HIGH PERFORMANCE BUILDINGS:
Achieving Superior Performance for Life

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Trane

EXECUTIVE SUMMARY

The high performance building concept has been around since the late 1990s, starting with the high performance schools movement that has since been embraced by school districts in most states. A decade later, high performance building principles are being applied worldwide in nearly every type of structure, from schools and municipal buildings to hospitals, technology centers, industrial plants and other kinds of facilities.

Studies have demonstrated that high performance buildings use fewer resources, have a smaller environmental footprint and provide a better place for people to work, visit and live. High performance buildings tend to have better occupancy rates, command higher rents and retain value or appreciate faster than comparable structures in the same real estate market.

So it stands to reason that more new buildings than ever before are being designed to enhance their performance in such dimensions as energy and water efficiency, environmental impact, operational reliability and occupant health and welfare. Meanwhile, owners and operators of existing buildings are using new technologies and practices to turn their older facilities into high performance buildings.

"The best sustainable designs are not just environmentally responsible. They also produce buildings where employees can thrive and productivity can soar. We call these high performance green buildings."

U.S. Green Building Council

High Performance Requires a Focus on Total Lifecycle Costs

The process for designing and constructing a high performance building represents a small fraction – between 5 and 10 percent – of the total lifecycle cost of a typical building, according to estimates from the National Institute of Building Sciences (NIBS) and the International Facilities Management Association (IFMA).

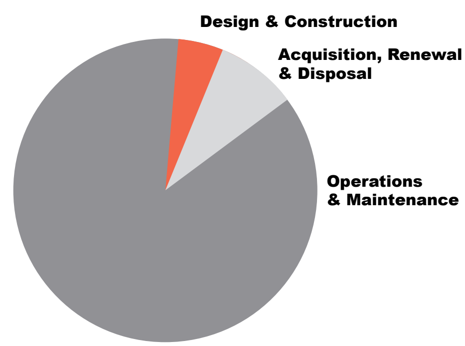
Acquisition, renewal and disposal costs are typically between 5 and 35 percent of lifecycle costs. Operating a building throughout its decades-long occupied life accounts for the largest share by far, representing between 60 and 85 percent of total lifecycle costs.

That is why it is important to consider all costs – not just first costs – when looking for ways to maximize return on the enormous investment that public and private enterprises make in the buildings that are crucial to achieving their missions.

Resource efficiency and environmental impact are often the first things that come to mind upon hearing the term "high performance building." Of course these dimensions of performance are critically important and often provide the initial justification for choosing "green," energy-efficient and water-efficient options during the design and construction phase, even in cases where these choices result in slightly higher building costs.

In fact, the incremental cost of building a fully-functioning high performance school or office building is relatively small and, in many

Typical Total Cost of Ownership



Source: National Institute of Building Sciences cases, there may be no construction cost premium at all. According to U.S. Green Building Council (USGBC) findings, incremental costs range from 0.66 percent to 6.5 percent, depending on building type. Meanwhile, lifecycle energy and operational efficiencies yield savings of between 20 percent and 50 percent per year, compared with conventional buildings.

These savings enable organizations to reduce their energy, operating and maintenance budgets and redeploy their increasingly scarce financial resources to other priorities that directly benefit their stakeholders.

A poorly designed building operated and maintained effectively will often outperform a well-designed building with poor operating and maintenance practices.

High Performance Buildings Improve Organizational Effectiveness

But as our thinking has evolved, the definition of "high performance" has expanded beyond the realm of energy efficiency and environmental stewardship. Today's high performance buildings are being designed, constructed, operated and maintained in a way that contributes to organizational and occupant effectiveness.

They must operate reliably, with minimum unscheduled downtime and fast recovery when problems occur, to minimize the effect of building problems on the organization and its stakeholders. They also must provide a safer, healthier and more comfortable environment in which building occupants can do their best – whether they are students, teachers, medical professionals, technicians or office workers.

