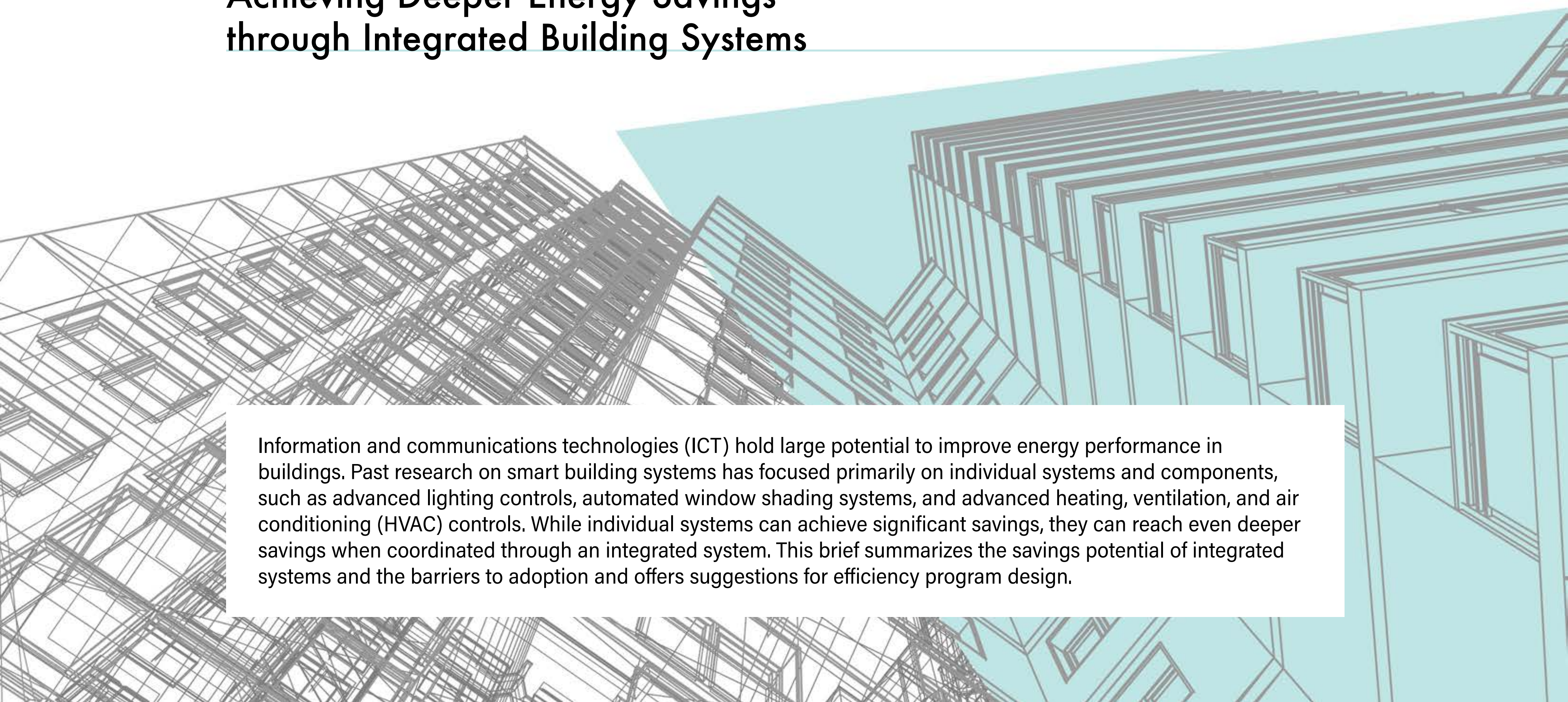
Emerging Opportunities Series

ACEEE
American Council for an Energy-Efficient Economy

Achieving Deeper Energy Savings through Integrated Building Systems



Information and communications technologies (ICT) hold large potential to improve energy performance in buildings. Past research on smart building systems has focused primarily on individual systems and components, such as advanced lighting controls, automated window shading systems, and advanced heating, ventilation, and air conditioning (HVAC) controls. While individual systems can achieve significant savings, they can reach even deeper savings when coordinated through an integrated system. This brief summarizes the savings potential of integrated systems and the barriers to adoption and offers suggestions for efficiency program design.

