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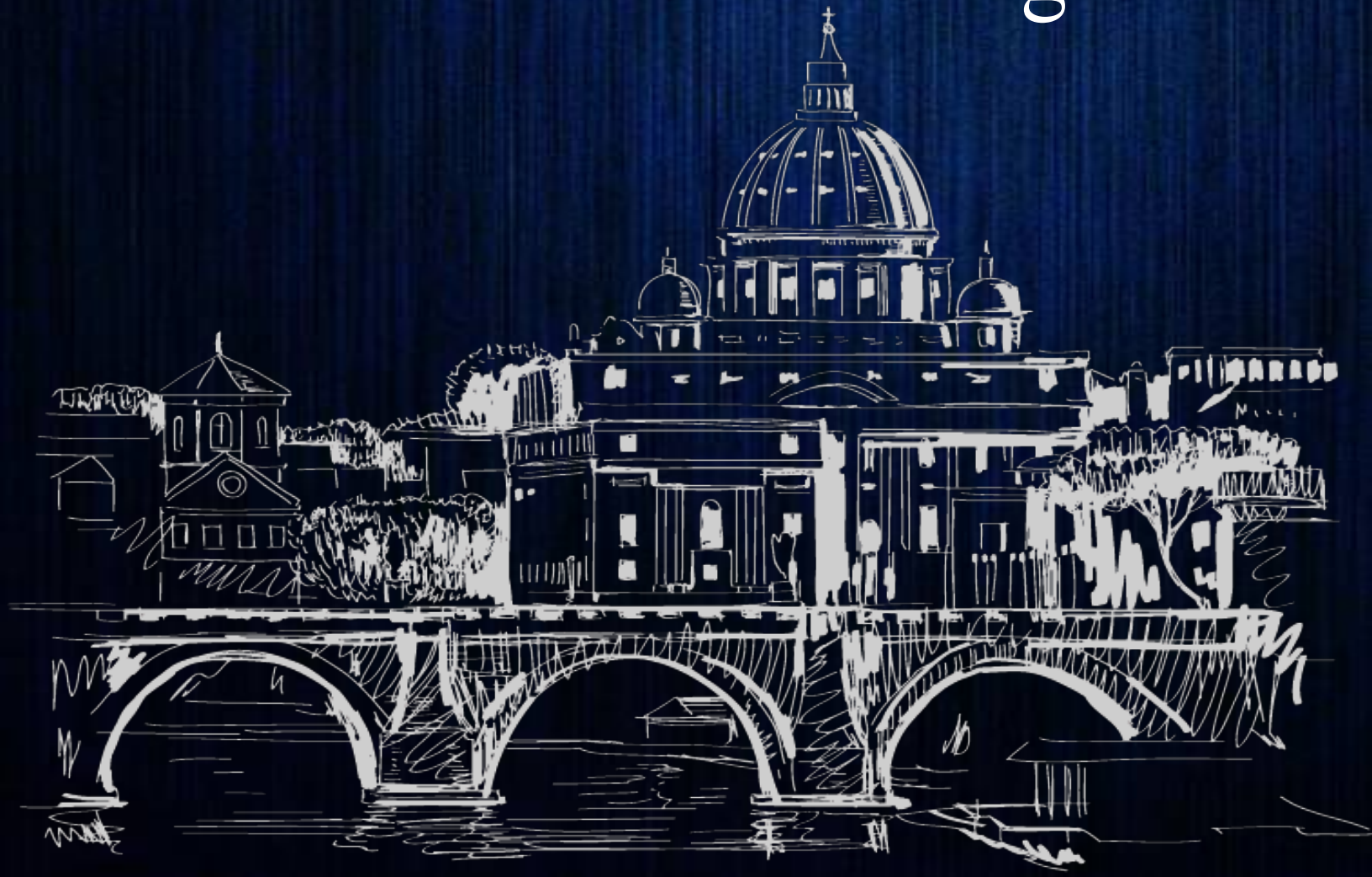
Laying the foundation for success in the connected- building era



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Laying the foundation for success in the connected-building era

Connected buildings could introduce a new way of working. Here's what it will take for them to become mainstream.

Commercial real estate has long depended on incremental advances in interior and exterior design, construction methods, and energy savings to keep pace with the evolving needs of owners and occupants. These improvements have accelerated over the past several years, with flexible workspace designs expanding employee collaboration, digital tools enhancing the construction process, and energy intelligence bringing new visibility into building efficiency.

