SMART BUILDINGS

FALL EDITION

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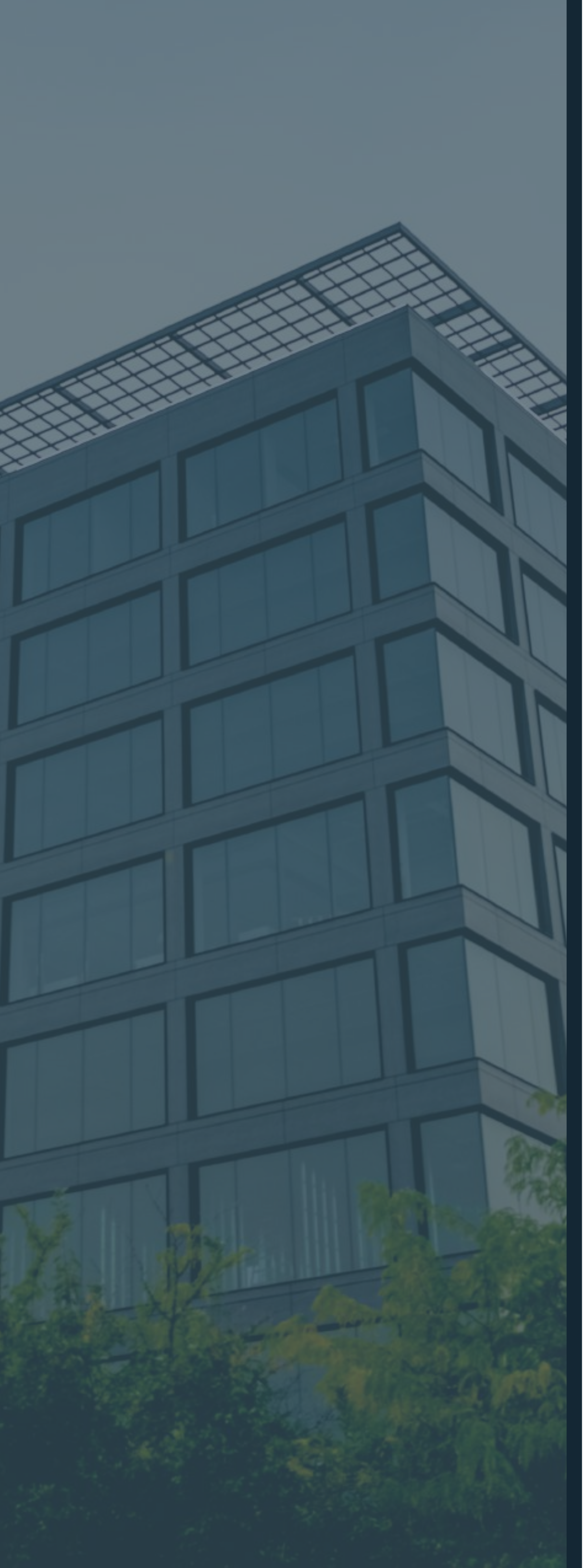

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Top smart building system essentials

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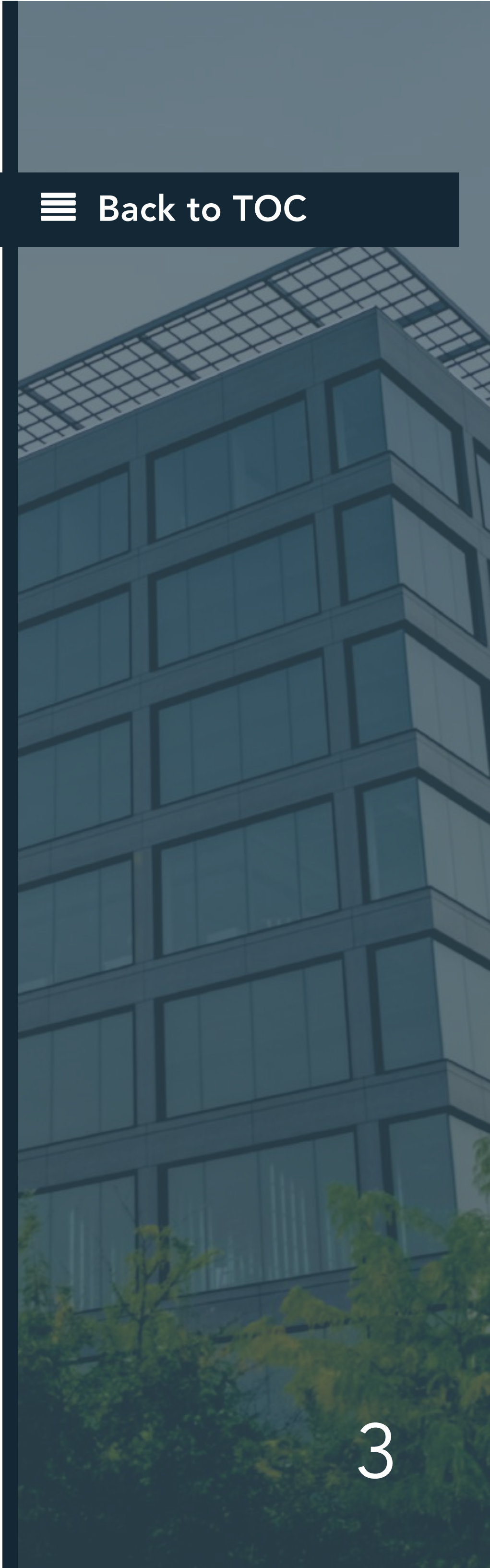
These three critical considerations, three best investments and three common pitfalls will help in the design of a smart building



Whether a building owner manages a hospital campus, military base or college or corporate campus, they all want the efficiency and resiliency that modern smart building control systems bring. How does the choice of systems get made? The answer is to study the details. Not every investment adds up to a positive return and there's a lot of noise to sift through before the final buying decisions are made.

As part of a consulting engineer's work guiding clients through implementing smart building control systems, our team has identified three essential guiding principles that would be beneficial to explore, three best returns on investment and three most common problems that arise in a typical installation.

Critical considerations when implementing smart building controls

1. Data highway capability: The data highway is the ethernet and fiber network to share data from end devices to the building automation system. It is highly likely that individual building systems were implemented a la carte rather than as an entire system that links all buildings. It is also common to see different generations of automation systems between buildings, with different vendor equipment and various levels of functionality. Success of a building's new smart system depends on having a big picture plan of how the owner is going to move data between facilities using ethernet and fiber.

Ethernet switch channel availability and network data transmission rates are two other elements of the data highway assessment. Ethernet switching is at the central hub

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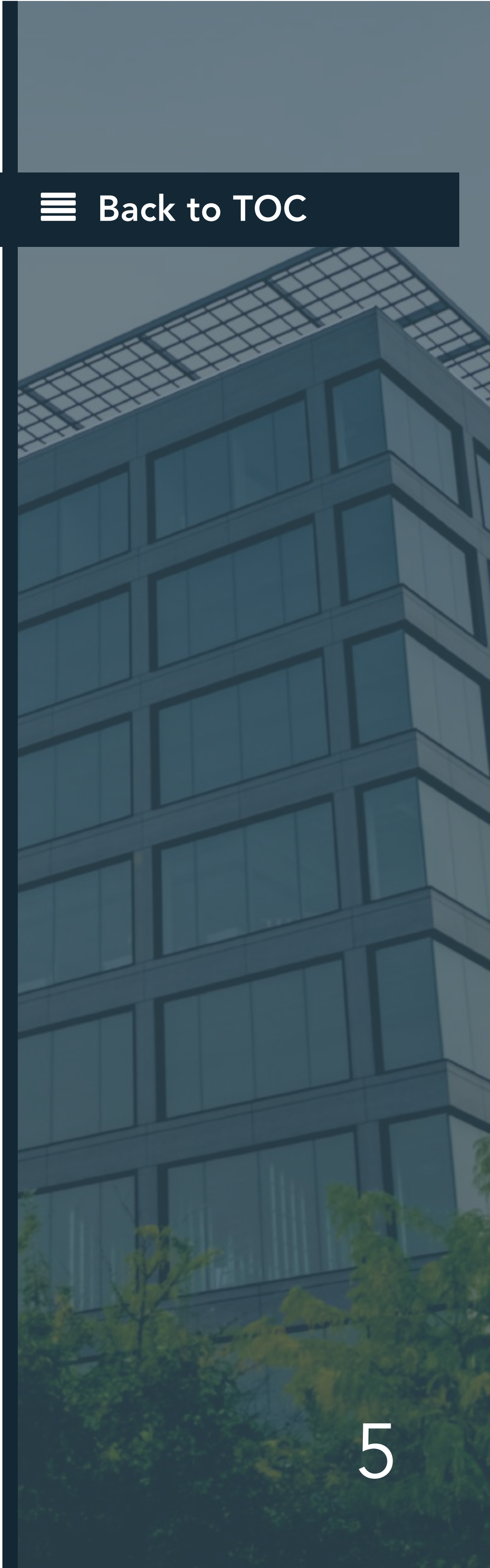
where internet protocol devices connect. Older systems did not have ethernet switching requirements. With new systems, end devices require ethernet IP connections.

Figure 1: Modern technology allows owners to consolidate controls into a single management center that acts as a gathering point for data produced by essential property systems. Courtesy: Stanley Consultants

Electrical engineers and information technology network engineers must increase the number of IP ports or channels in a building so that designers can incorporate the end devices into the building automation system. Security protocols are continuously developing as more layers of protection are added to switching hubs. Modern IP switches will provide the capability needed to meet cybersecurity policies.

System architects also need to understand network data transmission rates. Huge amounts of data passes over the network to the control system. The better and faster the network is, the more capable the data management. Component speeds need to be similar or the system will be only as fast as the slowest component.



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Engineers should review the original equipment specifications and perform a visual walkdown. Look at the database and discover where the weak points are. Though the entire process, including installation of new equipment, keep the database up to date. It may be surprising that few building operators keep these records. Modern building information modeling systems are designed to address this issue.

2. Cybersecurity policy: System designers and operators need a thorough understanding of security policy and needs of different users. Each campus will have different security policies, for example a university versus a hospital or military base. The complex may be served by a microgrid, which has its own security issues. What are the rules, requirements and firewalls the communication system has to navigate?

Vendors, for example, routinely need to troubleshoot their systems. How does that vendor gain access, remotely or do technicians need to physically access the facility and plug into the system? All this needs to be thought out and well-defined for each stakeholder.

3. Develop stakeholder profiles: How will each stakeholder be using the data produced from the controls system and what does each interface look like? The best way to accomplish this is to ensure that each stakeholder group has a representative on the project team.

For example, if it's a university, what is the faculty usage profile? What do they see and control? Look at it from the building engineer's perspective. Is mobile access allowed? How are alarms responded to? How is instrument technician access handled versus mechanical repair? Anyone who might be involved or impacted needs a profile, including building engineers, owner staff and tenant users.

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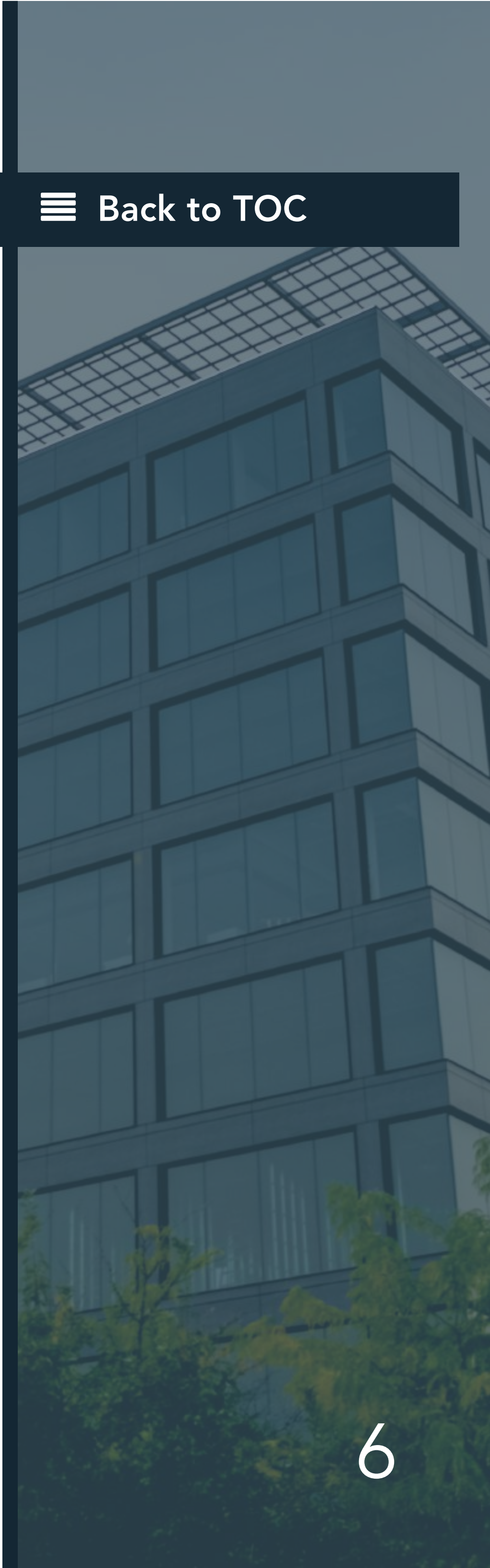
The best returns on investment in smart building control systems

1. Utility management: Most building and facility management energy systems are not "smart," in that they don't have automatic controls and motion sensors on lights or on heating and cooling. Systems are typically manually controlled and have many different versions of switches. Owners can install a seemingly limitless number of sensors and smart devices to improve energy management. Occupancy sensors can tell a system whether to heat or cool a room, lights can be activated by motion and water leaks can be detected by tracking flow anomalies.

Once the system designer understands how the building is being used, he can optimize the energy use profile for that building and choose which devices to optimize. Even older equipment can produce usable data. The smart building automation system can use present data combined with older information to tell a more in-depth story.

In the case of distributed generation management, the new system can manage different generation assets, such as solar or gas-fired combustion engines, under one smart system. Adapt controls to individual driving factors, such as lowering fuel costs and promoting efficiency, using green energy, maintaining a net zero carbon footprint or guaranteeing resiliency.

2. Security: Access management provides a bulwark against unauthorized access theft or vandalism. Like with energy, security often falls into separate systems that don't have management capabilities. For example, security and video monitoring would be on different systems. Today it's all included in one.



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Health-related security — say, when air exchanges and filtering being strengthened to fight the spread of airborne viruses — provides a high degree of confidence by users, which pays off in lease renewals.

3. Emergency response: The third bang-for-the-buck investment is made in emergency response technologies. Various alarm and response systems — fire, active shooter, natural disaster — can be reported to the same head end and single control. Managers can optimize a response with text messages, building messaging boards or voice over loudspeaker notifications that can direct people to shelters or identify threat areas. Doorway access can be managed centrally.

Figure 2: Whether it's temperature, room occupancy centers, lighting, air handling exchanges or security, a smart system allows owners to monitor and control from a single point. Smart systems must be customized to adapt to the property's unique characteristics and owner's priorities. Courtesy: Stanley Consultants

For example, an active shooter, shot detection system can have both video and audio components that track a shooter. It turns on lights in exit areas, making it safer for people to get out. Occupancy sensors know how many people are in a given space and the threat can be assessed.

Three common smart building pitfalls

1. Third-party devices don't always follow smart building industry protocol: If designers are working to save major headaches, ensure that third-party devices follow

industry standard protocols. One example is BACnet, developed by ASHRAE to facilitate common standard communication between control devices and sensors.

It is recommended that devices be certified by regulatory agencies to meet contractual obligations, such as guarantees that third-party products will communicate to a building control system. In one project the Stanley Consultants team worked on, the vendor had stopped paying to certify its system because of the expense involved. When the third-party device was added to the system, there was no initial confidence it would communicate correctly and it failed. It turned out the field installer made an error in ethernet login settings. Extra expense was incurred when it required two technicians two days to troubleshoot the problem. If the device was certified, the issue would have been much simpler and less expensive to resolve.

2. Hot technology of the moment: Although there is significant flexibility when committing to a high-performance building management system, “internet of things” vendors will try to convince owners that they must have the vendor’s latest widget and will perish without it. Some technology will indeed last and become valuable, while others will be a flash in the pan. How do owners decide what will stick?

Owners must do their own research. Talk to both other peer owners and experts for their opinions. Go to conferences and seminars and canvass the room. Explore user groups online. Most importantly, install a test bed in one of the buildings as kind of a technology nursery. Test the system’s value before you make a larger commitment. Don’t overlook the old system vendor, as it’s likely they offer a new system you can migrate to because new devices will communicate to older equipment.