The Opportunity

Increasingly, software companies are offering energy management and information systems (EMIS) to coordinate multiple connected building systems. Traditional building management systems (BMS) typically provide basic data on system operations as well as some level of controls. However newer types of EMIS can include additional features, such as real-time data analytics and greater system controls. Integrating building systems can lead to three major energy efficiency opportunities in commercial buildings: fault detection, optimization, and automated savings. Such integration offers nonenergy gains as well.

Fault Detection

A fault detection diagnostic system (FDD), can instantly detect, diagnose, and notify an operator about faulty performance (King and Perry 2017). This is an improvement over a traditional building automation system (BAS), which can notify operators of faults but often cannot diagnose the specific cause. For example, a simple BAS alarm may indicate that a room is overheating, but more advanced EMIS can trace that problem back to the fact that a damper is stuck open or a temperature sensor is out of calibration. This information allows building operators to address the issue and also helps them develop more accurate preventive maintenance schedules and prioritize the order in which to address alerts (Managan 2013). Furthermore, they can use a FDD as a continuous commissioning tool because it allows buildings to be fine-tuned on a regular basis, as opposed to once every few years. FDD can reduce building energy consumption by 5–25% (Energy Trust of Oregon 2017).

1670 Broadway installs EMIS technology and saves $180,000 in operating costs

1670 Broadway is a mixed-use office building in Denver with 700,000 square feet of rentable space. The building management team worked with SkyFoundry and Group14 Engineering to install EMIS to upgrade the existing building automation system. The software monitors and provides near-real-time interval data for hundreds of devices. These data revealed energy-saving opportunities such as upgrading certain equipment (including terminal boxes from pneumatic direct digital control [DDC]) and installing LEDs. In the first year, the building reduced its energy costs by 6%. In the second year, the building saved an additional 7.6% through continuous monitoring and operational improvements (SkyFoundry 2017).

Optimization

EMIS can act as a platform for data collection, coordination, and storage. Once data are synthesized, building operators or service providers can use trend analysis to identify opportunities to upgrade equipment. This can lead to great savings, as seen in the case study of 1670 Broadway in Denver. Beyond equipment upgrades, data analytics can also inform improvements in building operations. For example, buildings with hoteling workstations can use occupancy data to reorganize workers scattered throughout an office into more densely occupied areas. This can reduce not only energy costs (by shutting off the lighting and HVAC in newly vacated areas) but also operational costs by reducing the areas served by custodial and maintenance staff.

Automated Savings

Some EMIS can not only identify opportunities and faults but also automatically adjust system operations to optimize building performance. Automated system operation (ASO) technology can, for example, use information to optimize the amount of daylight in the building to reduce or maximize heat gain, depending on the season. Furthermore, integrating these controls with HVAC systems can drive deeper savings by optimizing heating and cooling loads (Alliance to Save Energy 2016). Beyond building energy systems, EMIS can also integrate with other types of building systems. For example, security systems can relay occupancy data to an HVAC system so it will turn off in unoccupied spaces. Systems with this level of integration are usually priced at a premium.

Nonenergy Benefits

Beyond energy savings, EMIS technology offers many nonenergy benefits, including improved tenant satisfaction. For example, EMIS can learn user preferences over time and automatically adjust to meet the tenant's needs. This increases not only tenant comfort but also tenant productivity; studies have shown that employees achieve more when ventilation is increased in underventilated areas. Perry (2017) details the nonenergy benefits EMIS can provide to Class B offices, retail stores, hotels, and hospitals.

