Leveraging Wireless Technology to Reduce Building Energy Costs

by Bas Jansen

Executive summary

Building owners and operators face many challenges, and energy cost is one of the greatest. It's estimated that 30% or more of energy used in commercial buildings is wasted. While building automation technology can help meet this challenge, the cost and complexity of these systems has been a roadblock to widespread adoption, especially for older buildings and smaller enterprises. New advances in wireless technology have changed this equation, offering new choices for building controls and management. This paper examines the advantages and disadvantages of the major wireless standards, and how building owners can use wireless products to reduce energy costs.

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Introduction

Building owners and operators face many challenges, including aging buildings, evolving green regulations, and the need to maintain a healthy bottom line. Rising energy costs are especially important. It's been estimated that as much as 30% of the energy that comes into commercial office buildings is wasted.[1]

Since up to 60% of a commercial building's energy use is consumed by HVAC systems, and up to 10% by lighting,[2] building automation systems have provided an important solution to this challenge. Through the use of automated sensors and controls, building operators can link their energy-consuming systems—such as lighting, HVAC, and humidity control —and manage them holistically for greater efficiency and savings.

Such systems have proven to be highly successful, reducing energy costs by as much as 30% where they have been implemented.[3] EnergyStar estimates that simply turning off lights when not needed—something that can be controlled automatically with occupancy sensors—can reduce lighting expenses by as much as 40 percent.[4] To enjoy these and other benefits, more than half of all large commercial buildings in the U.S. (larger than 100,000 sq ft/10,000 sq m), and even more in Europe, have implemented some kind of building automation solution[5]. Worldwide, most new construction now includes building automation to one degree or another.

However, the initial cost of building automation systems has been a roadblock to adoption for many, especially in the case of existing buildings and smaller enterprises. While the payback is clear, the cost and disruption to wire an existing building can be prohibitive, and smaller enterprises can find it difficult to make the necessary investment. Even larger enterprises may have delayed adoption in some locations because of the economics.

The good news is that in recent years, wireless technology has emerged as a viable and cost-effective method of achieving building control, making it possible for many more facilities to use building automation to reduce energy costs and improve building performance. Existing facilities especially are embracing wireless systems, because they can be retrofitted so easily without running new wiring or disrupting business operations.

This paper looks at the major wireless technologies and standards available, their advantages and disadvantages, and how they can be used in conjunction with traditional wired solutions to deliver a better building management system (BMS).

A technology that has arrived

Although wireless was once considered unreliable and not "industry-ready," it is now a rapidly growing technology that can be used in building control systems to provide more choices to more facilities for reducing energy costs and improving building performance.

Most misconceptions about wireless stem from early experiences in the home with entertainment and home control systems. Interference and signal reach problems were common in these early products. It's a different story today. Wireless products are everywhere, from tablets and smart phones to security systems and surveillance cameras. Most of these applications are high-bandwidth and very sensitive to latency, yet they perform reliably and consistently. Building automation, on the other hand, is a low-bandwidth

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[1] EnergyStar (http://www.energystar.gov/ia/partners/publications/pubdocs/C+I_brochure.pdf?0b55-1475)
[2] Ron Hoffman, "Reducing HVAC energy consumption," csemag.com, April 17, 2014
[3] Kristin Kamm, "Achieving Energy Savings with Building Automation Systems," automatedbuildings.com, April 2007 (http://www.automatedbuildings.com/news/apr07/articles/esource/070322105430kamm.htm)
[4] EnergyStar (http://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/stamp-out-energy-waste)
[5] Kristin Kamm, "Achieving Energy Savings with Building Automation Systems," automatedbuildings.com, April 2007 (http://www.automatedbuildings.com/news/apr07/articles/esource/070322105430kamm.htm)

application that is not particularly sensitive to delays and latency, so wireless technology is more than capable of meeting the performance demands.

Furthermore, contrary to its reputation, wireless building systems can be quite secure. In fact, wireless products can use commercial, government, and even military grade encryption with multilevel authentication. A report from Navigant Research states:

> *"Wireless systems are often more secure than their wired equivalents in terms of data security and resistance to intrusions. The systems deployed today use data encryption technologies that are similar in function and strength as those used in computer systems and include multilevel authentication in order to access the data or change settings or controls."*[6]

Today, almost 10% of the sensors and devices used in building controls are wireless[7] and that number is growing rapidly. In short, wireless is a technology that has arrived and should be seriously considered as a means to monitor and manage facility environments efficiently and cost-effectively.

