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Controls Go Wireless

Wireless technology has been in development for decades but has blossomed in recent years with the proliferation of cell phones and wireless computer networking, enabling greater communication and connectivity among electronic devices. The technology has affected telecommunication, transportation, and consumer electronics and now offers new tools for green building. Lighting is one of the key areas being affected, but ventilation and numerous others aren't far behind.

Wireless controls in buildings can eliminate the wire running from a device such as a luminaire to the source of control. The luminaire still needs to be wired for power, but it doesn't need to be wired to a switch or sensor. Thus a light switch needs to be placed only for convenience to the occupant. A daylight sensor can be placed where it functions best—and easily moved to further optimize it—without running wires. A variable-air-volume vent can be programmed to respond to a thermostat or occupancy sensor without needing additional wiring. The environmental and economic benefits of this technology include energy savings by more precisely serving the needs of occupants, and reduced wiring, which reduces material use. However, wireless controls remain relatively new, and questions remain about reliability and realizing promised savings.

Wireless Technology

Radio-frequency technology, the basis for wireless controls, has become common in manufacturing, where companies can tag individual products or components with microchips. These tags include tiny radio antennae that emit unique identification codes when prompted by a radio signal from a receiver, creating a radio-enabled barcode of sorts. Microchips can be programmed to transmit additional packets of information—in the case of light switches, an “on” or “off” signal; for occupancy sensors, movement or lack thereof; for thermostats, the temperature, and so on.

Instead of transmitting information through a wire to a luminaire or device, a wireless switch or sensor sends the information by radio waves. A receiver wired in line with the luminaire or device “listens” for a signal and provides direct electronic control of the device.

The technology itself is fairly complex, but several companies, including two discussed here, have packaged it in a way that makes it available to any building, with some fairly basic help from an electrician. GreenSwitch is a residential product that offers a fairly targeted use of wireless technology; EnOcean, which is applicable to both residential and commercial buildings, offers greater capabilities.

GreenSwitch

GreenSwitch was designed for homeowners or occupants who want to reduce energy use but who don't tend to use their programmable thermostats or turn off lights on their way out the door. Endorsed by green pitchman and actor Ed Begley, and boosted by his television show, “Living with Ed,” the GreenSwitch was launched for the residential audience in September 2007 after a six-year history of use in hotels.

The GreenSwitch package includes a “master” switch and a handful of “slave” light switches, wall receptacles, and a thermostat. The components work normally when the master switch is on, but when an occupant turns it off, it transmits a radio signal that turns off the lights and appliances powered by the slave components, and reverts the thermostat to a programmable “unoccupied” setting. Turning the master switch back on sets the thermostat back to “occupied” and

returns power to the receptacles. Light switches turned off in response to the master switch can be turned on independently anytime.

Used either in new construction or in retrofits, the components are wired in place of standard electrical components, and homeowners can choose which lights and appliances to tie to the master switch (such as appliances with phantom loads) and which should be left independent (such as fax machines and alarm clocks). The GreenSwitch system retails for \$1,125 and is available only through the company's website; it will eventually be more widely distributed. The price, said GreenSwitch CEO Gregory Hood, is much higher than conventional components due to the radio technology. "If you compare it to high-end home automation," however, "it's very inexpensive," he said.

The thermostat component of the GreenSwitch package offers the most potential for energy savings by giving homeowners a single switch at the door to adjust the heating or cooling system to a less consumptive unoccupied setting. The package addresses the key flaw in standard programmable thermostats—that most occupants don't use them, according to studies (see *EBN Vol. 16, No. 5*). Unfortunately, most heating or cooling systems take some time to return a home to a comfortable temperature after the occupants return, a factor that programmable thermostats account for by allowing occupants to set them for 30 minutes prior to coming home, for example. The price of the GreenSwitch's greater convenience appears to be a small loss in comfort.

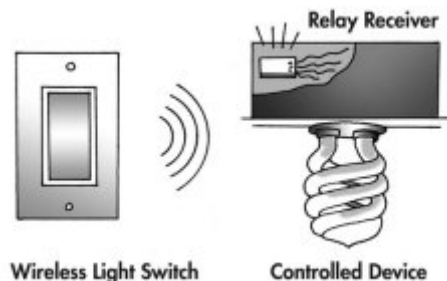


The components of the GreenSwitch system, including the master switch (upper left), allow a person to switch off lights and appliances and switch the thermostat to an "unoccupied" setting by flicking one switch on the way out the door.

