

**Zero Energy Commercial Building Codes Consortium:
Benchmarking and Performance Assurance Working Group Draft Report
September 2010**

OVERVIEW AND DEFINITIONS

Energy-efficient performance is a critical component and necessary condition of zero-energy commercial buildings. A building's performance is highly variable and complex, shaped by a web of dynamic interactions between its physical structure, mechanical systems, facilities operation and management, occupant behavior and space uses, and external factors like weather and climate. Many buildings that we expect to perform efficiently are actually very inefficient, while some constructed 40 or 50 years ago outperform new buildings designed to comply with rigorous energy codes. In many cases, we lack simple energy usage baselines and reliable energy performance metrics about the commercial building stock. Our knowledge of building performance is limited, yet it is clear that we cannot make the meaningful strides that will achieve broad-scale zero-energy commercial buildings if we cannot answer fundamental questions about how and why buildings use so much energy.

Benchmarking and performance assurance are indispensable tools that increase our knowledge of building energy performance, help us identify energy improvement opportunities and measure our progress toward zero-energy buildings. Benchmarking refers to the establishment and use of metrics for comparison of energy performance. These metrics may include results from comparable (peer group) buildings, a building compared to itself, best-practice references, codes and standards, or a goal, such as zero-energy. The best benchmark for any given case will depend on what is being measured and the specific questions to be addressed. Benchmarks are typically expressed as an amount of energy used within a set unit of measure, with the most common being the sum of the energy used per square foot of conditioned space, which results in an energy-use intensity (EUI) metric. For a benchmark to be relevant and appropriate, the comparison should identify and eliminate the effect of neutral variables, those that affect total energy use but are *not* being evaluated. Typical examples in this "normalization process" include building operating schedule and climate, although many other factors can also apply.

Performance assurance addresses policies and practices needed for achieving and sustaining building energy performance. The most cost-effective path to net-zero requires assuring best potential building energy performance in the field prior to supplementing with renewable energy, then making sure performance is maintained at net-zero over time. Performance assurance includes the following measures:

- New and existing building commissioning.
- Ongoing commissioning, energy performance tracking and energy savings verification, including the technologies used to accomplish these activities (EIS, FDD, control optimization routines).
- Facility operations and maintenance.
- Occupant behaviors that affect building energy performance.

The intended audience and beneficiaries of this report is the commercial building industry stakeholders, and any findings and recommendations are aimed for their benefit and use. In instances where a recommendation has an unspecified audience or actor, the audience or actor is intended to refer to industry partners and stakeholders.

TRENDS AND OPPORTUNITIES

Benchmarking

Benchmarked data is the basis or reference for all levels of recognition, ratings and compliance of building energy performance. Establishing a reasonable and valid reference to which a building is compared is the technical backbone of energy points in the U.S. Green Building Council's LEED system, the U.S. Environmental Protection Agency's Energy Star benchmarking tools, the Green Building Initiative's Green Globes rating program, building energy codes and standards, government and utility energy efficiency programs and several energy benchmarking laws.

Benchmarking can involve an evaluation of the building's physical characteristics, often referred to as an asset or "as-designed" rating, or an evaluation of a building's actual energy performance, known as an operational rating. An asset evaluation provides insight into a building's potential to approach net-zero energy usage based on energy modeling simulations. It is critical to both owner and design team decision-making to accurately estimate predicted energy use of a building and its systems. There are nine IRS-qualified energy modeling software tools for establishing the baseline energy use and estimated savings of commercial buildings¹, yet, there is typically a gap between predicted vs. actual energy use for the majority of buildings². New efforts to improve the predictive capability of design models include the Commercial Energy Services Network (COMNET), which provides standards for consistent baseline modeling.