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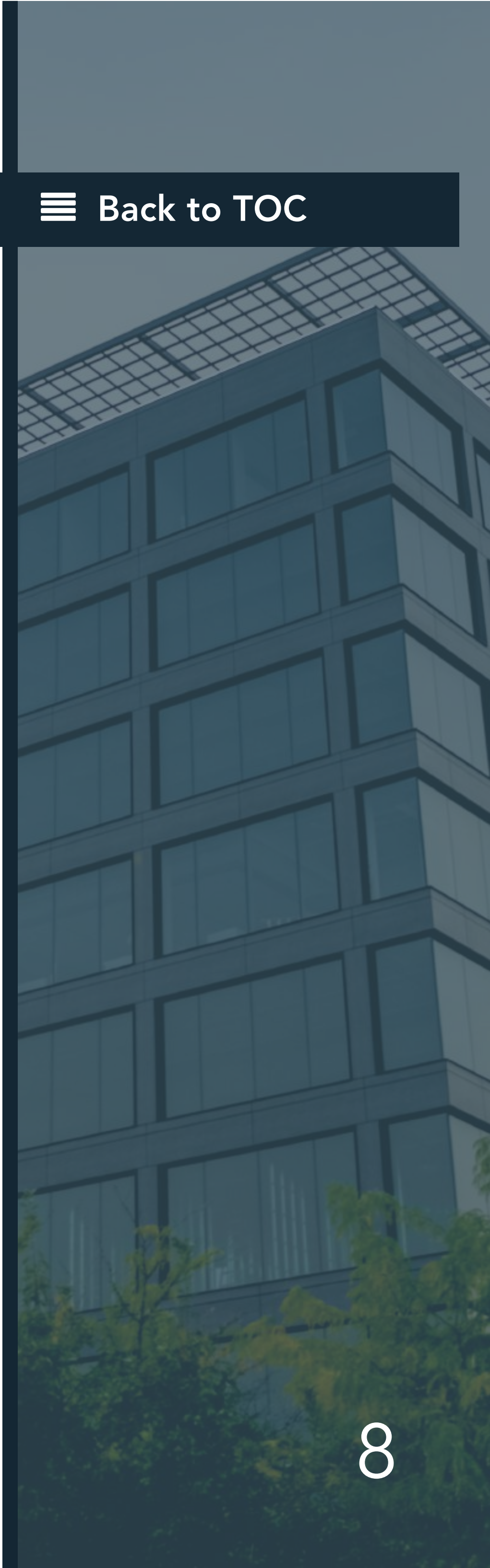

3. The danger of overpromising: The internet of things world makes almost anything possible, given money and time. Once designers and owners open the door with a state-of-the-art building management system, temper the desire to say that all the smart building goals and wishes will be fulfilled immediately. With sophisticated smart system controls, the details matter. Focus on providing a strong, well-defined backbone of data flow along with a unified control concept with easily deployed security capabilities and the end devices will come and go much easier. Take the time to understand them and the chances of success will multiply.

Aaron Szalaj

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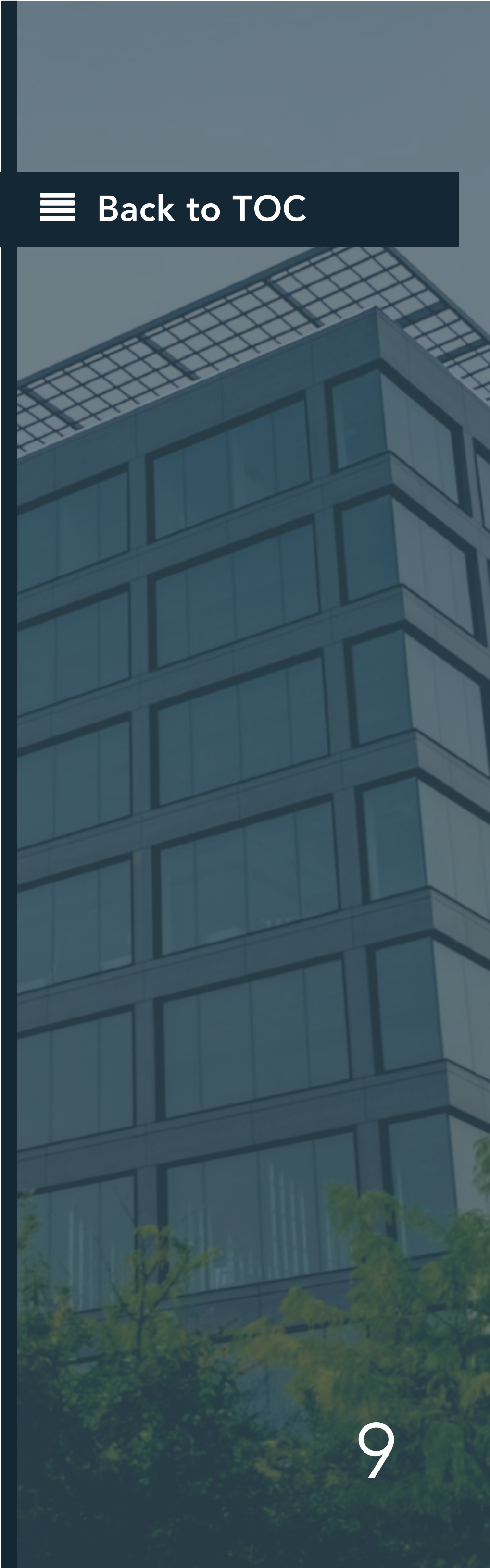

Deliver smart buildings using CSI Division 25, commissioning

The use of CSI Division 25 and commissioning are critical to the successful design and operation of a smart building

Building automation systems, which are now commonplace with heating, ventilation and air conditioning systems, are used to reduce operator interactions, provide stability and improve the operating efficiency of these systems. The automation industry has now moved from solely controlling HVAC systems into operating a wide range of building systems.

According to a Markets and Markets Research report, the BAS market is expected to grow from $73.5 billion in 2021 to $112.1 billion in 2026.

At the same time there has also been a movement in the buildings industry toward the integration of the "internet of things" into these systems. For buildings, the IoT describes the use of the internet to process of exchanging data between a device (sensor, controller, actuator) and a remote server, which uses the data to create a change in the operation on the devices system.

As the computational power of central processing units and microelectronics has increased, the spread of IoT within a wide variety of building systems has flourished. This technological advancement has created a strong movement toward its use in creating smart buildings.

Smart buildings, which use artificial intelligence and operational technologies, allow

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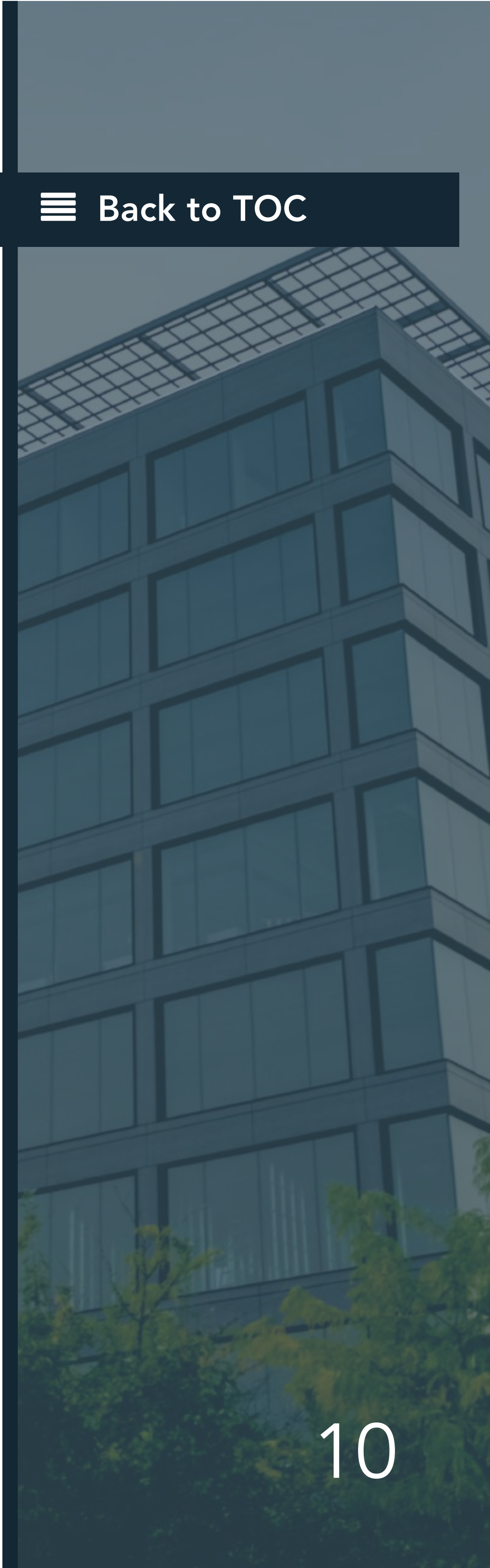

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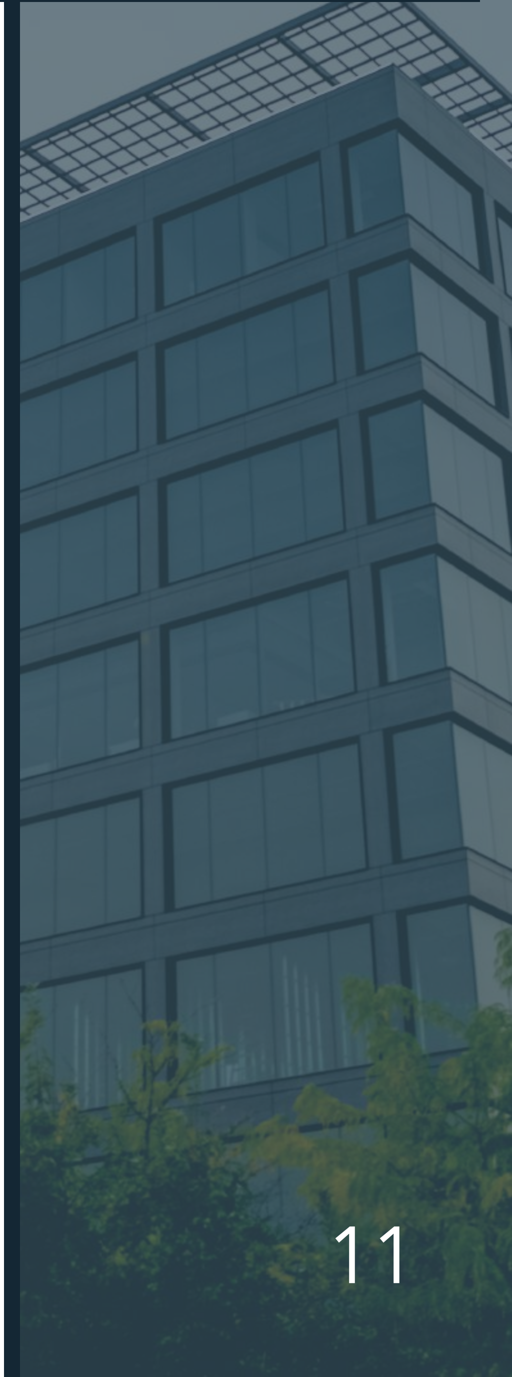
Figure 1: Smart buildings performance is based upon the amalgamation of multiple building systems into a unified building controller to achieve the benefits of remote monitoring and artificial intelligence/ operational technology. Courtesy: Stantec

for building systems to be automated in the process of predicting, identifying, analyzing and resolving performance issues. OT is used to monitor building systems and create changes to systems normally within the scope of a human operator. This enhancement to remote operation provides building operators with a wide variety of analytics and visualization.

Likewise, AI can improve energy efficiency, resiliency, indoor air quality and occupant comfort. A cloud-based server allows for the computational power needed to operate these solutions and is quickly being provided by many major control's manufacturers.



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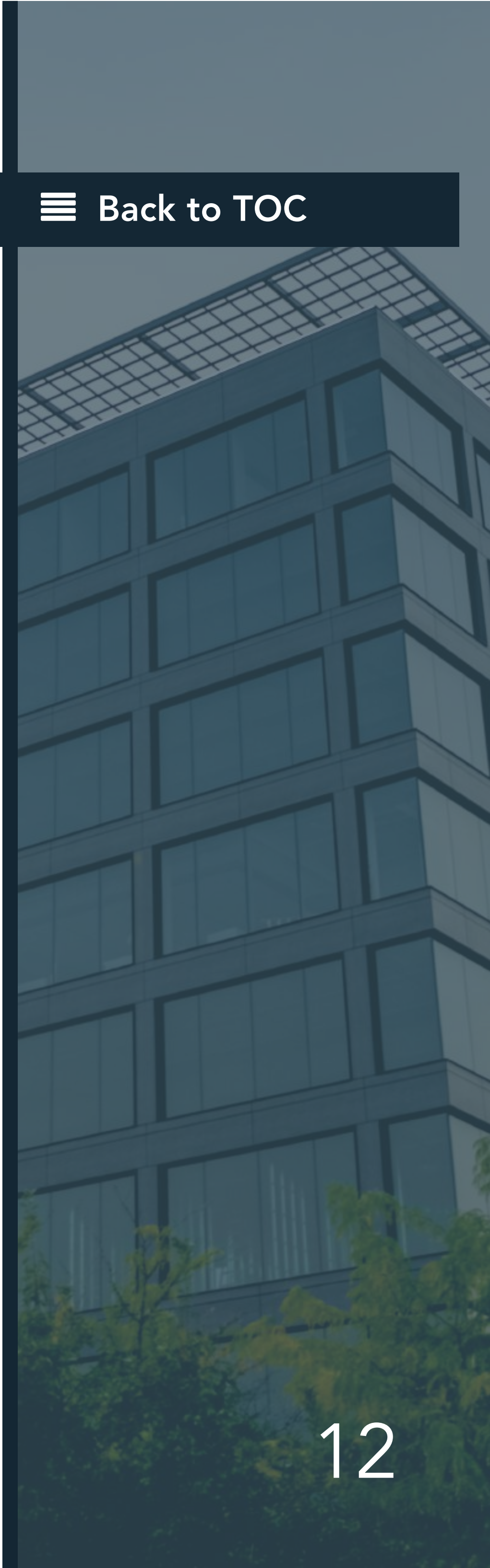
For engineers designing smart buildings, the use of the Construction Specifications Institute MasterFormat Division 25: Integrated Automation is essential to the success of a project. Complementing this with the implementation of commissioning is critical and works to remove the human errors in design and construction which can cause a smart building to underperform.

The COVID-19 pandemic has had the most unprecedented effect on the global economy and the operation of the built environment. Major weather and seismic related events were once thought of as the primary drivers behind resiliency in buildings until now. Many employees were required to follow shelter-in-place orders from local governments which left the buildings unoccupied and, in some cases, uncontrolled. Regardless of the event, buildings still need to be operated to maintain stable internal thermal and moisture conditions and to avoid damage to equipment if run unattended to for long periods of time.

The pandemic-driven stress test has uncovered weaknesses in remote facilities operations and has alerted the operators of buildings and the industry as whole to the need to create more rigidly defined preparation standards and guidelines that will make these systems more resilient and ready to handle the next major event. It has caused the industry to rethink how we should construct, renovate, operate and maintain buildings. Consequently, it has offered the perfect opportunity to advance the use of cloud-based remote monitoring and operation of building systems, which can be found within smart buildings.

With every opportunity there is always the potential to fail. The same applies to smart building design and construction. It can be the tendency of owners and design teams



to over commit to the level of which projects can sustain the implementation of new technologies. Smart building design contains a wide range of building systems that it can be applied to.

As such, the use of CSI MasterFormat Division 25 during design process will provide the details and framework for proper coordination and specification of smart building systems and components. In the construction phase, commissioning of these systems is required to confirm operational integrity and to provide the owner and operators with the skills needed to bring a smart building through its life cycle.

In the end, smart buildings do not fail because of technological restrictions, but rather from small incremental issues that culminate in the owner downgrading the systems to operate as a traditional building-level automation system.

Using Division 25 for smart buildings

According to the Memoori report "The Internet of Things in Smart Commercial Buildings 2016 to 2021," the analysis predicts a higher growth rate in the commercial real estate market of 31.5% compound annual growth rate. The report goes on to indicate this sector will grow to represent 34% of overall smart building devices, with more than 3.6 billion devices installed by 2021.

Division 25: Integrated Automation has existed for nearly 20 years and currently includes nearly 90 sections that specify everything from the systems architecture to the wiring needed to create a smart building. It also specifies the commissioning of these systems. The purpose of this division is to connect automation with multiple engineering disciplines/building trades and generate a coordinated, singular product delivery.