Maintaining performance throughout the long building lifecycle is no easy task. According to researchers at the Lawrence Berkley National Laboratory (LBNL) who studied nearly 650 facilities to assess the impact of commissioning on building performance "…most buildings drift, often 'invisibly,' to lower performance over time, indicating a need for ongoing performance monitoring and fault detection and diagnosis during routine operation."

ASHRAE – the American Society of Heating, Refrigerating and Air Conditioning Engineers – concurs. In 2009, the society concluded that a poorly designed building operated and maintained effectively will often outperform a well-designed building with poor operating and maintenance practices.

Service and Maintenance Innovations Enable High Performance for Life

These findings underscore the fact that an effective service and maintenance strategy is integral to establishing and maintaining high performance standards throughout a building's occupied lifespan, which can be 50 years, 75 years or even longer. Game-changing innovations are altering the way that building designers, administrators, owners, facility professionals and energy service providers think about keeping building systems running effectively and efficiently over the long haul.

The most effective service and maintenance approaches are holistic, technology-enabled and knowledge-based, with a focus that extends well beyond the run-to-fail and preventive maintenance, task-oriented strategies of an earlier time. Service offerings that support the full range of a high performance building's operations use robust and proven processes, computer modeling, diagnostic testing, predictive technologies and other state-of-the-art techniques.

An effective service and maintenance strategy contributes significantly to achieving best-in-class building performance. Improved efficiency reduces lifecycle costs so an organization can invest in other priorities. Ultimately, a high performance building becomes a strategic asset that helps an organization achieve its primary mission and pays for itself many times during its occupied life.

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WHAT IS A HIGH PERFORMANCE BUILDING?

The high performance buildings concept was a cornerstone of the U.S. Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007, which focus on reducing building-related energy consumption and dependence on foreign energy sources. The 2005 law directed the National Institute of Building Sciences (NIBS) to "explore the potential for accelerating development of consensus-based voluntary standards to set requirements for less resource-intensive, more energy-efficient, high performance buildings."

Comprised of representatives from government, academia, industry associations and the private sector, the High Performance Building Council (HPBC) was formed in 2007 to help develop these standards. The council adopted this definition of a high performance building:

> ***"High performance buildings, which address human, environmental, economic and total societal impact, are the result of the application of the highest level design, construction, operation and maintenance principles – a paradigm change for the built environment."***

NIBS elaborated in a Special Report to the U.S. Congress and Department of Energy on High Performance Buildings, presented to the High Performance Buildings Congressional Caucus in 2008:

> ***"This definition presupposes that buildings must be designed and built in the context of larger human, environmental, and economic concerns, and that high performance building standards are the means for doing so. All the parts of the building need to be addressed in a cohesive, 'whole building' approach, taking into account the ways in which the design, construction, operation, occupancy, repair, usability, extendibility and retirement of buildings are interconnected throughout their whole lifecycle."***

In support of these broad definitions, it is important to emphasize that:

- High performance buildings have standards that are created, measured and continually validated to deliver established outcomes within specific tolerances.
- Standards are typically set for energy and water consumption, system reliability, environmental compliance, indoor air quality and occupant health, safety and comfort. Standards should be set and priorities established with the organization's primary mission and key success factors in mind.
- Standards should be set high enough that the building ranks among the best-performing buildings in its class, as measured against established standards and benchmarks.

Concepts Embrace Every Major Aspect of Building Performance

While energy efficiency and good environmental practices are hallmarks of high performance buildings, it is important to recognize the distinction between high performance buildings and such programs as LEED (Leadership in Energy and Environmental Design), developed by the U.S. Green Building Council (USGBC), and the Energy Star program, which is sponsored by the U.S. Department of Energy (DOE) and the Environmental Protection Agency (EPA).

LEED is an internationally respected third-party verification system. As its name implies, LEED focuses on energy and environmental priorities, measuring building performance along five dimensions: sustainable site development, water usage, energy efficiency, materials and resources used, and indoor environmental quality. According to the USGBC, about 3 percent of all new construction projects have applied for LEED certification.