Operational evaluation determines how close a building is to net-zero energy use based on utility bills. Operational benchmarking often compares building performance to the performance of other buildings using regional or national datasets. The largest and most widely used database is the U.S. Department of Energy's Commercial Building Energy Consumption Survey (CBECS). The most recently published data (from 2003 experience) includes building characteristics and energy usage statistics from roughly 5,200 buildings. The total number of surveyed buildings can be insufficient for statistically valid comparisons when parsed by vintage, activity type, climate, schedule and other characteristics. Separately, the State of California has developed the California Commercial End Use Survey (CEUS), a 2006 comprehensive study of commercial sector energy use that supports the State's energy demand forecasting activities. A stratified random sample of 2,790 commercial facilities was collected from the service areas of Pacific Gas & Electric, San Diego Gas & Electric, Southern California Edison, Southern California Gas Company and the Sacramento Municipal Utility District. The sample is stratified by utility service area, climate region, building activity type and energy consumption level.

Ideally, building operators will be able to access both asset and operational evaluations to identify gaps between potential and actual performance. Eventually benchmarking must progress to the system level in order to be truly informative and actionable. The development of new

¹ http://www1.eere.energy.gov/buildings/qualified_software.html

² NBI EPA and USGBC studies, others

tools, such as Lawrence Berkeley National Laboratory's action-oriented EnergyIQ, are beginning to address this area, and developers of emerging tools such as Building Information Modeling (BIM) are exploring the possibility of linking these design tools to measured data in a way that would support focused system and feature benchmarking.

There are an increasing number of commercially available tools which provide some benchmarking capability. The nation's most popular benchmarking tool, Energy Star's Portfolio Manager, benchmarks operational building energy performance against similar buildings nationwide on a numeric scale using CBECS data. Energy Star has a similar tool for new buildings. Called Target Finder, it rates predicted energy performance as determined by energy modeling.

Two other commercial rating systems are under development. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) is piloting the Building Energy Quotient (Building EQ) rating system. The EPA and U.S. Department of Energy are developing the National Building Rating Program (NBRP). Building EQ includes an operational and an asset rating designed for side-by-side display. The program uses a letter-based technical scale that incorporates benchmarks (such as building energy codes) to contextualize the relative energy performance of a building. The NBRP aims to create a standardized commercial building rating methodology and an energy label, although details of the program are unknown at this time.

A new commercial energy measurement standard is also being developed by ASTM International. Standard WK24707, also known as the Building Energy Performance Assessment (BEPA) standard, creates rules for the measurement and reporting of building energy consumption during the due diligence phase of a building transaction. The standard is primarily concerned with energy measurement and reporting protocols and does not benchmark or comparatively rate the energy consumption of buildings but could potentially be applied in conjunction with other rating or benchmarking systems.

Performance Assurance

In the area of performance assurance, there are four key forward-looking U.S. trends that demonstrate opportunities for lasting changes in the commercial building market. While not common practice, these trends give insight into the direction the market may advance.

Automation of building analysis, fault detection and building optimization. The trend toward automation has mainly occurred for large commercial buildings through energy information systems that automatically process data from various sources, automated energy anomaly detection (using statistical energy models normalized for driving variables to predict energy use and compare this to actual usage) and system-level fault detection tools. Fault detection tools (expert rules) are getting easier to implement and have gained some limited market traction³.

The cutting edge of automation includes automated functional performance testing of buildings as well as continuous optimization routines that dynamically optimize energy and performance. The automation of demand response sequences is also becoming more prevalent, especially with the focus on using the smart grid infrastructure for two-way communication with end-users. In addition, BIM is now being used to compare performance data with design targets. In the market, large owners are beginning to use automated tools to gather data, detect problems and track

³ California Commissioning Collaborative, 2010. "Improving the Persistence of RCx Benefits: Energy Anomaly and System Fault Detection Toolsets". Prepared for the California Energy Commission Public Interest Energy Research Program.

results over time. Some of these automation technologies are being applied to medium-sized buildings, especially within campuses or chains; however, the general commercial building market has not implemented energy performance tracking tools.

Policy mechanisms that create trigger points for performance improvement and assurance.

Numerous states are addressing the need for performance assurance through codes and legislative mandates. Codes are beginning to incorporate commissioning activities, and new mechanisms for requiring building improvements at the point of sale are becoming prevalent. Rating systems such as LEED include commissioning and performance assurance activities and promote periodic re-rating.

