Shaping the Next…

Building and Energy

ASHRAE Journal is highlighting the 2013–14 Presidential theme "Shaping the Next—Our World, Ourselves, Our Work" (http://tinyurl.com/bahnfleththeme) by publishing groups of forward-looking essays about the future of areas of high importance to ASHRAE, our industry, and society. We began in the August issue with a group of articles focused on indoor air quality, a subject that I believe needs to be more in the center of our thinking. This group addresses a subject that has been very much in the center of ASHRAE's strategic goals and efforts for several decades: building and energy.

Paul Torcellini makes the argument that we must strive to get to a level of energy use 50% lower than current standards to make net zero energy buildings feasible and that we can do it with integrated design, but this will require control of plug loads. Larry Brackney highlights the importance of positively influencing occupant behavior to create a "conversation" between occupant and building. I wonder whether this can be extended to other areas like IEQ?

David Wade discusses the role of district energy in a cost-effective, low-energy future and holds up the ideal of low energy communities for our consideration. Eric Richman discusses the next generation of low-energy lighting technology and what needs to be done to realize its promise. Harry Misuriello comments on the important role of "minimum" standards like ASHRAE/IES 90.1 in improving the efficiency of new construction—a 60% reduction in energy use requirements since 1975. He gives a glimpse of a future in which performance-based standards lead in the direction of a net zero energy 90.1 by 2034.

In a related discussion, Steve Baumgartner questions whether energy use intensity, EUI, is the right metric to drive energy use reduction and proposes an interesting alternative. I hope that these short, but provocative reflections stimulate your own thinking.

Finally, Tim Wentz imagines a future in which commissioning and energy labeling work together to minimize energy wasted due to suboptimal operation and maintenance. What could we accomplish if all 50,000+ ASHRAE members put their best efforts into seeing and realizing a future of energy self-sufficient buildings and communities? I hope to find out.

– BY WILLIAM P. BAHNFLETH, 2013–14 ASHRAE PRESIDENT

Getting to Net Zero

BY PAUL TORCELLINI, PH.D., P.E., MEMBER ASHRAE

We probably have heard it too many times, but buildings consume more than 40% of the energy in the U.S. Take a moment to let that sink in—the energy footprint of buildings is huge, accounting for 70% of the electrical grid's end-uses. Is it possible to think about buildings producing as much energy as they consume—the concept of net zero energy buildings, or is that an impossible expectation?

Certainly, there are building types that cannot achieve this goal, but other buildings have the potential to exceed the net zero energy building mark. Making the boundary a bit larger, we can think about net zero energy buildings where warehouses and low-rise commercial buildings provide the power for more dense building types, such as hospitals.[1] There is continued discussion over exactly what net zero energy means, but in principle, we need to think of buildings as collecting energy for efficient use within the building and possibly having the potential to export that energy to buildings that cannot produce enough energy for their own needs. This leads to a discussion about communities that can produce enough energy to power their own buildings.

What does it take to get there? First, minimize the loads with energy efficiency—something that ASHRAE is taking a leadership role on. Efficiency still leads the charge over collecting renewable energy. To effectively get to net zero energy buildings, we need to target energy savings of more than 50% when compared to current standards.

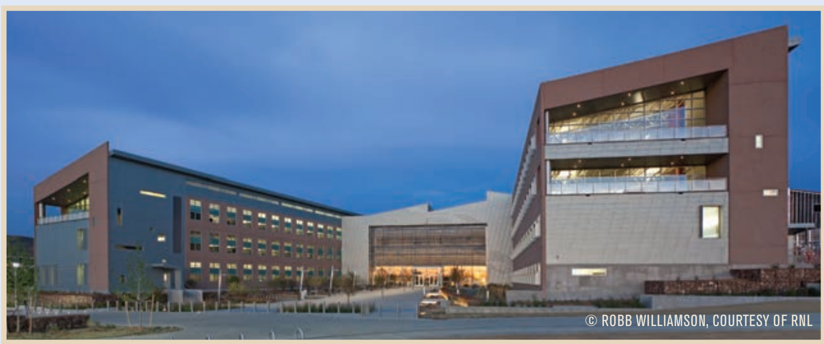
How do we achieve 50% savings? Better integrate our decision making into cost-effective, energy-efficient designs. The decisions we make today mortgage the energy futures of this country. Said another way, decisions in the built-environment are here for a very long time. Consider, if we had thought about net zero energy buildings in the late 1970s when energy efficiency hit the mainstream, we would use 70% the energy for our commercial buildings as we use today.[2]

