools.
- **Start where you are and build upon success.** For instance, if focusing on system tracking approaches leads to more empowered operations staff, then support those efforts. If upper management needs more information about portfolio-wide energy use, then benchmarking, utility bill analysis, and enhancing an EIS may be the best choice.
- **If needed, use additional resources to help get started.** Owners and building engineers may desire specific expertise to help implement building performance tracking. Energy consultants, commissioning providers, and performance tracking tool vendors are often good resources. Additionally, there may be incentives or support from a local utility to implement building performance tracking.

The future of the commercial building industry is being shaped every day by the decisions of forward-looking building owners, property managers, and energy managers. With this handbook, become a part of the growing push for more responsible and effective strategies for building energy management. Share the tools and ideas it contains with peers, use it to inspire teams toward action, and begin to see the operating costs fall, asset values grow, and market differentiation improve for your buildings.

Useful Resources

Relevant Publications

Existing Building Commissioning

- Mills, Evan. *Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse-gas Emissions*. Lawrence Berkeley National Laboratory, 2009. <http://cx.lbl.gov/documents/2009-assessment/LBNL-Cx-Cost-Benefit-Pres.pdf>
- *A Retrocommissioning Guide for Building Owners*. Developed by Portland Energy Conservation, Inc. for the U.S. Environmental Protection Agency ENERGY STAR® Program, 2007. <http://www.peci.org/documents/EPAguide.pdf>
- *California Commissioning Guide: Existing Buildings*. Developed by the California Commissioning Collaborative, 2006. <www.cacx.org/resources/documents/CA_Commissioning_Guide_Existing.pdf>

Business Case

- *BOMA Commercial Lease: Guide to Sustainable and Energy Efficient Leasing for High-Performance Buildings*. Product #GL2011. Building Owners and Managers Association International, 2011.
- *Business Benefits of Green Buildings SmartMarket Report: Building & Occupant Performance Driving Green Investment in Existing Commercial Buildings*. McGraw-Hill Construction, CB Richard Ellis, and the University of San Diego's Burnham-Moores Center for Real Estate, 17 Nov. 2010.
- *Green Leases Toolkit 2.0*. California Sustainability Alliance. <http://sustainca.org/green_leases_toolkit>
- Eichholtz, Piet, N. Kok and J.M. Quigley. *Doing Well by Doing Good? Green Office Buildings*. UC Berkeley: Berkeley Program on Housing and Urban Policy, 2009. <http://escholarship.org/uc/item/507394s4>
- Jewell, Mark T. "Energy-Efficiency Economics: What You Need to Know". *HPAC Engineering* (January 2003): 38-46.

Management Framework

- *The High Performance Portfolio Framework: Energy Management Strategies for a Competitive Office Market*. BetterBricks, the commercial initiative of the Northwest Energy Efficiency Alliance. <http://www.betterbricks.com/graphics/assets/documents/BB_RealEstate_Framework_R4.pdf>
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Basic Tools

- *ENERGY STAR Portfolio Manager*. U.S. Environmental Protection Agency. <http://www.energystar.gov/istar/pmpam>
- *ENERGY STAR® Snapshot: Measuring Progress in the Commercial and Industrial Sectors*. U.S. Environmental Protection Agency, Fall 2010. <http://www.energystar.gov/index.cfm?c=business.bus_energy_star_snapshot>
- *CalARCH: California Building Energy Reference Tool*. Lawrence Berkeley National Laboratory. <http://poet.lbl.gov/cal-arch/about.html>
- *EnergyIQ*. Lawrence Berkeley National Laboratory. <http://energyiq.lbl.gov/>
- *Experience Exchange Report®*. BOMA International and Kingsley Associates, Autumn 2010. <http://www.boma.org/resources/benchmarking/Pages/default.aspx>
- *Office Buildings: Standard Methods of Measurement and Calculating Rentable Area*. ANSI/BOMA Z65.1. BOMA International, 2010. <http://www.boma.org/MeasurementStandards/Pages/officestandard.aspx>
- *BOMA Kingsley REPORT: Practical Industry Intelligence for Commercial Real Estate*. BOMA International and Kingsley Associates, Autumn 2010. <http://www.boma.org/SiteCollectionDocuments/Org/Docs/BKR.pdf>
- *Income / Expense Analysis® Reports*. Institute of Real Estate Management. <http://www.irem.org/irempublications/ie.cfm>
- *Operations and Maintenance Benchmarks*. Publication no. RR#32. International Facility Management Association, Spring 2008. <http://www.ifma.org/resources/reports/pages/32.htm>