Project Economics and Savings Potential

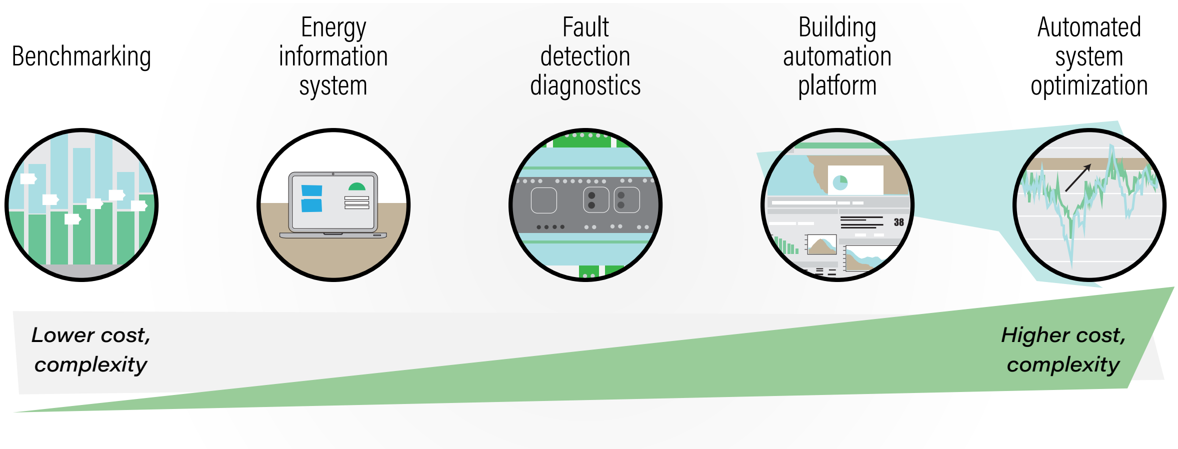


Figure 1. Cost of EMIS based on data analytics, control, and automation capabilities

The cost of EMIS varies greatly depending on how many features and services the system offers. Figure 1 shows a scale of EMIS costs based on the level of data analytics and control capabilities.

Cloud-based energy information systems (EIS) tend to be the least costly to install, approximately $0.01–0.77 per square foot, but often require service contracts. These systems save approximately 5–10% in whole-building energy consumption and reach payback in 1–2 years (King and Perry 2017). Traditional building automation systems can cost between $1.50 and $7.00 per square foot but yield 10–25% whole-building energy savings and pay for themselves in 3–5 years (King and Perry 2017).[1] Good cost and savings data do not yet exist for automated system optimization; presently these systems are priced at a premium, but costs are likely to decline over time.

Currently there is more research about the savings potential of individual systems than there is for EMIS. Figure 2 depicts energy savings from both individual and integrated building systems. The savings estimates for individual measures are expressed as a percentage of total energy consumption for that end use. The savings estimates for integrated systems are a percentage of whole-building energy use.

While research shows individual systems can achieve savings in the 20–50% range, estimates for whole-building savings from integrated systems are lower. ACEEE conservatively estimates that integrated building systems save an average of 8–18% of whole-building energy through the use of smart technologies (Perry 2017). Although other estimates may be higher, we consider that many buildings (especially small and medium-size ones) face budgetary constraints and may require costly infrastructure upgrades to install these technologies. Thus, in most retrofit projects, not every savings opportunity will be pursued. Additional research and data from demonstrations will better inform integrated system modeling and result in more accurate savings estimates.

1 Costs and savings will vary depending on the building and existing automation systems. Further research and demonstrations are necessary to better estimate the savings potential specific to building types and applications.