NREL Net Zero

BY PAUL TORCELLINI, PH.D., P.E., MEMBER ASHRAE

The National Renewable Energy Laboratory (NREL) recently completed a 360,000 ft^2 (33 445 m^2) office, the Research Support Facility. NREL put together a design-build request for proposal that prioritized a list of programmatic, aesthetic, and energy goals. The energy goal was based on a 50% reduction from what normally would have been built. Having an absolute energy goal of 25,000 Btu/ft^2 (79 kW/m^2) annually with all the other programmatic guidance was at the heart of the request for proposal.

NREL competitively selected a design-build contractor based on who would provide the best value for the prioritized set of requirements. The cost was fixed, such that all respondents had the same amount of funding available, yet the scope was variable.



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The owner then selected the team that provided the most scope for the fixed dollars.

The selected team used energy simulations to help guide the design and put limits on the orientation, floor plate width, and window sizing such that the building could be nearly 100% daylit during the day. The plug loads and schedules were specified by the owner, and the design-build team evaluated energy performance with every energy decision.

As part of the value-added scope, the design-build team provided a mechanism to provide enough photovoltaics to make the building "zero net energy" within the budget. After two years of occupancy, the building operates within 2% of the modeled predictions, provides daylighting to 100% of its occupants (typical daytime lighting load is 15 kW), uses radiant heating and cooling, and contains a corporate data center where 100% of the waste heat is captured when the building needs heat. The hydronic-based heating and cooling system is sized at approximately 25% of a typical system in the Denver area. ■

Advanced Lighting Systems

BY ERIC RICHMAN, MEMBER ASHRAE

When people think about advanced lighting systems, lamp efficacy and light emitting diode (LED) come to mind. Others look immediately to potentially complicated controls. Both views have merit and it is likely the combination of the two that will form advancements in lighting energy savings for a fair stretch to come.

A primary driver for advanced lighting for buildings is the building energy code that has been around since the 1970s and adopted by states to meet federal legislation. The legislation currently requires states to adopt a code that meets or exceeds the stringency in a version of ASHRAE/IES Standard 90.1 that is determined to be most effective.

It is true that LED technology has made great strides and products exist on the market that can generally compete with incandescent, CFL, HID, and even the workhorse of the lighted space—the fluorescent troffer fixture. However, the market is wide with many product offerings from many manufacturers (some who are very new to the lighting industry) and for each application where effective products exist, potentially poor substitutes will abound.

Therefore, some simple caution is warranted. But it is clear that energy effective lamp technology such as LED will be a primary component of advanced lighting for the future. Fortunately, much information is available to help users choose good and effective products and applications.

Lighting controls have been around since the first light bulb was produced, but much of the advancement toward more energy effective use of lighting (controls), has been more recent. One initial significant component of advanced lighting control was the simple occupancy sensor. Another was the basic daylight sensor used to control electric lighting when not needed. Since then, improvements in advanced lighting control have been primarily better ways to use these two initial controls such as combinations of the two, more effective placement, and more effective connection such as wireless systems and protocols.