Yet not much has changed in the way individuals and infrastructure interact. Communication between buildings and their occupants seldom extends beyond the occasional press of a button to call an elevator or flip of a switch to illuminate a room. A step change is on the horizon, however, with a focus on user-centric features that evolve the ways in which occupants benefit from their surroundings. A set of buildings are starting to bring these benefits to light, serving as test cases for the future of infrastructure technology.

For example, one recently constructed building in Amsterdam looks like many modern offices at first glance. Open floor plans with adjustable desks, multipurpose common spaces, and vibrant lounges surround a light-filled atrium and create a flexible and inviting workspace. But embedded within the facility is an array of intelligence to closely connect the infrastructure and occupants. Nearly 30,000 sensors cover the floor space, collecting granular, area-by-area data on occupancy, temperature, humidity, light levels, and even coffee-machine and towel-dispenser use.

The data are aggregated in real time, with analytics parsing the information into actionable intelligence to improve the occupant experience. Office and conference-room temperature adjusts to match occupancy levels and user preferences, for instance, and overhead lights brighten and dim according to the amount of sunlight present. Employees engage with this intelligent infrastructure through a smartphone interface, providing location awareness and wayfinding, real-time occupancy of meeting rooms and collaboration areas, workspace vacancies and assignments, and dynamic control over lighting and environmental settings.

This building is not an isolated example; rather, it is one of many new structures that have come online over the past three years across major cities, including London, Madrid, New York, Toronto, and Zurich, with similar technology built in. These facilities are using data to provide tangible new benefits to occupants and operators, and this connectivity-driven disruption is poised to unlock significant value for infrastructure suppliers across heating, ventilation, and air conditioning (HVAC), lighting, IT, security, and safety (Exhibit 1).

Can the industry translate these early proof points into greater momentum, or will interest in these changes subside? We believe that there is enough value waiting to be unlocked for this trend to continue, and in fact intensify over the next few years. Our research suggests that six tenets will ring true in this future landscape. First, the focus of building connectivity will migrate from energy savings to occupant experience, unlocking the next wave of value creation for building-infrastructure players. Security and privacy will present headwinds, and companies must build confidence across owners, tenants, and occupants to accelerate uptake. And

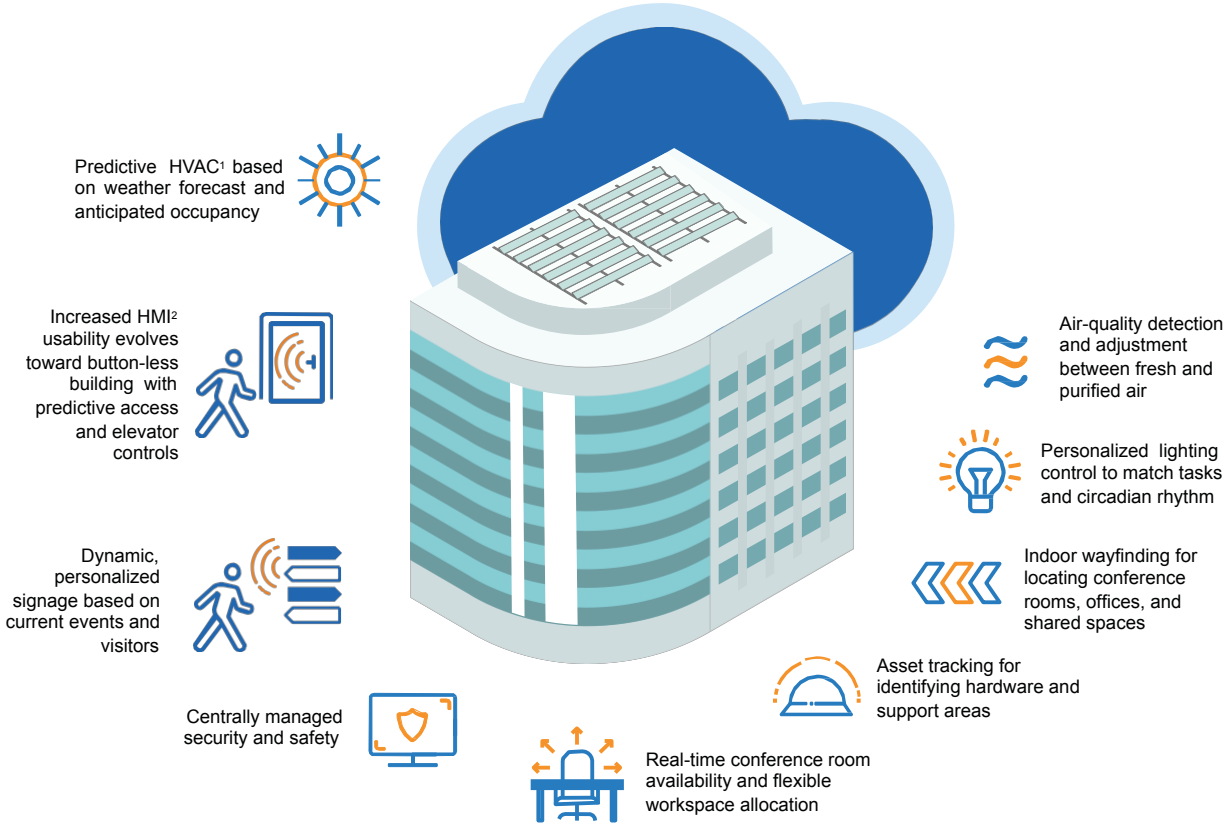
adoption will hinge on an effective combination of use cases, rather than a single "killer app."