Energy Star is a government-backed program that helps businesses and consumers choose energy-efficient products and practices. Energy Star began as a voluntary product-labeling program in 1992 and today provides energy guidelines and recommendations for use in homes, buildings and products. The DOE and EPA estimate that businesses and consumers saved enough energy using Energy Star products in 2009 to trim their utility bills by $17 billion and reduce carbon emissions comparable to taking 30 million cars off American roads.

The high performance building concept incorporates elements of both the LEED and Energy Star programs. However, the concept goes substantially beyond the energy and environmental parameters that define these two highly successful programs. The concept encompasses all major high-performance building attributes including energy efficiency, durability, lifecycle performance and occupant productivity.

It is distinguished by the idea that a high performance building that is designed-for-purpose, well constructed and well operated can be

CHARACTERISTICS OF A HIGH PERFORMANCE BUILDING

According to the National Institute of Building Sciences (NIBS) high performance buildings typically have these characteristics:

Cost effectiveness
Cost is the most common measure of efficiency in the design, delivery and operation of a high performance building. While first costs are always a consideration, better measures are full lifecycle costs, cost/benefit analysis and return on investment over expected life of the building.

Safety and security
High performance buildings place a premium on the safety and security of their occupants and consider the potential impact of a building failure on all stakeholders including employees, visitors and neighbors in the community.

Sustainability
Five principles express the NIBS sustainability philosophy: integrated design principles, optimized energy performance, water conservation, enhanced indoor environmental quality and reduced environmental impact of materials.

one of an organization's most valuable assets, capable of making a significant contribution to the effectiveness and efficiency of the people within.

THE HIGH PERFORMANCE SCHOOLS EXPERIENCE

The bulk of America's high performance building experience exists in the public schools, which were early adopters of high performance building concepts.

While the specific application of high performance technologies and practices can vary greatly depending on the building type, location, intended use, occupancy and other factors, high performance schools provide an instructive model for organizations adopting a high performance building approach.

The value of a high performance school is well established, according to Deane Evans, executive director of the Center for Architecture and Building Science Research at the New Jersey Institute of Technology. Professor Evans developed the *High Performance School Buildings Resource and Strategy Guide*.

He emphasizes that high performance schools are holistically designed to take advantage of all design elements, achieve long-term value and performance, provide an enduring asset to the community and create an enhanced learning environment. Professor Evans lists seven key benefits that high performance schools typically deliver:

- Better student performance
- Increased average daily attendance
- Increased teacher satisfaction and retention
- Reduced operating costs
- Reduced liability exposure
- Positive influence on the environment
- Ability to use the facility as a teaching tool

The *High Performance School Buildings Resource and Strategy Guide* includes these building blocks:

Lifecycle Cost Analysis – The school is optimized using a total cost of ownership over time perspective. Initial, operating and maintenance/repair replacement costs are evaluated using lifecycle cost analysis tools.

Indoor Air Quality – Students and teachers suffer no ill effects from the air inside the school. Sources of contamination are controlled, adequate ventilation is provided and moisture accumulation is prevented.

Renewable Energy – The school uses cost-effective renewable resources to meet its energy needs whenever possible. Solar, geothermal, wind and other renewable energy sources are evaluated during the design process.

CHARACTERISTICS OF A HIGH PERFORMANCE BUILDING

Accessibility
Improvements in productivity and efficiency can be gained by recognizing and addressing the needs of people with disabilities, the elderly and others with different accessibility needs.

Functionality
Regardless of any of its other attributes, no building can be called "high performing" if it does not fulfill its intended purpose or meet the needs of its occupants.

Productivity
Employee-related costs are the largest cost of operating any building throughout its lifecycle. High performance buildings enable their occupants to do their best work and contribute to achieving the organization's goals.

Historic Preservation
Reusing or adopting building shells, materials and the like can be cost effective and can help preserve the cultural heritage while improving efficiency.