However, although improvements can promise and deliver more energy savings, the complexity of each improvement can have its downsides. With more controls requirements in energy standards such as ASHRAE/IES Standard 90.1, the potential for misapplication and thwarted use increases as users get farther away from what they are used to and/or are capable of effectively working with. What this means is that innovative ways to simplify these advanced control systems must emerge soon for the potential savings to be consistently realized now and in the future.

Eric Richman is senior research engineer at the Pacific Northwest National Laboratory, Richland, Wash. ■

We make decisions all the time—we are paid to make decisions. Are we making the right decisions? What is needed to motivate us to make the right decisions? Integrated design is a "fuzzy" topic—everyone talks about it being core to their business— and many are doing it without changing their previous business practices. However, success in integrated design is about delivering substantially more for the same resources; for example, creating a building that uses half the energy without increasing the cost.

Avoiding the cost decision means there is no discussion about cost-effectiveness or return on investment—how much time do we spend justifying energy efficiency as a "bolt-on" to a design only to have it value-engineered out of the process? What is really needed is creative problem solving to meet the building's functional needs, while maximizing energy efficiency. Energy efficiency should be part of the overall design and functionality of the building, including the architecture.

Owners can motivate this type of thinking by using a performance-based procurement process for the building on a fixed price. In this procurement vehicle, a price is set and a team is competitively selected based on maximizing the value to the client. The team with the most creative ideas to maximize energy efficiency and programmatic needs wins the project.

Where are the opportunities? Designers need to help owners find them. Start with the plug loads. You can probably reduce your plug loads by 50% by reducing printers, shifting to laptops rather than CPUs, improving the efficiency of on-site servers and their configurations, and telephone switches. The next big area is turning things off when not in use. If your building operates 60 hours per week, 65% of the year the building should be sleeping. Next is making a commitment to purchase energy-efficient equipment. Starting this practice today with new purchases will probably result in a complete turnover in electronic equipment in

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Metrics and Measurements

BY STEVEN BAUMGARTNER, P.E., MEMBER ASHRAE

Traditionally, measures of energy efficiency are designed to compare usable energy outputs such as electricity, heat, etc., to units of fuel consumed. The current prevailing energy metric for buildings, energy use intensity (EUI), is fundamentally not a measure of energy efficiency; as the name suggests, EUI reflects annual energy consumed on a square-foot basis, never accounting for the ratio of any outputs to inputs.

Instead, EUI has always been intended as a metric to compare a building to itself over time. Energy Star comes closer in its efforts to approximate building efficiency by normalizing EUI by occupant density, schedules, and computer count, but the resulting metric, a 1 to 100 score, still reflects intensity of energy use, and cannot be used interchangeably with efficiency.

New benchmarking laws—including New York's Local Law 84 (LL84) and similar legislation forthcoming in Washington, Boston, and Chicago—have given way to new databases of publicly available building energy data. In these, we have already seen a huge range of EUI for commercial buildings. In an effort to understand these large ranges, some analysts in the New York region have been developing additional normalizers based on physical and behavioral characteristics for building energy intensity. Normalizing for glazing ratio, orientation, and floor depth can help when considering physical planning. On the behavioral side, tenancy is a key factor—particularly in determining the energy intensity described in LL84 EUI and Energy Star data—but currently there are no methods for connecting commercial tenant types and their economic contributions to the energy use of the buildings those tenants occupy.

In developing a measure for building efficiency, the inputs—electricity and other energy consumed—are fairly clear once utility data is in hand; the challenge is establishing the best outputs against which to measure. A recent study completed by Buro Happold has defined a commercial building's output as the combined economic contributions of a building's tenants. The resulting metric is intended to represent a new definition of commercial building efficiency: the relative economic contribution of a building's tenants per unit of energy consumed. This novel metric, called the Building Economic Energy Coefficient (or BEEC) has been presented at Greenbuild and will be presented at the 2014 ASHRAE Winter Conference and other national conferences, initiating discussions about building performance metrics and opportunities to link energy benchmarking data to other economic and even social datasets to more fully understand the role of buildings in our communities.