Service approaches that promote long-term relationships and persistence. Traditional commissioning for new and existing buildings has followed a consulting model that is typically project-based rather than an ongoing service. As building systems get more complex and owners wish to maintain lasting benefits of commissioning, there is movement toward long-term relationships with consultants or contractors to ensure performance over time. Examples include:

- **Consulting approach.** Texas A&M's Energy Systems Lab is one model of this approach, where commissioning includes implementation services and ongoing performance tracking.
- **Software as a service.** There is a significant trend toward energy performance tracking software as a service, where data is hosted and technical consulting services help building operations staff interpret data and diagnose problems.
- **Delivery of heating and cooling services.** Outsourced O&M service relationships are beginning to expand into the delivery of heating and cooling service. For example, refrigeration equipment manufacturers are starting to deliver refrigerated space rather than simply selling the equipment. This trend can be expected to expand with the increased complexity of systems and attention toward ongoing performance.

Willingness to address occupant behavior change. In relation to performance assurance, occupant behavior is often overlooked. With the desire to achieve zero-energy buildings comes a renewed interest in combining technology solutions and service approaches with changes in behavior. Methods to get occupants involved in and accountable for building energy performance include company policies, triple-net leases and tenant challenges and competitions. Widening comfort conditions are also beginning to gain favor.

GAPS AND BARRIERS

Benchmarking

The barriers to widespread effective use of benchmarking to improve energy performance fall into three categories: 1) the very limited and delayed benchmark data available, 2) cost and accuracy issues with asset and operational evaluations, and 3) the lack of effective connections between basic benchmarking results and clearly actionable information.

- **Data Limitations:** Limitations exist in number of sampled buildings, frequency of sampling, timeframe for release of results and inclusion of sufficient data characteristics for complete normalization. A richer database of sub-metered data, by building type, is needed for benchmarking.

- **Tools and Procedures:** Energy Star Portfolio Manager uses a statistical scale that does not measure a building's relative performance compared to zero-energy, making it difficult to use in a zero-energy context. It is free, helping it achieve broad market penetration, but offers no tailored energy improvement solutions. The ASHRAE Building EQ tool is set on a technical scale with zero-energy as the baseline; it requires an energy audit to determine an operational rating, however the cost of the audit is a potential concern, especially for owners of smaller commercial buildings. The ASTM BEPA standard standardizes the energy data collection and reporting process but does not specify any benchmarks.

For asset evaluations, a methodology does not yet exist. ASHRAE's Building EQ labeling program is a potential solution; however, the high cost of an asset rating assessment is a deterrent.

- **Programs:** Existing programs that impact energy efficiency are fractured and have no common protocol or procedures to collect measured performance results.
- **Inconsistency:** Inconsistent nomenclature, imprecise definitions of activity type, variations in measurement of building area, and wide-ranging interpretations of occupancy and schedule all dilute the accuracy of benchmarking data. As benchmarking moves from an optional act to one with results tied to regulatory compliance or financial penalties/incentives, problems with these inconsistencies will become more apparent. Even when clearly and consistently defined, different activities that have distinct *averages* for activity-required factors such as schedule and equipment will still encompass a wide range for the values of these factors *within* each type.

Performance Assurance

The development of performance assurance processes is occurring in the U.S., but at a pace insufficient to move the market to net-zero within the desired timeframes, if ever. Lack of market incentives, barriers to technical integration and a lack of accountability with regard to energy performance goals are key issues of concern. The following section describes these barriers divided into three broad areas: financial, technical and market.

Financial: While market incentives and programs exist that promote performance assurance, incentives do not spur action at a large scale or at an integrated whole building level.

- **Incentives to save energy are misaligned.** Often the parties with the greatest ability to impact energy use have the least incentive. O&M staff and occupants are not rewarded for energy performance, nor provided the tools or training to understand potential impacts.
- **Utility energy efficiency programs are not viewed as a resource on par with supply-side options.** Since energy efficiency programs are expensed and not capitalized, they are not valued on par with constructing new power plants. Without earning a rate of return on energy efficiency programs, utilities have no clear financial incentive to invest in all cost-effective energy savings opportunities.
- **Historical approaches to energy savings are based on incremental measures.** Measure-by-measure approaches to saving energy move us incrementally toward net-zero but do not provide the required holistic solutions. Utility regulatory requirements most often support the measure-by-measure approach.