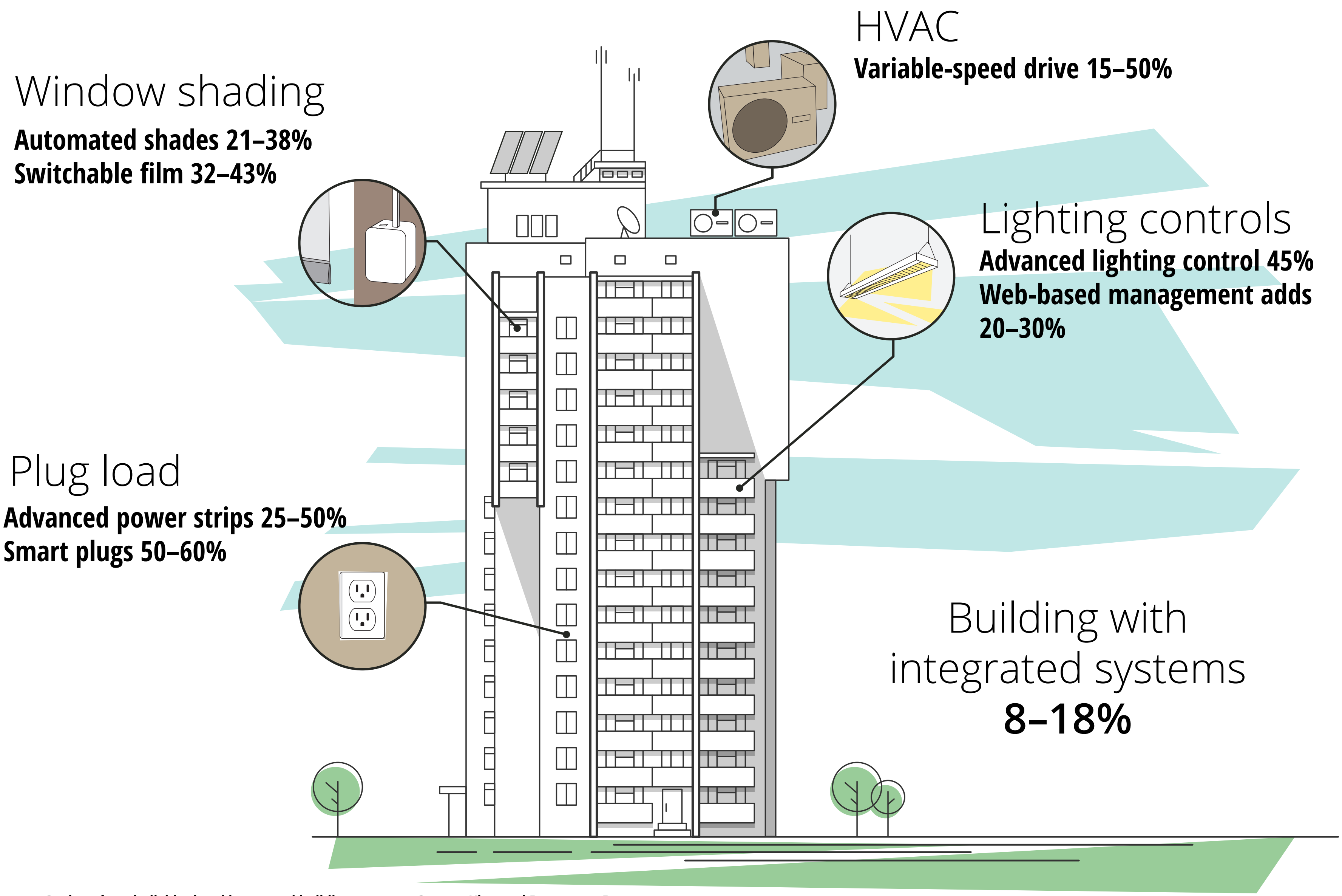


Figure 2. Savings from individual and integrated building systems. *Source:* King and Perry 2017; Perry 2017.

Challenges

Since the market for ICT and system integration is still relatively new, many barriers to adoption must be overcome.