A white paper on this topic analyzes nearly 1,000 buildings in Manhattan by building height, year built, and LEED ratings (if applicable) to begin to reveal trends in commercial building's energy use and their tenant's economic contribution. As several conclusions were highlighted from the data, this paper (www.tinyurl.com/khntvgc) discusses the broader implications of these metrics and that future studies have the potential to inform infrastructure, policy and market trends in New York and cities throughout the world.

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three to five years. Start today. That being in place and a realistic idea of plug loads allow engineers to design electrical and HVAC systems to meet this load.

Next, attack the lighting loads. On a national average, 80% of the area of commercial buildings is within 15 ft (4.6 m) of an exterior surface, which means a huge potential for daylighting.[3] Lighting a building should be primarily from daylighting augmented with electrical lighting. This will lead to proper sizing of glass: first for daylighting and then providing an appropriate amount and type of glass for views. All of this results in a substantial reduction in cooling loads and sometimes can help the heating loads.

Finally, design the HVAC system to match these loads. I have seen reductions in HVAC systems of more than 75% when integrated design concepts are used. Moreover, it leads to innovative systems that further increase efficiency. One final note, keep the complexity down. Otherwise the setup and O&M practices become a dominant factor in operational success.

Take it on as a personal goal to design buildings to the 50% savings benchmark. Anyone who makes a decision related to buildings plays a part, and together we can all make a difference on "what is next" for the performance of the built environment.

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What's Next for District Energy

BY DAVID W. WADE, P.E., MEMBER ASHRAE, RDA ENGINEERING, MARIETTA, GA.

What's next for district energy? This technology was commercially applied 135 years ago in upstate New York to heat a group of buildings from a central plant. By ASHRAE's definition, district energy provides heating and/or cooling services to groups of buildings from a central plant through a piping distribution network.

According to the latest DOE survey, of the 64 billion ft^2 (6 billion m^2) of commercial buildings in the United States, 8.6% used district heating and 4.5% used district cooling. Austria provides 21% of its citizens with district heating, Germany provides 12% of their energy needs by district energy and Danish district systems serve 60% of all buildings. The reason for the difference in use is largely institutional rather than technical. Implementing district energy requires considering the energy needs of multiple buildings in a community setting. Most U.S. buildings are conceived, designed and constructed by individuals who rarely consider the energy characteristics of surrounding buildings.

U.S. codes and design protocols deal with energy use at a single building. We think "net zero energy buildings," not "net zero energy communities." Private utilities in the U.S. reinforce this approach through their focused marketing of electric or natural gas service. The future may change though if the building industry adopts a new paradigm that considers reducing community energy use.

Even net zero buildings require a grid to balance annual energy production and use. Designers think of the grid as the electric utility; however, the possibilities for energy efficiency expand greatly when a district energy thermal grid is included. Thermal grids providing low-temperature hot water for heating and chilled water for cooling allow a community to use waste heat from power production (combined heat and power), heat generated from refuse incineration, solar energy, and industrial low grade waste heat normally lost to the atmosphere. Thermal grids can interface with heat pump systems, natural cooling from lakes, geothermal wells or deep ocean thermal sources. Both heating and cooling grids can incorporate daily and annual thermal storage as community energy requirements dictate. District energy, along with micro-electric grids, allow combinations of technologies to meet a building's energy requirements through waste heat recovery storage and the use of biomass, wind, solar or geothermal on a community scale.

More than 8.5 million refrigeration tons (29 million kW) of district cooling infrastructure will be in place by the year 2015 in Middle East cities, helping to reduce electric peak loads and provide for long-term integration with multiple energy sources. In Germany, engineers are mapping locations, temperatures and quantities of waste heat available from industrial and power plant facilities to develop hot water district networks that will reduce greenhouse emissions.