Technical: Significant technical barriers exist to scalable and automated solutions for integrating HVAC, lighting, refrigeration, renewable and distributed generation, and demand response.

- **Custom solutions reign.** Systems are generally difficult to integrate consistently, and automated solutions such as fault detection tools and continuous optimization have had limited uptake.
- **The workforce is not prepared.** There is a limited workforce that is skilled in making buildings work in an integrated way (designers, Cx providers, O&M staff). It will only get more complex as additional systems are added in an effort to achieve net-zero.
- **Small commercial is neglected.** The focus for automation has been at the large commercial building level. It is very difficult to provide cost-effective solutions for the small commercial market.

Market: A lack of accountability for energy performance and consistency of delivery processes exist.

- **While energy performance goals are becoming widespread, no entity is accountable to meet design or operation targets.** Inherent problems (sub-par performance relative to design, poor hand-off and training for operators, limited attention to ongoing operations) lack a mechanism for accountability to actual energy performance results. Some owners are implementing performance-based service contracts, which are a useful start in defining accountability for energy performance. But what to measure and how to compare metrics to design models are key barriers.
- **Inconsistent commissioning scopes are specified, and varying results are delivered to owners.** The commissioning process is often fragmented, with results that may not support zero-energy goals. Commissioning as an incidental service in the life of a building is not well positioned to assure zero-energy performance.

I. POLICY CONSIDERATIONS

Commercial benchmarking and performance assurance policies are not widespread in the United States. Until recently, legislators have shown relatively little interest in building energy performance policy. Those dynamics are beginning to change. In the past few years, two states – California and Washington – and four major cities – New York, Austin, Seattle and Washington, DC – have enacted benchmarking and data disclosure policies for privately owned buildings. Additionally, the New York City policy requires periodic energy audits and retro commissioning, while the Austin policy requires energy audits (and mandatory upgrades in some cases) for multifamily buildings. With similar policy activities underway in more than a half-dozen jurisdictions and new support for benchmarking and performance assurance initiatives by the Obama administration, a proliferation of policies appears possible or even likely over the next five years.

Current U.S. benchmarking regulations are already set to have a significant impact on property markets. In New York City alone, roughly 22,000 buildings totaling more than 2 billion square feet of floor space must be benchmarked by 2012. In Austin and Seattle, a combined 9,000 commercial buildings and more than 7,000 multifamily buildings will be affected by new benchmarking and audit regulations. States and cities have tailored rating and disclosure policies

according to local needs and political considerations. This has resulted both in policy innovation and widely varying requirements between jurisdictions.

Voluntary or Mandatory?

Voluntary benchmarking and performance assurance initiatives have had a small overall impact on the massive commercial real estate industry. The majority of commercial building stock has never been benchmarked, audited or retro commissioned. Energy Star Portfolio Manager has achieved significant penetration in some large real estate markets, yet only 130,000 buildings comprising less than 3 percent of the national commercial stock have been cumulatively benchmarked over the past decade.⁴

Benchmarking and performance assurance policies can achieve greater market penetration much more quickly than voluntary initiatives and can play a significant role in reducing energy consumption in new and existing buildings in the following ways:

- **Catalyzing market demand for energy-efficient buildings:** Real estate consumers do not have access to building energy performance data when considering leasing, buying or financing a building. With transparent benchmarking data and comparative energy ratings, the market can compare energy performance and create demand for efficient buildings, thus creating competition among owners to improve building performance.
- **Increasing accountability:** Measured performance, such as benchmarking, energy audits, BIM and commissioning and retro commissioning, will make architects, engineers, builders and operators more accountable for building performance by completing the feedback loop.
- **Capturing measured data:** Utilities, policymakers and building stakeholders can use benchmarking and performance assurance data to learn which buildings are efficient or inefficient and why buildings perform well or poorly. This will result in smarter public policy related to building energy efficiency, targeted financial incentives to improve performance and better building design, construction and operation by industry stakeholders.