Homeowners achieve energy savings from GreenSwitch in relation to their existing energy use and habits. Homes with high plug loads and space-conditioning costs and in which occupants are lax in turning things off will see the greatest savings—up to 30% and a one-to-two-year payback, Hood claims. In efficient homes with energy-conscious occupants, the savings will be smaller. The ideal home for a GreenSwitch may be one in which the occupant (or a building owner who pays the energy bill) is interested in saving energy and wants to make doing so more convenient. Begley's wife, Rachelle Carson, said that she hopes the product will cut down on her husband's nagging her to turn off the lights when she leaves the house. "It's very idiot-proof," she said.

EnOcean

EnOcean, a spin-off company of the German engineering conglomerate Siemens, offers an entire platform of energy-harvesting wireless automation products manufactured by multiple companies.



In a typical wireless control, a light switch sends a radio signal to a relay receiver, which might be in the same room, or a few dozen feet away. The receiver, wired directly to the controlled device, turns it on or off.

In order to transmit a signal strong enough to be "heard" by receiver: that may be separated by some distance and walls, a wireless control such as a light switch needs a source of power. A battery could provide this power, or it could be hard-wired, as with GreenSwitch. Instead, EnOcean's sensors have been engineered to operate with a tenth the power needs of conventional sensors, says EnOcean's vice president for marketing, Jim O'Callaghan. When an occupant presses the light switch, the motion generates power with a simple electromagnet. This minuscule amount of power is all the switch need: to transmit its signal. For other components, like daylight or occupancy sensors that aren't manually operated, EnOcean uses sma photovoltaic cells to generate power from ambient light. A low-voltag capacitor, rather than a battery, stores electricity—enough to operate a sensor whenever it's needed, even if it has been in darkness for days. By avoiding the use of batteries, EnOcean reduces maintenance needs and environmental costs. (According to O'Callaghan, a European company considering installing wireless controls in a large

office building calculated that with 4,200 battery-powered devices, it would need a full-time maintenance person just for battery upkeep.)

While the wireless sensors harvest their own energy, the receivers continuously draw 0.09 watts of power. In a well-designed system, however, that energy consumption should be far surpassed by the savings. (To break even in terms of electricity savings, every 0.09-watt receiver should be responsible for reducing the use of a 100-watt luminaire by one-and-a-half minutes a day—which shouldn't be difficult. GreenSwitch's components, which draw 0.3 watts, need to work slightly harder.)

EnOcean offers peel-and-stick switches and sensors that can be placed at the occupant's convenience and are easily moved if necessary. The sensors communicate with receivers that are wired in-line with lights, wall receptacles, ventilation system components, or anything else, and switch power on or off, up or down. The sensors and receivers are programmed in the factory to perform a specific function; it is up to the installer to "train" them to match that function to other system components. Once wired into place, the installer switches a specific receiver into its "learning" mode, and then activates the switch or sensor that is intended to control that receiver.

EnOcean components are significantly more expensive than conventional components, but as a system, including wiring and labor costs, O'Callaghan says, EnOcean is "a little more expensive" than conventional residential systems for new construction, and "a little less" in new commercial buildings. EnOcean really shines in retrofits, like a Toyota plant O'Callaghan discussed where the lighting control is a circuit breaker. "For janitorial staff to work, they have to turn on an acre of lights," he said. To allow finer control of the lighting, with the potential for energy savings, the plant installed EnOcean controls on sets of four lights. The job would conventionally be done by running wires to each set of lights, but given the size of the plant and the amount of wiring, "they budgeted \$500 for each set of lights to do the job with conduit," O'Callaghan said, whereas the EnOcean system cost "quite a bit less than half that." The energy savings accrue over time, but as in the Toyota example, savings on labor and the cost and environmental impact of wiring occur on installation. Along with large factories, the system is a natural fit with open, flexible office plans—it reduces wiring and switches embedded in walls and makes controls more flexible.

"EnOcean has saved a significant amount of effort," said remodeler Troy Davis of Fizgig Builders in Salt Lake City. Davis said that putting a three-way switch into a retrofit took 5–10 minutes with EnOcean, compared with 90 minutes to do the same project conventionally, without including drywall repairs and painting. Davis frequently works on historic buildings, and said, "It's great—we don't have to get into cutting old baseboard or crown moldings" to run wires. Davis said that the cost of materials was higher, but that it was more than offset by reduced time on the job and quicker project completion.

EnOcean manufactures the key components of its system—the energy-harvesting switches and sensors and very efficient wireless devices. EnOcean then partners with other manufacturers to provide a variety of sensors and receivers that can be combined to create systems for commercial, industrial, or residential buildings. Sixty companies offer 265 interoperable components based on the EnOcean platform, said O'Callaghan. "Some companies specialize in sensors, others in building automation systems," he said, explaining the diversity of manufacturers. For specifiers or builders looking for the right set of products, EnOcean offers a directory of the various products available. Davis said that for his remodeling projects, he simply worked with a single electronics supplier who offers the line.