Why go wireless?

Building control systems, whether wired or not, all function in about the same way. They monitor conditions like temperature and humidity, and activate fans, lights, heating, air conditioning, alarms, and other building systems as appropriate to maintain the optimum balance of comfort, security and efficiency.

Depending on the facility, wireless products running on a wireless network can offer many advantages over traditional systems. Following are some of the major reasons why a building owner might choose to go with wireless.

Ease of installation

This is one of the major advantages of wireless systems. Traditionally, setting up a building automation network involves running communication wires throughout the building, to connect the various controllers to the network, and the network to the software that provides management and reporting screens. For new construction this is not so important, but for retrofitting existing buildings, wiring costs have been a prohibitive factor.

Wireless devices can be installed with no special wiring, which means no renovation, no working through ceilings, no repainting—and most importantly, no disruption to the occupants of the building. Retail stores, office buildings and other establishments can easily stay open for business while the wireless systems are installed.

In addition, many wireless devices have built-in intelligence that enables them to identify and link to the wireless building network automatically—simply pushing a button adds the device to the network.

Wireless sometimes provides the only practical solution, such as in heritage buildings, glass meeting rooms, and other situations where there are construction limitations. A closely adjacent building, for example, could be added to a network with wireless devices, whereas running wires between buildings might be prohibitive.

[6] Keith Kirkpatrick and Bob Gohn, "Wireless Control Systems for Smart Buildings," Navigant Research, Q1 2013
[7] Ibid

Table 1[8] compares installation time and costs for wireless versus wired building systems. As can be readily seen, wireless building systems are significantly faster and less costly to install, which leads to lower cost of ownership and faster ROI.

Table 1
Comparison of installation costs for wired vs. wireless devices

	Wiring cost per ft/0.3m (USD)***	Total wiring cost (USD)	Renovation/ repair cost (USD)	Downtime = revenue loss (USD)
Wired device*/**	2-6	100-300/200-600	$	$$$
Wireless device****	0	100	0	0

* Assuming 50 feet/15 meters of networking cable in between controllers
** Assuming 100 feet/30 meters of networking cable in between controllers
*** Typical data for USA - $2 in non-union city, $4 in union city, $6 when conduit is required
**** Extra cost for wireless capabilities: $50 on both ends

Scalability

Another advantage of wireless is the easy scalability the technology offers. Most wireless building control devices are based on industry standards, and typically offer both protocol openness (ability to communicate) and application openness (ability to add new functions).

Wireless lends itself to staged deployments, since new nodes, sensors, actuators and controllers can be easily added to an existing network. Some buildings begin with only a single zone under automated control—as a proof of concept, to measure results before proceeding further, or to fit within budget constraints—and then expand from there.

Building systems based on wireless networks can scale to the most advanced BMS. Wireless products are usually compatible with one or more of the standard wired protocols used by BMS, such as BACnet®, LonWorks®, and Modbus®. Similarly, one building can be expanded to system-wide control of thousands of devices across a distributed enterprise, using web-enabled applications to monitor, report, and manage energy use.

Wireless also makes it easy for building owners to take advantage of upgrades and new technologies as they become available, allowing buildings to continually improve and yield more efficiency and energy savings over time. This can significantly enhance the lifetime value of a facility. Studies show that green buildings have a significantly lower life cycle cost than non-green buildings. For example, green retrofits can increase building asset valuation by 4% and decrease operating costs by as much as 8.5%.[9]

Green operations

Wireless technologies comply with green building regulations and guidelines such as LEED, and may qualify for utility and government rebates. Not only does wireless enable systems that use less energy, but it also helps reduce the use of expensive resources, particularly copper which is used in wiring.