With little guidance on benchmarking and performance assurance policy, state and local governments have taken the initiative. While local policy innovation should be encouraged, this trend has the potential to create market confusion as more local policies are enacted and more rating systems (some of which may be incompatible with each other) become operational. Other barriers include:

- Very few performance assurance policies.
- Opposition to benchmarking and performance assurance policies by building owners.
- Difficulty in quantifying energy reductions from benchmarking and performance assurance.
- Insufficient national data sources on measured consumption of buildings.
- Little involvement or interest from real estate finance community.

RECOMMENDATIONS FOR ACTION

⁴ EPA Energy Star Snapshot Spring 2010 report

Benchmarking Recommendations

Effective benchmarking requires more data availability and a suite of tools to create useable feedback from the whole building to the more granular level of occupant, system and operating characteristics. Actions to fill the above gaps and circumvent the barriers include:

- 1. Encourage improvements in existing commercial buildings energy consumption surveys, including depth of coverage, frequency, and methodology.** Databases of sub-metered data for all building types should be developed.
- 2. Establish and develop a national measured performance database.** Alternatives to existing commercial buildings energy consumption surveys, even if they do not generate a statistically representative picture of all regions of the country or new construction, are essential to foster competition to be the best and/or achieve more fixed goals such as net-zero energy usage.
- 3. Gather all Public Building energy data in the next five years.** This important and diverse data could be used to test and inform benchmarking and retrofit strategies for the private sector while making significant energy efficiency gains in the public sector, saving taxpayer dollars used for energy costs.
- 4. Standardized Data Collection Methodology.** It is recommended that governmental agencies seriously consider industry efforts directed at standardizing data collection methodology, such as the ASTM BEPA standard. This would result in a level playing field for all building operating energy data collected and reported and provide a firm and transparent foundation for benchmarking initiatives.
- 5. Monitor Asset Evaluation.** Experience gained over the next few years in the asset rating of ASHRAE's bEQ program should provide sufficient information on which to base other asset rating programs and procedures, whether for use in the public or private sector.
- 6. Untie restrictions on disclosure of existing building energy use data sets.** Certainly, appropriate options for anonymity and additional screening protocols for reasonability of this self-reported data will be needed, but facilitated access for research and benchmarking purposes would be a major step forward.
- 7. Increase availability of benchmarking data.** Implement approaches taking advantage of modern smart grid data availability, building management systems, data management and communications technologies to create an automated way to populate the minimum required information (location, gross square footage, activity type) so very timely data could be available.
- 8. Improve normalization capabilities and other inconsistencies in benchmarking assumptions.** Foster consistent use of a single set of activity types with unambiguous definitions and protocols for normalization. A statistically representative field survey on building type, worker type, occupancy data, daylighting potential, current controls status and other information can be used to develop probability functions for various space use types. This will help improve the accuracy of predictive models and provide updated information to inform the next generation of codes and standards.

9. **Promote better tools for interpreting and acting on benchmark results.** Support easy-to-use high-level tools and metrics that extract as much useful insight as possible from readily available benchmark data, and automatic translation from basic metrics to actionable information.
10. **Support benchmark scales such as zEPI, for credible, forward-looking benchmarks.** For the ultimate zero-energy goal, forward-looking benchmarks are essential, rather than reliance solely on historic norms. Successful implementation will also require better linkage of modeling and real-world measured results.
11. **Train Building Operators on the use of benchmarking.** Provide training on simplified tools and benchmarking to the majority of building operators.

Performance Assurance Recommendations

As an overarching recommendation, the commissioning process needs to be integrated throughout building delivery and operations in order to deliver net zero energy in: a) new buildings and maintain them over time, and b) existing buildings as possible, considering the as-built infrastructure. The increasing complexity of systems and integration requirements may lead to more scalable solutions in a service provider model, except potentially for large owners that can develop approaches for their portfolios. There are three key recommendations:

1. **Create a framework for accountability and verification of zero-energy performance in design, construction and operations.** Without a mechanism for accountability through a combination of direct mandates and public disclosure requirements, the market will not meet an aggressive net-zero timeline.
 - a. **Codes set the baseline.** New construction codes should support integrated system design. The energy models developed during design should be quickly calibrated to actual performance to help identify when new buildings do not meet their targets. Additional code triggers for performance assurance over time (point of sale, renovation, lease, periodic) are important for improving performance of the existing building stock.
 - b. **Define accountability for energy performance and set benchmarks by building type.** Owners should be accountable for meeting energy performance targets, and they may pass this accountability on to their design and operations teams. Building occupants will also need requirements set by the owner related to space use and plug loads.
 - c. **M&V Standards and reporting.** Buildings must adhere to M&V protocols and reporting requirements to prove net-zero building performance.
2. **Demonstrate the feasibility of delivering systems that integrate all building energy performance components and track performance over time.** To cost-effectively achieve targets net-zero energy buildings will need to integrate loads (HVAC, refrigeration, lighting, plug loads), generation (distributed generation and CHP), and demand response. These systems should be designed in a more scalable fashion where standardized system control routines can be developed to streamline and automate the performance assurance process. The systems should be designed or retrofitted to track energy performance and implement M&V requirements. Further, the systems should automatically detect faults and, where possible, continuously optimize system operation.

- 3. Determine the value of net-zero energy buildings and demonstrate proactive business models for delivering energy performance through pilots and partnerships.** For new buildings, approaches such as “design, build, operate, maintain” - which includes full-service building construction and ongoing management of facilities - should be tested and, if valid, promoted. Traditional designer, contractor and commissioning provider models should add a framework for accountability. In existing buildings, various business models for assuring integrated performance in scalable ways should be tested, including O&M service provider delivery of heating and cooling services and in-house low-energy building programs within large real estate companies or retail operations. Innovative mechanisms for incentivizing occupants to save energy should be tested in parallel.

CBC Years 2/3: Near-term actions

There are a number of near-term prerequisites for the long-term changes described in this chapter:

1. There is significant need for a better understanding of energy performance tracking options for owners and the management systems integral to making changes, as well as the expected savings from implementing these systems and research on the accuracy of fault detection systems.
2. The industry needs clear, cost-effective M&V standards and tools to certify net-zero.
3. Workforce development of engineers and technicians with building science expertise is necessary to scale the industry up quickly.

Building Rating Program Recommendations

In designing a wide-scale building rating program, this working group suggests that the following actions be considered:

1. **Build on existing rating systems.** A wide-scale program should build on and leverage significant market penetration, consumer recognition and consumer trust of existing systems and programs, such as Energy Star and ASHRAE BEQ. Such a program could also gain valuable insight from other measurement protocols such as the forthcoming ASTM BEPA standard and rapid energy modeling⁵ workflows (such as those from Autodesk). An asset rating should build on the existing system of commercial building ratings based on energy modeling comparisons to codes and standards. The most widely used commercial standard is ASHRAE 90.1. Additionally, COMNET technical procedures in energy modeling for asset ratings, code compliance, tax deductions and other applications could be leveraged in such a system.
2. **Bring stakeholders together.** To cultivate broad acceptance and support for wide-scale building asset and operational rating, industry stakeholders from all major interests need to engage, including from the real estate and financial industries, property management and consumer interests, ratepayer efficiency programs, state energy offices, weatherization providers and efficiency advocates.

⁵ A streamlined process that involves moving rapidly—and with minimal data—from image capture of building exteriors through simplified simulation to building energy analysis

3. **Incorporate local flexibility into a larger program.** A wide-scale program for building energy rating should be malleable at the state and local levels to meet specific policy needs related to benchmarking, disclosure, performance assurance, data collection and incentives.
4. **Design financing and retrofit programs.** Benchmarking and performance assurance strategies will become significantly more effective when combined with retrofit financing. Further development of auditing and modeling tools such as rapid energy modeling will also encourage more retrofits.
5. **Incorporate building information modeling (BIM⁶) in operations and maintenance phase.** BIM applications go beyond the design and construction phase of the building lifecycle. There is strong interest from the commercial real estate and architecture, engineering and construction communities to develop workflows that connect models derived through BIM with building management systems.
6. **Lead by example.** State and local public agencies should “lead the way” by benchmarking, auditing and retro-commissioning their own facilities and publishing those ratings and supporting data.

⁶ An integrated process for exploring a project’s key physical and functional characteristics digitally before it’s built. The coordinated, consistent information used throughout the BIM process helps architects, engineers, contractors, civil engineers, and owners to see what their design will look like and how it will perform