Impact of Building Automation and Energy Efficiency Measures on K-12 School ROI

by Tim Doulgeropoulos

Executive summary

Schools spend more on energy than on any other expense except for personnel. Traditional building control systems reduce energy costs, but most school districts can't afford them. New, intelligent room controllers enable energy cost reductions of up to 30% without requiring high, up-front investment. Grants may also be available from government and utilities to help reduce costs. This paper offers guidance on how schools can achieve ROI through greener operations.

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Introduction

One of the greatest challenges of K-12 schools is containing energy costs. Schools typically use simple thermostats in their classrooms, cafeterias, libraries and other areas. Often, these are set according to schedules, allowing heating or air conditioning to be turned down during off-hours and activated during the school day.

The problem with this approach is that schedules are never rigidly followed through the year, and schools invariably sacrifice comfort and end up wasting energy, at significant cost.

According to the US Environmental Protection Agency and US Department of Energy, schools waste up to 20% of their lighting budget, and up to 30% of their overall energy budget.[1] On average, this waste is estimated to cost $12 per square foot,[2] or anywhere from $100,000 to $400,000 annually — enough to hire at least one or more new teachers, buy several hundred new computers, or purchase thousands of textbooks.[3] And that's just the average—large school districts waste far more. For example, Washington, D.C. schools spend approximately $30,000,000 a year on energy and have instituted energy improvements that have the potential to save millions.[4]

"Most schools in the US waste 25-30% of their energy".

The leading cause of this waste is the unoccupied classroom. Many rooms are empty even on regularly scheduled class days, due to field trips, assemblies, sick days and other events. When lighting and HVAC continue to run—which they usually do--waste adds up across a school district throughout the year. Energy is also wasted when the school days is cancelled as a result of inclement weather and holidays. In snowy regions, it's not uncommon to find school buildings following the thermostat schedule routine, heating hundreds of empty classrooms.

The traditional method for addressing these energy waste problems has been costly. Schools often look to how commercial facilities address the issue. As a result, they try to shoehorn an automated Building Management Systems (BMS), with central reporting and control, and remote room environment control into their tight budgets. This may be the proper course in a new school construction scenario, but for most school districts across the country, which have to operate on strict annual budgets and make do with existing facilities, the cost has been prohibitive.

Fortunately, new technology breakthroughs are now enabling affordable solutions for K-12 environments. New intelligent room controllers that use either wired or wireless communications offer simple, low cost options for existing schools that hope to upgrade while generating a rapid payback. These investments are also scalable and can be expanded year by year by adding networking and building management applications. These help to expand the magnitude of the energy savings for relatively small incremental costs.

Note that these potential savings are achieved without sacrificing comfort and performance. On the contrary, improving environmental control in a school usually leads to better student performance. For example, an Illinois school found that indoor air quality improvements resulted in a 5% increase in student attendance.[5] In another study, schools in Chicago and

[1] "DC Green Schools Challenge," Government of the District of Columbia and the US Green Building Council's National Regional Chapter

[2] "Greening America's Schools: Costs and benefits," G. Kats, Oct. 2006 (http://www.usgbc.org/Docs/Archive/General/Docs2908.pdf)

[3] www.centerforgreenschools.org

[4] Op. cit., "DC Green Schools Challenge"

[5] Illinois Healthy Schools Campaign, "Apparently Size Doesn't Matter: Two Illinois School Districts Show Successful IAQ Management." School Health Watch, Summer 2003

Washington, D.C., added 3 to 4 percentage points to standardized test scores as a result of building improvements.[6]

This paper discusses the new technologies that are available, reviews how schools are using them, and examines the issues to consider when making a technology investment decision.

Intelligence in the classroom

The most basic room control system is the simple thermostat, which can be programmed for different temperature settings based on time and day. This is the typical control technology in use in today's school classroom.

In recent years, a more advanced technology, called the integrated room controller, has emerged (see **Figure 1**). Like thermostats, integrated room controllers can be easily programmed to maintain room temperature according to a schedule. They can be configured and adjusted (with limits) at the classroom level because they look like a normal thermostat. Room controllers, however, introduce an entire range of new intelligent capabilities that directly reduce a school's energy costs—often by as much as 30%.[7]