According to Navigant Research, “The use of wireless controls can also contribute toward satisfying credits in the categories of Sustainable Sites, Energy and Atmosphere, and Indoor Environmental Quality under the U.S. Green Building Council’s Leadership in Energy and Environmental Design (LEED) green building certification program.”[10]

[8] Based on Schneider Electric experience
[9] “The Business Case for Green Building,” US Green Building Council, July 27, 2012, (http://www.usgbc.org/articles/business-case-green-building)
[10] Keith Kirkpatrick and Bob Gohn, “Wireless Control Systems for Smart Buildings,” Navigant Research, Q1 2013

Wireless standards: Understanding the choices

As we've seen, there can be many advantages to using wireless technology in building automation. While there are several wireless standards in use (such as Z-Wave® for home automation), this paper will focus on the two standards that make up by far the greatest number of commercial wireless installations in the world—EnOcean® and ZigBee®.

Devices within these standards perform the same types of functions, but they differ in the protocols they use to network and communicate with each other and with other devices. Let's look at the advantages and disadvantages of each standard.

EnOcean

The EnOcean standard was developed commercially, but is now controlled by the non-profit EnOcean Alliance, which is comprised of 350 member companies. In 2012, EnOcean was ratified as an IEC international standard (ISO/IEC 14543-3-10).[11] Typically, EnOcean devices are used for lighting controls and sensors.

Advantages

- More devices support EnOcean than any other standard. There are more than 800 products certified by EnOcean, most of them specifically for building automation including "switches, sensors, actuators and controllers, gateway and BMS, and accessories." Users thus have a wide choice of products from many different vendors.
- EnOcean products are "energy harvesting" by requirement, meaning they do not need to be wired to power sources and do not use batteries. Instead, they utilize kinetic and thermal energy harvesting techniques such as solar cells. This makes them economical to use and environmentally friendly.

Disadvantages

- EnOcean devices have a relatively short "reach," meaning they must be within 100 feet (30 meters) maximum of whatever device they communicate with. In general this is not a problem, but distance can be an issue in some applications.
- EnOcean is based on point-to-point communications. This is the simplest type of network, and if one link in the network goes out, devices will be unable to communicate. This is in contrast to mesh networks, which are self-healing (see ZigBee advantages, below).

ZigBee

ZigBee is a wireless standard developed by the ZigBee Alliance, established in 2002. It is a non-profit association of several hundred businesses, universities and government agencies. ZigBee is based on an IEEE 802.15 standard. The latest version of the standard is known as ZigBee Pro. Typically, ZigBee devices are used as room and HVAC controllers, as well as door/window contacts and occupancy sensors.

Advantages

- ZigBee products have a much longer "reach"—up to 300 feet (100 meters) at least and often much further, or easily three times the reach of EnOcean devices. This creates more options for users: for example, it is possible to control larger zones with fewer devices, or connect nearby buildings beyond the reach of EnOcean devices.
- ZigBee protocol supports a mesh network topology that is self-repairing and auto-routing. Mesh networks do not depend on any single connection; if one link is broken, devices search through the mesh to find another available route (see **Figure 1**). This

[11] http://en.wikipedia.org/wiki/EnOcean

capability makes a ZigBee-based network very reliable and flexible. Where EnOcean devices must be connected directly to a controller, a ZigBee device can be several jumps away from its controller.

Disadvantages

- Fewer devices use this standard, so choices somewhat limited. Interoperability has also been an issue with some vendors choosing to support a proprietary version of ZigBee.
- Typically, ZigBee devices must be wired for power. However, ZigBee is moving toward energy harvesting, so this disadvantage is expected to disappear in the future with the emergence of ZigBee Green Power.