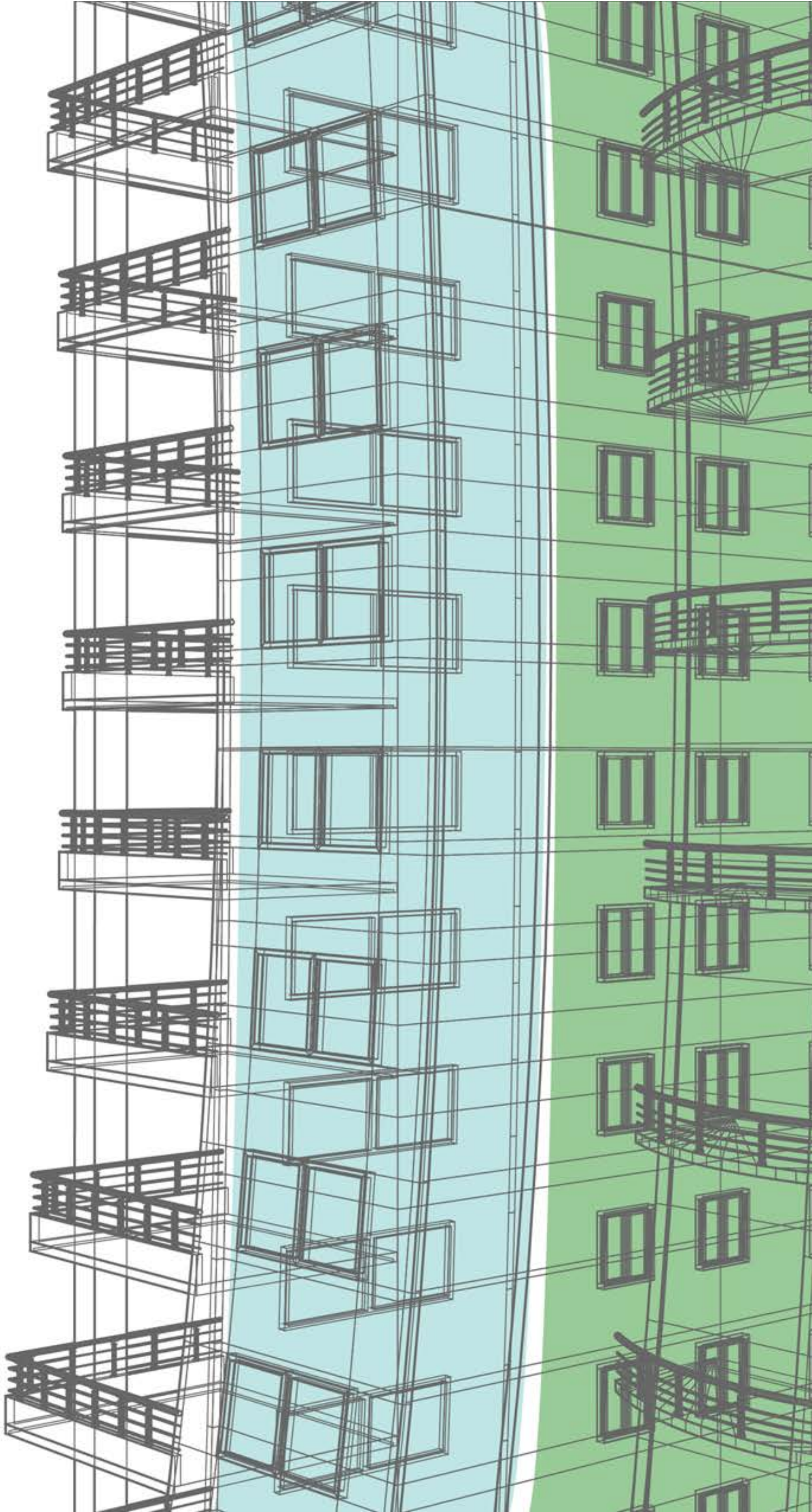
Up-front cost. This is the largest barrier to widespread ICT investments, as few organizations are willing to make the high initial outlay associated with ICT technologies and integration software. Vendors are beginning to offer energy management as a service (EMaaS) to help reduce the up-front costs. Typically, these vendors will provide EMIS software, sensors, and energy management services for a monthly service fee over a set contract period. This allows customers to see immediate cash flow without capital investments.

Skepticism among building owners and operators. Newer technologies, EMIS in particular, are complex and have a steep learning curve. Additionally, since new technology hits the market every day, owners worry that the technology they invest in today will quickly become obsolete. Improved outreach and workforce training programs could help educate owners and operators about the benefits of ICT and integrated systems.

Interconnectivity issues. No standard protocol exists to let all smart equipment and devices connect to one another. However a number of alliances and coalitions (e.g., buildingSMART Alliance, Project Haystack) have formed to try to solve this problem.

Cybersecurity concerns. Weakly secured BAS systems can be vulnerable to cyberattacks. If hackers gain access to connected building systems, they can often also reach the corporate networks operating within the building. For example, hackers were able gain access to Target's payment system by hacking its third-party HVAC vendor. Cybersecurity experts have demonstrated that this story is not unique and are calling on industry stakeholders to push vendors to develop more stringent security protocols.