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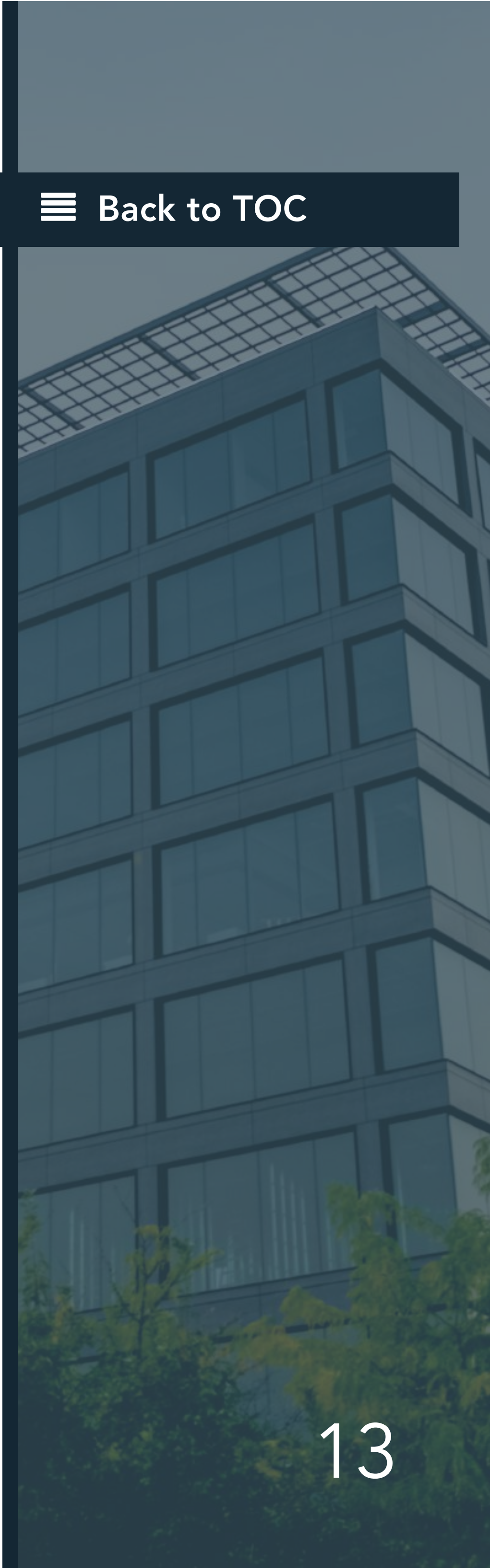

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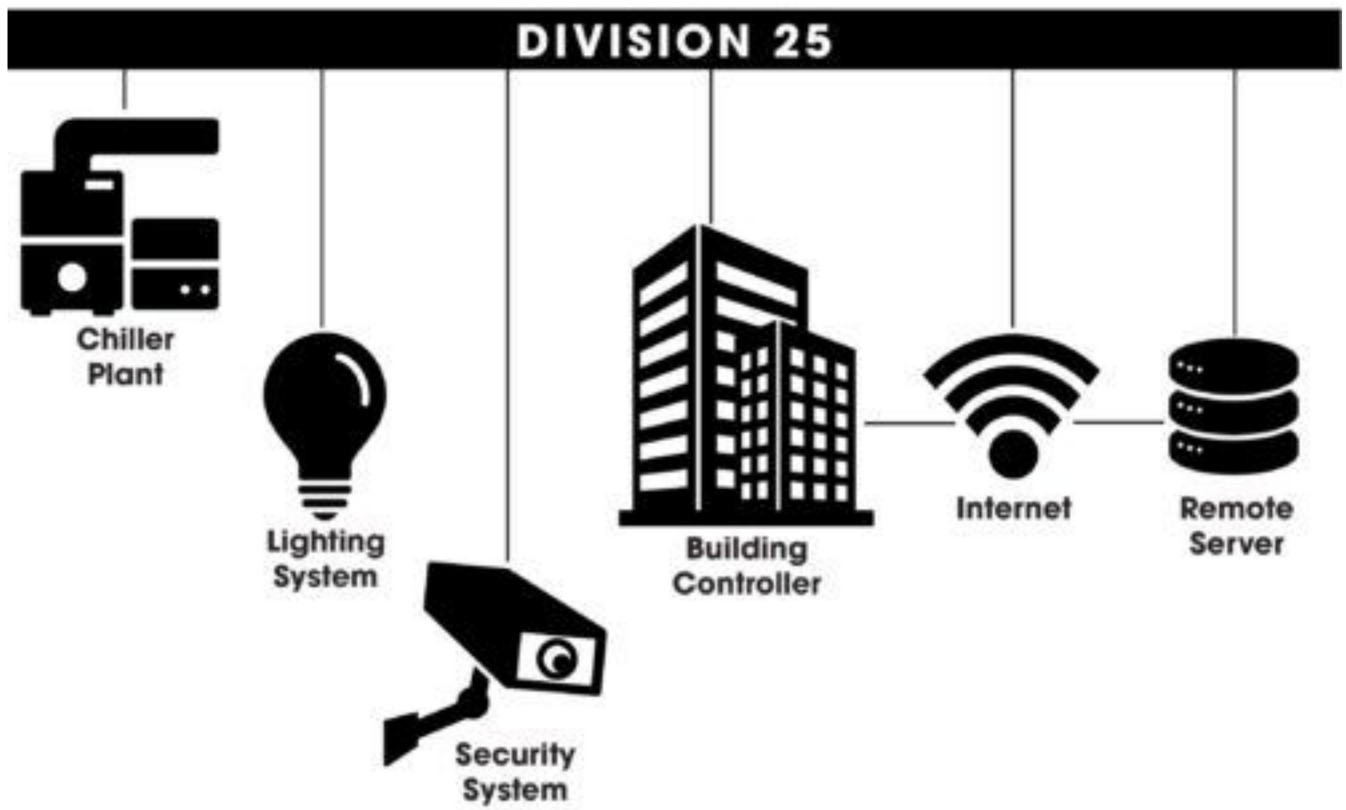


Following the framework of Division 25 allows engineers to connect end devices, supervisory systems, network pathways and remote operation of AI/OT solutions together. Coupling proper Division 25 specifications with commissioning can offer a long-lasting, successful smart building solution.

Figure 2: Integrated automation allows for the leveling of layered and siloed building systems into a unified platform. Coordination between construction trades and manufactures occurs in the design phase to allow for a properly executed construction and operational phases for a smart building. Courtesy: Stantec

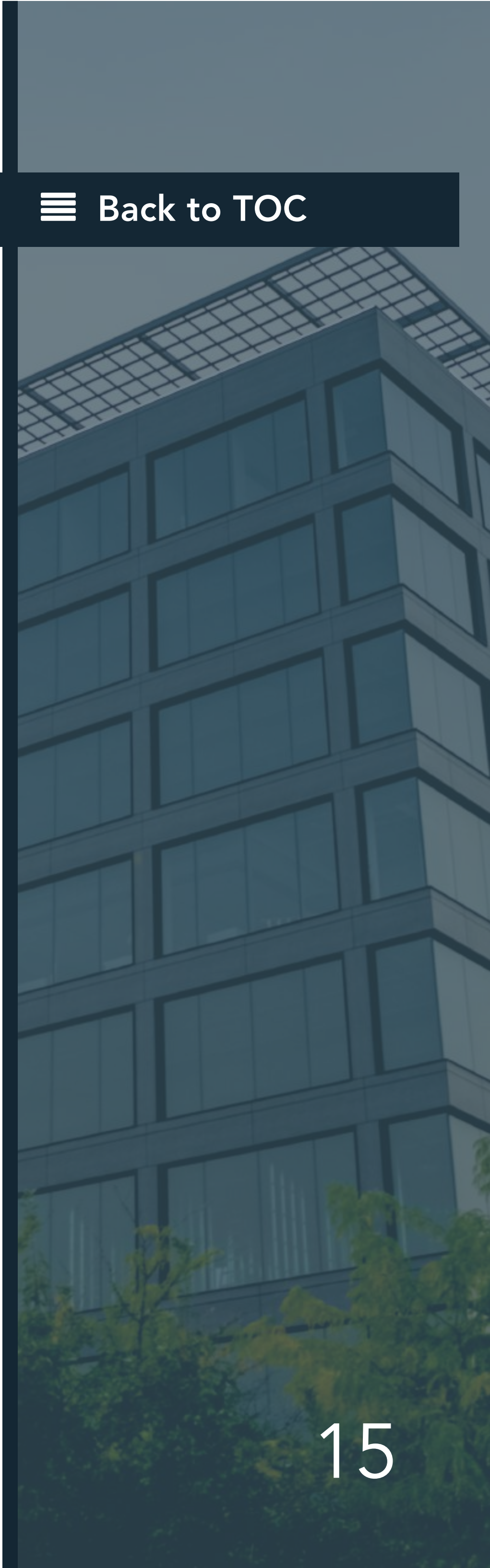
However, the use of Division 25 is typically limited to large organizations with multiple buildings (industrial, higher education, health care) where impacts of energy and operations and maintenance costs have a larger overall impact on the organization. It is a missed opportunity for those of smaller building footprints that can leverage local incentives for smart buildings to reduce implementation costs or for commercial real estate building developers where the O&M costs are the tenant's responsibility.

Without the proper validation of needed control points, sequences, sensors and data management methods during early design phases there may be functional issues of remote AI/OI tools baked right into the design. Likewise, when reaching the turnover phase of a project a building commissioning professional or commissioning agent should conduct point-to-point checks to validate that all is operating as intended.

The complexity of multiple systems layered on top of each other in a smart building solution requires a higher level of owner and operator training that is best achieved though the involvement of a commissioning agent. Not only does training need to teach the specific approach to controlling the systems installed, but it also needs to include how to deal with data management and analytics to properly set up an owner's team for success. A commissioning agent will ensure that all of this takes place.

Smart buildings and commissioning

With the design and specification of smart buildings being facilitated by Division 25, there is still the opportunity to degrade the performance of the systems via the unpredictable aspect of human error during construction. Each device, pipe, electrical connection, controller, valve and all other building components are manufactured and installed by skilled individuals. Commissioning has been created as the last defense to ensure that these human errors will be identified, mitigated and resolved early in the life of the building. Errors are typically simple mistakes that can cause a negative com-



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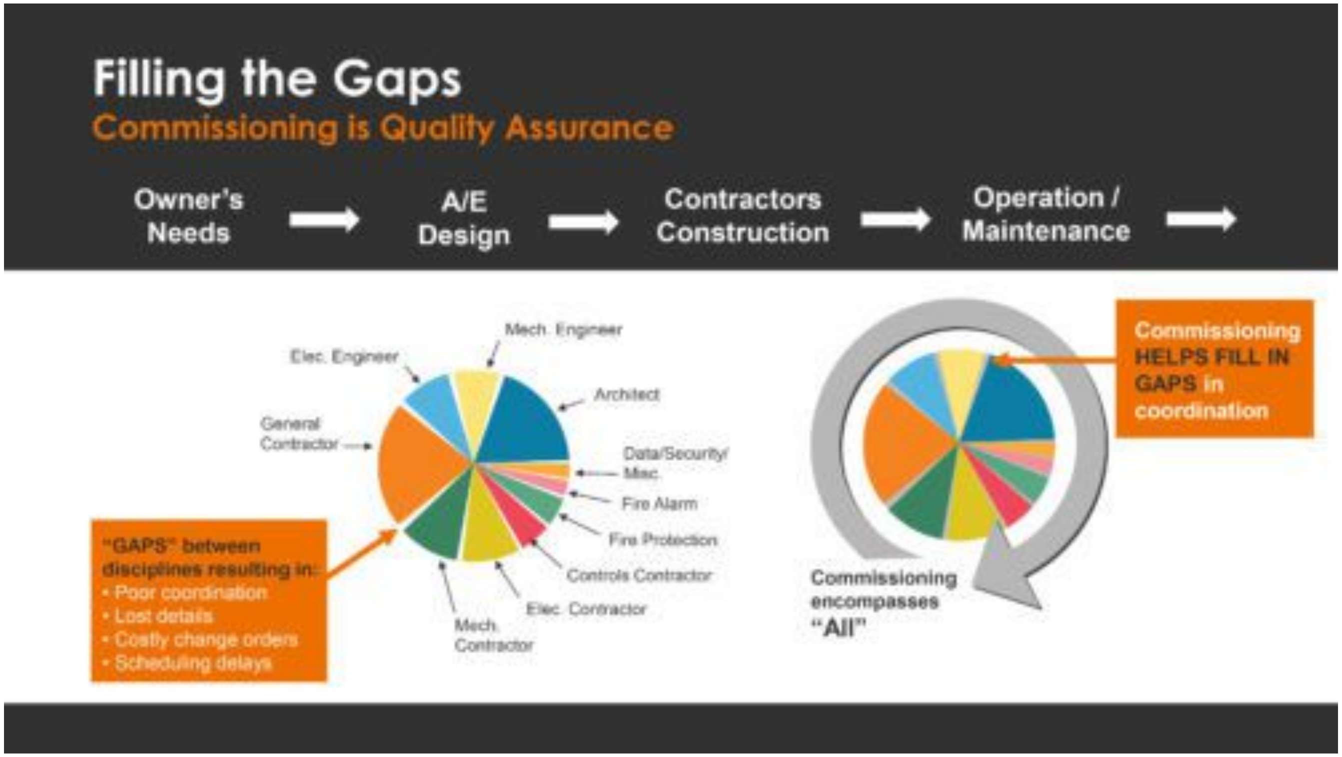

Figure 3: Smart buildings require a higher level of coordination and operational performance to achieve the desired functional benefits of the artificial intelligence/operational technology. Including commissioning in each phase of a smart building design and construction allows for scope gaps to be identified and resolved. Courtesy: Stantec

pounding effect on occupant comfort and energy costs or early failure of equipment while the building is under operation for the next 40 years.

Some examples of errors include:

- **Pump motor wiring:** Wiring a pump's motor is backward, it will cause a pump to flow backward through the discharge to the suction side. Small loops may appear to be operating correctly but will not have the correct heat exchange in coils or through boilers/chillers. In larger systems with multiple floors, it may appear that the flow

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is not reaching the coils located on upper floors during balancing.

- **Chiller compressor arrangement:** Without proper factory startup a multiple compressor circuit chiller may be incorrectly set up to have the on/off compressor as the lead compressor rather than having a digital scroll or variable speed compressor as the lead. This will cause short cycling to happen, which will degrade the operation of the chiller's performance, increase energy costs and will cause early failure of the compressor.

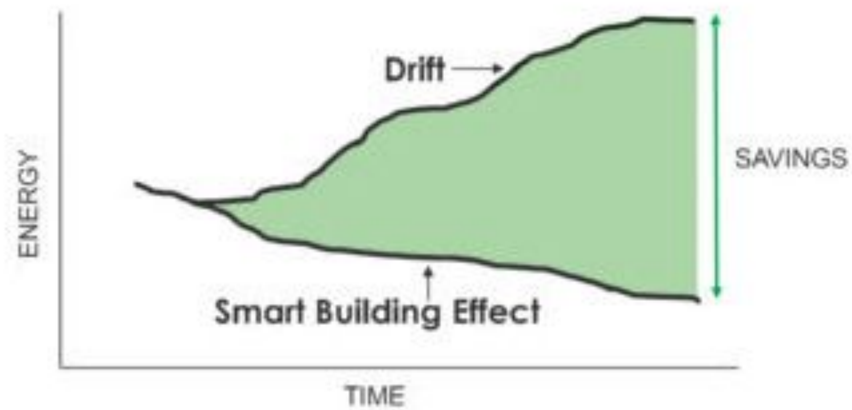
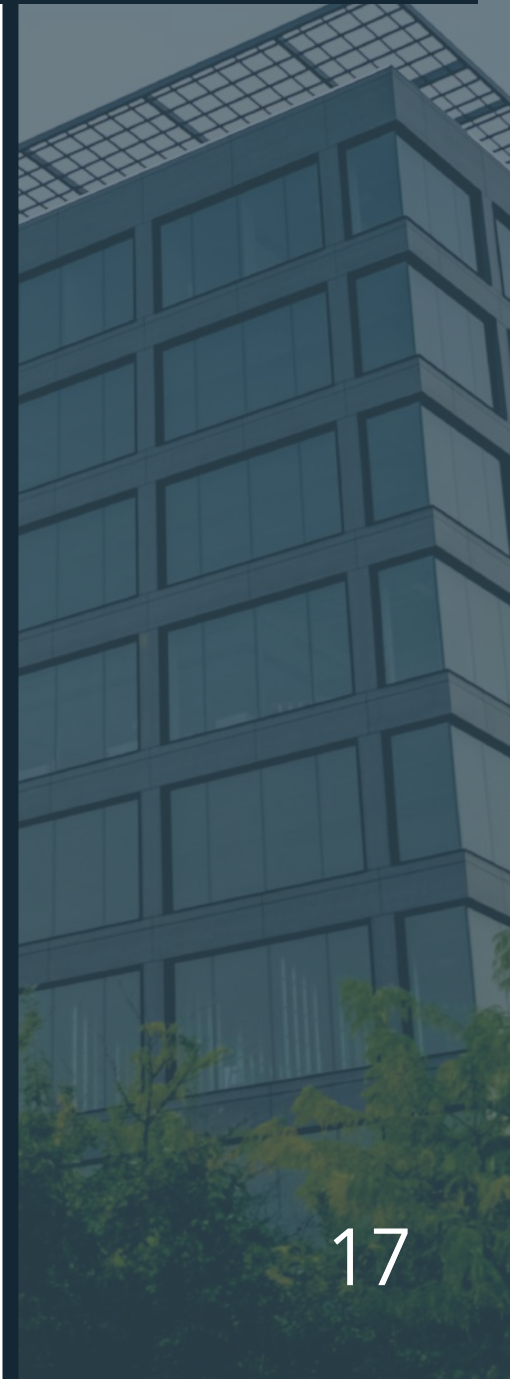


Figure 4: Smart buildings allow for the ongoing and increased energy conservation to occur via artificial intelligence/operational technology. Traditional buildings will experience an energy usage increase drift due to unseen deficiencies in calibrations or improper operational conditions. Courtesy: Stantec

Commissioning provides the quality-focused process for enhancing the delivery of a project and casts the best and most reliable safety net for the simple or complex problems generated by human error. Commissioning is the last defense and best assurance to offer an owner that these human errors will be identified, mitigated and resolved early in the life of the building and specifically directed at reaching this goal during the construction phase.