Aesthetics
Building aesthetics can contribute to the productivity of employees, the reputation of the owner and operator, and the quality of life in the community.

Safety and Security – Students and teachers feel safe anywhere in the building or on the grounds. A secure environment is created by design and access is controlled using security technology.

Thermal Comfort – Temperature and humidity are maintained in the comfort zone to avoid rooms that are hot and stuffy or cold and drafty. Teachers control temperatures in their classrooms.

Acoustic Comfort – Noise is minimized inside and outside classrooms. Studies show a direct link between noise levels and student performance and health; for example, a 2001 study of two otherwise similar schools found that students attending the quieter school scored as much as 20 percent higher on word recognition tests.

Daylighting – Design provides as much natural daylight as possible, particularly in classrooms where daylighting has been shown to correlate directly with improved test scores. Daylighting systems are designed to avoid excess heat loss or gain and minimize glare.

Energy Analysis Tools – The facility is designed to reduce short- and long-term energy costs as much as possible while maintaining a comfortable and efficient learning environment.

Energy Efficiency Building Shell – Walls, floors, roofs and windows are as energy efficient as possible. The building shell integrates and optimizes insulation levels, glazing, shading, thermal mass, air leakage and light-colored exterior surfaces.

Environmentally Preferable Materials and Products – Whenever possible, the school incorporates materials and products that are durable, non-toxic, derived from sustainable-yield processes, high in recycled content and easily recyclable.

Environmentally Responsive Site Planning – To the extent possible, the building site conserves existing natural areas and restores damaged ones, minimizes storm water runoff to control erosion and enhances the building's high performance features.

Visual Comfort – A rich visual environment is provided. Lighting for each room is designed. Daylight and electric light are integrated and optimized. Glare is eliminated.

Commissioning – A formal commissioning process ensures that building systems are operating properly and that the building meets design specifications.

SERVICE AND MAINTENANCE INNOVATIONS ENABLE HIGH PERFORMANCE FOR LIFE

The high performance schools experience validates the fact that an effective service and maintenance strategy is essential to a total lifecycle approach to high performance buildings.

New and innovative intelligent service offerings are especially designed to help high performance buildings of all kinds reach and maintain optimum levels of performance throughout their occupied life.

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Research by the Lawrence Berkley National Laboratory (LBNL) shows that many buildings do not live up to the performance standards their designers anticipated, even when new. Most buildings will begin to perform less efficiently as their functions and uses change, equipment experiences normal wear and tear, and controls strategies and schedules deviate from original design intentions.

The LBNL advocates the systematic, forensic approach called "commissioning" to ensure that buildings deliver or exceed the performance and energy savings goals promised in their design. In a 2009 report, researchers noted that "… commissioning identifies the almost inevitable 'drift' from where things should be and puts the building back on course, often making it perform even better than the original designers intended."

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The concept of "re-commissioning" existing buildings has become a mainstream element to sustainably optimizing building controls and setting operational standards. Re-commissioning follows a similar disciplined process that includes setting operational objectives, benchmarking energy use, inspecting building systems, identifying building deficiencies, estimating performance improvements and making system adjustments. The LBNL estimates that following a disciplined re-commissioning process typically yields energy savings of about 16 percent in existing buildings and that organizations recoup the cost of re-commissioning in first-year savings.

The preferred approach to building systems maintenance has changed dramatically over the last several decades. The traditional preventive approach to maintenance relies on a calendar or hour meter to determine when equipment needs to be serviced. A set of highly prescribed tasks is routinely performed, even though the benefit to ongoing operational performance is often unsubstantiated.

But with today's advanced technologies, building managers have the information they need to perform service when it is actually needed, not just at scheduled intervals. With advanced sensors, microprocessors and techniques such as condition monitoring and fault detection and diagnostics, facilities teams have actionable data to predict and, in many cases, prevent failures before they happen.

Total maintenance costs are significantly reduced when a proactive, information-enabled maintenance approach is adopted. For example, avoided service costs are generated by eliminating scheduled but often unnecessary tasks and planning the repair or replacement of equipment before an emergency breakdown.