Applications

Wireless controls offer unique advantages, depending on the building type. The malleability of the controls and the lack of wiring are especially useful in office or industrial settings. The ability to retrofit existing wiring and avoiding running wires down walls could be useful in any building, but homes, historic buildings, and open offices offer particularly strong opportunities.

The controls work particularly well at achieving environmental benefits with a sound lighting design. Konstantinos Papamichael, Ph.D., associate director of the California Lighting Technology Center at the



Installation of two components as part of the EnOcean platform of wireless lighting controls allows a garage light to be operated from a switch inside the home's front door—without running any new wires from the garage to the

University of California–Davis, told *EBN* that wireless controls are a boon for designing with daylight. “As a designer, when I specify the location of sensors, I’m taking huge risks—I don’t know how the space will be furnished,” he said, noting that the color of finishes and location of furniture can significantly affect how well a sensor is calibrated to actual conditions, if it is pointed at a spot that is unusually light or dark. With peel-and-stick sensors, “you can change them and find better places if they don’t work where you have them,” he said. “That may be the single most important aspect of wireless technology.”

home. In the first and second photos, a wireless signal receiver is wired into the existing light switch in the garage. This converts that switch into a three-way switch. The activator for that wireless receiver is installed inside the front door (in the third photo) using an EnOcean peel-and-stick switch. Next, let’s hope the homeowner installs a more efficient outdoor light that doesn’t send light pollution skyward!

As a researcher, Papamichael is a proponent of bi-level lighting. In many lighting applications, such as stairwells, parking lots, and building exteriors, lighting is often required to be continuous but is only used for a fraction of the day. In these situations, a very-low-wattage light source would suffice a the continuous light source, with an occupancy sensor triggering a higher level of lighting only when needed. Wireless controls could add the automation needed for these applications, while saving costs in retrofit situations.

Francis Rubinstein, a lighting researcher at Lawrence Berkeley National Laboratory (LBNL), agrees that “if you want to put advanced controls into existing buildings, wireless technology is the key to letting you do that.” Rubinstein points to California, where dual-level lighting is common inside commercial buildings due to Title 24 energy codes. Research has shown that, when given the ability to switch manually to a lower level of lighting, occupants use the lower amount 30% of the time. Of the potential for controls like EnOcean’s to improve occupant control of lighting and sensitivity of lighting systems to daylight, Rubinstein said, “We are seeing an indication that people will take advantage of it.” Rubinstein also argues for the use of these wireless controls in demand-response or *dispatchable-load* controls, enabling a utility on the verge of a blackout due to excessive demand to “reach in” to participating buildings wirelessly and reduce lighting levels

Lighting controls have been the emphasis of the first generation of wireless devices, but mechanical systems will be the emphasis of the second generation, says O’Callaghan. “We’re working with a major [manufacturer] on a home automation solution,” he noted, including lighting controls, security features, and ventilation control.



To provide the energy they need to send a radio signal, EnOcean’s wireless switches contain small components that harvest the energy used to press the switch. The switches stick into place depending on the occupants’ needs.

Already, some manufacturers are bringing those products to market. Shawn Pederson is in charge of sales and marketing at Echoflex Solutions in Squamish, British Columbia. Using components supplied by EnOcean, Echoflex manufactures items that work as part of the EnOcean platform, including lighting-circuit modules, and control valves for heating and cooling systems. “A lot of companies can give you central building control systems, and our sensors are interoperable with those systems,” he said, “but we’re designing for smart rooms.” Echoflex’s components allow for situation-dependent room lighting as well as comfort. Modulators like air-handlers and hydronic heating valves offered by Echoflex can be programmed to respond to a thermostat in a room rather than to a central system, which may not accurately reflect the comfort needs of that room.

In general, with more components more finely tuned with each other and occupants, wireless technology holds potential for greater sensitivity to building conditions and occupant needs and thus greater comfort along with energy savings. Although EnOcean allows decentralized, customized control of building systems, facility managers could use it in centralized building automation, measurement and verification (M&V) of mechanical systems, air-quality monitoring, and leak detection.

Potential Drawbacks

Wireless controls offer numerous benefits, and at this early point in the development of their use in buildings, the sky appears free of clouds. There are some drawbacks that are worth noting, however.

Cost

Although promoters of wireless technology emphasize the operational cost savings as well as savings from installation, the components themselves are sold at a significant premium over conventional non-wireless components. Retrofits and other projects where the installation savings are larger are more likely candidates for use of the technology. Over time, "I expect the technology to become cheaper," said Papamichael.

Durability

As with any new technology, there is a danger that early adoption could come at the expense of long-term durability. Wireless controls currently on the market for buildings appear to be of high quality, however, in part due to their longer history of use in Europe compared with the U.S. (with the exception of garage-door openers, which have enjoyed a long history here). O'Callaghan said that EnOcean's switches have been mechanically tested for 300,000 uses, or about 90 years' worth of operation. At that point, he says, the plastic switch fails, not the internal technology.