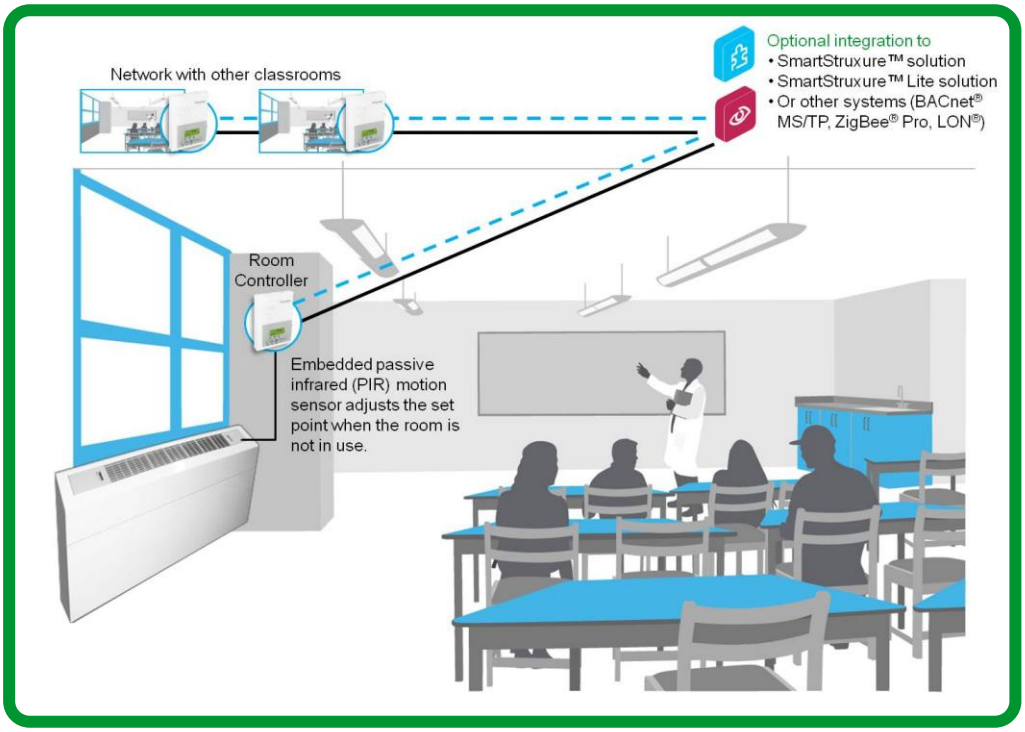

Figure 1
Illustration of an integrated room controller in a school classroom

Below is a list capabilities are now available from many room controllers, either as built-in features or added later as field upgrades:

Occupancy sensors

Occupancy sensors use infrared, ultrasonic, or microwave technology to detect motion in a room, and then adjust the heating or air conditioning accordingly. Essentially, occupancy sensors override the standard settings of the room controller, based on actual room usage.

[6] Schneider, Mark. "Public School Facilities and Teaching: Washington, DC and Chicago," November 2002

[7] Based on Schneider Electric customer experience

For example, when a classroom takes a field trip, the occupancy sensor will detect that the room is unused and, after a certain length of time, revert to the appropriate set point. On a snow day or other day off, the controllers will automatically adjust room temperatures accordingly, even if the rooms are pre-scheduled to be in use.

Occupancy sensors also provide a valuable safety and security capability in evacuation scenarios due to weather or threats to the school.

Estimated Savings: Schools save 5% in heating costs for every degree they lower the temperature in winter (or raise it in summer).[8] If schools can improve their average temperature settings by 6 degrees or more (which most do), that equals a 30% reduction in heating and air conditioning costs.

Lighting control

Room controllers can be equipped to control lighting, as well as heating and air conditioning. This is usually accomplished through simple wiring connections that any certified electrician can install. With this capability, lighting in a classroom can be set to turn on and off on a schedule, just as temperature controls are. And, like HVAC, lighting can be controlled by an occupancy sensor so that lights are turned on and off based on use.

Estimated Savings: Eliminating the lighting of unoccupied rooms can reduce a school's overall lighting costs by as much as 20%.[9]

Room and door sensors

Some room controllers offer the ability to link to sensors that can detect when doors and windows are open, and then take appropriate action—such as sending an alert to a BMS, and/or turning the HVAC system off automatically. Also, these sensors can add security value to a school (such as indicating an illegal entry), and they can be linked to CCTV systems for additional security benefits.

Estimated Savings: Savings data are not available for this specific capability, since it is usually bundled with other features. However, this capability is a requirement in many school districts in the southern and western United States, where open architectures often include classrooms that directly access unconditioned outdoor space in their physical designs.

Ventilation control

Room controllers can include CO_2 sensors (a requirement in many multi-purpose rooms and for newer building codes) with the ability to control ventilation fans. The idea is to accurately control the amount of fresh outside air that needs to be brought into the building, to ensure that CO_2 levels are within limits. Tempering outside fresh air is extremely costly compared to tempering recycled indoor air. Using this kind of ventilation control can equate to massive savings in cold and hot weather climates. It improves indoor air quality, and reduces energy costs and fan wear by running the fans only when needed and only introducing the correct amount of outside air.