The newest results-centered maintenance approach takes intelligent service to the next level by also considering the cost and operational implications of potential failures. Working with service providers or well-trained internal staff, facilities managers can use this information to make faster, better and more cost-effective maintenance decisions while focusing on the services that have the greatest impact on mission-essential operations.

Underscoring the importance of a sound maintenance strategy in achieving high levels of performance for the life of the building, the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) concluded that a poorly designed building with proven operations and maintenance practices will often perform better over time than a well-designed building that is poorly maintained.

Building a convincing business case for taking a high performance building approach requires gathering and analyzing specific project data.

MAKING THE BUSINESS CASE FOR HIGH PERFORMANCE BUILDINGS

A search of the words "high performance buildings" on Google returns more than 10 million results, including useful information on the subject from government, university, industry and other sources. But building a convincing business case for taking a high performance building approach with a new or existing structure requires gathering and analyzing specific project data.

Identify and quantify mission-critical factors

Start building a business case by identifying what is most important to the organization's success. Consider such factors as: customer service; product or service quality; employee, student or teacher productivity; production volume; and other factors. Consider how a high performance building affects the organization's ability to succeed in each category identified and estimate the financial impact if a mechanical failure or other problem interrupts normal operations.

For example:

Building Type	Category	Cost of Failure
School	Health and welfare	Total costs per day of a winter HVAC failure (teacher salaries, revenue from student attendance, cost of student transportation, etc.)
Industrial facility	Reliability/uptime	Total costs per hour of shutting down an assembly line (worker salaries, missed deadlines, restart costs, etc.)
Retail location	Reliability/uptime	Total cost per hour of shutting down a store (lost revenue, employee salaries, lost customer loyalty, etc.)
Municipal building	Health and welfare	Total cost per hour of employee absenteeism due to poor indoor air quality (employee salaries, lost productivity, risk to reputation, etc.)

Armed with this information for each of the organization's critical success factors, administrators and facilities professionals can work with experienced third-party experts to determine how avoiding these costs can justify the slightly higher first costs associated with a high-performance building project in a new or existing building.

Conduct a critical building systems audit

A critical systems audit (CSA) is a valuable tool for determining the current level of performance of critical building systems such as HVAC, water, lighting, electrical, mechanical, controls and instrumentation. A third party can be engaged to help with a thorough CSA or qualified internal staff may choose to conduct a self assessment.

Today's advanced building automation systems provide a wide range of capabilities including web-enabled dashboards that make it easier than ever for audit team members to collect, access and apply relevant information to analyze the performance of building systems.

New predictive modeling technologies compare system and component operating characteristics with aggregated information from many similar systems to evaluate their performance. Other innovations make it possible for technicians to look deep inside HVAC components, uncover potential problems and predict when components will fail, sooner and with greater accuracy than ever before.

Automated HVAC fault detection and diagnostics (FDD) is another potential game-changing technology. FDD can detect and report significant faults in air handlers, chilled water systems, boilers, cooling towers and other critical HVAC components to help find and isolate problems that are currently wasting energy and provide early warning of potential failures.

Self assessment or audit information provides a clear picture of the facility's current health and overall building fitness information that can be used to develop a high performance building proposal using accurate, project-specific data.

Predictive modeling technologies compare system and component operating characteristics with aggregated information from many similar systems to evaluate their performance.

