Powered by Penton

IOT LEADS TO BUILDING EFFICIENCIES:

what this means for **consulting engineers** and **mechanical contractors**

Brought to you by:

CONTRACTING BUSINESS.com

CONTRACTOR

HEATING/PIPING/AIR CONDITIONING HPAC ENGINEERING

CONTENTS

WELCOME

We hope you enjoy reading these specifically selected articles regarding IoT, building efficiencies and what this means for mechanical contractors and consulting engineers.

The editorial content team of Penton's Mechanical Systems Group decided to select their favorite articles regarding IoT and building efficiencies for this special Ebook. And this is the perfect time to create such an ebook given the AHR Expo 2017 is upon us — From product designers and engineers to installers and end-users, AHR Expo attracts the professionals who work with HVACR-related products and services. Attendees include OEMs, engineering & design/build firms, contracting firms, distributors and rep firms, as well as public utilities, commercial, industrial and institutional facility operators and educators. They come to the Show each year to source the latest products, learn about new technologies and develop mutually beneficial business relationships.

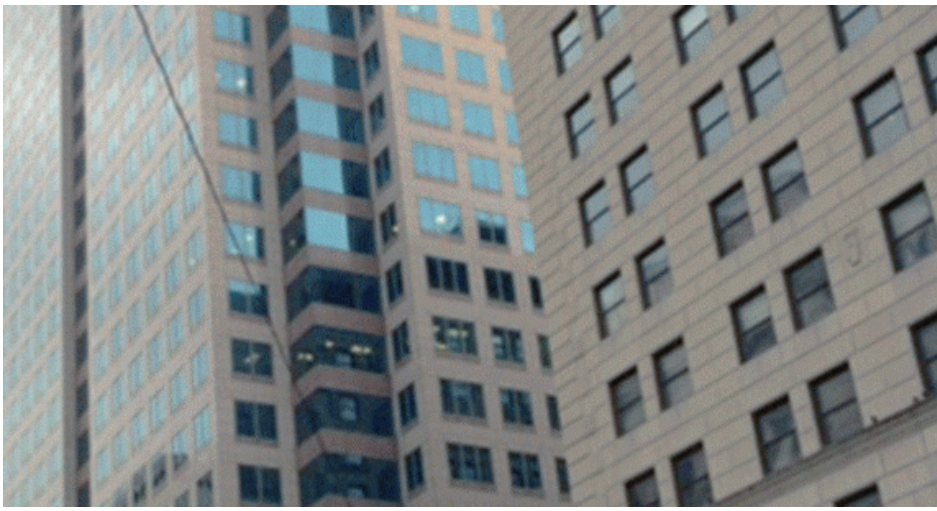
Executive Editors Scott Arnold of HPAC Engineering, Terry McIver of Contracting Business, and Candace Roulo of Contractor, and Bob Mader editorial director of the Mechanical Systems Group will be at AHR Expo. If you are attending the Show in Las Vegas, make sure to stop by Penton's booth, C1132, to say hi and share projects you have worked on — we are always all ears and want to know about your cutting-edge projects, and projects you plan to oversee in the future.

Applying the 'Internet of Things' to Create Smart Buildings

by Leroy Walden, LEED AP

The Internet of Things (IoT) promises to create smart buildings by uniting disparate facility systems into an integrated whole. With the IoT it can be possible to manage and control temperatures, ventilation, lighting, access, parking, room occupancy, elevators and energy usage in a facility, either on-site or remotely.

IoT applications sound futuristic but many of them are available now. All building automation systems (BAS) contractors and integrators will be fielding questions and requests from customers about the IoT for buildings this year, so being prepared with thoughtful answers is essential.



The application of smart building and IoT technology should reduce operating costs, reduce risk, and improve the occupant experience. – *Photo by Terry McIver.*

The "Internet of Things" can be defined as a large number of data sending points brought into a cloud environment where analytics can be applied to influence outcomes.

The "Internet of Things" can be defined as a large number of data sending points brought into a cloud environment where analytics can be applied to influence outcomes.

IoT makes possible a variety of applications using connected devices and data driven decision support systems.

To begin, what is the IoT?

In the context of building management applications, the IoT can be defined as a large number of data points brought into a cloud environment where analytics can be applied to influence outcomes.

IoT makes possible a variety of applications using connected devices and data driven decision support systems. The most beneficial of these provide predictive or pre-emptive knowledge of building or facility operating parameters outside the target zone. Examples include space temperatures above or below service level agreement values or energy consumption rates above targeted operating ranges. Using analytics to understand what's happening in a building and then making appropriate corrections is probably the most important advance using IoT and smart building technology. This allows for quick resolution to issues and even makes it possible to take pre-emptive steps to resolve problems before they emerge. IoT technology can even be used as a method to continuously commission a facility.

Using analytics to understand what's happening in a building and then making appropriate corrections is probably the most important advance using IoT and smart building technology.

As more articles and conferences focus attention on the concept of intelligent buildings and IoT, building owners are asking integrators to "make their building smart." While an integrator could take advantage of this as an opening to start selling any number of advanced technologies, the better response is to find out what facility owners think a smart building is and understand their expectations. In the final analysis, using the IoT to create a smart building must add value to a business in order to be worthwhile. The application of smart building and IoT technology should accomplish three important things:

- Reduce costs
- Reduce risk
- Improve the occupant experience

Meeting all of these objectives ultimately adds value to a property through cost savings and enhanced revenue. When contractors can provide these to customers then the IoT technology they offer is delivering a measurable ROI.

Using analytics to understand what's happening in a building and then making appropriate corrections is probably the most important advance using IoT and smart building technology.

The first step is to explore the facility operator's specific goals for the building. These will vary based on the type and use of the facility.

The first step is to explore the facility operator's specific goals for the building. These will vary based on the type and use of the facility.

The goals for a hospital will be different than those of a university which will differ from those of a commercial office building. Whatever IoT and smart building technology is applied must drive outcomes that address business issues related to the specific facility. Just having technology doesn't make a building smart – it must have the technology that supports the goals of the operator and occupants and there must be people in place to apply and use the technology effectively.

From a business perspective, owners are interested in improving customer experiences and processes, increasing a building's operational effectiveness, and reduce energy consumption, all to meet the goal of optimizing the financial performance off the building. There are several innovations facility operators are looking for that can be delivered using IoT. One is greater flexibility in systems management, such as wireless system access via phone and tablet. There is also a desire to make more operational adjustments, including temperature adjustments, schedule overrides and intelligent sub metering, available to building occupants. Some facility operators believe applications such as personalized comfort control, dimmable lighting, and work space adaptation can contribute to higher workforce productivity and customer satisfaction. But in order for these applications to be available, there must be sensor points in place and mechanical systems zoned accordingly, so this level of connectivity is easier to apply in a new building than in a retrofit application.

Just having technology doesn't make a building smart – it must have the technology that supports the goals of the operator and occupants and there must be people in place to apply and use the technology effectively.