Estimated Value:
These measures will produce savings in the form of more efficient fan use. In addition, improving air quality is known to enhance student and faculty performance.

[8] "DC GREEN SCHOOLS CHALLENGE," Government of the District of Columbia and the US Green Building Council's National Regional Chapter, 2014

[9] Ibid.

Wireless technology drives low retrofit costs

Room controllers can be retrofitted to existing buildings. Cost benefits are maximized when they are configured for wireless communication with sensors and networks. This minimizes installation time and costs because the need to run new wiring through the ceilings or walls no longer exists. Most room controllers come equipped with a choice of default settings for controlling their various capabilities. Therefore, they are easy to customize, which further simplifies the installation.

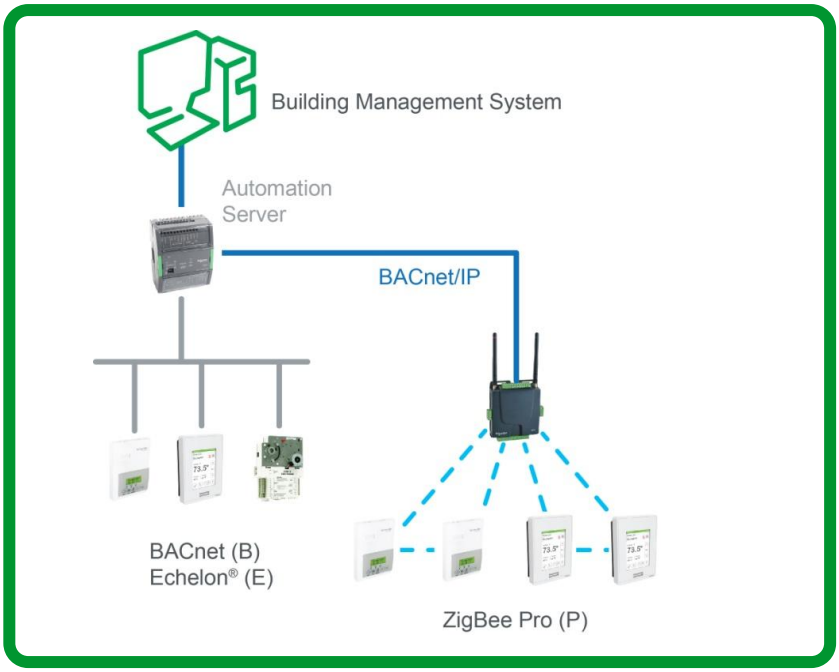

Figure 2
Simple diagram showing various wired and wireless systems in a single ecosystem

Networking and intelligent Building Management Systems

Integrated room controllers can be easily cost-justified when used as stand-alone technology. However when networked and integrated with an intelligent Building Management System (BMS) the benefit grows in an exponential manner.

A BMS provides a computerized, holistic management layer to room and environmental control, allowing facilities managers to optimize performance, reduce energy waste, and save money. The system gathers data from the various sensors and controllers from one building or many, and provides alerts, alarms, real-time visualizations, and aggregate reporting for facility and business managers. BMSs can include software applications for dynamically visualizing building activities and energy usage. They can also include control capability, such as the ability to remotely adjust temperatures or other settings in a room or zone, via a web or software interface.

Intelligent BMSs enable school executives to manage energy in a holistic fashion, to plan and budget more accurately, and save more money over the long term. Additional capabilities of connectivity to a BMS include the following:

- Notification via alarms if a classroom is out of a certain threshold
- Remote modifications of parameters in a room or zone
- Pre-cooling or pre-heating to an "occupied" set point when it's known a classroom will soon be occupied (such as for a scheduled evening conference)
- Notification to the maintenance department to turn off the HVAC system when a door or window has been left open (if door/window sensors have been deployed)

- Identification of trends that signal equipment in need of repair or inefficient energy use
- Leveraging of building analytics to understand and manage long-term energy use
- Central or remote management of multiple buildings and building systems
- Efficient use of manual labor since technicians may troubleshoot a problem before going on site
- Monitoring of systems in a continuous, real-time fashion
- Real-time alarm management and alerts
- Customization of analytics, modules and dashboards
- Standardization of an open energy management platform that eases future integration
- Expandable to support growth and adapt to future needs

Proactive Facilities Management. Note than an intelligent BMS has a big impact on the role and effectiveness of the school's facility manager. Typically this role is one of reaction and fixing what breaks. With a BMS, facility managers can become much more proactive, able to better budget time and resources to take corrective actions early, and mitigate hazards that impact security and safety.