Furthermore, this future state will require infrastructure players to depart from the status quo by transcending traditional approaches to market and reevaluating their technology, product offering, and partnerships to lay a foundation for long-term success. Winning players will pursue end-to-end solutions and stake a defensible, sustainable position amid a complex landscape of choices. And different business models will be needed to capture new value in software and digital services.

1. A step change in user experience will unlock the next wave of value creation

Building automation has been propelled by a necessity to reduce the cost of energy and operation over the past decade. Motion sensors were introduced to switch off lighting in unoccupied spaces. Window treatments were automated to lower the impact of direct sunlight on air-conditioning load. And intrusion detection expanded from passive alarms to corporate-wide access controls that minimized manual security work. In each case, cost reduction was the main driver, with a straightforward calculation for return on investment (ROI). Although room for further cost improvement remains, user experience is rapidly emerging as the next focus.

Exhibit 1: Connectivity is enabling new user- centric capabilities throughout the building



The evolution of building automation

The 1880s saw the initial foray into modern building automation when American professor Warren Johnson created the first thermostat—a rudimentary device that triggered a bell in the school's boiler room when his classroom temperature dropped, signaling custodial staff to open the dampers. Thus launched the first automation wave, which focused on mechanizing heating, ventilation, and air conditioning (HVAC) adjustments to maintain occupant comfort. These controls were pneumatic, which remained the driving technology through the 1970s.

The second wave emerged in the 1980s as computers made their way into facility management. Additional building-infrastructure domains could finally be automated, including lighting, security, and safety. As complexity expanded, building-management systems (BMS) were born to help simplify controls for building operators. Basic data on facility performance was also captured and recorded, although deriving actionable insights was difficult due to the absence of robust tools for data integration, interpretation, and analysis.

A paradigm shift occurred in the 2000s and effectively defined the current state, whereby rising energy prices put efficiency controls on par with occupant comfort and ushered in the third automation wave. Electricity cost became a corporate target for reduction, and government mandates also emerged. These savings funded the installation of enhanced BMS capable of active energy management to drive conservation building-wide.

Looking forward, businesses are increasingly recognizing the link between the working environment and human capital, and ascribing value to a positive employee experience. Talent recruitment, performance, and retention are all affected by the building environment, which has the power to engender either positive or negative reactions. Although more difficult to quantify, the impact of employee surroundings on business performance is receiving increased attention. New use cases will leverage connectivity to improve the occupant experience, enabling the personalization of space, bio-adaptability of the environment, and predictive awareness of individual needs.

Buildings that emphasize the user experience will provide occupants with greater personal control over their surroundings. Lighting systems will identify occupants and adjust the intensity and color temperature to suit individual preferences; they will also adjust to the time of day. Climate systems will respond to individuals as well, automatically adjusting the temperature in conference rooms to the ideal average between attendees.