Denmark has seen a private company develop a multicity grid that connects municipal district energy systems to take advantage of installed boiler capacity and waste heat availability. Here in the United States, a Midwest college is installing a new low-temperature hot water district system to replace an aging steam system. Energy is provided by heat pumps connected with geothermal wells installed under practice football fields.

David W. Wade, P.E., is president at RDA Engineering, Marietta, Ga. ■

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Paul Torcellini, Ph.D., P.E., is a principal engineer at the National Renewable Energy Laboratory, Golden, Colo. ■

Zeroing in on Future Energy Codes

BY HARRY MISURIELLO, MEMBER ASHRAE

ASHRAE has served the nation as a leading developer of building energy standards since 1975. The Society is unique in that federal law mandates ASHRAE/IES Standard 90.1 as the benchmark for state energy codes for most commercial buildings as well as setting national performance standards for most types of HVAC equipment. ASHRAE has been handling this responsibility effectively.

From 1975 to 2013, Standard 90.1 has improved new commercial construction energy efficiency by

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Getting Buildings to Operate How They Should, According to Design, And Keeping Them There

BY LARRY J. BRACKNEY, PH.D., MEMBER ASHRAE

The thermostat at right illustrates the gap that often exists between design intent and operational reality better than I could describe in mere words. A full 30% of a building's energy performance is related to occupant behavior and simply can't be ignored as we envision a path to a better built environment.

Helping occupants understand their role in achieving and sustaining performance goals and arming facility managers with the tools they need to proactively maintain increasingly complex systems are requirements for persistently efficient buildings. Evolutionary software technologies allow the sector to move beyond passive signage and lackluster alarms, trendlogs, and dashboards that have remained largely unchanged for decades. Human-centric interface designs available on desktop and mobile devices that provide transactional value for all stakeholders are key to meaningful engagement with occupants and decision-makers alike.

For example, in NREL's Research Support Facility (RSF), new applications establish "conversations" between building and occupants, and provide energy performance feedback that appeals to a range of personalities. Spatially registered comfort feedback is combined with measured data to provide a view into how well the building is meeting comfort objectives. This enables facility managers to address occupant complaints proactively, and with the context needed

BELOW Thermostat setpoint at Denver business.

BOTTOM Spatially registered comfort and performance data helps facility managers quickly assess RSF operations.

RIGHT NREL's Building Agent application enables collection of occupant comfort data and communication of building performance.

NICHOLAS LONG/NREL

MARJORIE SCHOTT/NREL

for fault diagnosis and human-in-loop whole building optimization. These software solutions are proving to be an important component of an overall set of strategies that are helping the RSF achieve aggressive net zero energy performance targets.

Industry development of open communications standards and application program interfaces will also contribute to the accelerated development and adoption of new interfaces that will help ensure buildings are operated as they were designed.

Larry J. Brackney, Ph.D., is section manager for Commercial Buildings Sensors, Controls, and Analysis Tools at the National Renewable Energy Laboratory, Golden, Colo.

approximately 60% with half of that gain since 2004. This is significant for a minimum standard when commercial buildings account for about 20% of national energy use. So what are the next steps? What will be the concepts that shape future versions of Standard 90.1, and what might we expect in the 2031 or 2034 versions?

SSPC 90.1 is actually working on that right now as part of the Standard 90.1-2016 work plan. While the proposed short-term goal for the 2016 version is a 40% improvement in whole building energy use (compared to 2004), the long term strategic direction is to publish a Zero Net Energy (ZNE) standard in the 2030 timeframe—about six or seven Standard 90.1 development cycles from now. There is a growing consensus among policy makers, design professionals and code developers that this is the right goal to meet national needs, and it is a view supported by ASHRAE leadership.

One step along the path to a ZNE standard is to expand the scope of what is covered in Standard 90.1 so that whole building energy use is truly considered. Recent updates to the Title, Purpose and Scope of the Standard allow the SSPC to include previously unregulated loads, on-site renewable energy use, new equipment or building systems that are part of industrial or manufacturing

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processes, and plans for operation and maintenance. On-site use of renewables and energy recovery systems are bound to be a needed major contributor to ZNE standards.