Limiting a project by not including the commissioning process from concept to operation allows for a wide variety of potential errors and omissions and leaves the facility vulnerable to early failures, repeated tuning and higher operating costs.

Commissioning of buildings has evolved significantly over the past 40 years with the initial driver coming from ASHRAE in 1984 with the formation of the commissioning guidelines committee. It wasn't until 1989 that ASHRAE first released Guideline 1: Commissioning of HVAC Systems. ASHRAE then created a more complete commissioning document titled Guideline 0 in 2005. ASHRAE Standard 202: Commissioning Process for Buildings and Systems was updated in 2018 and facilitated its maturity into a code-level document.

U.S. cities, municipalities and states have begun adopting the 2018 International Building Code, which includes the International Energy Conservation Code containing commissioning scope under section C408 – Maintenance Information and Systems Commissioning. The IECC contains limited scope of systems to be commissioned (HVAC, lighting controls and service water heating) and, as such, it should be augmented with additional scope to allow for a sufficient level of validation for smart building purposes.

Smart building control systems can and do vary in complexity depending on the desired function/type and the objectives determined by the building owner and design team. Installing a new BAS with smart building technologies or updating an existing system can be a major capital investment and, like most business decisions, must yield an acceptable return on investment.

A smart building can provide many benefits such as lower energy costs, lower operat-

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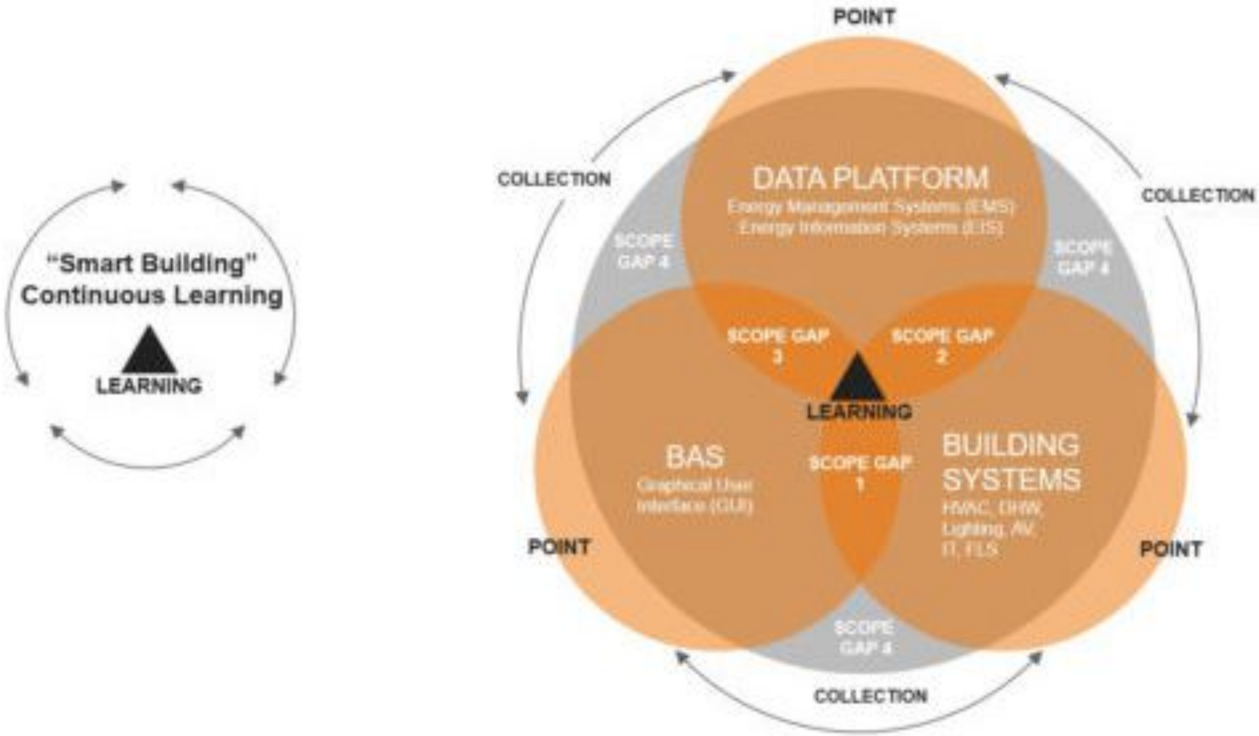
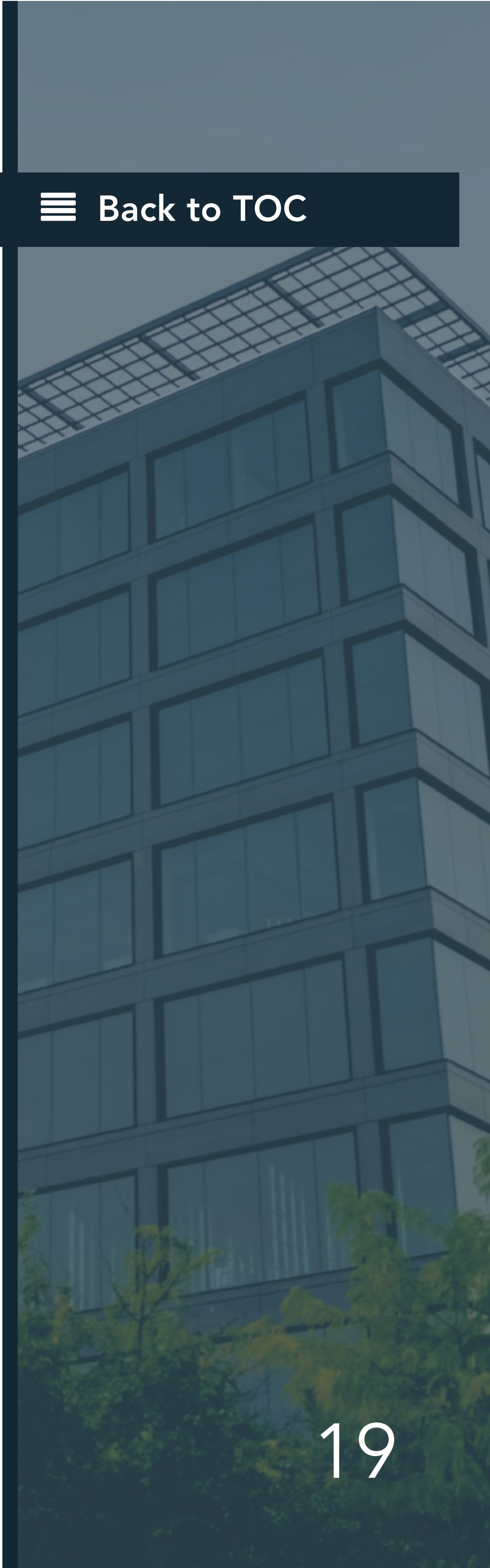


Figure 5: Smart buildings allow for continuous learning of the building's true operation, which can only be assumed during the design of a project. This process of testing, verifying and improving the operation of a building will allow for a greater level of energy conservation. Courtesy: Stantec

ing and maintenance costs, better indoor air quality, improved occupant comfort, increased productivity, increased security and data collection. There will be less reliance on human interaction to operate a smart building as remote monitoring abilities continue to take over routine activities.

Commissioning a BAS will help to deliver consistent quality in performance, reliability and programmability of smart buildings. With each new technology, there are risks to implementing them and smart buildings are not immune to a variety of issues.



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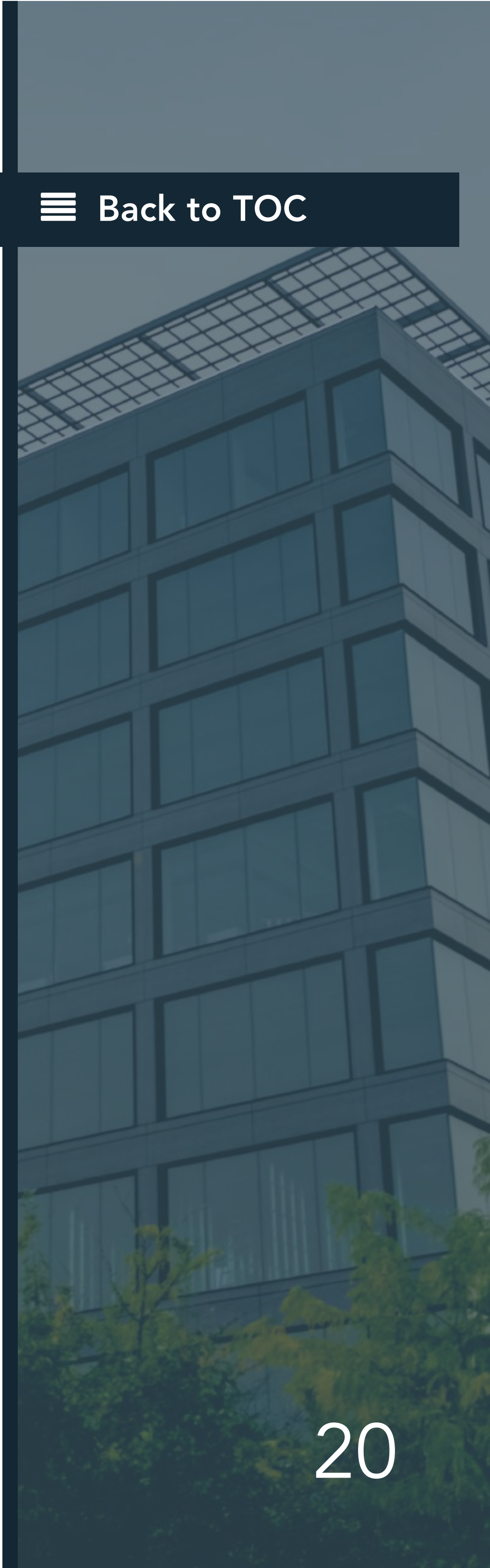
Creating a data connection between a building and a remote server allows for potential infiltration by cyberattacks. A study of 40,000 smart buildings in 2019 by Kaspersky found that 37.8% of computers used to operate the buildings had been compromised by variants of spyware, worms, phishing or ransomware attacks. In addition, design phase mistakes made by owners or design teams by integrating in too many smart building AI/OI applications will result in data not being used, degradation of the system performance and in some cases sidestepping the application and moving back to a more traditional BAS approach.

This will cause unneeded expenditure of first costs of designing and constructing smart building systems that will not be used. While the technology exists to integrate nearly every building system into the IoT, a targeted approach to limit first costs and create real savings for the owner is the responsibility of the design team.

Why do we need smart buildings?

Smart building providers have created a set of enterprise applications that have been advanced over the past decade to seek out more energy savings and operational efficiencies. The applications typically consist of analytics, visualization, data collection and management and AI/OI to predict and reduce energy consumption.

Recently, the construction industry has been driven by consumer trends that place more focus on climate change and the desire to reduce the carbon footprint. With the typical construction budgets and schedule constraints in the design of a building, it is required that the practitioners be trained in the application of smart building design and understand the benefits and limitations. This effort requires the industry to be proactive and not rely on standard design and construction practices.



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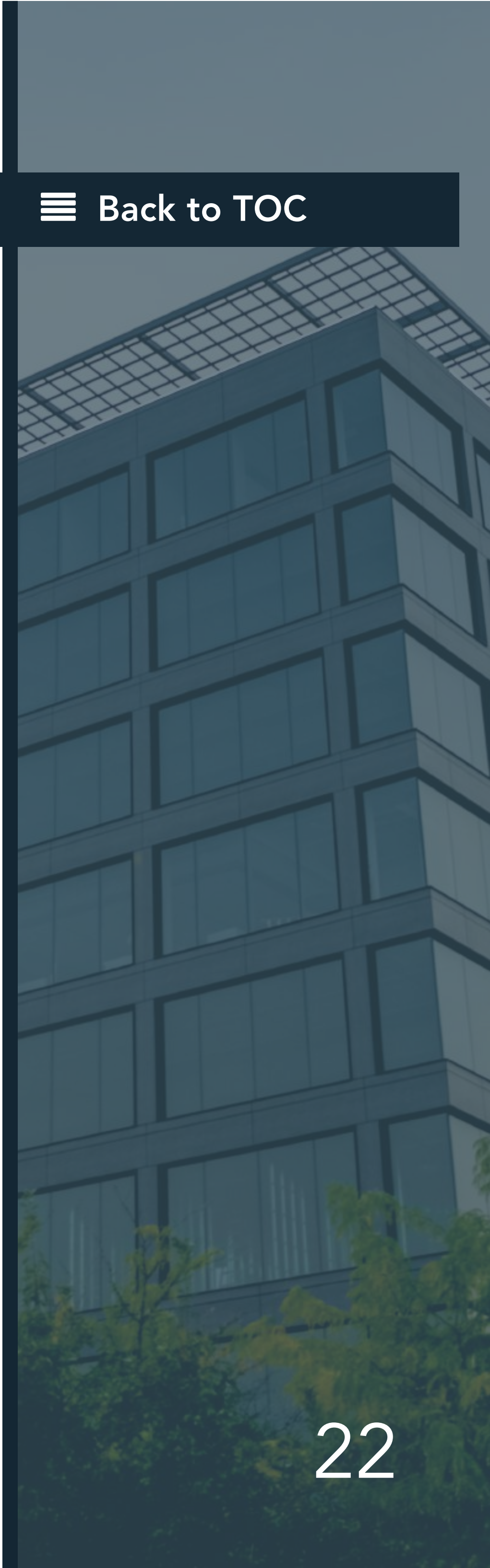
Another limitation to the delivery of a smart building rest within the education of owners and operators. When a project is complete, they are the responsible party to be caretakers of a building for the next 40+ years. While they are willing to invest in new technologies, there is an inherent risk taken by them to make the leap forward and as such hesitation is expected. It is incumbent upon the design team to not reach smart building solutions that the owner cannot handle.

Similar to direct digital control integration into building systems, the approach to smart buildings needs to be a gradual process of providing more integration of the enterprise solutions into more building system systems as the industry grows into the next phase of automa-



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tion. The industry has been provided with a framework via Division 25 and now it is up to engineers to meet the expectations set forth for smart buildings. But then why do smart buildings fail more often than work optimally?

The smart IoT technologies that are implemented in BAS, energy management systems and energy information systems, gather a large amount of data from energy using and nonenergy using devices and systems. This effort takes a significant amount of capital to design, construct and operate. When things fail early in the process of operating a building, the tendency is to fall back to standard operating procedures and pull the intelligence out of the building.

That can be avoided with proper commissioning and, most importantly, owner dedication to training and understanding of what to do when things go wrong without backsliding to the traditional BAS. Building systems are interactive in practice and a variety of system types will impact the operation of others.

For example, building envelope insulation and window properties will impact the heating and cooling operation of terminal units and the operation of central plant equipment. The lighting system will impact how the heating and cooling systems will operate. The occupants may impact the operation of the systems with the way they use the spaces within the building. What is created in a smart building is a living system that must react and optimize performance based upon the actual construction operation of the building, which may be significantly different from what was conceptualized during the early phases of design.