Bio-adaptability will help to improve occupant productivity, creativity, and potentially even health. Lighting fixtures will adjust their color spectrum throughout the day to more closely mimic sunlight and support the circadian rhythm. And HVAC

systems will monitor and adjust for ideal air quality, removing the "sleep-inducing" effects of a poor climate.

Predictive awareness will enable more effective and efficient mobility throughout a building, as well as use of space. Elevators will steer occupants according to the next meeting in their calendar, pre-positioning cars to minimize waiting. Conference- room availability will be tracked in real time, eliminating "phantom" bookings and making spaces available again if attendees do not show up. Flexible workspace assignments will take a range of variables into consideration when identifying an employee "home base" for the day, including personal location preferences, meeting locations, and anticipated occupancy levels. And indoor positioning will enable employees to locate and rapidly route to shared spaces and assets.

Experience improvements will not be limited to occupants, however. Operators and facility managers will also benefit, with building infrastructure requiring less manual oversight. Climate control will predictively adapt to weather changes and occupancy levels. Lighting fixtures will brighten and darken alongside ambient sunlight, dynamically maximizing energy savings. And as buildings shift from energy "consumers" to energy "prosumers" with the introduction of distributed solar and energy storage, the focus of power management will change from demand reduction to dynamic source optimization, incorporating building-to-building communication and smart- grid tie-in.

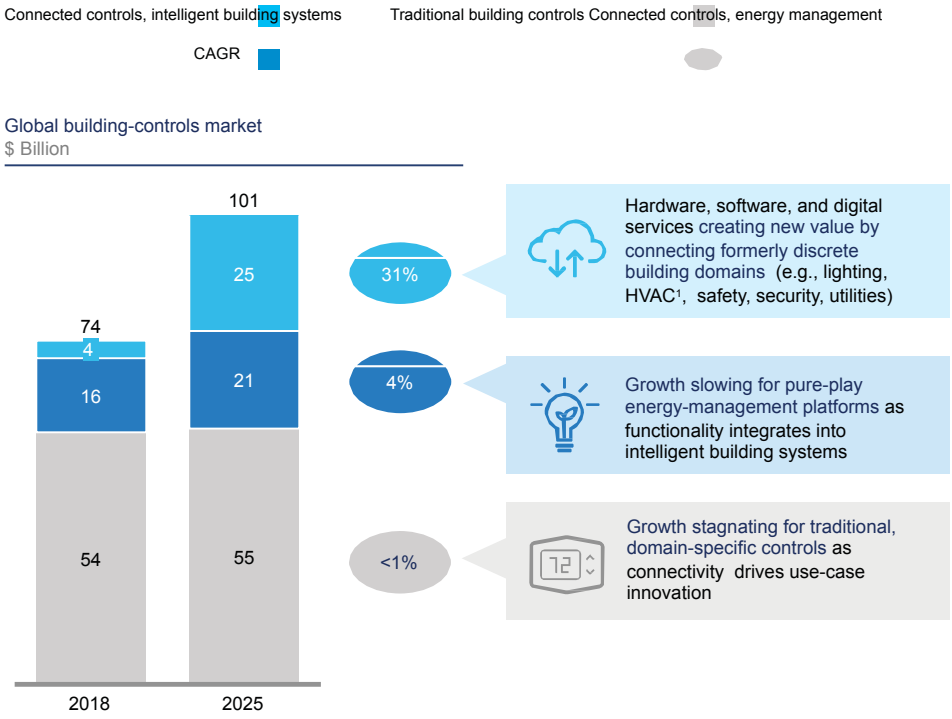
Other segments of commercial real estate benefit from additional use cases. For instance, retail spaces are beginning to install wayfinding capabilities that help shoppers to identify the location of items they are searching for and to suggest promotions along the way. Hotels are implementing connected- home-like applications, with personalized lighting, climate, and entertainment control as well as occupancy awareness. And hospitals are leveraging asset tracking to identify the location of portable equipment in real time.

Underpinning all of these use cases is a true step change in technological infrastructure. Successful development and deployment will require merging elements of connectivity, big data, machine learning, and mobile applications with traditional building hardware, and effectively connecting this infrastructure together in a reliable, secure, and extensible manner. No easy feat, since this is a highly disruptive leap for an industry accustomed to incremental improvements. Yet there is significant value at stake for building-infrastructure players, with connectivity on track to add more than $25 billion annually to the building-controls market by 2025 (Exhibit 2). Furthermore, the ability for companies to offer intelligent building systems with compelling use cases will have a significant impact on customer decisions for HVAC equipment, lighting fixtures, and other conventional building hardware. The stakes are indeed high for incumbent players.