When applying IoT technology it's crucial to get all the stakeholders involved – the con-

Just having technology doesn't make a building smart – it must have the technology that supports the goals of the operator and occupants and there must be people in place to apply and use the technology effectively.

sultants, designers, installers, integrators, owners, renters, facility management, corporate IT — on the same page. The design and implementation has to be a joint effort with all parties because if one piece of the IoT puzzle is not implemented right, then parts of the building will not function.

The specifying stage is a crucial phase when integrating a building into the IoT. Don't fall prey to a siloed procurement method whereby the various systems which would comprise the backbone of the building's IoT are purchased separately with no overarching program management focused upon integrating the various systems in a comprehensive and durable fashion. Make sure that data from the various devices and systems in a building can be acquired and aggregated with the IoT applications. For the most part, building equipment is designed to operate in a fully automatic, totally self-contained fashion. This means that even if the specific piece of equipment includes a microprocessor for managing its internal functions, the data stream that would be of interest for inclusion in an overarching building analytics eco-system may not be easily accessible through common web interchange formats, such as XML or SQL. Frequently, liberating the interesting data from these systems becomes the work of a specialized systems integrator and involves some higher level protocol conversion and separate data storage server.

Network security is enormously important when integrating a building into the IoT because, unlike the traditional BAS that operates independently, the IoT relies on the corporate IT backbone.

Network security is enormously important when integrating a building into the IoT because, unlike the traditional BAS that operates independently, the IoT relies on the corporate IT backbone. Coordination and trust between the integrator, facility operations personnel and the IT staff is critical from day one. By working together, all parties can agree on standards for incorporating the IoT platform into the overall IT infrastructure. At a minimum, there should be firewalls, data encryption and authorization and authentication protocols in place.

Contractors and integrators will discover that servicing a smart building integrated into the IoT is a completely different experience than working on a conventional building. Using real-time 24/7 data shifts the focus from a reactive service model to one that is more

Contractors and integrators will discover that servicing a smart building integrated into the IoT is a completely different experience than working on a conventional building.

preventative. For example, the IoT technology will be able to alert operators to changes that indicate a potential problem is coming before a system failure occurs. This allows technicians to pro-actively make repairs or adjustments in advance, rather than after occupants complain.

Finally, because the investment required to create a smart, IoT integrated building is high, make sure that solutions in place are scalable and adaptable. Be prepared to expand systems as new technologies emerge and operators request additional features and capabilities that have not even been considered today. Advancements in algorithms and analysis, new technologies for business and personal use – all of these will be coming in the future and integrators should prepare today's smart buildings to develop into the intelligent buildings of tomorrow.

Leroy Walden is president of the InsideIQ Building Automation Alliance, an international alliance of independent building and facility automation companies representing common automation and security system platforms. Walden is also Vice President - technical Systems Sales, Automation and Control Solutions for Atlanta-based McKenney's Inc., a leading systems integration and BAS contractor in the southeastern US.

To view this article online, ***click here****.*

Back to the ***Table of Contents***

HVAC Fun & Profit with the Internet of Things

by Phil Zito

Quick! What do the Nest Thermostat, Ralph Lauren Polo Shirts, and Fitbit Motion Trackers have in common?

Here's a hint: it has to do with the Internet of Things. The answer is:

All three companies managed to take saturated commodity markets and release products with obscene profit margins.

Ask yourself, when is the last time you sold a job at 200% margin? Chances are you're still struggling to pull in 20% to 40% margins on owner direct, key account, and service work. Therefore the question we pose in this article is, how can you bottle up a little bit of The Internet of Things magic and sprinkle its profit making dust on your projects?

The Internet of Things gives you a new way in which you can impact your

The average person can create value through the new connections now made possible by Internet of Things innovations. *Photo by Thinkstock.*

customer's business, whereas, in the past, you were limited to the sensors and devices that were available with your controls offering.

That reminds me of an experience I had recently. I was sitting down watching television with my kids, and a commercial came on trying to sell me on the benefits of subscribing to my cable company's smart home service. As of late, I've noticed more and more companies trying to tap into the "Internet of Things" to transform their industries and services. That got me thinking about what kind of possibilities exist for contractors within our space to create new solutions and deliver value to their clients.

You can imagine it was quite timely that I was asked to write this article about what the Internet of Things means for those in the HVACR contracting space. While brainstorming what exactly I would say, I realized that this was less of a "technology" discussion and more of a process conversation.

You need to be able to use the Internet of Things to impact business outcomes.

Process, you say? How in the world is process going to help you close business in the typical world of low margin, bid-and-spec, relational selling? I will challenge you by saying that process is exactly where the conversation needs to be. The Internet of Things promises to unleash a torrent of devices into the market, but in reality, all those new devices do is provide you with more ways to increase the size of your low margin work. If you're truly going to achieve breakout velocity, then you need to be able to use the Internet of Things to impact business outcomes, and that is what this article is about.

You need to be able to use the Internet of Things to impact business outcomes.

The Internet of Things gives you a new way in which you can impact your customer's business, whereas, in the past, you were limited to the sensors and devices that were available with your controls offering.

How Can 1 +1 = 3 ?

Do you want to increase your likelihood to win a project? Of course you do, but what are your current options to do that?

Well, you can take the age old strategy of being the low bidder, cut your costs, and hope you make it up on change orders and service work. Or maybe you can go after the relationship route. You can take clients out

and hope that after you get them to like you that you don't get blindsided when the decision maker retires and his or her replacement invites their own friends to the party.

Fortunately for you, the Internet of Things gives you a new way in which you can impact your customer's business, whereas, in the past, you were limited to the sensors and devices that were available with your controls offering.

The Internet of Things allows you to solve customer problems, improve their processes, and differentiate yourself in a way that adds value.

The Internet of Things allows you to solve customer problems, improve their processes, and differentiate yourself in a way that adds value.

But before we go any deeper it will help if we pin down what the Internet of Things really is.

After reading multiple definitions for the Internet of Things, I wasn't able to find one that I felt did the Internet of Things justice. Therefore, I created this definition that I feel really captures the essence of this article.

The Internet of Things is less about the introduction of more widgets, gadgets, and devices. Rather, the Internet of Things is about the connections. From these connections come new processes; some will be more efficient, and some will not. However, with the Internet of Things, the barrier of entry is lowered, and for the first time the average person can create value through connections.

Did you catch the subtle nuances in the last sentence? If not, let me explain. Because of the Internet of Things, the barrier of entry for work in the BAS space is lowered. This means that the average person can create value through the new connections they create. It used to be that you needed a fully funded Research and Development team. That has since changed, because now, with open Application Programing Interfaces (API's), off-the-shelf solutions, and open systems, if you can dream it, you can create it.

Enough of the grandiose talk. What does this mean for me?

If you're thinking that I've been talking in large, undefined concepts, you're correct. The good news is, this was by design. In order to get you to appreciate the gravity of the next several paragraphs I needed to shift your focus off the device and onto the outcome.

The problem is, when I say Internet of Things what do you picture? Do you picture sensors?