The primary reason behind early failure is the scope gaps between the BAS, build-

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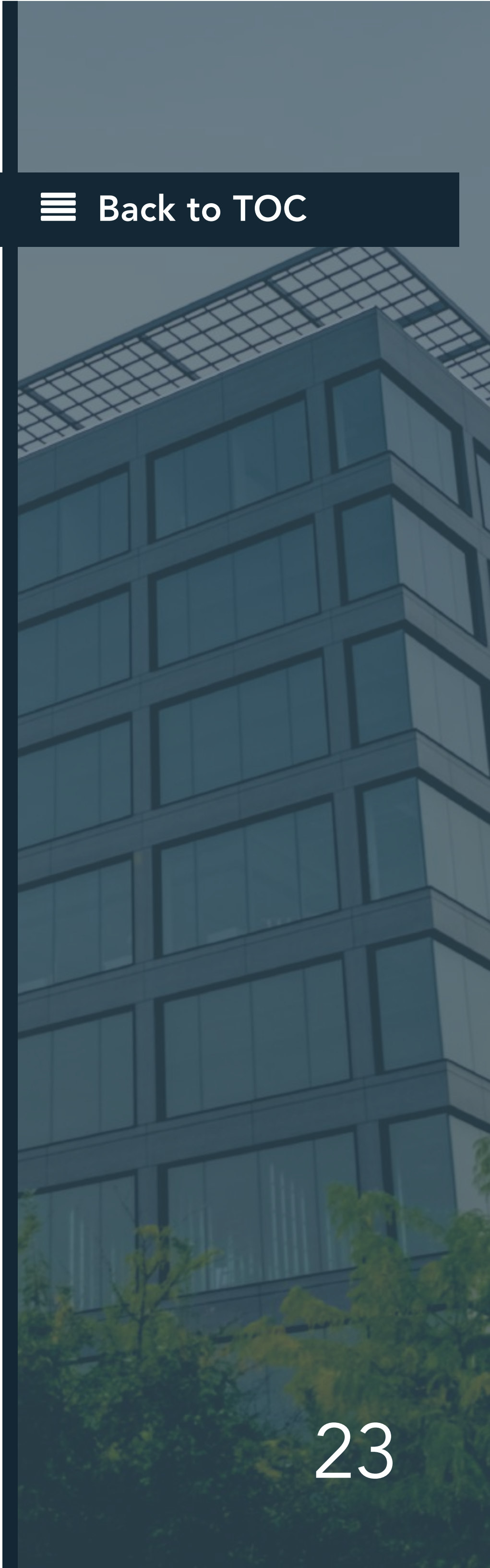
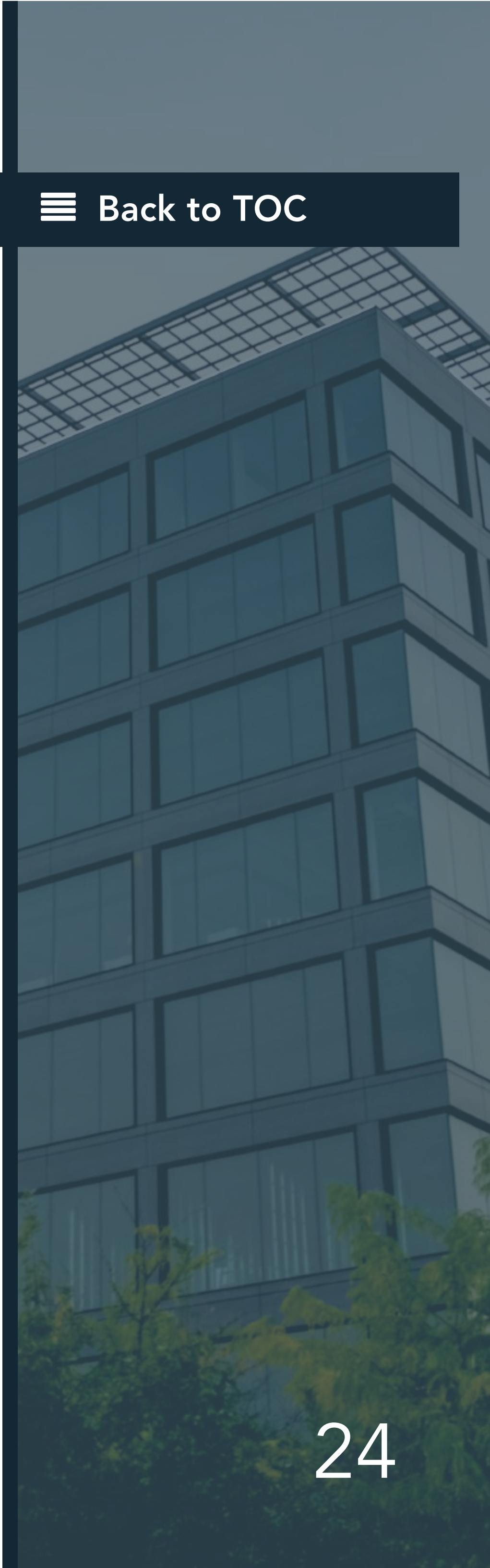
ing systems and data platforms. Scope gaps can be as simple as failure to coordinate communication protocols or as complex as cascading sequencing problems causing equipment to work against each other. The layers of system typologies that interconnect within each other begin to expose scope gaps during the process of operating the building or even during construction.

Beyond physical equipment scope gaps, the data being collected in an improper way can cause a failure in the AI/OI applications to analyze and correct a simple problem within the systems. This does not always mean the methodology or engineering was flawed. In most cases, it means that the critical paths were not tested or commissioned to make sure the data was collected in a clear and relevant way that allow the algorithms and protocols to perform as the design intended.

The macro view of this issue shows how all of this is intended to work together as with a simple switch or sensor that is tied into a pump or air unit that controls it functions. A temperatures or pressures sensor is typically an analog device, which requires a link to a digital component and produces a digitized signal. This is also referred to as a direct digital control.

Once the potential thousands of points begin to get installed, many failure points issues can occur. All these points must be put through a vigorous process of testing and verification that is referred to as a point-to-point check. If commissioned properly, this will be the main connection to a unified and integrated system. After the point-to-point is concluded, the final issue is tying this all back to the system that collects all this information and serves as an overlay to the systems. This is where the majority of the “learning” scope gaps occur.





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It is important to understand the focus with these smart systems and determine what to look at it in part and on the whole. The parts need to work together to achieve the goal of a smart building. Once in operation, without a committed ownership team and a wiliness to conduct the learning phase, systemic problems may start to arise and overshadow potential capabilities that the system should be able to perform as promised or intended.

The industry has reached a stage in which smart buildings can be an obtainable goal. With proper planning from the early stages of design, using Division 25 and including commissioning of these systems, a successful smart building delivery is possible. Smart buildings are obtainable with a collaborative team of design professionals, trade workers, commissioning agents and owners/operators who are committed to the overall goal.

Timothy Howe, Marcus Myers and Jeri Pickett

Timothy Howe, PE, CEM, Stantec, Rochester, New York; *is a project manager and mechanical engineer with Stantec. He has spent the last 15 years designing and commissioning project for higher education, industrial and science and technology facilities.* ***Marcus Myers, CxA, CEM, LEED AP, Assoc. AIA, LFA, Stantec, Chandler, Arizona;*** *is a project manager and director of commissioning and energy services, U.S. West with Stantec. He has spent the last 20 years commissioning projects for higher education, industrial, biopharma and science and technology facilities.* ***Jeri Pickett, PE, Stantec, Rochester, New York;*** *is a project manager, electrical engineer and principal with Stantec. He has spent the last 30 years designing and commissioning projects for higher education, industrial and science and technology-based facilities.*

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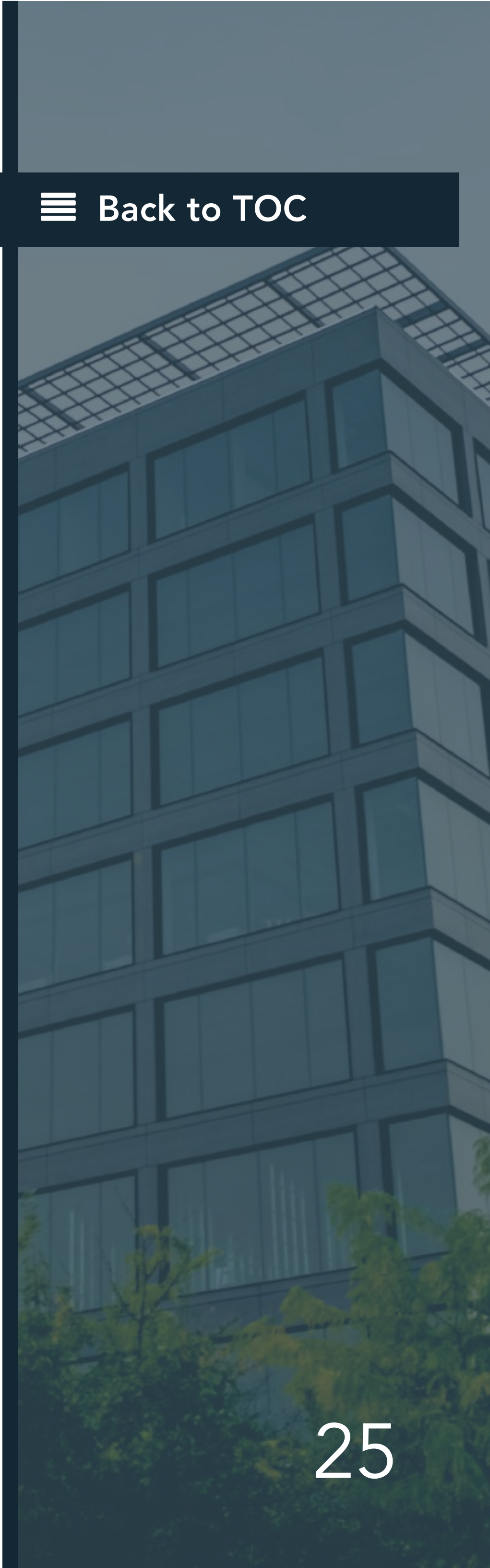

ABB

ABB Ability™ Building Ecosystem: The simplest way to a smart building

Achieving all the benefits of a smart building may seem a distant ambition, but ABB Ability™ Building Ecosystem makes the journey simple. This open and scalable digital platform fits with your building needs, enabling you to optimize energy efficiency and sustainability. The ABB Ability™ Building Ecosystem is built on an open platform that accommodates scalability and interoperability.

Video: Designing smart buildings with Aaron Szalaj

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In this conversation with Aaron Szalaj from Stanley Consultants, hear how designers can help their clients select the most appropriate smart building technologies

Smart buildings and smart control systems are being requested by building owners, but how does a consulting engineer select and design smart systems for the client? What types of buildings or campuses are appropriate for smart, integrated systems? Aaron Szalaj talks about how smart buildings can help with reliability and sustainability, as well as managing emergency response using these smart building controls.

Aaron Szalaj, PE, is a principal control systems engineer with Stanley Consultants, Denver. He has more than 20 years of professional engineering experience. His project experience includes renewable energies, water and wastewater, energy systems and federal installations. He specializes in control systems and project management, providing a unique perspective on each project to which he contributes. Szalaj has extensive experience with control systems and electrical engineering.

Canadian Shopping Centre Made More Efficient with AI for HVAC

WESTCLIFF

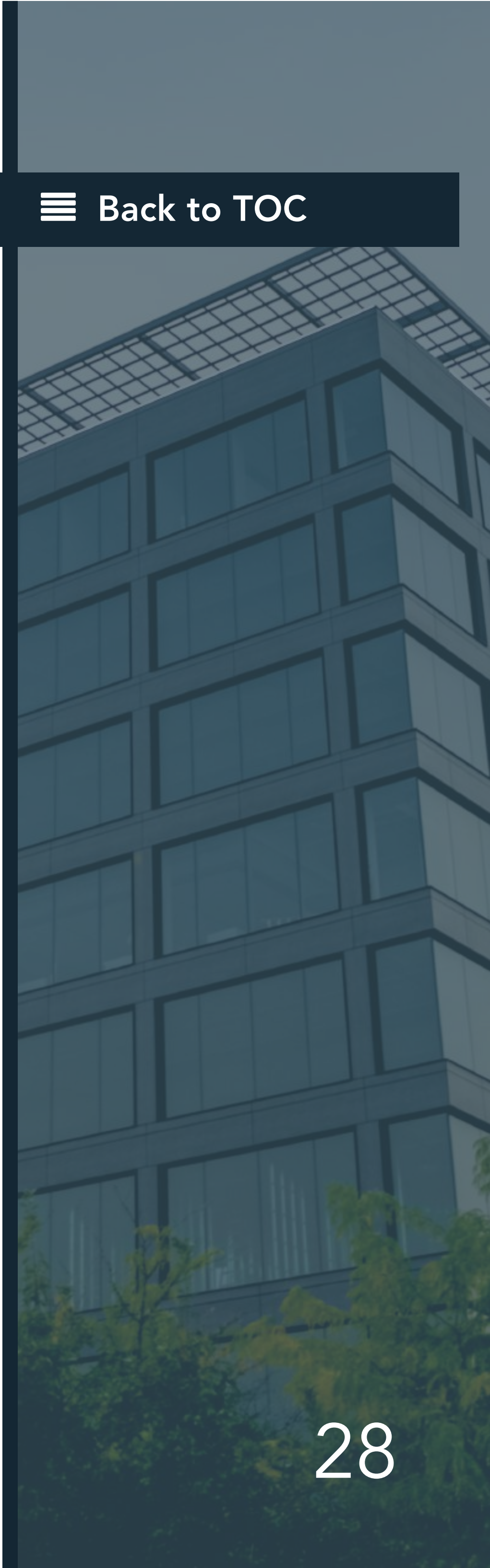
Westcliff, a Canadian private real estate development and investment company, has a portfolio of more than 10 million square feet of leasable space in Canada and the United States. For this asset, Granby Galleries located in Quebec, the primary project objective was to achieve energy savings while also improving the efficiency of the building's individual HVAC equipment.

Building details
Shopping Centre

Location
Granby, Quebec, Canada

Controls system
Automated Logic

Total square footage
509,612



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Total square footage controlled by BrainBox AI

315,000

HVAC equipment controlled

Heat pumps

Fresh air handling units (FAHU) at pumps

PROCESS

Transforming a Granby shopping mall into a self-adaptive building

Installed its leading-edge technology into a 509,612 sq. ft. shopping centre in Granby, Quebec, where approximately 60% of the building was controlled, to convert the existing HVAC system into an autonomous one using artificial intelligence, cloud computing, and a set of custom curated algorithms. After a few weeks of data mapping, building analysis and an AI learning period, we were able to establish a strategy unique to the building by enriching its existing data sets with external weather and tariff structure data, resulting in a significant reduction in asset and equipment runtimes as well as energy consumption from HVAC operations.

Having a small building management team, engineers and project managers also offered significant value by delivering ongoing client support and acting as an extension of the client's team.

IMPACT

Achieving significant electricity and gas savings

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Electricity savings on HVAC equipment

-21%

Electricity savings on HVAC equipment

205,214kWh

Average runtime reduction by equipment type

Supply fan runtime

-33.5%

Heating stage runtime

-62%

Cooling stage runtime

-5%

Reheat stages runtime

-30%

Global reheat utilisation

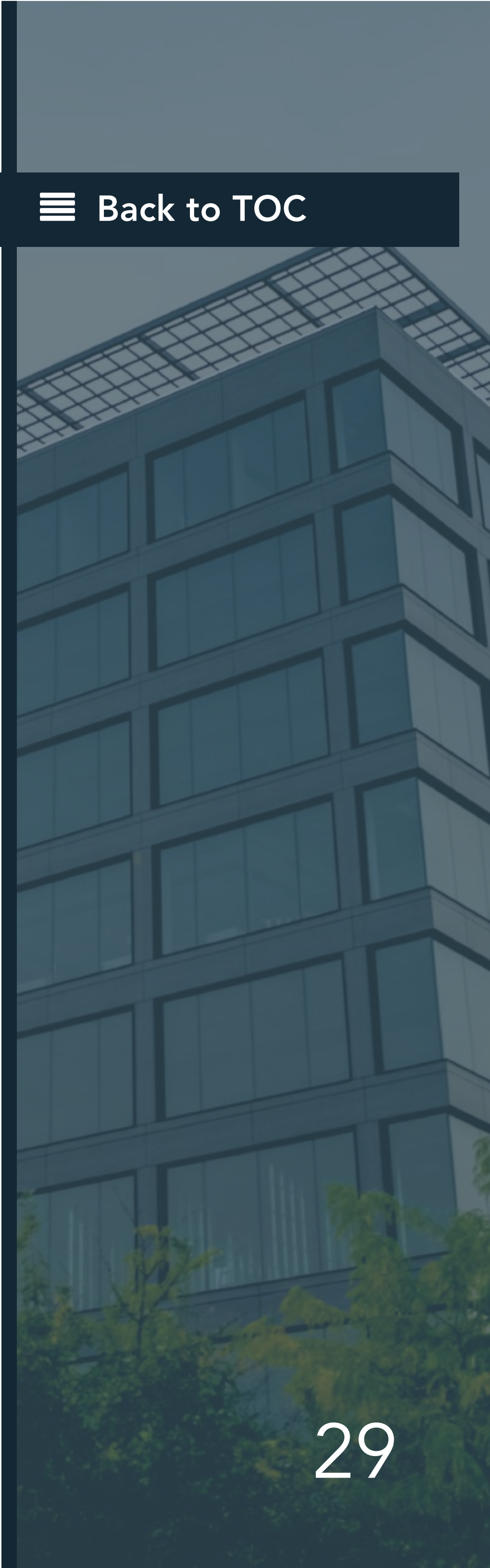
-78%

Overall fan runtime

-61%

Heating modulation runtime

-91%



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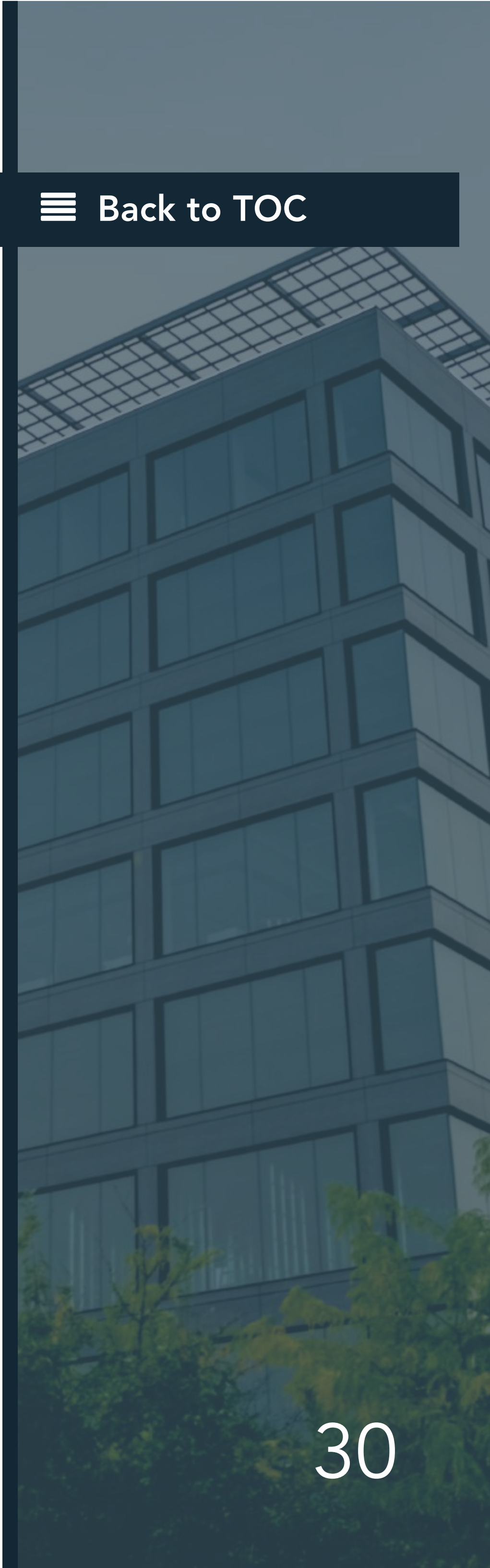
Heating state runtime
-81%