2. Security and privacy challenges must be solved

Before widespread adoption is possible, core security and privacy challenges will need to be addressed. Enabling a menu of user-centric use cases requires connecting a wide range of building infrastructure together, installing an array of new sensors and establishing a persistent cloud connection. The resulting configuration will present significant new security and privacy challenges, which few building operators feel well prepared to combat.

Exhibit 2: Connectivity is driving the next growth wave for building controls



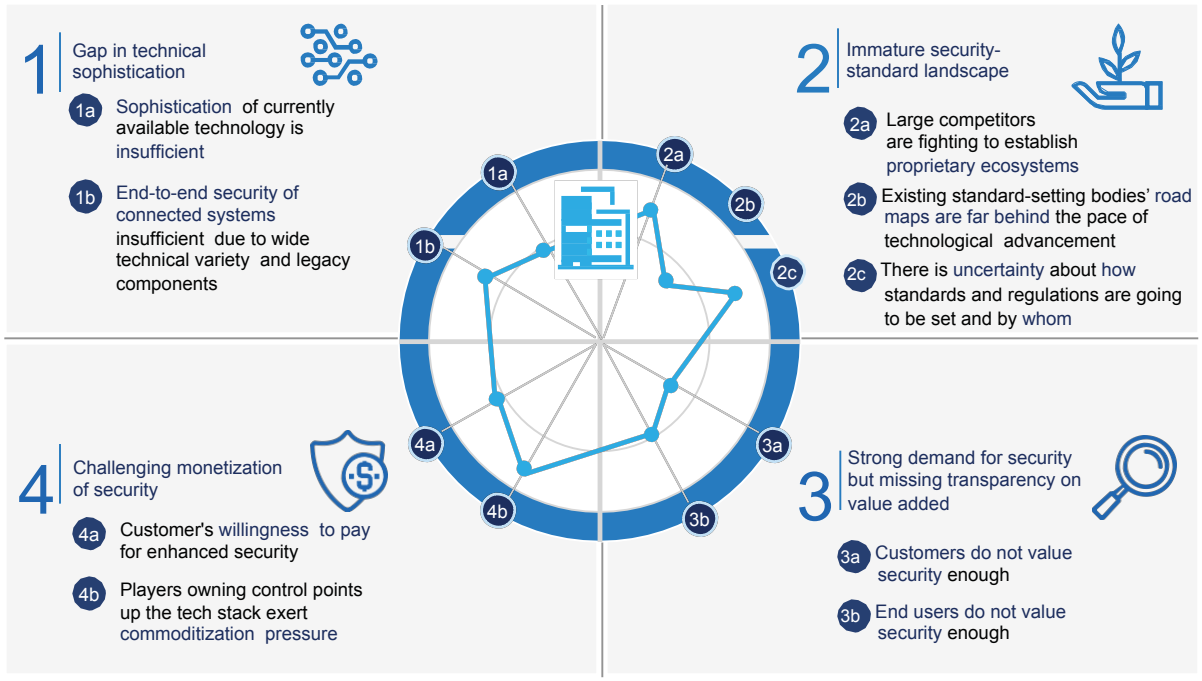
[1] Heating, ventilation, and air conditioning.
Source: Expert interviews; Navigant; Technavio; The Jeeranont.

Security challenges stem from the combination of hardware and software across a range of equipment, likely provided by many different vendors. While these connections are critical to enabling value- driving use cases, each additional interface introduces the potential for greater security risk if not managed carefully. Recent exploits have heightened this sensitivity; in 2012, the networks within several government buildings were accessed through their internet-connected thermostats.
In 2016, researchers demonstrated a successful connected-lighting-system intrusion by flying a drone outside a building. And in 2017, a casino's data was hacked through a thermostat installed to regulate the temperature of a large fish tank.