Energy Tracking

- Effinger, Mark, H. Friedman and D. Moser. *Subtask 4.2 Research Report: Investigate Energy Performance Tracking Strategies in the Market*. Prepared by the California Commissioning Collaborative for the California Energy Commission's Public Interest Energy Research (PIER) Program, Sept. 2010. <http://www.cacx.org/PIER/documents/Subtask_4-2_Report.pdf>
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System Tracking

- Greensfelder, Erik, H. Friedman and E. Crowe. *Subtask 4.4 Research Report: Characterization of Building Performance Metrics Tracking Methodologies*. Prepared by the California Commissioning Collaborative for the California Energy Commission's Public Interest Energy Research (PIER) Program, Nov. 2010. <http://www.cacx.org/PIER/documents/Subtask_4-4_Report.pdf>
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Related Organizations

The organizations listed below are driving action and thought leadership around building performance tracking, energy efficiency, commissioning, and facilities management. In addition to this list, many utility companies offer free resources, workshops, training, and information on rebate programs through regional energy centers. It is highly recommended that owners contact their local utility to find out what is available.

Guides and Resources for Building Owners / Property Managers

- California Commissioning Collaborative (CCC)
  www.cacx.org
- EPA ENERGY STAR
  www.energystar.gov

- Portland Energy Conservation, Inc. (PECI)
  www.peci.org
- BetterBricks
  www.betterbricks.com
- Natural Resources Canada
  http://oee.nrcan.gc.ca/commercial/

Industry Groups for Building Owners / Property Managers

- Building Owners and Managers Association (BOMA)
  www.boma.org
- International Facility Management Association (IFMA)
  www.ifma.org
- Institute of Real Estate Management (IREM)
  www.irem.org

Engineering & Building Certification Resources

- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
  www.ashrae.com
- U.S. Green Building Council (USGBC)
  www.usgbc.org
- Building Commissioning Association (BCA)
  www.bcxa.org
- Building Operator Certification (BOC)
  www.theboc.info

Energy Industry Research

- California Energy Commission (CEC)
  www.energy.ca.gov
- American Council for an Energy Efficiency Economy (ACEEE)
  www.aceee.org
- Lawrence Berkeley National Laboratory (LBNL)
  www.lbl.gov

Useful Acronyms

AHU	Air handling unit
BAS	Building automation system
Btu	British thermal unit
CBECS	Commercial Building Energy Consumption Survey
CDD	Cooling degree days
CEUS	California Commercial End-Use Survey
cfm	Cubic foot per minute
CMMS	Computerized maintenance management system
CO_2	Carbon dioxide
EBCx	Existing building commissioning
EER	Experience Exchange Report
EIS	Energy information systems
EUI	Energy use intensity
FDD	Fault detection and diagnostics
HDD	Heating degree days
HVAC	Heating, ventilation, and air conditioning
kW	Kilowatt
kWh	Kilowatt-hour
LEED	Leadership in Energy and Environmental Design
M&V	Measurement & verification
NOI	Net operating income
O&M	Operations and maintenance
SaaS	Software as a service
VAV	Variable air volume

End Notes

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5. Jewell, Mark T. "Energy-Efficiency Economics: What You Need to Know." *HPAC Engineering* (January 2003.): 39.

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14. *Income / Expense Analysis® Reports*. Institute of Real Estate Management.

15. *Office Buildings: Standard Methods of Measurement and Calculating Rentable Area*. ANSI/BOMA Z65.1. BOMA International, 2010.

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17. *Portable Dataloggers: Diagnostic Tools for Energy-Efficient Building Operation.* Prepared by Portland Energy Conservation, Inc. for the U.S. Environmental Protection Agency and the U.S. Department of Energy, Sept. 1999.

18. *Building Energy Information Systems: State of the Technology and User Case Studies*. Granderson, Jessica, M.A. Piette, G. Ghatikar, P. Price. LBNL-2899E. Lawrence Berkeley National Laboratory, Nov. 2009: 31.

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20. *Fault Detection and Diagnostics: Moving the Market and Informing Standards in California*. Prepared by the Western Cooling Efficiency Center for the California Energy Commission, Mar. 2011.