This resulted in electricity savings on HVAC equipment of 205,214 kWh (21%) after a year of operation with BrainBox AI. Total monetary savings for the year amounted to 19,249 CAD, significantly reducing the shopping centre's operating expenses and improving its net operating income.

Aligned with the clients' primary goals, the technology helped improve operational efficiency by optimising the usage of certain HVAC equipment autonomously, the result of which was an average reduction in equipment runtime of 55% (see table for breakdown per piece of equipment). We were able to achieve these savings and reduction in equipment runtime while avoiding any fluctuations in average zone temperature* (average temperature of 69 °F with AI, versus 68.9°F without AI.)

The success story of this shopping centre is a prime example that building efficiency can be easily and quickly achieved with smart HVAC technology. We are proud to have helped the client in realising these great results.

*Based on a 1-week assessment in April 2021.



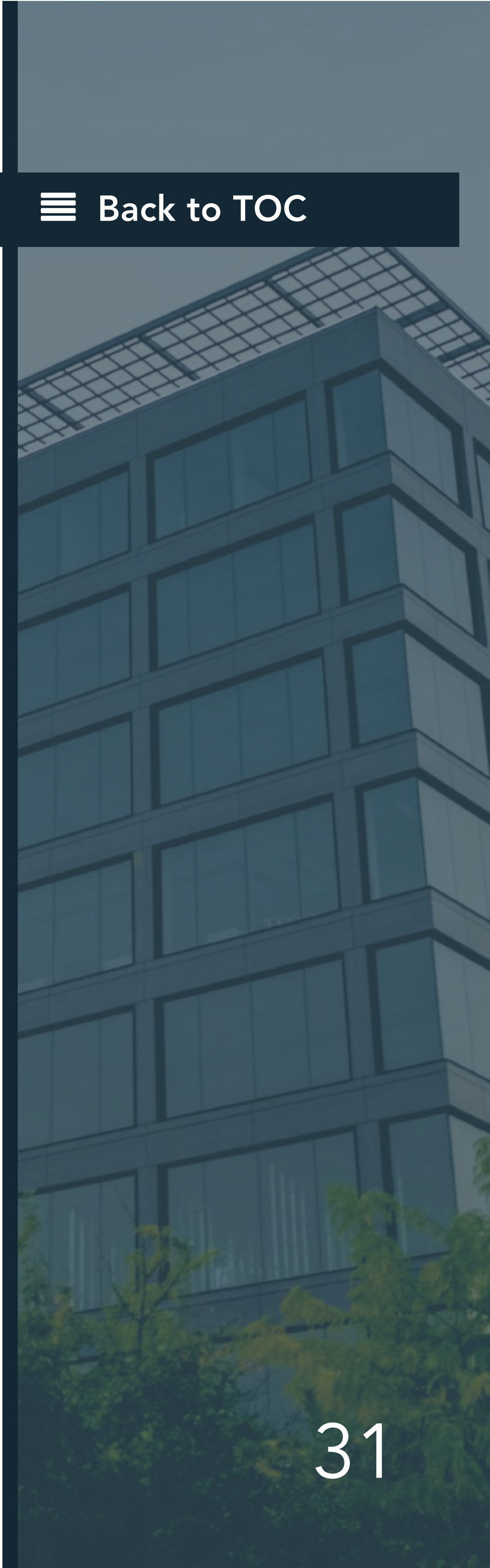
Smart building basics

In this transcribed article, Julianne Laue gives an overview of smart buildings

There's no single definition or set of requirements for a building to necessarily be considered smart. Smart really takes on more of an implied state of being rather than a true definition. Smart building is loosely defined as a building or structure that uses processes to manage and control its operations, whether that's heating, ventilation and air conditioning; lighting; security; or a variety of other systems. It does so via virtually integrated network of sensors and actuators, microchips, all stuff that can generate a constant stream of data that can be converted into key insights.

When we talk about buildings being smart or smart buildings, there are some basics that just always apply. And it goes to note that you don't always have to have all of them to be considered smart. Big pieces are listed on this slide. You need to have an interconnection of technology, meaning how different technologies integrate with each other. There is this connection of people, computers and data and HMI, or human machine interface. It really applies in this instance, too, with us being able to interact with all of these things. The ability to measure and report. That adage that you can't manage what you don't measure. And the piece of it too, is, is you have to be able to report it and report it in a way that can be interpreted and understood as well as being useful to those who are going to use it.

They need to be intelligent. A lot of times it's synonymous, whether you're saying smart building or intelligent buildings. Those things, really, are in a lot of ways the same. And it's just another loaded word. In terms of buildings, it means that it can do various actions in response to other actions or situations and experiences. Internet of things, we can't live without it these days. Automation is really in a lot of ways that



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Smart buildings have many drivers, many of which are based on the type of client. Courtesy: Consulting-Specifying Engineer

magic things can happen without human interaction and that automation between systems use and data analytics.

These are drivers and goals behind smart buildings. They can be organized in any way, shape or form. And they're sometimes also listed as some of the success factors for

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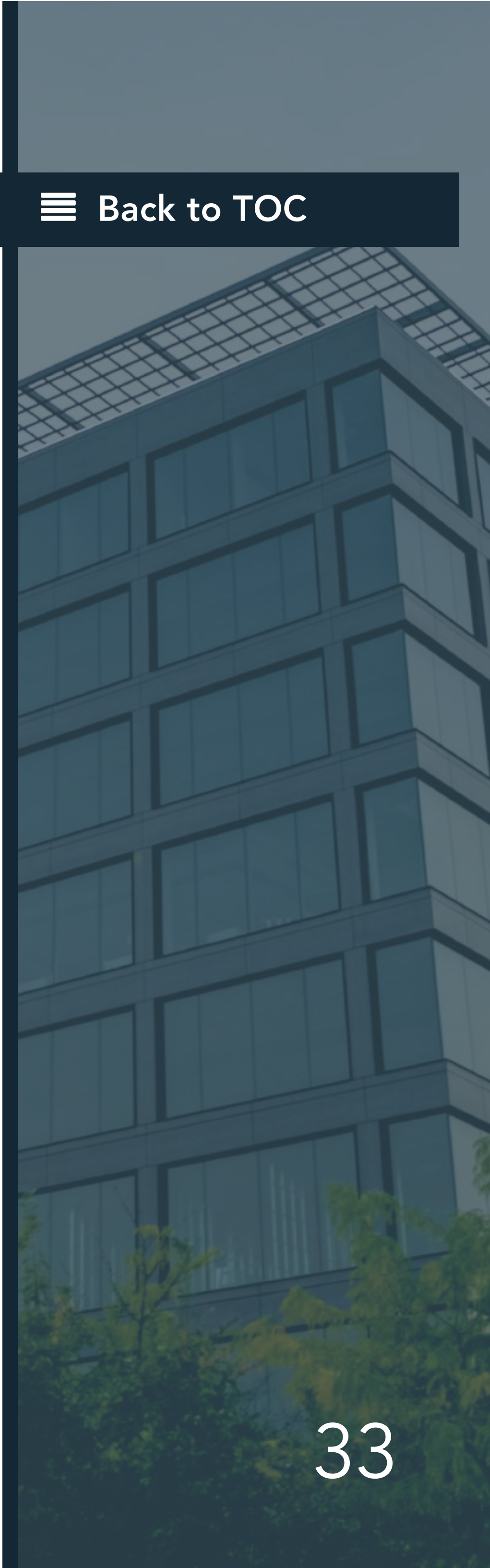


smart buildings. And why might someone want any of these? These great things are a good starting point and discussion point. Great success stories exist out there in relationship to energy savings, operational efficiency, maintenance and carbon. Those things are measurable and tangible. You can really calculate that return on investment. Things that are taking longer to gain usage and traction are things like space use and cybersecurity.

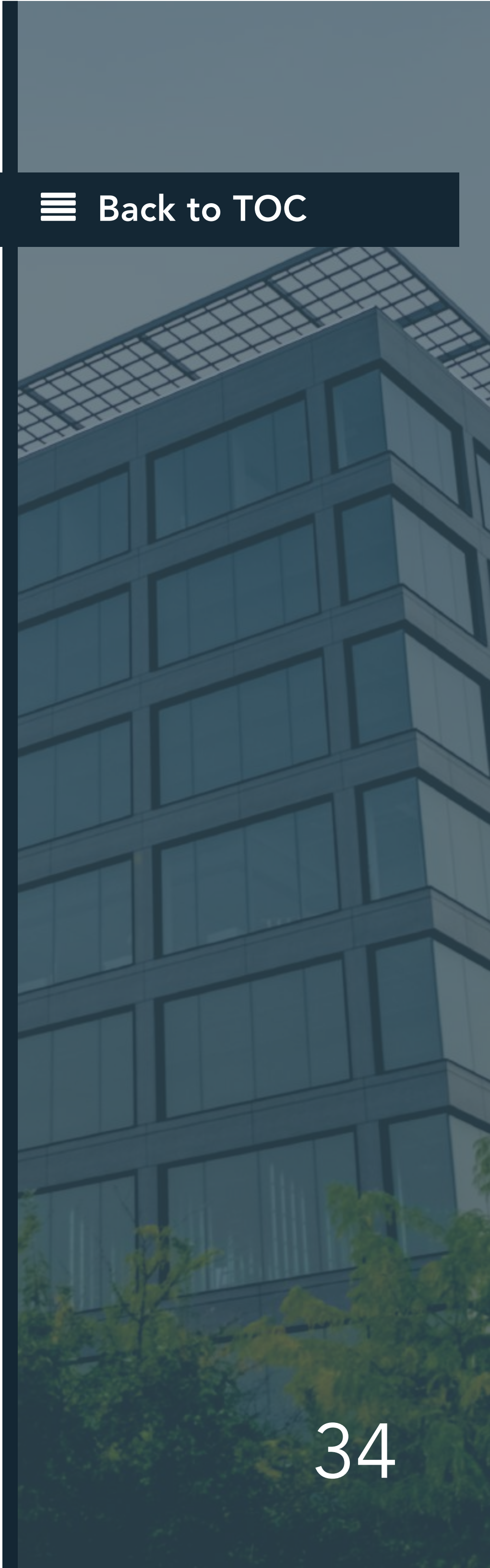
In a recent report by Smart Energy Decisions, they noted that the most used information technology applications are building automation and control. While the least is going back to that optimizing space use. All of these things are coming up and coming up quite quickly.

Client goals can also be different by different client types. Just like how we wouldn't do the same thing architecturally or mechanically for every client, we're going to be doing the same thing when it comes to smart buildings. Health care goals are going to be vastly different from a commercial office, sports and entertainment versus multitenant building. Additionally, these things can vary based on climate or location and availability of products. Ultimately, the biggest impact that smart buildings can have is really dependent on clients, their business and their definition of success. We can't measure that as the designer or builder or an installer, the end user is the one who's going to ultimately determine if we succeeded or failed in our design of their build things.

Where does someone begin and how do you get started and where might you be looking for things? The great thing about all of this with the integrated design processes that have been coming about information sharing groups that are out there, look to other fields for insight and knowledge sharing, listen to others, really be broad in what you're looking at and use the tools that are out there sharing is absolutely huge. Being able to go with others, share the information, be open with your sharing, be involved in those networks in groups and be OK going in and saying, I don't understand this.

I always get a little nervous when I put out literature sources or resource, because this list is in no way exhaustive. The best way to get any information is to go out on the internet and start doing a search. Look for things that you recognize, anything that comes from ANSI or ASHRAE or NEMA is going to be something where you know that there's a group out there that's going to vet a technology or system.

Julianne Laue, PE, LEED AP BD+C, BEMP, BEAP, Mortenson, Minneapolis
Julianne Laue *is the director of building performance at Mortenson. She is a 40 Under 40 award winner, and a member of the Consulting-Specifying Engineer editorial advisory board.*



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Demystifying lighting controls

When it comes to designing lighting systems and lighting controls, it's important to look at the lighting design from a holistic standpoint

The lighting controls are an integral part of any lighting system design and with all the components that impact system selection, it can seem intimidating. It doesn't have to be.

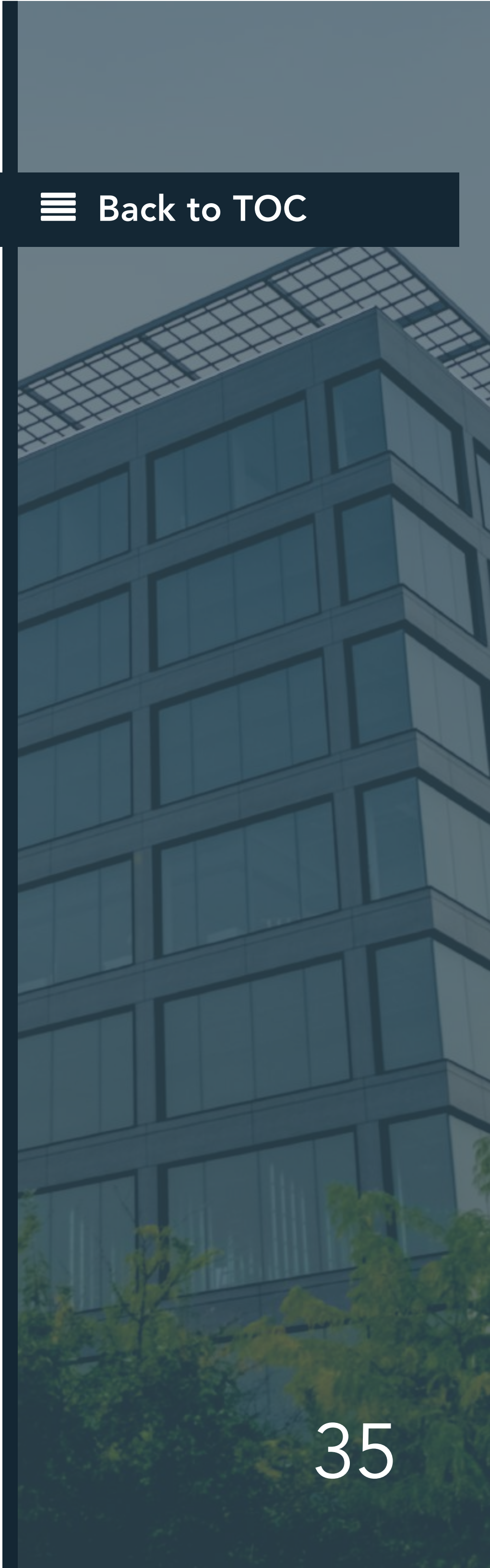
Once you understand the lighting system design intent and basic architecture of the main lighting control system types, designing any lighting control system can be a relatively straightforward process.