Devices? Networks? All of those are definitely important, but those are not what makes the Internet of Things valuable to you.

What does the IoT provide to you?

- The Internet of Things allows you to solve customer problems, improve their processes, and differentiate yourself in a way that adds value.
- The Internet of Things gives you permission to continue doing business with your client long after the installation is completed.
- The Internet of Things opens up other buyers and departments to you.

Contact your building automation provider of choice and discover if they have an Internet of Things Framework and/or Reference Architecture.

In the past, when I needed to validate an environment for a client, I would purchase ridiculously expensive sensors. I would then proceed to place them throughout the building, and after a week I would collect those sensors, tally up the data points, and I would create heat maps to help the client validate the environmental condition of their environment.

With the Internet of Things, I no longer need to install sensors, upload data, and graph values. Using some simple programming, I can literally purchase a series of sensors off-the-shelf, and tie these sensors back via an open protocol like Bluetooth Low Energy (BLE), Zigbee, or Wi-Fi. With the data now captured, I can use some basic programming and open-source visualization software to create a living, breathing, heat-map of low-cost commodity sensors that provides the customer with real-time data.

I can hear some of you saying, "Hold on a minute, you want me to be a programmer? You want me to design networks? You want me to design technology? I thought this was going to open up opportunities not create new work?"

What exactly is an opportunity? Is it a chance to do the same things you've done before, or is it a chance to be one of a select few who work differently and end up bringing value to their clients and opening new markets for their companies?

Some of you in the Building Automation Space may remember when we switched

What exactly is an opportunity? Is it a chance to do the same things you've done before, or is it a chance to be one of a select few who work differently and end up bringing value to their clients and opening new markets for their companies?

from pneumatics to Direct Digital Controls (DDC). Do you know where those folks who didn't want to learn that "computer stuff" are today? I can say one thing with certainty, they aren't out selling million dollar contracts. Actually, the few of them that survived are struggling daily to defend their value. I have seen this first hand on jobsite after jobsite.

So how do I learn this stuff?

And therein is the real challenge. The purpose of this article was not to teach you the technical aspects of designing and implementing the Internet of Things. The purpose is to get you to visualize your problems differently. After all, that is what the Internet of Things is really all about.

Does it make sense to buy five hundred flow sensors at $2,000 a sensor? No, of course not, but what if a company in China can make the same sensor for $100 each and you can use a wireless network to connect the sensors and make real-time adjustments to flow, reducing the usage of a central plant by 5 percent? Up until recently, only the major manufacturers could boast about such technology. However, with the lower barrier of entry, if you can dream and procure it, then you can sell it. That my readers, is a recipe for success.

With the lower barrier of entry, if you can dream and procure it, then you can sell it. That my readers, is a recipe for success.

Therefore, your challenge is to look at things differently. How can you combine technologies to produce different outcomes? Can you look outside your traditional box and identify issues that exist, that an interconnected system could solve? The ability to deploy cheap sensors and newer devices is useless if you don't help your clients realize that they have problems that the traditional solutions cannot solve.

Next steps in learning

In this article, I created a compelling case for systems integration, and demonstrated a few ways you can grow your business by thinking differently about the role that technology plays in your projects. Naturally, I would expect that you would want to know a couple next steps to guide you forward. The following are the three steps I recommend you follow in order to grow in your knowledge and capabilities around the internet of things:

No. 1: I would recommend that you contact your building automation provider of choice and discover if they have an Internet of Things Framework and/or Reference Architecture. This will provide you with a specification to design

your integrated systems off of. Currently there are only a few companies that have Reference Architectures for the Internet of Things.

No. 2: I would encourage you to pick up a copy of *Building Wireless Sensor Networks: with ZigBee, XBee, Arduino, and Processing*, by Robert Faludi. Robert is one of the leading experts around Machine to Machine communication and he has wrote an excellent book around wireless sensor networks. At the end of the day, most of the work you will be doing with the Internet of Things revolves around sensors. Therefore if there was only one book I could recommend it would be Robert's book. I have no relationship to him or his book at all. I am simply recommending it because it is an amazing write up on sensor technologies.

No. 3: I am working on a project called The Internet of Things Database. The Internet of Things Database exists to provide an easy to use database of all of the Internet of Things frameworks, open-source projects, standards, and vendors. I update this list weekly and I am gradually adding my own personal reviews of each technology.

Finally, I would like to leave you with one parting comment. The Internet of Things is complex, it is a market that has not yet jelled and it is full of companies, frameworks, and ideas. This can be scary for someone who is new to the Internet of Things landscape. My advice to you is to not let this complexity scare you away. While there are hundreds of companies competing for your business in this space, you can narrow them down if you simply know what you want to do. If you follow my steps above, you will be in a good position to further expand your business into the world of the Internet of Things. I look forward to your feedback and responses.

The Internet of Things is complex, it is a market that has not yet jelled and it is full of companies, frameworks, and ideas.

Phil Zito is a senior technical program manager at a Fortune 100 Company. He is focused on Systems Integration and program management and has 12+ years in the smart building space. The thoughts in this article are based on his experience and do not represent the views of his employer.

To view this article online, ***click here.***
Back to the ***Table of Contents***

Helping Schools Make the Grade

ABM helps South Carolina schools upgrade facilities, save money

by CHRISTOPHER KING

NEW YORK — When Rick Higginbotham tells cash-strapped school boards that they can upgrade their aging mechanical equipment and pay for some or even all of the improvements with the money they'll save on energy costs, they often tell him it sounds too good to be true. That's why Higginbotham, a sales executive for ABM, keeps a list of references from previous projects ready for prospective customers to call.

An ABM technician checks on the EVAPCO Evaporative Tower at Honea Path Middle School.

He's now added the contacts from his two most recent projects in South Carolina, where ABM's Bundled Energy Solutions program helped Anderson County School District 2 and School District 3 upgrade outdated equipment at eleven schools. The company estimates the improvements will save the school districts $6 million in energy and operating costs over the next 15 years.

Headquartered in New York, ABM helps clients throughout the country meet their infrastructure needs and achieve sustainability goals. "We go into any organization that owns or operates buildings, and we help those organizations make those buildings more energy efficient and more cost effective to operate," said Higginbotham, who operates out of ABM's office in Atlanta.

ABM's Bundled Energy Solutions program helped two school districts in South Carolina's Anderson County. In Anderson School District 2 and School District 3, ABM provided upgrades to outdated equipment at eleven schools, including Crescent High School. *Photos courtesy of ABM.*

"We help generate savings from funds they are already spending, usually with energy providers and with upkeep of aging equipment. We also do preventive maintenance."

A former school superintendent himself, Higginbotham knows many schools just cannot keep up with repairs on outdated equipment. "Often they are just putting out fires and working on old A/C equipment, trying to keep it running," he said. "We go in and help them to upgrade or replace outdated equipment – HVAC, lighting, controls. We do water conservation. We work on the building envelope. We look for any type of energy conservation measure that can save them money."