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BUILDING PERFORMANCE SELF-ASSESSMENT EXAMPLE

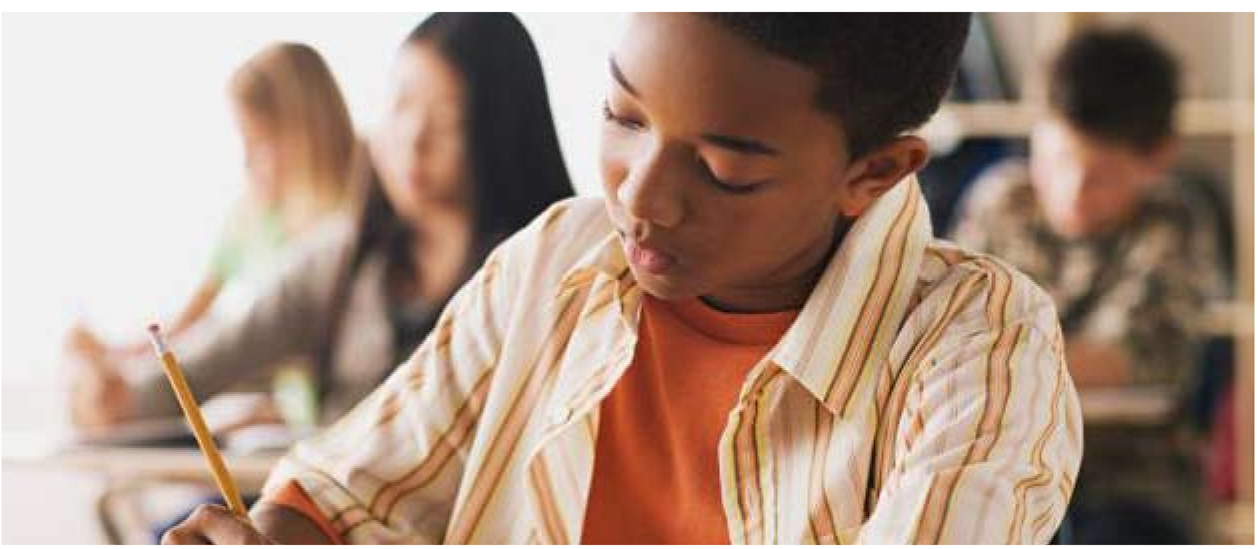
This is an actual self-assessment conducted by a school district facilities team on three buildings – an elementary school, high school and administration building. Information from the assessment was used to develop the district's high performance schools program – creating metrics, benchmarking existing performance and identifying performance gaps to be addressed and improved.

Assessment Category (examples)	Current Performance	Performance Objective	Performance Gap
Energy Performance	(cost/sq-ft)	(cost/sq-ft)	(cost/sq-ft)
Elementary school	$2.15/sq-ft	$1.50/sq-ft	$0.65/sq-ft
High school	$2.90/sq-ft	$2.25/sq-ft	$0.75/sq-ft
Administration building	$3.10/sq-ft	$1.80/sq-ft	$1.30/sq-ft
Occupant Health & Welfare			
Reduce noise levels	NC 35-38	NC 30	NC 5-8
Reduce CO_2 levels (8 hr avg.)	3,000 - 5,000 ppm	500 - 1,000 ppm	2,500 - 4,000 ppm
Reduce CO_2 levels (short term)	12,000 - 15,000 ppm	5,000 ppm	7,000 - 10,000 ppm
Classroom lighting levels	150 - 1,000 lux	250 - 300 lux	-150 - 700 lux
Cafeteria lighting levels	1,000 - 1200 lux	150 - 200 lux	850 - 1,000 lux
Classroom humidity levels	35 - 60% rh	45% - 55% rh	-10 - +5%
System/Component Reliability			
Data storage facility 24/7	99.85%	100.00%	0.15% (13 hours)
Vehicle storage 24/7	99.25%	99.50%	0.25% (24 hrs)
Admin office 60 hrs/wk	99.50%	99.75%	0.25% (8 hrs)
Environmental			
Elementary carbon footprint	675 tons	350 tons	325 tons
High school carbon footprint	2,800 tons	1,100 tons	1,700 tons
HVAC leak check	undocumented	Annual, documented	
Duct cleaning	deferred	assess air quality	
Oil storage, PCBs	undocumented	documented	

CRITICAL AREAS PERFORMANCE PARAMETERS EXAMPLE

Following the assessment shown in the previous exhibit, the school district identified four critical areas for improvement. Following are examples of the acceptable quality limits and validation methods that were established for several systems in each of the four areas.