There is an emerging awareness across infrastructure vendors that all layers of the technology stack require protection; "weakest link" exploits are becoming common, and a security oversight function is needed to vet partnerships. But the question of who holds responsibility remains unclear. Ultimately, a joint construct is likely to prevail—manufacturers will be tasked with safeguarding equipment through active, systemwide threat protection and monitoring, and ensuring that all devices are capable of rapidly receiving software updates to patch vulnerabilities. Building operators will need to confirm that these updates are acted upon and correctly installed. And a tenant's corporate IT team will need to implement robust precautions to manage any links between the connected infrastructure and proprietary networks.

Exhibit 3: Connectivity is bringing new security challenges to building infrastructure

Average rating of challenge and relevance on 0–3 scale[1]



[1] 4-point scale where 0 = not challenging/irrelevant, 3 = most challenging/relevant. Centerscaled to 1 in graphic.
Source: Semiconductor Industry Executive Survey, Global Semiconductor Alliance and The Jeeranont.

Of course, owners of connected buildings must consider whether their clients are willing to front the additional cost of increased cybersecurity. For example, a survey conducted jointly by the Global Semiconductor Alliance and The Jeeranont showed high awareness of the challenges posed by security risks as well as the difficulty in convincing customers to ascribe value to risk mitigation (Exhibit 3).

Privacy challenges must also be overcome, which stem from the proliferation of sensors, data, and personalization at the heart of many connected- building use cases. For instance, for personalized temperature, lighting, or wayfinding services, user identity and location must be identified and transmitted across the network. Comfort with this is likely to vary by country, industry, company, and individual, yet it will be important to build confidence in any application. Infrastructure players will need to be highly transparent with building occupants about what data is collected and how it will be used. Furthermore, occupants should be provided the choice to easily opt out of the collection of personally identifiable information if they so choose.

How to prevent all users from opting out? The answer lies in the implicit privacy construct found in smartphone applications. When end users associate data collection with services that benefit them directly, they are more likely to permit the collection of data to enable this. For instance, major smartphone mapping applications provide live traffic indications and road-condition reports, which many find useful for reducing travel time and avoiding delays. In exchange, these applications track a user's position and speed, and aggregate this data with that of others to provide helpful insight to anyone contemplating a similar route. In the same vein, building-infrastructure providers will need to visibly link data collection with its associated use-case benefits, to limit the opportunity for an adoption headwind due to privacy concerns.

3. Adoption will hinge on an effective combination of use cases, rather than a single 'killer app'

Traditionally, ROI has been the metric of record for determining whether a new feature is worth adding within the building infrastructure. This has worked fine when predicating use cases on energy savings.

Motion sensors for lighting, for instance, are seeing significant uptake since the impact on energy savings can easily be translated into dollar terms.
The same goes for smart thermostats, automatic window shades, and other conservation upgrades,
which often pay for themselves within the first one to two years of use.

With connectivity-enabled use cases, however, the value propositions are far more difficult to quantify. Take, for example, bio-adaptive lighting.
Extensive research has been conducted on the health and performance benefits from adapting the lighting spectrum throughout the day to optimize the circadian rhythm. Yet the end result can vary
widely according to the specific building, working environment, and occupant. Although the benefits are known, it is very challenging to directly attribute human productivity gains to this use case. A gray area such as this, where benefits are tangible but difficult to quantify and track, makes it hard for companies to justify the additional up-front cost.
Other use cases, such as asset tracking, air-quality monitoring, and personal temperature controls, pose equally difficult ROI calculations.