Radio interference

Possible interference from other wireless devices may be a greater concern than the physical components for durability of the system. O'Callaghan acknowledged that there was some disagreement in the wireless community over which radio frequency is preferable. "Most people coalesce around 2.4 gigahertz," he said. "It got popular with wireless LAN [local area network] and Bluetooth, and almost every country around the world will allow devices to operate at 2.4 gigahertz" without a radio license for the device. But the popularity of that frequency is its drawback, he said. "Every year there are hundreds of millions of new 2.4-gigahertz devices being installed throughout the world," he noted, leading to congestion in that zone, which he likens to traffic: "Would you like to work in downtown Manhattan and drive from New Jersey?"

For wireless controls to operate reliably at 2.4 gigahertz, O'Callaghan says, they would need to increase their power output and use longer antennae and more sophisticated communication protocols. All of these translate to larger devices consuming more power, with longer lag times, or *latency*, between initiating a signal and having that signal take effect. With some controls, like thermostats, latency may not be such a big deal. But with lighting, security, or many other controls, a three to six second lag time, which could occur in a system experiencing interference, could be problematic.

EnOcean's solution is to use a less popular band, 315 megahertz, for its devices in North America. The band is legal for controlling devices such as garage-door openers but not for broadcasting data or much else. Devices operating at this lower power level also cause less interference with each other, O'Callaghan noted. "We consistently get 50 feet" (15 meters) of signal, he said, with almost no latency or interference.

Whether a building uses EnOcean or other wireless devices, interference and latency are issues that designers should be aware of—not just now, but in the long term, as wireless devices become even more common.

Health risks

All operating electronic equipment and circuits in buildings generate electromagnetic fields (EMFs), which have been the subject of numerous studies in recent decades for possible health concerns. Some observers (like *EBN*, in [Vol. 3, No. 2](#)) have recommended *prudent avoidance* of such radiation, while others have downplayed any possibility of risks.

Meanwhile, microwave radiation from cell phones has become the hot EMF topic in environmental health, with researchers in Europe especially concerned. While a number of studies have shown no link between cell phone use and health problems, the most significant study to date, a 13-nation collaboration under the auspices of the International Agency for Research on Cancer, has found, in an early release of data, an increased risk for two types of brain tumors on the side of cell phone use after ten years of use. "We should be worried," concludes Louis Slesin, editor of *Microwave News*, an expert watching the research results.

The type of radiation emitted by wireless devices is more like that of cell phones than building wires, but the power of

the devices is much less, and they are not usually located so close to a person. Offering an admittedly rough estimate, Slesin said, "It's about a thousand times less exposure from the cell tower or from Wi-Fi [a branded term for wireless communication] than from the phones." Putting that in context, he said, "Worrying about Wi-Fi with so many people using phones is like worrying about passive smoking before you address smoking." Research results should be watched, especially by cell phone users, but available evidence suggests that the introduction of wireless technology into buildings especially in the low and infrequent doses that would result from building controls, is a minor concern.

Looking Ahead

Wireless controls represent a relatively new approach to building automation, and it's likely we'll see additional environmental applications in coming years. One company now developing a product, Adura Technologies, is researching the use of webs of wireless controls distributed throughout a building, in every luminaire. "It's like having a small computer inside of a light fixture," Josh Mooney at Adura, a California startup, told *EBN*. "You can call on it to turn on and off, get energy use of that light fixture, and set schedules." Like the Internet, which gains synergies from the web of computers plugged into it, Adura summons a vision of a building as a network, a potential dream-come-true for the green builder who wants better energy performance data, better monitoring of controls, and better ability to control systems.

In this article we've only looked at a portion of the available products, and designers may find that products from other manufacturers meet specific needs. Numerous other manufacturers offer wireless control systems, boasting security features, remote control options, and elaborate programs for combining light levels for a certain mood. Due to the cost of these features, they are often marketed for high-end homes. They also create the potential for greater energy consumption, and they may be so complex that they are installed but rarely used. It's important to remember that wireless controls in themselves may not reduce energy consumption. Well-designed systems that meet occupants' needs save energy, and wireless controls are a tool for creating these systems.

For now, systems like GreenSwitch and EnOcean offer workable systems designed to meet goals today, with both packaged and open-ended systems. Although he has packaged GreenSwitch with a specific intent, Hood said that was a conscious choice to appeal to the broadest possible audience. "If we're asking people to turn off one switch, we're not asking very much," he said. Speaking for GreenSwitch but also describing EnOcean and the field in general, he said, "There's so much we *can* do with the system, it's not even funny."

– *Tristan Korthals Alte*

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