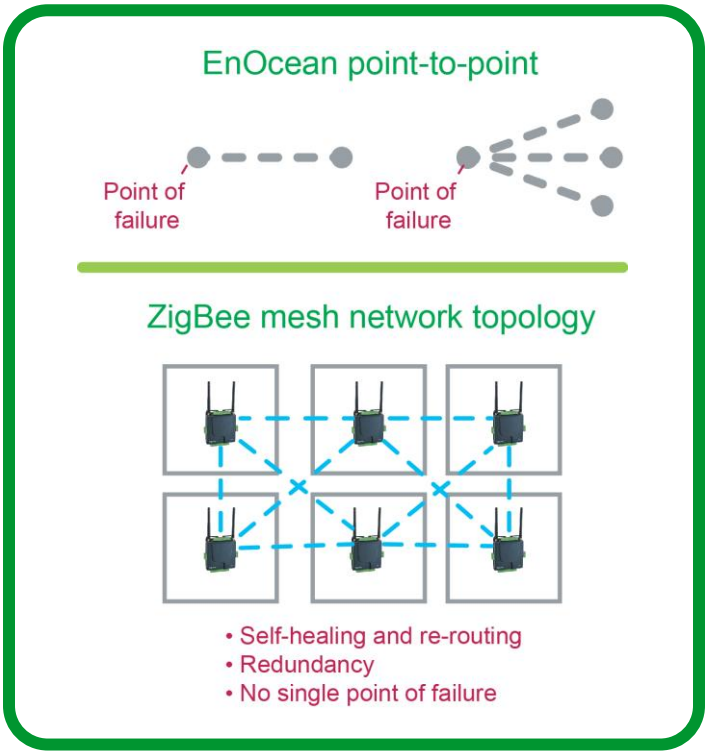

Figure 1
Comparison of wireless topologies

A note about distances

Note that distances given are for the North American standards of 2.4GHz for ZigBee and 902MHz for EnOcean, but distances will vary depending on the region. (See next section for more details on this.) Best practice is to plan for half the rated distance between nodes to be certain, but many installations can extend to the full rated distance or even further.

How wired and wireless systems co-exist

It's important to emphasize that while there are several choices for building automation—wired versus wireless, and EnOcean versus ZigBee—in practice, these approaches often co-exist within a single facility. That's because each has its own advantages and disadvantages, and using all the choices enables building owners to optimize a system to their particular needs and budgets.

Some building automation systems will incorporate both EnOcean and ZigBee products, with each being used based on their capabilities, advantages, and perhaps the specific product features that are available from a particular vendor or system integrator. As noted above, EnOcean products are typically used for lighting and room control where energy-harvesting is

desired, while the same facility may use ZigBee-based products for HVAC and network controllers.

Wired communication systems can also coexist with wireless, and there are cases where wired systems are still needed or preferred. Some reasons for using wired communication systems include:

- In new construction, running wires is not a significant extra expense.
- Some structures, because of their nature or materials used, may need wired systems to avoid problems with signal clarity.
- Very large facilities and campuses may use both wireless and wired systems, running wiring between buildings and widely separated zones.
- Some uses may preclude wireless in certain areas of a building—for example a lab or facility with high-energy equipment could interfere with wireless systems.
- For some building owners and contractors, wired systems are simply a preference based on training and experience.

This ability of the different technologies to coexist can be a significant advantage for building owners, who for example can start with ZigBee room controllers and later add EnOcean lighting controls, and eventually even expand to a full BMS across large campuses.

The diversity of solutions should not be seen as an “either-or” choice. Rather, when properly understood, it is an opportunity for every building to have a solution that fits its own requirements, goals and budgets.