Lighting control system considerations

The first step to designing a lighting control system is understanding the lighting design intent. There are three main categories to consider when designing a lighting control system: codes and standards, operations and maintenance and installation.

Codes and standards are first and foremost. There are really three types: codes, standards and owner preferences.

National and local energy codes dictate the minimum level of lighting controls required for both commercial and residential projects. Energy code requirements can include automatic shut-off, dimming, daylighting, demand response and manual controls, among others. These are incredibly important to understand early on in a project, because not meeting these requirements could cause issues during the permitting process or inspections and it could even delay receiving the coveted certificate of occupancy.



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Sustainability standards or goals such as U.S. Green Building Council LEED or WELL building, if pursued, can add control requirements to the baseline such as additional dimming, daylighting or manual control.

- Owners of multiple properties might have additional preferences to follow regarding manufacturers or design. They may have a national (or global) account with a specific manufacturer or have had good or bad experiences leading them toward or away from certain manufacturers. They may also have certain preferences, such as wanting a chandelier to dim or wanting color tuning cove lights to reflect the time of day.

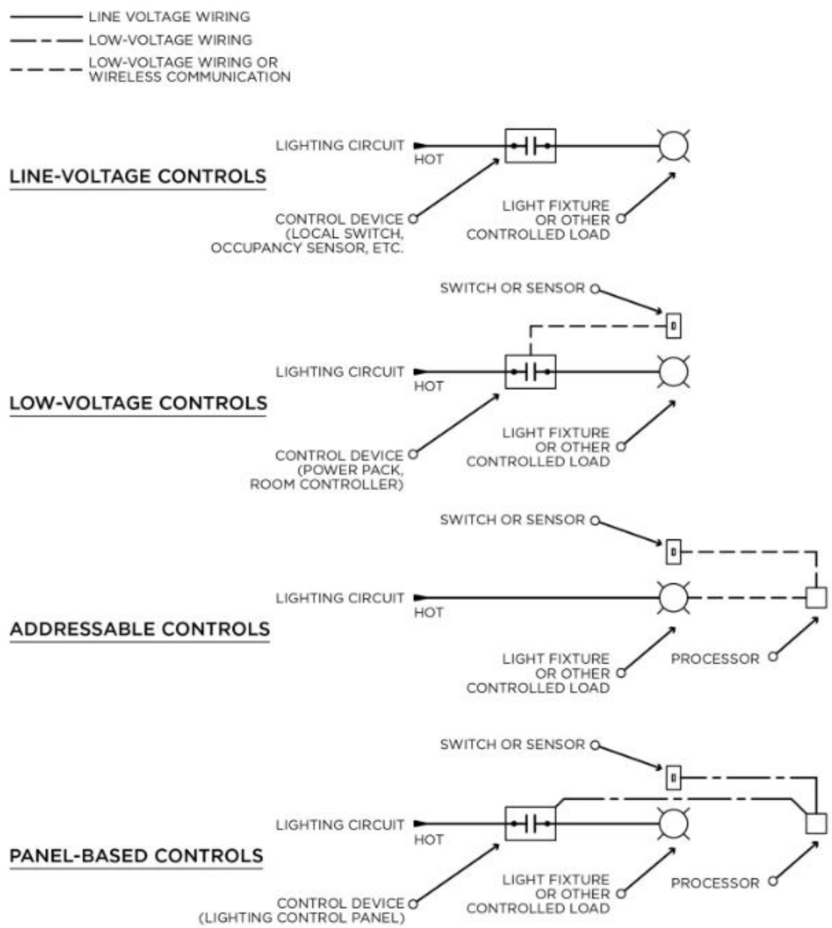
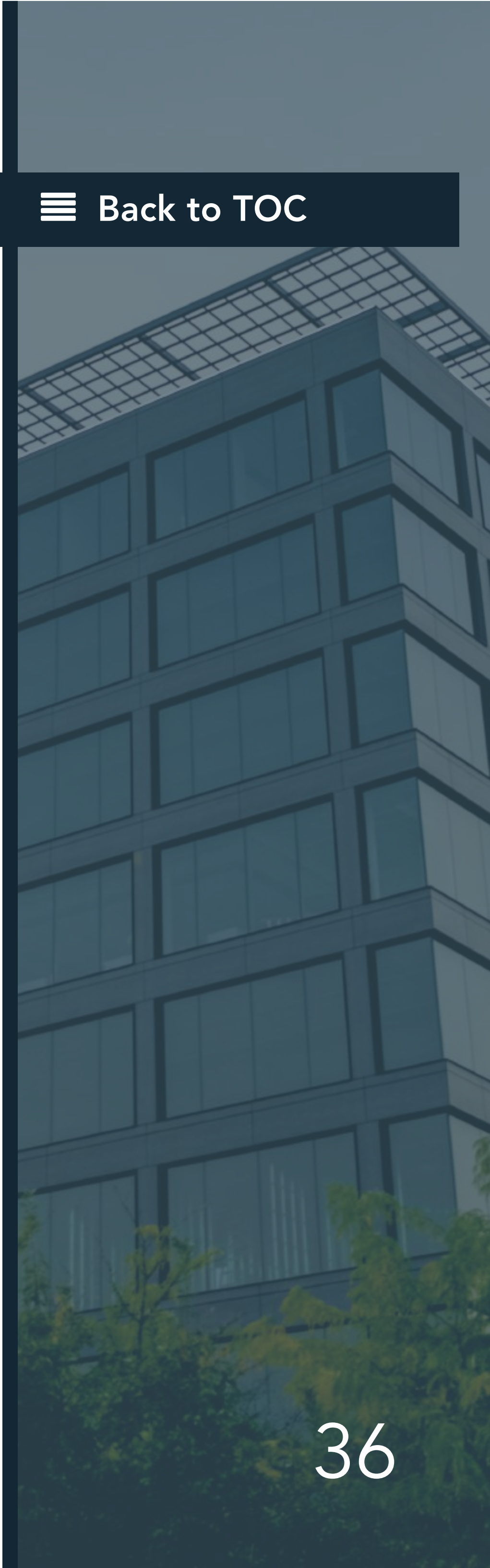


Figure 1: The four main lighting control architectures include line-voltage, low-voltage, addressable and panel-based. These one-line diagrams show how the main components connect. Courtesy: Henderson

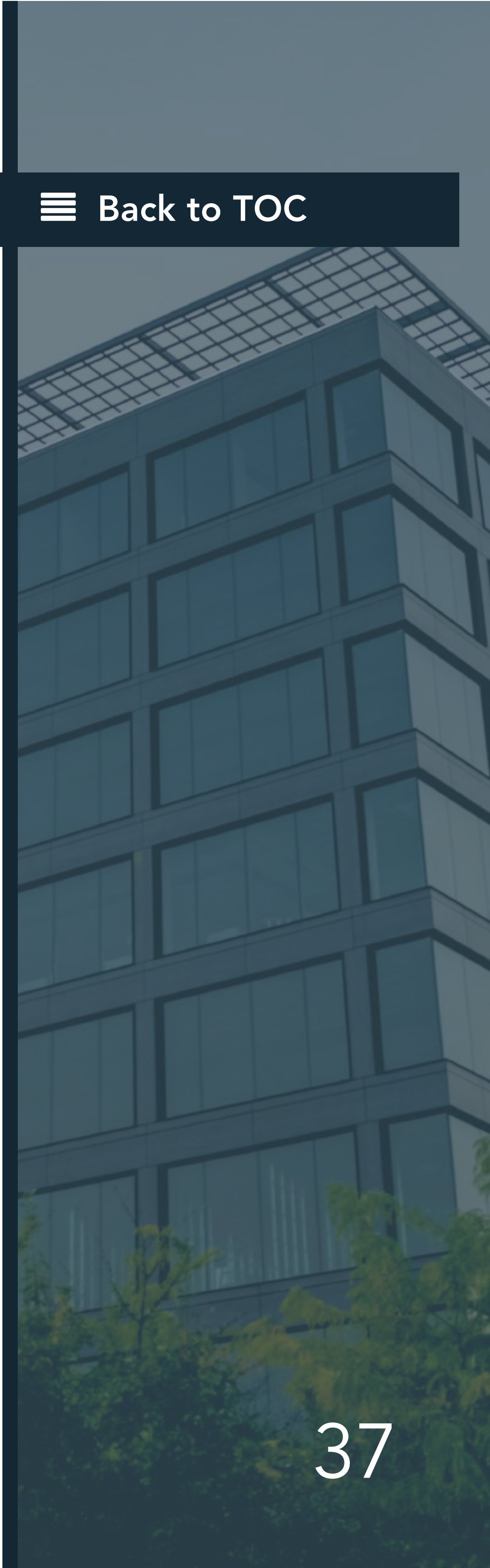


After reviewing codes and standards, we need to consider how the owner would like the system to function, both now and in the future. Below are a few questions to ask:

- How flexible should the controls be? Will the design be set from day one or should it be able to adapt to changing partitions or furniture arrangements?
- Does the owner want the ability to control certain areas or groups of fixtures independently from each other?
- Are there other systems that should be integrated with the lighting system such as audio/visual, window shading, security, etc.?
- Does the owner want remote access to control or program the lighting control system, such as with a mobile device app or computer?

Last, we need to consider how the system will both be installed and maintained. Specific site restrictions could direct the lighting controls toward one system type or another due to accessibility and feasibility. Here are a few considerations:

- If ceilings are accessible and at a reasonable height, lighting control equipment can often be located above the ceiling. This is also helpful if wall space is at a premium.
- If ceilings are not accessible or if the facility is expansive, it might be useful to consolidate lighting control equipment on the wall.



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- If the owner wants to remotely monitor the system for maintenance or sustainability purposes, a networked system is essential.

Once the above is understood, it's time to look at the light fixture selections. Many may think light fixture selections and lighting control selections are two independent items. There are various dimming technologies, however and they are not interchangeable. This makes it essential to select lighting controls equipment that will properly control the selected light fixtures and vice versa. Additionally, if the fixture is also being used for emergency purposes via an inverter or generator, special considerations will be required for both the fixture and the controls.

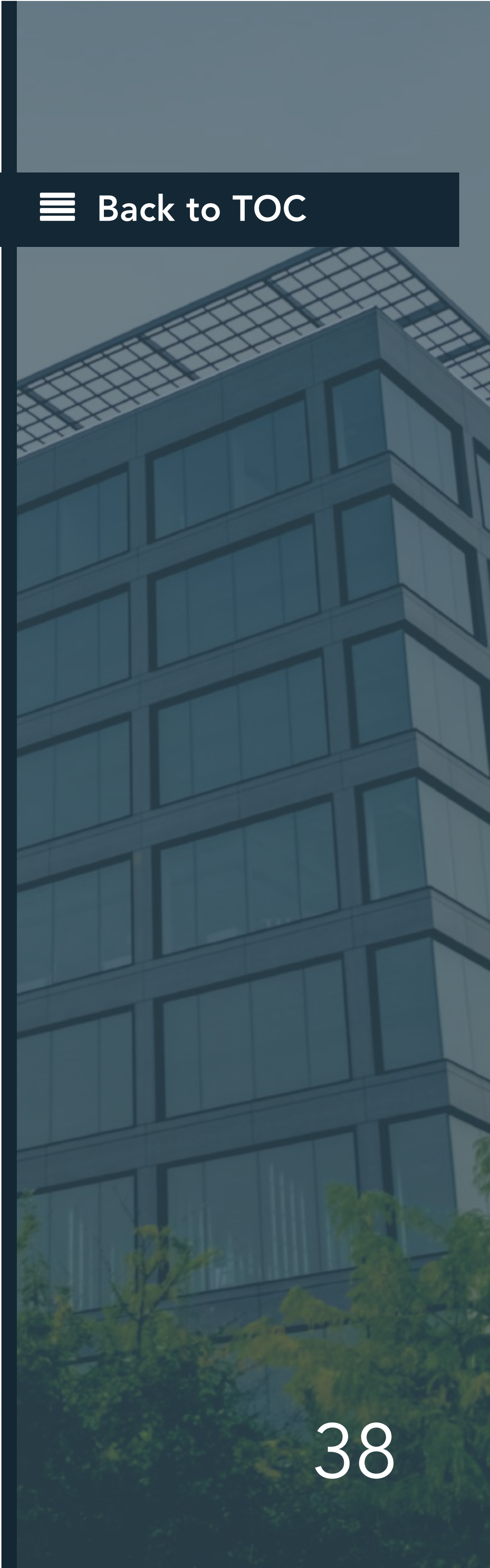
Lighting control system architecture

Now that we've discussed important considerations regarding the lighting design intent, let's discuss the basic architecture of the main lighting control system types available. This includes line-voltage, low-voltage, addressable and panel-based. Before we jump into details, we should all get on the same page regarding verbiage:

- Stand-alone: The controls in a space are completely independent.

- Networked: The controls in a space are connected to controls in other spaces and there is a single user interface to program and/or manage the entire system.

- Distributed: The controls are located within or near the space they serve. If a distributed system is also networked, a lighting control communications bus connects all individual controllers together to a central processor for timeclock functionality and central user interface.



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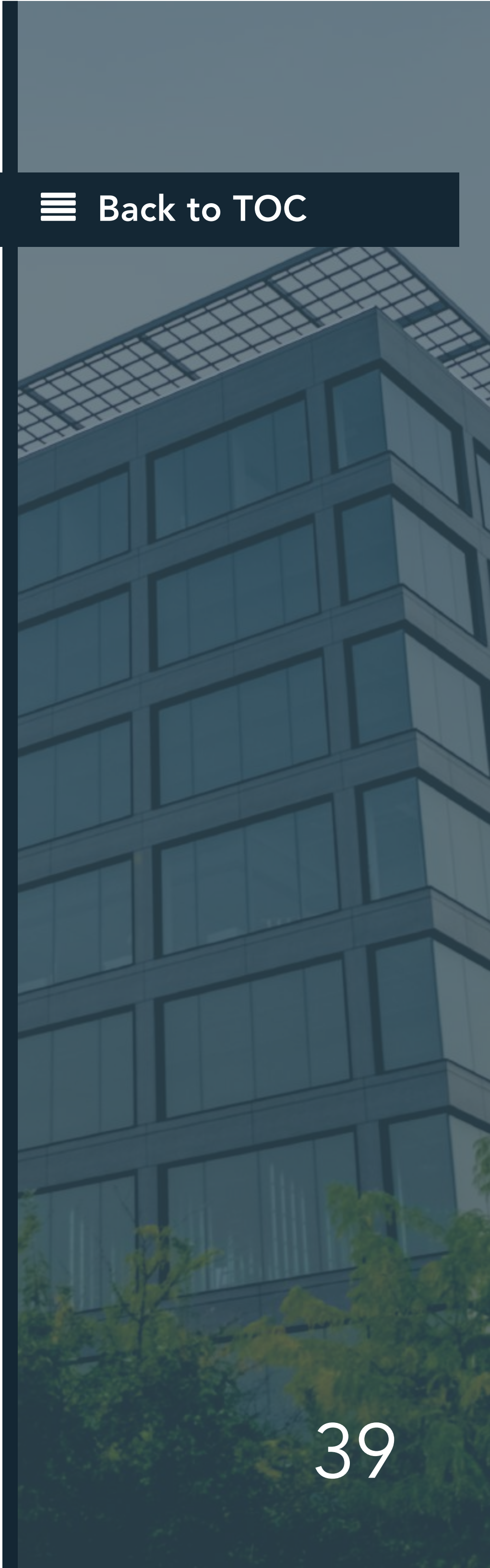

- Centralized: The controls are in one space. These are typically panel-based solutions where the main components and 'brains' of the system are centrally located. Wires extend out to the loads and devices in each space.

- Control zone: Multiple light fixtures are grouped together and controlled in the same way.

Line-voltage lighting controls are not used in commercial projects as much as they used to be due to modern energy codes, but they still have their place. The most common types include the standard wall switch (like we use in our homes), wall occupancy sensor switches and wall box dimmers. These systems offer limited control options and are truly standalone solutions.

Low-voltage lighting controls have a much wider range of use than line-voltage. While some of the technicalities of these systems can vary (e.g., power pack versus room controller, analog versus digital, wired versus wireless, etc.), the general architecture is similar. Most low-voltage systems have a power component that then connects to manual control devices and sensors via twisted-pair wires, category cable or a wireless protocol. These power components must be accessible and are often located above accessible ceilings in the same room or space as the loads they control. Low-voltage systems can often be either standalone or networkable.