Critical Areas Served	Equipment System	Performance Parameters-Acceptable Quality Limits	Validation Method
Chemistry lab	Exhaust fan 1	400 cfm	24/7 monitoring
	Unit ventilator 1	100 cfm OA	quarterly inspection
Swimming pool	Air handling unit 1	2,500 cfm	24/7 monitoring
	Pool pump 1	82ºF; 200 gpm	24/7 monitoring
Data storage facility	Rooftop unit 1	48ºF SA	24/7 monitoring
	In-ceiling unit 1	45% RH	annual inspection
Cafeteria	H&V unit 1	8,000 cfm	quarterly inspection
	Exhaust fan 1	9,000 cfm	annual inspection
	Freezer	28ºF	24/7 monitoring



Gather and analyze current energy and operating costs

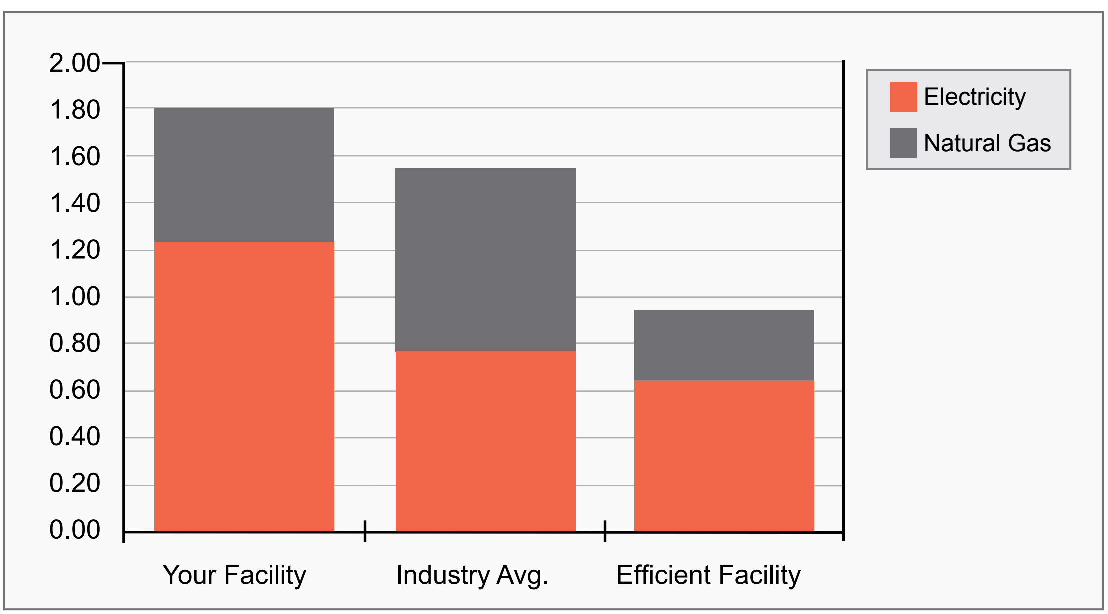
For an existing building, it is important to understand current operating costs and to compare them to the projected costs of operating a more efficient high performance building. An energy services company can help acquire and analyze energy use over a period of several years.

The USGBC estimates that high performance buildings are 20 percent to 50 percent more energy efficient than conventional buildings. In the case of an existing building, an energy engineering specialist can provide more accurate estimates by comparing a particular structure against standard industry benchmarks and peer group facilities.

A wide range of benchmarks are currently available, including the U.S. Energy Information Administration (EIA) Commercial Building Energy Consumption Survey, a nonbiased source of energy information, analysis and forecasting.

The availability of this information and the use of energy analysis tools enable building operators to compare their building's energy performance profiles with industry averages and best-in-class performance for comparable buildings. This graph shows the actual energy use of a particular building, compared with the industry average for similar building types and a best-in-class facility.