In addition to these common barriers, each commercial building type faces unique challenges. For example, older hotels constructed with concrete and rebar often require costly and disruptive re-cabling to install smart devices into an integrated system. These buildings often have insufficient funds to overcome these additional costs. Perry (2017) details barriers related to Class B offices, retail stores, hotels, and hospitals.



Program Approaches

Across the United States, program administrators are interested in incorporating EMIS into their program portfolios. Developing programs that serve a variety of commercial customers is challenging because each building differs by size, energy end uses, and other characteristics. Fortunately, this technology offers deep and sustained energy savings, thereby motivating administrators to pursue EMIS programs.

There are four types of programs that can promote EMIS technology adoption. Table 1 summarizes these four program designs and gives an example of each. King and Perry (2017) provide further details about these programs and others.

A number of utilities have developed pilots and programs to promote the adoption of EMIS technology. These pilots and programs are achieving energy savings. Table 2 summarizes the results for three of them.

Table 1. Programs to promote EMIS technology adoption

Type	Design	Example
Prescriptive rebates	These programs provide financial incentives for equipment upgrades, such as lighting and HVAC systems. Increasingly, utilities are incorporating individual smart components like sensors, meters, and controls in their portfolios.	Mass Save: Business rebates
Custom incentives	These programs pay incentives per unit of energy saved and sometimes include setting a building-wide energy savings goal to encourage system-level efficiency improvements.	District of Columbia Sustainable Energy Utility (DCSEU): Custom rebate program
Smart building service contracts	These programs provide incentives to commercial buildings that purchase advanced energy management software and enter service agreements for a required time period.	NYSERDA: Real Time Energy Management (RTEM) program
Demand response	Utilities offer credits to building owners who enroll in these programs and curtail their energy consumption during peak demand events.	National Grid: Smart Energy Solutions program

Sources: **King and Perry 2017; Mass Save 2018; DCSEU 2018; NYSERDA 2018; National Grid 2018.**

Table 2. EMIS pilots and programs

Program	Description	Savings results	Expenditures (2017$) and levelized cost
Efficiency Nova Scotia: EMIS Program (pilot)	Prescriptive rebates for industrial customers	In 2015, the pilot had 3 participants who saved 3,786,000 kWh at the generator.	$176,334; levelized cost: $0.004
Xcel Energy: Energy Management Systems (EMS) Program	Custom incentives for commercial and industrial customers	In 2016, the program had 94 participants who saved 8,775,881 kWh and 68 participants who saved 5,229 decatherms.	$1,080,358; levelized cost $0.010 (for kWh savings)
BC Hydro: Continuous Optimization Program	Funding for approved consultant and software providers to install RTEM systems for commercial buildings	On average, each building has saved 4.7% kWh and 7.3% gigajoules and has seen a 1.6-year simple payback.	N/A

We calculated levelized cost from the program administrator perspective by annualizing costs using the loan payment function in Microsoft Excel (PMT) and dividing by annual kWh saved. Assumptions include: half the incremental cost paid by program administrator, program administration costs of 20% of incentive costs, a 5% real discount rate, cost estimates adjusted to 2017$ using the Federal Reserve Implicit Price Deflator, and a 10-year measure life. *Sources:* A. Henwood, program manager, Efficiency Nova Scotia, pers. comm., June 6, 2018; Xcel 2017; BC Hydro 2018.

Case Study: NYSERDA RTEM Program

The New York State Energy Research and Development Authority (NYSERDA) has implemented a comprehensive program tailored for integrated systems that shows promise for yielding significant energy savings. The Real Time Energy Management (RTEM) program provides custom incentives to commercial building owners who purchase both EMIS and services from a qualified vendor list.

While the program provides incentives to building owners, NYSERDA has focused on engaging system and service vendors instead of commercial building customers. EMIS vendors apply to become qualified, which requires a detailed application, interview, and demonstration. NYSERDA set broad requirements in order to avoid favoring any particular technology and to allow the companies to develop their products naturally (see the text box "Qualified Vendor Requirements"). Much of the program marketing is accomplished by leveraging and upselling the vendors' existing customers.

Through research, NYSERDA determined that having contractors make regular site visits helps building operators use the systems to achieve actual energy savings. To qualify for incentives, building owners must enter a three-year service contract with a qualified service vendor. NYSERDA requires customers to submit a service report every six months to track savings and progress.