We go into any organization that owns or operates buildings, and we help those organizations make those buildings more energy efficient and more cost effective to operate.
— Rick Higginbotham

Get the ball rolling

Higginbotham worked as a teacher, assistant principal, principal and superintendent in Georgia before he joined ABM in 2013. He now taps into his experience to advise his school district clients. If the school district likes the concept, the first step is a preliminary study, which is conducted at no cost to the client. At this stage the developmental team benchmarks the school buildings and calculates the energy cost per square foot. Then an investment-grade audit is conducted. "We look at every light, every motor, every pump, every compressor," Higginbotham said. "Everything in that school we can touch, we measure."

The project developer then designs a program that provides the most energy-efficient and cost-effective way to operate the buildings. At the same time, an energy engineer determines the exact amount of energy savings ABM can guarantee. Then the ABM team recommends the

We look at every light, every motor, every pump, every compressor. — Rick Higginbotham

best systems and products to meet the client's needs. "Every program that we do is different," Higginbotham noted. "It's designed specifically for that exact situation."

The next step is to determine how much of the investment will be self-funding. ABM also works with clients to set up a lease and ensure they obtain federal and state subsidies and rebates, as well as any rebates from energy providers. Anderson 2 decided to adopt a $7.2 million program, which was designed to save $3.5 million over 15 years. Anderson 3 decided to do $5 million worth of work, with a guaranteed savings of $2.7 million over 15 years. The school districts funded the balance of their programs with 15-year municipal leases at low interest rates, and they will own all of the equipment after the lease is terminated.

Upgrading HVAC, conserving water

Ciepierski, who has 25 years of experience in the HVAC field, the last eight years with ABM, oversaw the system upgrades for both school districts. He points to the detailed development phase as the key to success on ABM's Bundled Energy Solutions projects. "We spend so much time in development that by the time we get the green light on a project, everything is ready and I just go to town as the project manager," he said.

Within Anderson County School District 2, energy and facility improvements were made in the school district's three elementary schools, two middle schools, and the high school building, as well as the primary school. District-wide measures included replacing the existing lighting with LED lighting, installing new transformers, upgrading controls and sealing the building envelope. Electric hand dryers

HVAC upgrades at Crescent High School included two Paterson-Kelley condensing boilers.

To save water, ABM replaced water-cooled chillers with air-cooled chillers, like this Daikin air-cooled chiller at Starr Elementary.

were installed throughout the district's buildings, which saved money on paper towels and trash bags.

Replacement of HVAC systems included installing 64 Carrier water-source heat pumps at Honea Path Middle School, as well as a new Lochinvar boiler and an EVAPCO cooling tower. The HVAC systems covering the guidance office, library, gym and principal's office in both middle schools were replaced with Daikin mini-split systems.

In Anderson County School District 3, ABM provided infrastructure upgrades within its three elementary schools, the middle school, the high school and the Board of Education building. In addition to district-wide LED lighting, energy efficient transformers and water conservation measures, improvements included new controls and PC power management software that made the system's computer network more energy efficient.

New HVAC units at Crescent High School included two Daikin air-cooled chillers, two Patterson-Kelley boilers, 40 Trane unit ventilators and 13 Trane fancoil units. Daikin VRV split systems were installed to provide front office air conditioning three schools. Other products installed included Taco pumps and Spirotherm air and dirt separators.

Water conservation measures were crucial in both of these projects. Low-flow toilets and urinals from Kohler were installed in the bathrooms. Kitchen sinks were retrofitted with pedal valves to limit water waste in cafeterias. "When we perform work in the schools, we pay a lot of attention to the water use in cafeterias," Ciepierski said. "There is a lot of sloppy water management in kitchens. The pedal valves we install eliminate the possibility of people turning a faucet on and just walking away."

There is a lot of sloppy water management in kitchens. The pedal valves we install eliminate the possibility of people turning a faucet on and just walking away.

— Brian Ciepierski

Challenging installation

Installation began in the fall of 2015, so scheduling was a concern, as regular school activities could not be disrupted. "All of our activity on these jobs was done on second shift, starting at 3:30 in the afternoon and working until about 2 in the morning," Ciepierski said. "On the significant infrastructure interruptions — chillers, cooling towers, boilers, hot water heaters — all of that takes place on the weekend."

For weekend projects, planning ahead is critical. The foremen, crews and any subcontractors make sure all materials are ready to go. They also have to be ready in case of emergencies. "We need to have the phone number of the supply house and be ready to pay the extra price to have them open the garage doors so we can roll in there, get another 20 flanges or whatever we need, and come back to the job and keep working through the night. So all of those things are in place when we do one of those crunch weekends."

Weekend projects included replacing water-based chillers with air-cooled chillers to help cut water costs. Ciepierski made sure the transition was seamless. "In order to get that done, we will leave the existing infrastructure operating and we'll get the new chiller wired, piped and controlled before we integrate it with the building system," he said. "We start on Friday night and work three shifts until Sunday afternoon. We've got those down. It's almost like a three-day-long pit stop."

The Daikin split systems specified for the administrative offices were also installed while the old systems were still running. Crews used aluminum tubing with Refloc fittings for the refrigerant lines to avoid using torches in the plenums. The aluminum was cheaper than copper and easier to install, cutting labor costs.

We need to have the phone number of the supply house and be ready to pay the extra price to have them open the garage doors so we can roll in there, get another 20 flanges or whatever we need, and come back to the job and keep working through the night.

— Brian Ciepierski

A few surprises

Old buildings can be full of surprises. At Crescent High School in Anderson 3, for example, Ciepierski discovered there were no isolation valves in pipes throughout the school, so the

We proved by cutting out a sample of the pipe and sending it out for testing that the walls of the pipe were sufficient, so we the dried out the plenums during the summer months and put a coating on it that added R-Value. — Brian Ciepierski

entire system would have to be drained to work on any of the wings. "This would add hours of labor," he noted. "At one point we drained the whole system and put in 150 valves to expedite our night work. We just took the hit on the job."

Crews also discovered that some interior walls extended through the acoustical ceiling but were never properly completed, in violation of the building code. "These demising walls were supposed to run all the way up to the deck, but they didn't, so piping had to be rerouted to go through true demising walls to meet the fire rating," Ciepierski said. "That had to happen, but it was a time penalty and a dollar penalty."

The ABM team also tackled other problems they discovered. At Iva Elementary School, for example, condensation from a poorly insulated chiller pipe had been dripping onto ceiling tiles. The school's maintenance crews had been working under the assumption it was a roof leak, and they were changing out 75 to 125 ceiling tiles a week. "We proved by cutting out a sample of the pipe and sending it out for testing that the walls of the pipe were sufficient, so we the dried out the plenums during the summer months and put a coating on it that added R-Value," he said. "We eliminated the sweating by creating a vapor barrier around the pipe."

ABM tackled these additional tasks without change orders or additional cost for the school districts. "We just had to make it work," said Ciepierski. "We have a guarantee. We guarantee the energy savings on these projects, and we were able to do that on this job, even with all of these difficulties."