Predictive modeling technologies compare system and component operating characteristics with aggregated information from many similar systems to evaluate their performance.



The next step is to calculate the average annual cost of planned and unplanned maintenance, using several years of actual cost data, if available. It is also important to calculate the potential impact of any significant system failure on operations. For example, estimate the cost of responding to an unplanned failure, including the cost of repairs made in a reactive mode. Also consider the disruption to normal operations that an unplanned failure can have and its associated cost.

Evaluate operational benefits of high performance buildings

Finally, high performance buildings deliver several valuable operational benefits including:

- **Human performance –** It stands to reason students are better learners, teachers are better instructors and employees are more productive in an environment that is safer, more secure, healthier and more comfortable. For example, a 2009 Michigan State study found that better indoor air quality, daylighting and other factors result in a productivity boost of between $69,000 and $250,000 in groups moving to LEED offices. Even small productivity improvements resulting from better building performance can make a significant contribution to an organization's success.
- **Organizational performance –** Investments in high performance buildings often result in improved organizational performance by creating a better lit, more comfortable and welcoming place for occupants, customers and visitors. The USGBC cites a recent study concluding that improving the indoor environment has resulted in $20 billion or more in productivity improvements nationwide.
- **Property values –** A 2008 study of more than 1,300 buildings by the CoStar Group found that commercial buildings with the Energy Star label or LEED certification not only performed better, they also commanded premium rents, enjoyed higher occupancy rates and sold for higher prices on the open market.
- **Brand and reputation –** Many organizations consider social responsibility a key element of their brand identity. Having a high performance building can help an organization – whether it is a school district or a private business – attract and retain critical employees, students, customers, suppliers and community supporters.

A high performance building can help an organization attract and retain employees, students, customers, suppliers and community supporters

ACHIEVING SUPERIOR PERFORMANCE FOR LIFE

The technologies that enable high performance buildings have advanced dramatically over the last decade as a focus on costs, energy efficiency and sustainability has become a way of life for those involved in the design, construction and operation of buildings.

But the true potential of the high performance building movement requires a whole building, whole lifecycle approach. Such an approach puts as much emphasis – or perhaps more – on the total cost of ownership over a building's occupied life as it does on first costs.

The cost of operating a building throughout its total lifecycle is typically many times the cost of design and construction. Yet many building owners and operators give comparatively little consideration to the cost of energy, maintenance, service and other factors that can account for as much as 80 percent of total lifecycle costs.

True high performance operation can only be achieved if a building is recognized as a highly complex integrated system that needs to be proactively and continuously managed and maintained to keep it operating at peak efficiency.

High performance buildings are energy-efficient, durable, environmentally responsible and much more. They are not mere brick and mortar or an overhead cost to the organizations that occupy them. High performance buildings are organizational assets with the potential to improve occupant productivity and contribute to achieving mission success.

The true potential of the high performance building movement requires a whole building, whole lifecycle approach that puts as much emphasis on the total cost of ownership as on first costs.

About the author:

Louis J. Ronsivalli Jr. is the global service offers development leader for Trane's commercial systems business of Ingersoll Rand. He is responsible for creating service offerings and platforms and deploying methods for effectively leveraging service growth strategies. Lou is active in the energy and facilities management community, acting as an adjunct faculty member in the continuing education program at Northern Essex Community College. He is also a long-time participating member in the Association of Energy Engineers and the Boston Chapter of the U.S. Green Building Council.

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SELECTED SOURCES OF MORE INFORMATION

Energy Star, www.energystar.gov

High Performance Building Council, http://www.nibs.org/index.php/hpbc

Lawrence Berkley National Laboratory, www.lbl.gov

National Institute of Building Sciences, www.nibs.org

Trane Commercial Building Services, www.trane.com/commercial

U.S. DOE Energy Efficiency and Renewable Energy, www.eere.energy.gov

U.S. EPA, www.epa.gov

U.S. Green Building Council, www.usgbc.org

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