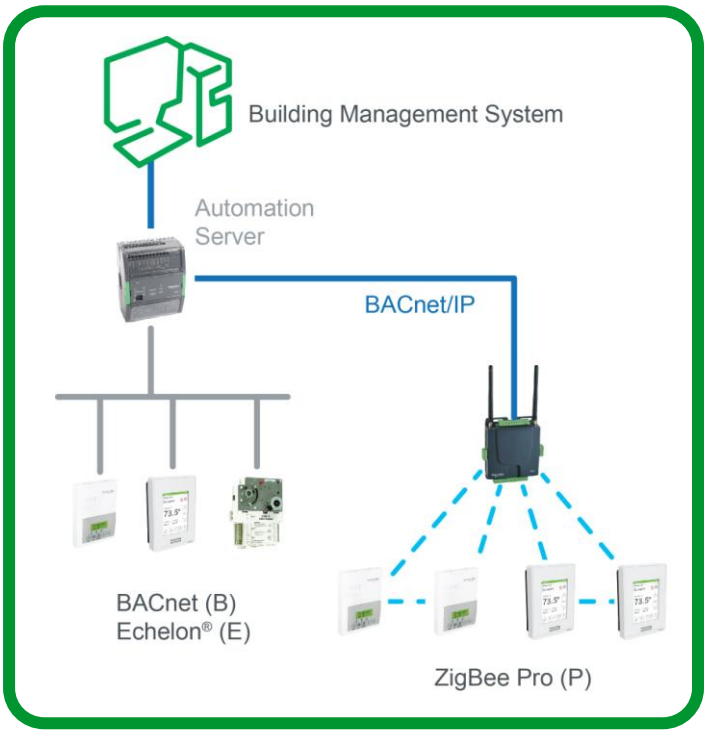

Figure 2
Simple diagram showing various wired and wireless systems in a single ecosystem

Guidelines for success

To ensure a successful building automation investment, it is not necessary for a building owner to be an expert in the technology. Most building owners, and even professional facility managers, rely on vendors and their systems integrators to guide them on product and technology choices.

Below are some guidelines that help decision-makers find and implement a building automation solution that is right for them:

- **Understand your own needs and goals.** As always with technology, this is the place to start. You can then evaluate wireless and wired choices in the context of your business goals and budget.
- **Choose vendors and contractors that offer a choice.** As this paper has tried to make clear, there are many options available in the marketplace. To take advantage of these options, it's important to work with providers that offer a wide range of product and technology choices. This is key to achieving a solution that is optimal for each facility.
- **Look for vendors that offer distributed intelligence in their products.** Whether you go with wireless or wired, you will probably want the ability to have distributed intelligence. This will improve network performance and reliability, and eliminate the bottleneck that can result from a single point of control.
- **Adapt to the region.** The frequency range of a wireless signal that can be used is largely dependent upon the region in which the system is deployed. The higher the frequency the better the performance, but the choices will be limited by regional regulations. (See the **Table 2**[12].)
- **Open protocols:** Ensure that you use open-standard protocols to enable cross-vendor interoperability to avoid being locked into a single vendor.

Table 2
Frequency ranges used in building wireless systems

Standard	Region	Frequency*
ZigBee Pro	Worldwide	2.4 GHz
EnOcean	Americas (except USA), Hong Kong, India, Japan, Thailand, Taiwan	315MHz
EnOcean	Europe, China, Malaysia, Singapore, Vietnam, New Zealand	868MHz
EnOcean	USA	902MHz

*USA transitioned to 902MHz in 2013 and other countries may follow. Contact EnOcean and ZigBee for the latest information about frequency in your country.

[12] Keith Kirkpatrick and Bob Gohn, "Wireless Control Systems for Smart Buildings," Navigant Research, Q1 2013

Conclusion

It is clear that wireless technology is here to stay, and building owners can take advantage of wireless to automate building controls that previously could not be cost-justified. While the initial purchase cost of wireless products may be somewhat higher, wireless is usually much easier and less costly to install than traditional wired systems, and allows most existing buildings to be retrofitted economically.

The optimum solution for a given building will often be a combination of wired and wireless technologies, often using both EnOcean and ZigBee devices in a single network. To help understand the choices, building owners will want to educate themselves on the various technologies and options. Much can be learned from the organizations that develop and support the standards. Both EnOcean and ZigBee have active organizations and websites that provide a wealth of information. Readers are encouraged to visit www.enocean.com/ and www.zigbee.org/ to find out more. Building owners may also want to consider conducting a low-risk, low-cost pilot test of wireless. Unlike traditional building control solutions, which require a sizeable installation investment just to find out if it will be effective, wireless controls can be easily added in pilot zones at minimal cost, with the results used to guide further expansion as warranted.

By understanding the wireless options now available, and selecting vendors that offer a wide range of choices, most building owners and operators can now afford to implement building automation systems to reduce energy waste and costs, improve performance, and enjoy the many benefits of a well-managed, automated building ecosystem.

About the author

Bas Jansen is a Senior Commercial Marketing Manager within the EcoBuilding Business of Schneider Electric; supporting the SmartStruxure Lite solution, and global / transverse room controller and field device offers. Driving product releases in all regions, he enables Schneider Electric organisations to better promote customer solutions. Bas has over 13 years of experience in the building energy management domain and holds both an engineering degree and management science degree from Saxion University in Enschede/The Netherlands.