Work is now complete at Anderson 3 and just wrapping up at Anderson 2, and Higginbotham and Ciepierski note that feedback from the school districts has been overwhelmingly positive.

Dr. Richard Rosenberger, Superintendent for Anderson School District 2, notes the schools' maintenance departments can now focus on routine preventive maintenance, instead of frantic band-aid repairs. It's also helped improve the learning environment. "It's made a big difference in what we're trying to accomplish here in the district," Rosenberger said.

Rosenberger also believes the partnership with ABM shows the school board is being

proactive when it comes to taking care of the buildings' infrastructure. "The people want to know you are good stewards of the taxpayers' money, and this program proves we're doing the best job possible with it," he concludes.

Christopher King is a writer and editor who has covered the construction industry for more than 15 years. He previously served as editor of Roofing Contractor, managing editor of the Air Conditioning, Heating & Refrigeration News, and associate editor of Plumbing & Mechanical. He can be reached at kingc61@gmail.com.

To view this article online, **click here**.
Back to the **Table of Contents**

The Art of Holistic Efficiency

Unique mini split installation at an off-Broadway theater

SPECIAL TO CONTRACTOR

NEW YORK — The Manhattan neighborhood of SoHo, so named for its location South of Houston Street, claims the highest concentration of iron-front buildings in the country. The metal's addition to countless buildings, in the mid-1800s, revitalized the neighborhood, bringing new commercial tenants with it.

The same can be said of the art movement that swept into SoHo more than a century later. The otherwise stagnant industrial area gained new purpose and vigor as painters and performers began occupying the spacious lofts throughout SoHo.

The Performing Garage, an off-Broadway theater that's been operating in SoHo since 1975.

The old manufacturing spaces converted beautifully into large studios full of natural light. But that's where the amenities ended. Restrooms were few and HVAC was generally non-existent. Over the next few decades, creature comforts were often added, creating more livable spaces for the visionaries who occupied them.

Spectacularly monstrous system

At 33 Wooster Street, you'll find the Performing Garage, an off-Broadway theater that's been operating in SoHo since 1975. While the brick structure has changed little, it received its first

Custom steel framework was erected to mount the units several feet above the flat roof.

central HVAC system in the early ‘90s. With the addition of two massive gas furnaces, the factory-turned theater could be used in the depths of winter without the fear of frostbite.

Half a block away, on top of a building shared by the same co-op, two condensers made a valiant effort to provide cooling while achieving only marginal comfort. In addition, four through-the-wall units also served the upstairs studio. The biggest issue was noise, both inside and out.

The reason the condensers weren’t installed directly on top of the theater was that tenants in adjacent apartments wouldn’t tolerate the noise. Inside the theater, system noise from the colossal ductwork was worse yet.

Their focus is “holistic efficiency,” as they call it, where cutting-edge heating and cooling equipment is paired with building envelope improvements.

“During rehearsals and recording, we had to shut the HVAC system off,” explained Kathryn Valk, a founding member of The Performing Garage. “We’d periodically take a break and turn them on just so the temperature was tolerable.” To add insult to injury, the cooling system began leaking refrigerant, and energy consumption was unforgivable, year ‘round.

Enter help, stage left

Last summer, Valk and other managers at The Performing Garage were introduced to Green Star Energy Solutions by manufacturer’s representatives at Wales Darby. While HVAC is a core service provided by Green Star, the company is a full-spectrum building performance contractor.

Their focus is “holistic efficiency,” as they call it, where cutting-edge heating and cooling equipment is paired with building envelope improvements. Windows, doors, weatherization and insulation are an integral part of their solution.

“NYSERDA [New York State Energy Research and Development Authority] looks for 10 to 15

percent energy savings," said Tom Esposito, director of business development at Green Star. "But we strive for 40 to 70 percent, and regularly achieve it."

Members of The Performing Garage toured condos at nearby 400 Central Park West, where Green Star had recently installed a large VRF system. Brendan Casey, New York sales engineer at Fujitsu, was involved during the design, and joined the tour to help answer any questions.

Not long after, papers were signed to begin a two-phase effort to bring the theater into the 21st century. Phase one would include installation of a new HVAC system, and phase two would drastically improve the building envelope.

Act 1, scene 1

Green Star didn't foresee any issues with installing new equipment in the building. What did pose a challenge, however, was getting a high-efficiency system to fit into a non-profit budget.

"The Performing Garage had a design before we met with them," said Joe Novella, owner of Green Star. "There was no way the original design would fit in the budget. So we cut the price tag in half, and reduced the total capacity by 24 tons just by zoning more intelligently with a Fujitsu HFI system."

"We use Fujitsu equipment regularly to provide solutions and energy savings for old buildings in New York," said Esposito. "From the Halcyon mini-splits up through their Airstage VRF systems, the equipment is very reliable."

Green Star Energy Solutions' technicians install the Fujitsu equipment.

Green Star initially considered using a VRF system, but the smaller Halcyon HFI systems were capable of handling the load and still offered plenty of flexibility through the use of branch boxes.

Installing the smaller condensers shaved upfront costs further, because a crane wasn't needed. Instead of blocking off Wooster Street

for a day to crane larger condensers onto the roof, four, 48,000 Btuh units were lifted through a skylight. Custom steel framework was erected to mount the units several feet above the flat roof, and all refrigerant lines enter the building through a single penetration.

Inside, 16 evaporators are used across four zones. The main theater is conditioned with wall-hung units down low, and two slim ducts on the ceiling toward the back of the room. Upstairs offices and common areas are also heated and cooled with wall units of various sizes. A small archive room is served by a 9,000 Btuh evaporator, mostly for humidity control.

The units selected are smaller, flexible, and handle the load.

Act 2, a better building

"The HVAC system can run during rehearsals now," said Valk. "We're far more comfortable, and the work was complete before our large annual banquet, as promised." The star-studded event, which included Frances McDormand and Steve Buscemi, among others, raised funds for the building improvements.

Phase two is slated to begin later this year. Building improvements will bring the envelope up to par with the systems that serve it.

"Right now, the roof insulation is about R-8," said Esposito. "We'll create an air barrier, blow in a thick layer of L77 insulation and bring it up to R-45 or 50. The skylight will be sealed off with an energy barrier, and the old through-wall units will be removed and bricked off."