This strategy has many benefits. NYSERDA is able to ensure customers are entering contracts with vendors who provide quality systems and services. This also has broader implications for the entire EMIS market, as it issues a clear set of vendor standards that ultimately builds market confidence.

The program went into effect in 2015. As of April 2018, approximately 135 vendors have applied and 50 have qualified. Some 175 customers have enrolled in the program—about 140 commercial buildings and the remainder multifamily residential buildings. The program has not reported savings results yet. Refer to the NYSERDA website for updated program progress information.[2]

Qualified vendor requirements

NYSERDA requires system providers to offer the following features:

- Energy consumption tracking
- Energy performance analysis
- System integration
- External data integration
- Reporting and data export
- Data capabilities
- Interface capabilities
- Networking capabilities

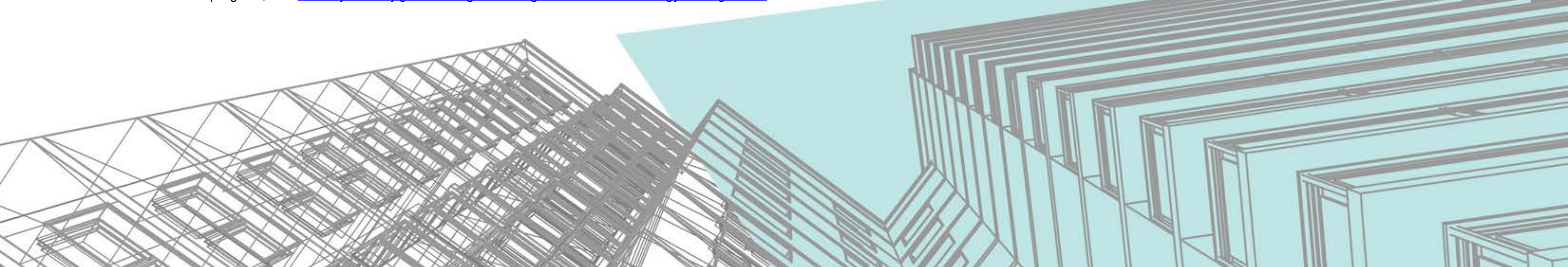
Data collected from the system must be:

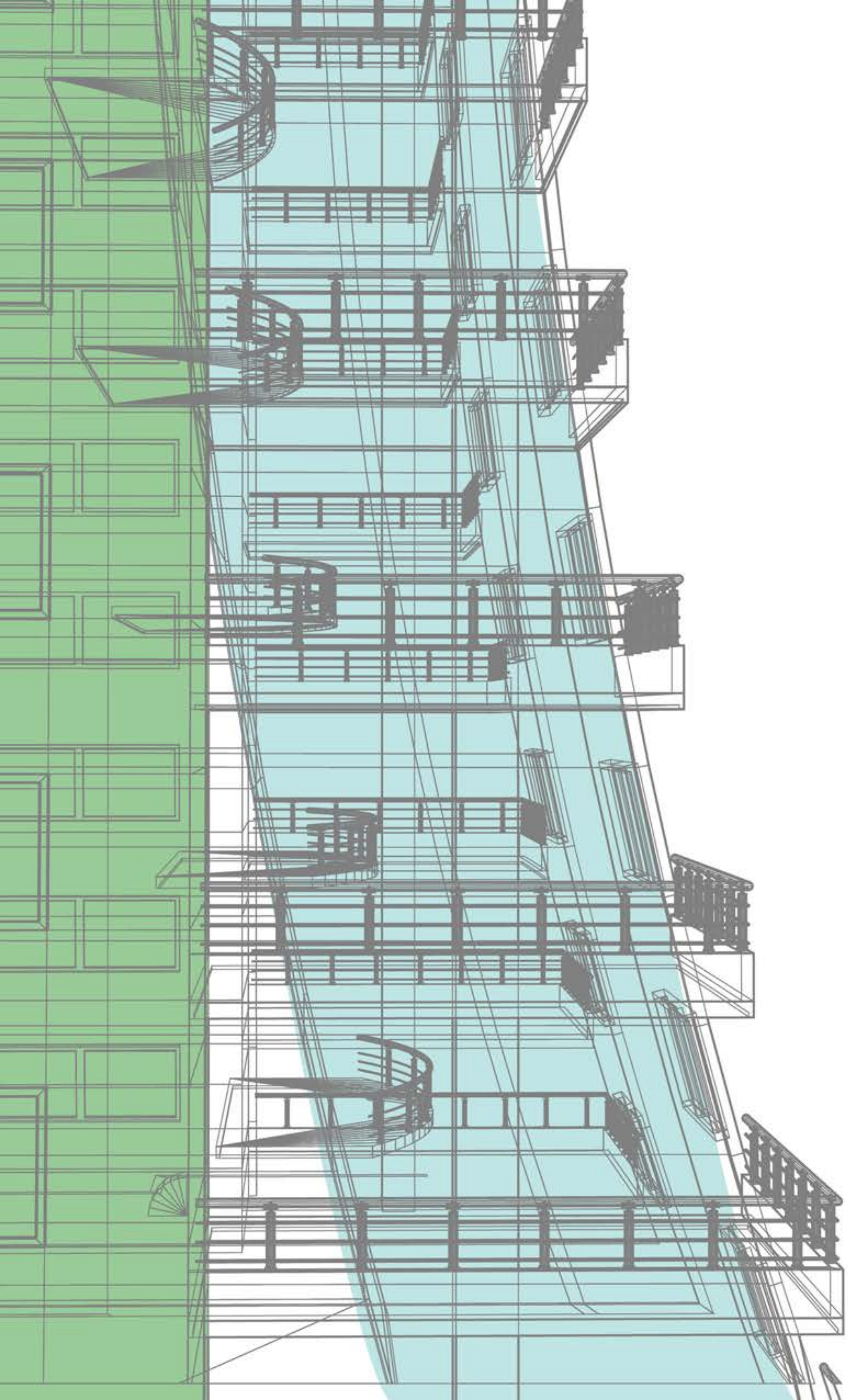
- At least equipment level
- At a minimum of 15-minute intervals
- Cloud-enabled

Service providers must:

- Analyze energy usage data
- Provide, enable, or implement actionable items based on analysis

2 To track NSYERDA's progress, visit www.nyserda.ny.gov/All-Programs/Programs/Real-Time-Energy-Management.





Next Steps

Utilities and program administrators are cautiously optimistic about incorporating EMIS into their future program portfolios. However they need more robust research about the full savings potential of EMIS technologies. Fortunately, several organizations are collaborating with various stakeholders to conduct studies and share findings. Examples include the US Department of Energy's Buildings to Grid Integration Initiative and Better Buildings Smart Energy Analytics Campaign.[3]

Program administrators can take several actions to encourage the uptake of EMIS technology. For one, they should work with vendors and large building owners in their service territories to document energy savings and performance in buildings that have installed EMIS. Beyond demonstrations, more utilities and program administrators need to implement programs that encourage building owners to invest in EMIS software and ongoing services. Working groups for program administrators should be established to encourage information sharing and coordinate efforts. This will help create consistency across programs and send clear messages to vendors about the types of products to develop.

Program administrators can also become involved with various initiatives working to remove barriers to this market. For example, the OpenADR Alliance is tackling interconnectivity issues by fostering the development and adoption of the Open Automated Demand Response (OpenADR) standard. Several utilities have joined the alliance to help support the development of this standard because interconnectivity is crucial for cost-effectively implementing demand response. Program administrators may also want to become more involved in groups working toward increasing building system security. Recently, the IoT Security Foundation started a smart buildings working group to facilitate the discussion among stakeholders on best practices.[4]

Through steps such as these, program administrators can help bring ICT strategies and EMIS systems to many more buildings, saving energy and improving building management.

3 See www.energy.gov/eere/buildings/buildings-grid-integration-0 and betterbuildingsinitiative.energy.gov/alliance/smart-energy-analytics-campaign.

4 To learn more about joining the working group, visit www.iotsecurityfoundation.org/iot-security-foundation-announces-smart-buildings-working-group/.

Resources

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