When low-voltage systems are wireless, one component receives line-voltage power (usually a power pack or wall switch) and the others are battery operated (sensors or wall switches). When the switch is the component that receives line-voltage power, there generally isn't an additional power component (such as power pack or room con-

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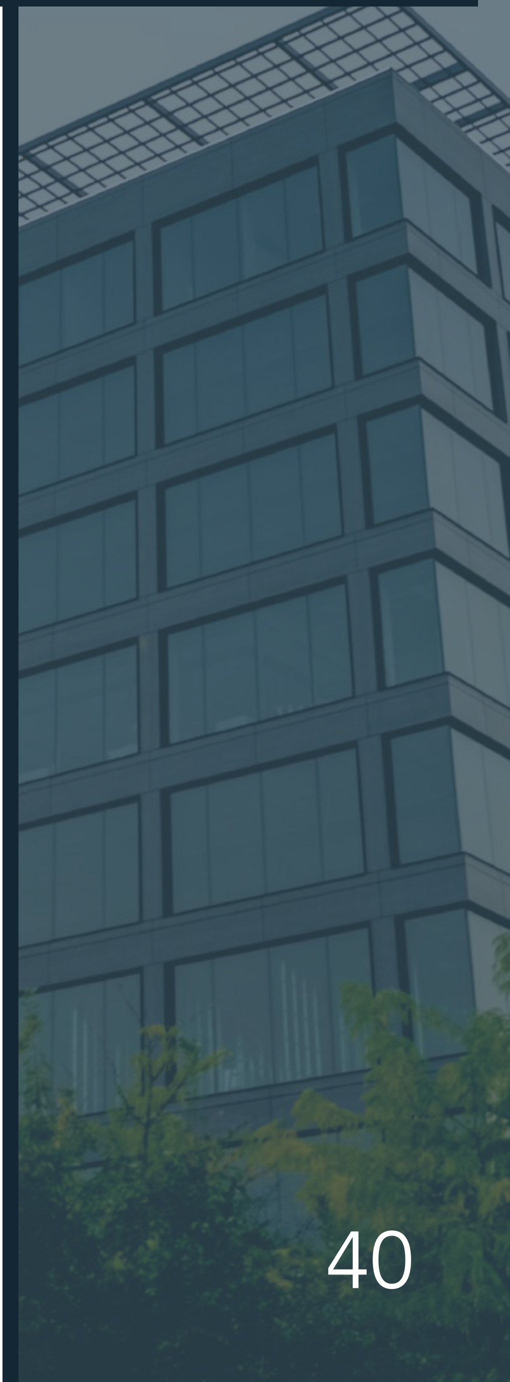

troller). It's also important to remember that all components of any low-voltage lighting controls system must be by the same manufacturer and of the same communication technicalities to function. For example, a momentary light switch from manufacturer X won't work with a wireless power pack from manufacturer Y.

Addressable lighting controls are when each individual light fixture has its own "brains." In these systems, the light fixtures have specialized drivers or ballasts that all connect on a communications bus routed back to a central processor. The tricky part to addressable lighting control systems is that the required parts are spread out between the lighting controls package and the light fixture package.

Power over Ethernet lighting controls is the new kid on the block. They can generally be categorized as an addressable system, with the distinguishing component being the network switch. PoE lighting control systems require special light fixtures and devices that are all powered over ethernet cabling and connect back to a centralized network switch. Only a few manufacturers offer PoE solutions right now and if emergency lighting is being powered by a generator or inverter there are still a lot of questions regarding appropriate UL listings for the various components.

Panel-based lighting controls are often referred to as a centralized solution. These require the homeruns from all controlled loads to be routed through the control panel. Devices such as switches and sensors are often daisy-chained together with low-voltage cabling and also homerun back to the control panel or centralized processor.

When thinking of the four main architectures listed above, it's also helpful to know that a design isn't limited to just one. Often projects will have at least two or more of the

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Figure 2: Networking lighting controls with other systems can provide an enhanced experience for owners and end-users, allowing them to control multiple systems from a single app or interface. Courtesy: Henderson

above systems. For example, a project might use line-voltage occupancy sensor wall switch for restroom lights, low-voltage room controllers for office space ceiling lights, task lights and receptacles, a centralized panel for common corridors and a retail space with gypsum ceilings and addressable drivers for light fixtures in a flex space.

Networked lighting control systems

Most of the lighting control system architectures discussed above are capable of being networked. The main feature most commonly associated with networked systems is time clock functionality; all networked systems have a basic capability to schedule lights to turn on and off based on a schedule. Most of these systems contain astronomic time clocks, meaning the on and off operations can also be set to sunrise and sunset based on the project's location. However networked lighting control systems can offer so many more benefits to owners and end-users.

One of the biggest perks of networking a lighting control system is having a single user interface to control multiple spaces or facilities. These user interfaces can range from a wall switch with touch-screen controls, an app on a tablet or other mobile device, specialized software on a computer or a dedicated website. Manufacturers often offer a range of options over this spectrum. An owner of one building may be comfortable with a standard app, while an owner of numerous facilities across the nation (or world) may want a website to access programming and statistics on any of their systems from one location.

There are also ranges of networking regarding the light fixtures themselves. In addition to adjusting time schedules, networking low-voltage and panel-based lighting control systems often provide the ability to adjust programming for digital keypads, dimming thresholds and sensor settings. The overall control zoning of these systems is wiring based, which means that if an owner wants to change how light fixtures are grouped together an electrician would need to adjust the wiring.

Networking provides additional benefits for addressable lighting control systems. Since each light fixture has its own address, owners can adjust the control zoning simply from programming (no electrician required). Each light fixture can also report its

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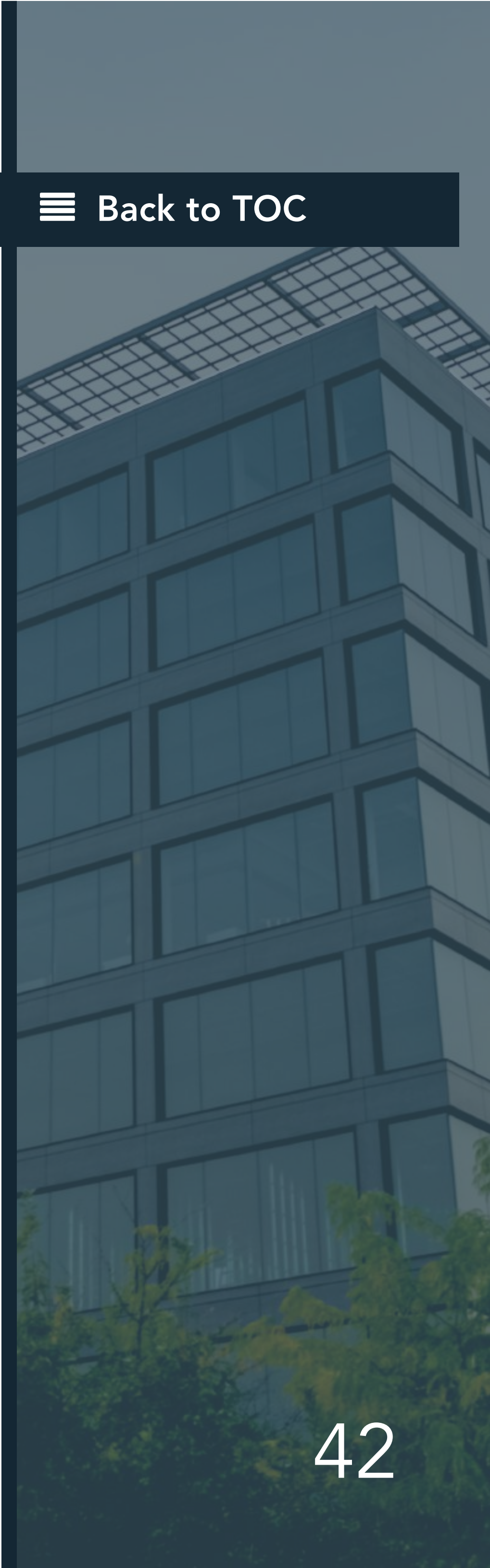

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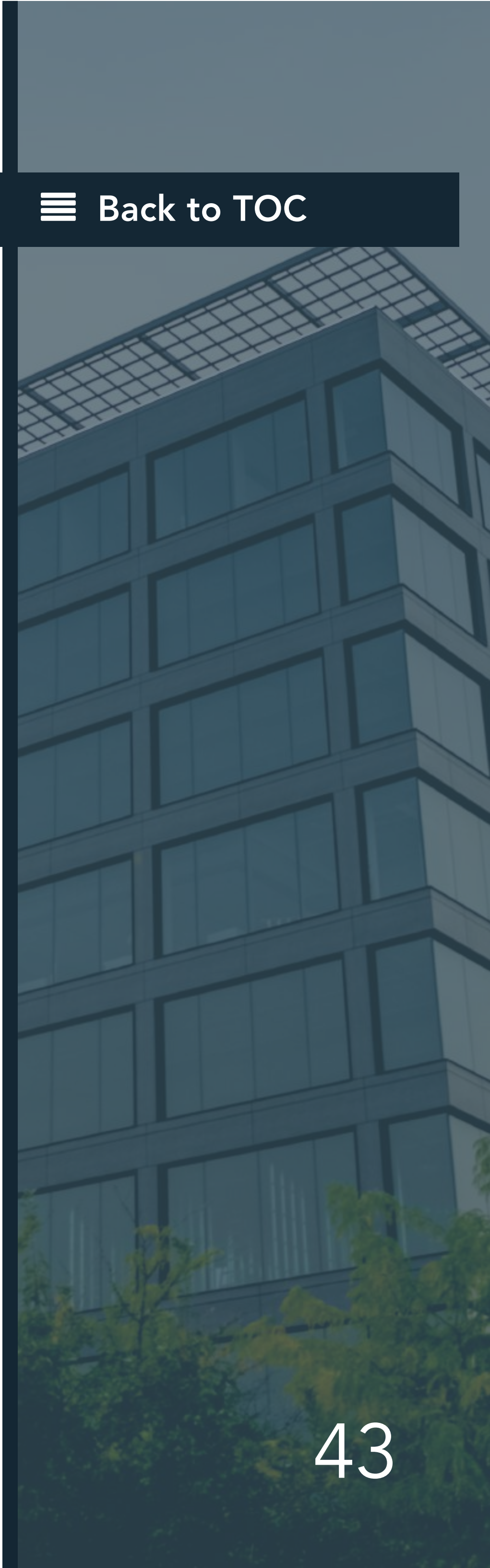

status, so maintenance can know when a driver is nearing end of life or if there is a malfunction. These individual light fixture reports can help owners strategically maintain their lighting control systems.

Finally, networking allows for enhanced integration with other systems. Integration can mean many things. At the most basic, it can be a contact closure that tells the system to do something. The most frequently integrated systems are security and fire alarm, as a simple contact closure from these systems can tell all lights in the system to turn on. Certain types of mechanical equipment can also be connected to lighting controls to receive an occupied/unoccupied signal which limits equipment runtime. At the other end of the spectrum, a single user interface can be used to control and program multiple systems. An example might be using a single touch screen to control the lighting, motorized shades and audio system in a room. Connecting the lighting controls to a full building automation system expands into fully controlling the mechanical systems as well. Another example may be to pull a timeclock or occupancy schedule directly from the BAS.

Systems commonly integrated or interfaced with the lighting controls are:

- 8 A/V systems.
- Building automation system.
- Demand response.
- Fire alarm system.

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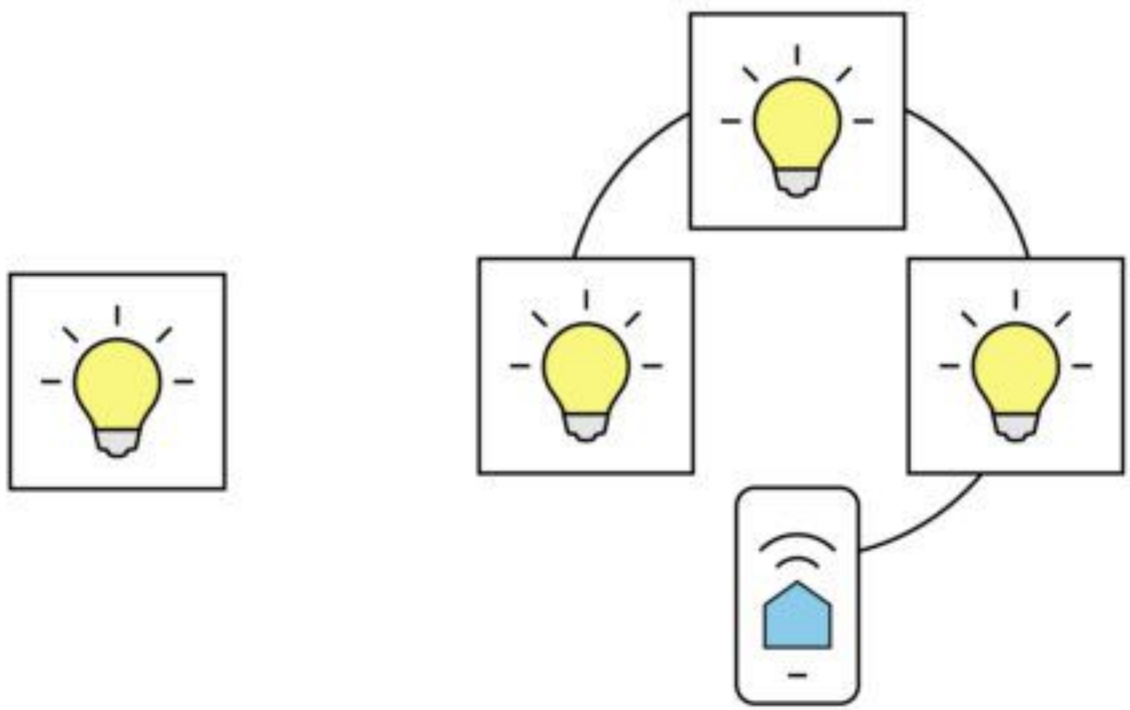

- Mechanical systems.
- Motorized window shades.
- Security system.

Figure 3: Both stand-alone and networked lighting controls still have their place. However, networked controls are becoming more prominent as energy codes become stricter and sustainability efforts increase. Courtesy: Henderson

Selection and design

There's bound to be a solution for every project given the wide variety of lighting control system manufacturers and options available. As technologies continue to change

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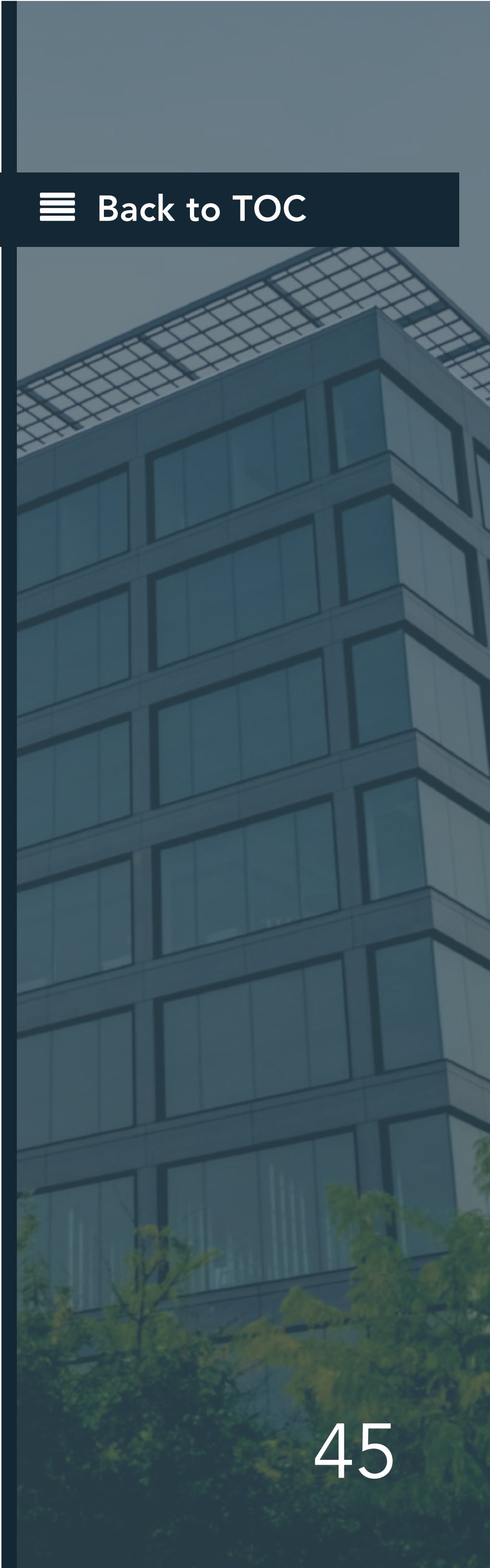
and develop at lightning speed and lighting controls become more data driven, it's also imperative to think ahead to the future. This is especially important for projects and buildings with long life spans. Carefully designing a lighting control system increases the life cycle of the system and equipment, which is good for both the owner's pocketbook and for sustainability.

Designing lighting control systems can be a daunting task, but when armed with the proper knowledge as outlined above, it does not have to be an intimidating process. With the variety of systems available, it is critical to select and design the proper system for each specific application.

Angela Faught

Angela Faught *is a retail sector technical manager at Henderson Engineers, a national building systems design firm.*



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