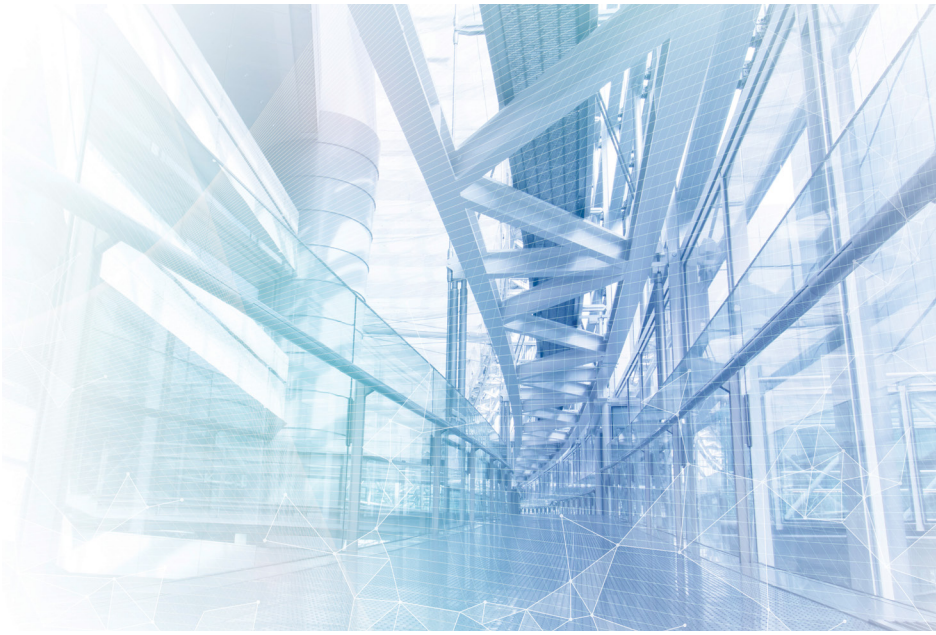
These improvements are similar to those made by Green Star on more than 4,000 homes and hundreds of commercial buildings. But it's the first time they've worked on a theater. So far, everyone using the space has seen, heard and felt a vast improvement. Before the curtains close on the project entirely, the bookkeepers are sure to agree.

To view this article online, ***click here.***
Back to the ***Table of Contents***

The Internet of Things and Intelligent Facilities Management

by LEROY WALDEN, LEED AP; InsideIQ Building Automation Alliance, McKenney's Inc.; Atlanta, Ga.

The Internet of Things (IoT) is ushering in new possibilities for building integration and allowing for the emergence of truly intelligent buildings. The IoT makes it possible to understand what is happening within every component of a building and for building-automation systems (BAS) to optimize performance of the smallest part. The IoT even enables BAS to anticipate problems and make necessary adjustments to avoid failures, resolving issues before occupants are impacted.



The application of intelligent-building and IoT technology should support three important goals: reduce costs, reduce risk, and improve the occupant experience. *Photo by Thinkstock.*

How does the IoT enable BAS to achieve this level of intelligence? In the context of building-management applications, the IoT can be defined as a large number of data points brought into a cloud environment in which analytics can be applied to influence outcomes. The IoT makes possible a variety of applications using connected devices and data-driven-decision support systems. The IoT uses one common Internet Protocol (IP) platform to connect all of the sensors and devices in a building to exchange and analyze information and optimize controls automatically. An important benefit is access to knowledge of outside-the-target-

zone operating parameters enabling quick resolution of issues, even before problems emerge.

Because the possibilities of IoT technology are so compelling, it is easy to get caught up in the hype and disconnect from the reality of operating and managing a facility. That is why it is important to stay grounded and remember the application of intelligent-building and IoT technology should support these three important goals:

- Reduce costs.
- Reduce risk.
- Improve the occupant experience.

If the application of IoT technology creates an intelligent building that meets these objectives, then the owners and operators will be in a position to realize a full return on their investment in the facility while users enjoy a comfortable, dynamic environment.

The connected, IoT-enhanced building

Accumulating, sharing, analyzing, and acting on data creates dynamically connected, smart systems that are the foundation of intelligent buildings, which are efficient, secure, and productive and even can continuously improve. The IoT facilitates this by integrating all of the devices in a building and converting information into big data that can be stored, analyzed, and used to manage the building through its BAS. While, beyond controlling HVAC, modern direct-digital-control (DDC) BAS typically are used to schedule and trend access controls or lighting systems, they can do much more and, thus, are ready to take advantage of the IoT.

The combination of BAS and the IoT is a union of engineering and data. BAS are from the domain of engineering, related to engineered systems and how building systems operate, while the IoT comes from the realm of information technology (IT) and is all about data and statistics. Turning all of the data collected from a building and its components into building intelligence that can be applied to enable better, more efficient facility operations is where analytics comes into play. While a BAS runs systems and sends alerts if there is a problem, it is not predictive. Likewise, the information gathered by IoT data points is just data. The analytics platform fills the gap by tracking and trending big data and analyzing the performance of a building. Analytics can identify problems before they occur, allowing

While a building's systems may be smart, without the ability to share data, they are functioning as silos and not delivering their full benefits.

chombosan/iStock

preventive maintenance to become predictive maintenance.

While a building's systems may be smart, without the ability to share data, they are functioning as silos and not delivering their full benefits. By expanding the collective intelligence of buildings, the IoT exponentially increases the effectiveness and efficiency of systems. Traditionally, the BAS was the smartest system in a building; the IoT is shifting intelligence away from the BAS to connected devices and the cloud, where data is stored and analyzed. Once data analytics determines the best operational choices or corrective actions to take, a BAS assumes its role of coordinating the functions, such as turning systems on and off, sending alarms, and making other adjustments, of all of the devices in a facility.

Additionally, the IoT can give building occupants and users more control over their environments. Mobile applications that enable users to control heating and cooling setpoints, lighting, and daylighting, for example, can be created. The BAS, however, will have the authority to reverse changes when occupancy sensors indicate a space is empty.

One of the most important stakeholders in an intelligent building is the IT department.

Integrating the built environment with the IoT

The effective application of IoT technology to create an intelligent building requires careful planning from the beginning. Adding components later in the process can be costly because of the large number of metering and sensing devices that must be applied to so many systems—from electrical switchgear to HVAC equipment to water distribution systems. Starting early also can lower costs by eliminating redundancies, such as parallel networks, multiple software systems, and even the need for multiple electrical contractors.

Early involvement by all of a facility's stakeholders also will contribute to success. The specific stakeholders will vary by project,

but the interests they represent can be summed up as financial, operational, sustainability, security, and productivity. Working with these groups to establish goals and objectives as early in a project as possible will reduce the number of last-minute change orders as the project develops. For instance, the constituents can determine which are the most important intelligent-building features—the "must-haves"—and eliminate the features that would have only marginal benefit. Finally, during this preliminary engagement is the time to work through conflicts between the stakeholders and reach a consensus regarding how to apply IoT and intelligent-building technologies.