The most significant advance in the standard over the mid-term could be "system metrics." Future efficiency requirements for HVAC systems would be set for total performance of all mechanical equipment within the boundary of a defined system, instead of just for the individual components comprising the system. Tradeoffs between all equipment within the system boundary could be allowable as long as the system performance metric is met. This would allow the HVAC systems metric to move to a higher level of performance over time to reflect available improvements in systems design best practices, equipment efficiency and controls. There is a growing consensus among design professionals that just improving individual component requirements will not carry us to ZNE.

Compliance with the Standard will likely take some new turns. Proposed Addendum *bm* would establish the Performance Rating Method found in Appendix G of Standard 90.1 as a new alternate method of compliance. With further development, the addendum would set a common baseline requirement (i.e., Standard 90.1-2004) that would stay the same for 2016 and future versions of Standard 90.1. The improvement target could be updated with each new edition. A 45% improvement target has been initially proposed for the 2016 version, but the improvement target for compliance could conceivably reach 90% in the 2030 timeframe. Other concepts for Standard 90.1 performance compliance include use of building rating systems such as ASHRAE's Building Energy Quotient (bEQ) program where minimum "As Designed" rating scores would be required.

Clearly, the future emphasis of building energy codes will be on performance requirements and compliance tools as ASHRAE takes on the long-term ZNE challenge.

Harry Misuriello is an energy efficiency advocate in Arlington, Va. ■

Shaping the Next...Step

BY TIM WENTZ, P.E., MEMBER ASHRAE.

ASHRAE is the world leader in identifying design, commissioning, construction and operation and maintenance techniques needed to produce a high-performance building. The evolution of Standards 62.1, 90.1 and 189.1, and the mass distribution of the Advanced Energy Design Guides are just a few of the landmark advances ASHRAE has produced in "Shaping Tomorrow's Built Environment Today."

Then why do so many of our buildings still not perform as they were designed and constructed? President Bill Harrison (2008–09) noted in his presidential theme that most buildings will lose up to 30% of their energy efficiency in the first three years of operation. This great paradox has forced us to look at building performance in a more holistic and strategic manner.

How can ASHRAE influence our industry to take the "Next Step" getting buildings to operate as they should, according to design, and keeping them there? The first step is to recognize that ASHRAE can't accomplish this goal alone. To that end, President Bill Bahnfleth has empowered the Building Performance Alliance presidential ad hoc committee to develop a high-level, strategic document that will provide overarching goals and objectives for all providers of commissioning services.

A broad spectrum of industry representatives are working on the document, including the National Environmental Balancing Bureau (NEBB), American Institute of Architects (AIA), U.S. Green Building Council (USGBC), Building Owners and Managers Association (BOMA) among many others. Commissioning ensures that the high-performance design is consistent with the owner's requirements, properly installed by the contractor and operated effectively by the owner. Commissioning, employed at the beginning of the project concept and design process, is the ideal starting point and preserves the energy conservation strategies of the designer and contractor.

There are other ways ASHRAE can influence our industry to operate and maintain a building to high performance standards. One example is ASHRAE's new Building Energy Quotient (bEQ) program, which generates a straightforward rating based upon potential and/or measured energy consumption. The overall rating of A+ to F is easy and intuitive for anyone to understand and provides an incentive to improve the building's performance. The rating, backed by ASHRAE's rigorous scientific expertise, reinforces the adage that "if you can't measure it, you can't control it."

Focusing on building performance will require a new paradigm, coupled with a commitment to work collaboratively. ASHRAE's leadership and technical expertise will be critical if our industry is to take the "Next Step."

Tim Wentz, P.E., is an associate professor at the University of Nebraska, Lincoln, Neb. ■