A staged approach for school budgets

Some school systems may be able to afford a full upgrade to integrated room controllers, sensors, networks and BMS software. For most schools, however, an incremental approach is more in line with annual budget realities.

A natural progression would be:

- Stage 1: Identify the school or building with the most need. Install integrated room controllers in the identified building for proof of concept and ROI measurement.
- Stage 2: Expand to other buildings or the rest of the school district
- Stage 3: Add networking and building management in not already available

Stage 2 could be done in a few months or a few years, depending on school size and budgets. For the longer term projects, a school system might want to add BMS as soon as the first building has been upgraded, to better plan future actions. This kind of staged approach allows a school system to use incremental ROI to help pay for each new stage. Eventually, all schools in the district can be folded into a centralized BMS for maximum benefit and ROI..

Managing the cost

A wireless integrated room controller can be installed in an existing facility in about 15 or 20 minutes by a single electrician. This means that even for hundreds of rooms, the installation cost is relatively minor.

The main expense will be the integration of the controllers themselves, which will depend on the set of features chosen, the vendor and type of product selected, the size of the purchase, and the area of the country where the school is located. In general, today's integrated room controllers cost little more than an average residential electronic thermostat.

Many local, state, and federal governments offer incentive programs and funding packages that support the installation of renewable and energy-efficient technologies such as energy management systems. In California, about $550 million is budgeted each year for energy efficiency and clean energy improvements in schools. Utility companies also offer programs for sustainable installations, such as product rebates or low-interest loans. Further

information on state, local, utility and federal incentives and policies in the United States can be found at the www.DsireUSA.org website.

Considerations

To ensure that all the full potential of energy savings are realized, schools should weigh the following variables when considering the solutions they select and partners with whom they choose to work:

Full range of capabilities

It's important to select a vendor that offers a full range of products and services. This gives schools more flexibility when reviewing options needed to plan and implement energy improvements. Below are examples of some of the technologies that will address the gaps:

- Occupancy sensors
- Lighting sensors
- Door/window sensors
- Wireless communication
- Ability to provide and train on an intuitive BMS system

Look for vendors that can provide long-term solutions and that can help when the energy management system needs to grow in the upcoming years.

Note that both wireless and wired communication (meaning communication with sensors, HVAC controls, and building networks) are often used together in the same schools, as the best solution will depend on the specifics of each facility.

Scalability

Whatever solution is implemented today, schools will need a growth path for future enhancements in order to leverage their investment and achieve maximum ROI over the years. At a minimum, the selected room controllers should be able to migrate to new buildings and also have the capability to be networked at some point in the future, and scaled to include BMS applications for management and analytics.

Standards

Room controllers and building management systems communicate with each other using open and industry standard protocols. There are several standards in use, the most common of which are:

- Wireless: ZigBee and EnOcean
- Wired: BACnet and LonWorks

A detailed discussion of standards is beyond the scope of this paper. However, standards should be discussed with any vendor that undertakes an energy management project to ensure that the products installed today will be able to communicate with those planned for the future.

School experience

School systems face unique challenges and budget constraints that are not typical for most businesses. Thus, it will be helpful to work with vendors that have a track record in schools, and that offer the services and support needed to ensure success.

Conclusion

School systems have a vital mission to educate, and every dollar saved on energy and building operations can be directed to vitally-needed teachers and/or equipment. New advances in technology allow schools to incorporate advanced room control systems within their strict budgets.

By choosing scalable products, a school district can start small with room controllers, and gradually build on that investment year by year, eventually achieving full BMS capability if desired. Experience has shown that this approach can pay for itself through energy savings, freeing up more funds for mission-critical expenditures.

Administrators and decision-makers who wish to learn more can find helpful information at www.epa.gov, including papers on energy savings for K-12 schools. Information is also available at the “Green Your Schools” website at http://energy.gov/eere/education/green-your-school, which provides links to multiple documents and resources specifically aimed at education.

Building automation, once an investment beyond the means of most schools, is now within reach for nearly every district. By starting small today, K-12 schools can ensure energy savings and greener performance far into the future.

About the author

Tim Doulgeropoulos is a Business Development Manager for Schneider Electric. He is responsible for growth and development of the Room Controllers and SmartStruxure Lite solution products in the Western US region for markets such as education, hospitality, government, and healthcare. He has 26 years of experience in management, sales, and tech support in building automation, energy management, mechanical systems and mechanical systems integration. Mr. Doulgeropoulos also has been working as an educator, educating engineers, contractors and end users for the past 20 years and has achieved many prestigious awards including, on multiple occasions, tech support person of the year, and trainer of the year.