Specification is a crucial time when integrating a building into the IoT. Do not apply a siloed approach to procuring the various systems that comprise the network backbone. If these are purchased separately, with no overarching focus on integrating them in a comprehensive and durable fashion, the IoT integration will fall short. Make sure data from the various devices and systems in the building can be acquired and aggregated with the IoT applications. Most HVAC equipment, for instance, is designed to operate in a fully automatic, self-contained fashion. But even if the equipment includes a microprocessor for managing its internal functions, the data stream that needs to be included in the building-analytics ecosystem may not be easily accessible through common Web interchange formats, such as XML and SQL. Additionally, while all systems in a building are available with industry standard protocols, these still can contain variations that inhibit communications between devices. For example, BACnet has several variations: BACnet/IP, BACnet over Ethernet, and BACnet over ARCNET. Each of these has a different means of transmitting data and varied wiring methods. Reversing either of these mistakes will be costly and may even require a specialized systems integrator to implement a high-level protocol conversion. Fortunately, the industry is catching on. In response to the emergence of the IoT, BACnet is defining new Web-service standards that will support information technologies and integrate with enterprise-

To protect investments in smart, IoT-integrated buildings, apply solutions that are scalable and adaptable. Be prepared to expand systems as new technologies emerge and operators request additional features and capabilities.

level applications and cloud services.

One of the most important stakeholders in an intelligent building is the IT department because, unlike in the past when a BAS operated on its own network, intelligent buildings must rely on their IT backbones. Coordination and trust between the integrator, facility-operations personnel, and IT staff from Day One is critical. By working together, all parties can agree on standards for incorporating the IoT platform into the overall IT infrastructure. At a minimum, firewalls, data encryption and authorization, and authentication protocols should be in place. Anticipating potential weak spots is one strategy to ensure a network is secured to the standards of the IT department. There are many options for optimizing network security, ranging from fully integrating intelligent-building and corporate networks to partitioning portions of networks to specifying totally separate networks. The best solution for each application will be determined by open discussions and negotiations between the integrator, building operators, and IT department.

To protect investments in smart, IoT-integrated buildings, apply solutions that are scalable and adaptable. Be prepared to expand systems as new technologies emerge and operators request additional features and capabilities. It is reasonable to expect that advances in algorithms and analysis, new technologies for business and personal use, and more will be coming in the future. Integrators should prepare today's smart buildings to develop into the intelligent buildings of tomorrow.

Analytics packages must be robust enough to provide useful information and intelligence for all of a building's stakeholders. Most likely, a traditional, site-based building-analytics technology will not be adequate when it comes to analyzing the large volume of building data available through the IoT. The best way to capture and analyze IoT data is through a cloud-based building-analytics solution. It should be designed to scale across an unlimited number of devices and buildings and be able to access data using a flexible reporting method. This will resolve one of the larger challenges with big data—sorting through statistics and figures to find relevant, actionable information. The analytics likely will need more data points within sensors than

Analytics packages must be robust enough to provide useful information and intelligence for all of a building's stakeholders.

the BAS, so make sure there are plenty and that adding more points is cost-effective. As noted previously, use established communication protocols in the BAS that work across media and applications. Finally, select a solid, reliable cloud provider with staying power. Although this remains a growing and developing sector, it is mature enough that some stable players have emerged.

Bringing all data together requires a series of dashboards tailored to the needs of key stakeholders—for example, a dashboard for viewing overall facility functions for facility operators and a dashboard focused on energy use in real time and energy-usage trends over time for the sustainability team. A financial stakeholder needs to see how daily operations tie in to the overall facility budget. To define what each dashboard should entail, engineers must understand what each stakeholder values and his or her overall goals. Then, they must consider which components and systems within the building need to communicate to deliver the data required for each dashboard.

Although technology in the form of data points and analytics is essential to the success of IoT-based smart buildings, the human element still is required for optimal success.

Conclusion

The IoT creates vast opportunities for integrating systems and creating intelligent buildings that operate more efficiently and with less risk while delivering superior occupant experiences. Although technology in the form of data points and analytics is essential to the success of IoT-based smart buildings, the human element still is required for optimal success: While the analytics made possible by the IoT provide insights, people are needed to process the information and apply it effectively to obtain desired results.

Leroy Walden, LEED AP, is president of InsideIQ Building Automation Alliance, an international alliance of independent building-automation contractors. He also is vice president, technical-systems sales, automation, and control solutions, for McKenney's Inc., a systems-integration and building-automation-system contractor serving the southeastern United States.

To view this article online, **click here**.
Back to the **Table of Contents**

Commercial Buildings and the Retrofit Opportunity

By LISA TRYSON, Danfoss North America, Baltimore, Md.

Countries around the world are showing new signs of readiness to act on carbon emissions. That means new pressures to make buildings highly efficient in their use of electric power, particularly as a recent report from the U.S. Environmental Protection Agency1 shows that, between 1990 and 2013, indirect greenhouse-gas emissions from the electricity use of homes and businesses increased 28 percent. However, perceptions of ultramodern, high-efficiency commercial buildings may not align with the realities of a low-carbon built environment. The United States will need to work primarily with existing buildings, as opposed to new construction. Thus, the future of high-performance commercial buildings is linked integrally to retrofits, and a successful retrofit strategy for environmentally sustainable commercial buildings will require a fresh approach and new kinds of innovation.

Building performance is stalled, necessitating a fresh approach and a new standard of innovation. *Photo by vitomirov/iStock.*

Buildings by the numbers

First, it is vital to understand the profile of commercial buildings in America is changing.

According to the U.S. Energy Information Administration's Commercial Buildings Energy Consumption Survey, there were about 5 million commercial buildings in the United States in 2003. By 2012, that number had risen 14 percent to 5.6 million. Over the same period, total commercial-building square footage increased 21 percent, from just over 70 billion to 87 billion.

First, it is vital to understand the profile of commercial buildings in America is changing.

The median building today is 32 years old; about half of America's commercial buildings were built before 1980. Only 2 percent of buildings are larger than 100,000 sq ft, while about half are 5,000 sq ft or smaller.

America's building profile varies significantly by region. For example, the South has 46 percent of new buildings and 37 percent of the population. Almost half of all buildings built in the United States since 2000 are in the South. By contrast, the Northeast is home to the largest and oldest building. Whereas the median age of commercial buildings in the South is 29 years, in the Northeast, it is 46 years, with the buildings on average 4,000- to 5,000-sq-ft larger. Buildings in the Mid-Atlantic region average 22,300 sq ft.

The Rise of Retrofits

Citing McGraw Hill data, the U.S. Green Building Council observed that 61 percent of all construction projects today are retrofits; in many population centers, the percentage is much higher. The importance of retrofitting grew in the wake of the 2008 financial crisis and recession, which were hard on commercial properties and created uncertain loans and major losses for banks. The impact remains significant, as bank losses have weakened capital reserves and the ability to make new loans. Falling real-estate prices and tighter credit standards weakened the new-construction market.2,3

The rise of retrofits, however, has not translated directly into more sustainable buildings. Whereas "retrofit" means changing out elements or components of a building, and "green" retrofit means upgrading a building to a higher environmental-certification standard, achieving genuine sustainability requires something more.

Deep Energy Retrofits

Rocky Mountain Institute (RMI) has been working on what that something more might be: the deep energy retrofit. In 2010, RMI proposed a deep-energy-retrofit plan for the

Byron G. Rogers Federal Building and U.S. Courthouse in Denver, a project it regards as "a powerful case study for dramatically improving performance of existing buildings."

In addition to chilled beams and solar collectors, the deep-energy-retrofit toolkit offers access to demand-response technology, thermal-energy storage, cogeneration (combined heat and power), and more.

The plan was very aggressive, with a goal of reducing the building's energy consumption by 70 percent. The U.S. General Services Administration (GSA), which owns the 620,000-sq-ft building, used $147 million from the American Recovery and Reinvestment Act to fund a large portion of the project, which, in total, cost about $160 million.

New ideas in space use, including flexible work spaces and shared meeting rooms, were deployed for the Byron G. Rogers Federal Building and U.S. Courthouse, which houses 11 government agencies. Central to the retrofit strategy was chilled-beam technology, whereby chilled water is fed through beams that act as radiators. Solar collectors were added to provide all of the building's hot water.

The GSA reports the building now uses less than 45.1 kBtu per square foot per year (note the "whole building" metric) and achieves annual energy savings of about 55 percent.

In addition to chilled beams and solar collectors, the deep-energy-retrofit toolkit offers access to demand-response technology, thermal-energy storage, cogeneration (combined heat and power), and more. Integrated, these technologies can dramatically improve building performance in absolute terms and relative to peak load. By not only cutting total energy use, but shifting the time at which electrical power is demanded by the building, such technologies woven into a whole-building systems strategy can draw on the grid during low-demand periods and reduce load during peak or high-demand periods, cutting the need for the added high-cost, high-carbon peak power generation otherwise required.

Despite the many advantages of deep energy retrofits, owners have been reluctant. As Building Science Corp.'s Ken Neuhauser said4: "Deep energy retrofits are hard. They are not simple, quick, or cheap." In most cases, that translates directly into a financing challenge because, to a bank with tight credit standards for buildings, hard, complex, slow, and expensive means risky.

Financing Deep Energy Retrofits

Financing deep energy retrofits requires innovative and collaborative thinking. For example, in 2013, Seattle Mayor Mike McGinn announced a pilot project between Seattle City Light and the Bullitt Foundation to make deep energy efficiency in new and existing commercial buildings economically feasible.

"Very few building owners now make the large, long-term investments needed to achieve 'deep' savings of 35 to 50 percent," the announcement of the project5 notes. "Yet the rates of return on such investments would be attractive to utilities and other investors that have access to cheap, long-term capital. The new pilot program aims to overcome this obstacle."

The two pillars of the program are (1) an "energy-efficiency meter to objectively measure real-time energy savings and (2) a 20-year contract between a utility and energy-efficiency investors," the latter of which "allows an investor to profitably invest in energy-efficiency upgrades with longer payback times." Investments can be made through traditional vehicles, such as bonds, though the best mechanisms for getting returns have yet to be determined.

In an article for the Seattle Daily Journal of Commerce,6 Thulasi Narayan explained the program.

"At the net-zero Bullitt Center, Seattle City Light and the building owners are pioneering a potentially game-changing power-purchase agreement termed MEETS, or metered energy-efficiency transaction structure," Narayan wrote. "City Light pays the building owner for energy saved against a baseline, similar to the credits that homeowners receive when solar panels on their roof generate more energy than the house is using.

"Making this incentive structure a reality relies on sophisticated technology that identifies how multiple factors (such as occupancy, schedule, or weather) impact energy consumption and comparing that to how the building actually performs at the utility meter," Narayan continued.

"By understanding the environmental factors that influence energy consumption, the utility knows it is paying for real energy savings, rather than incidental savings coming from fewer occupants being in the building or unseasonably mild weather," Narayan concluded.

By understanding the environmental factors that influence energy consumption, the utility knows it is paying for real energy savings.

The article quotes Rob Harmon,

president and chief executive officer of Energy Resource Management Corp., maker of the baseline metering system utilized for MEETS, who said the project is a way to "enable a true 'pay-for-performance' market, including long-term power-purchase agreements that will allow deep energy-efficiency retrofits to join wind and solar as at-scale solutions for our energy system."

Increasingly, the world is facing up to its carbon emissions and sustainability challenge and recognizing the significant opportunity within aging commercial buildings.

It is not hard to see how monetized energy savings could add to the book value of a building and create new incentives for transparency regarding energy consumption. Owners have not always warmed to the idea of reporting energy use and disclosing it at the time of sale. Transparency has been seen as more of a risk factor in determining building value, though cities such as Philadelphia and Boston have mandated the reporting of energy use for midsize and large buildings, and others are exploring the possibility of doing so. A building that creates an income flow to the owner or investor, however, is a different matter.

All of this said, valuation in a new era of high-performance buildings is a science yet in its infancy. Projects in the United States and Europe are exploring possibilities, some building brokers have built such calculations into their business models, and the underlying logic is clear enough. But establishing the value of an investment in a deep energy retrofit with sufficient specificity to influence the price of a building remains a work in progress.

More Than Timely Innovation

The Denver and Seattle projects illustrate how new alignments and opportunities for breakout levels of energy savings through retrofits—from those in technology and building-system integration to those among the public and private sectors, foundations, non-governmental organizations, and others—can develop. The Denver project highlights the advantages of holistic retrofit design, while the Seattle project identifies a value not assessed by the marketplace and creates an instrument permitting the marketplace to assess it.

Increasingly, the world is facing up to its carbon emissions and sustainability challenge and recognizing the significant opportunity within aging commercial buildings. But typical

improvements in building energy performance are too modest and too slow to meet the goals now being deemed necessary. Building performance is stalled; there is less of the dramatic new construction many thought leaders envisioned and more of the "lite" retrofits that comparatively lack impact. Together, the Denver and Seattle projects represent a new standard for innovation that will need to be met if the world's aspiration for high-performing and efficient buildings is to become reality and the retrofit opportunity is to be realized.

References

EPA. (n.d.). Sources of greenhouse gas emissions. Retrieved from http://bit.ly/EPA_GHG

Veiga, A. (2009, August 22). Commercial real estate: Inside the crisis. HuffPost Business. Retrieved from http://bit.ly/Veiga_HuffPost

Viau, K., & Kim, Y. (2015, February 26). Commercial real estate in economic crisis: An interview with James O'Brien of Davis Polk & Wardwell. Business Law Journal. Retrieved from http://bit.ly/Viau_Kim

Stefanakos, V.S. (2010, March 11). What is a deep energy retrofit? Experts at the NESEA Conference respond. Retrieved from http://bit.ly/Stefanakos_EnergyCircle

OED. (2013, June 12). New pilot unlocks deep energy efficiency in buildings. Retrieved from http://bit.ly/OED_DeepEnergy

Narayan, T. (2015, February 26). Energy tools that could change the game. Seattle Daily Journal of Commerce. Retrieved from http://bit.ly/Narayan_Energy

Lisa Tryson is director of corporate communications and public relations for Danfoss North America, manufacturer of controls and components for HVAC and allied industries. Previously, she headed global marketing communications for the company's Refrigeration & Air Conditioning division in Denmark. She leads Danfoss' EnVisioneering thought-leadership program.

To view this article online, ***click here****.*

Back to the ***Table of Contents***