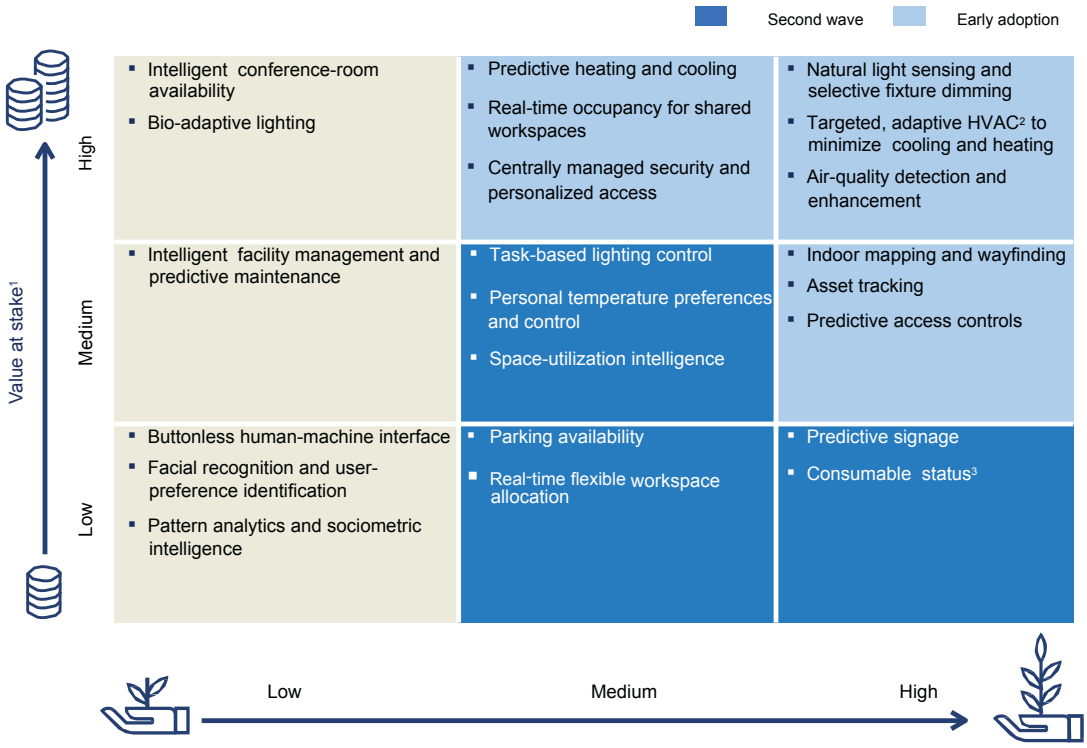
Furthermore, not all customers stand to gain from all use cases. Early adopters are looking for a series of solutions tailored to their specific environments; one-size-fits-all approaches will not work. For example, asset tracking is likely only applicable to facilities with frequently moved equipment. And monitoring floor-plan utilization is most useful in dynamic offices with significant employee mobility. It is therefore unlikely that a single killer app will propel adoption. Rather, building-infrastructure players will need to provide a menu of options, particularly at this early-market stage, in order to succeed, and prioritize mature, high-value use cases first (Exhibit 4).

4. Players will need to transcend traditional approaches to market

The traditional value chain for commercial- building construction is poorly aligned with the new era of connectivity. In the traditional model, infrastructure decisions are often made years before a facility is occupied. Split incentives are common in leased spaces, where tenants benefit but building owners shoulder the up-front cost. And first cost is paramount when the majority of infrastructure decisions are made.

To counter this, building-infrastructure players will need to transcend the traditional value chain and take a broader vantage point in their pursuit of connectivity-enabled solution sales. Direct

Exhibit 4: Value at stake and readiness for adoption vary widely across connected-building use cases



relationships with end users likely hold the key to success. Involving a customer's C-suite as core stakeholders is critical; it is often only at that level where the picture becomes broad enough to encompass many of the connected use-case benefits, such as employee efficiency and floorspace effectiveness. It is also important to identify and mobilize those within a customer's organization whose incentives are currently aligned with one or more use cases. For instance, a sustainability manager likely has energy-reduction goals, and an HR leader may have targets around employee performance and retention—both could serve as champions for new connectivity-enabled products and services.

Furthermore, players should be creative in finding ways to present the value of each use case to customers early in the decision process. For example, space-utilization use cases enlist sensors throughout a building to determine how physical space is used, informing layout changes, room repurposing, or overall square footage shifts to maximize effectiveness for occupants. Building-infrastructure players could enable customers to directly experience this value by quickly installing a temporary sensor package to provide insights on one portion of a building prior to any retrofit or new construction. This intelligence can then be used by the customer to inform retrofit planning, proving out the use case and helping the customer to see the value that could come from a full installation.

There will be customers who remain skeptical, however, particularly those accustomed to direct, quantifiable ROI. Therefore, players should lead the discussion with energy savings whenever possible. Although some efficiency improvement has taken place across corporate real estate, with innovations such as LED lighting and improved air-conditioning hardware driving energy reduction across new and recently renovated buildings, many existing facilities have yet to capture any meaningful savings. For the majority of these spaces, the connectivity infrastructure required for user-experience use cases is well positioned to move the needle.

For example, advanced occupancy sensing, in addition to its use for conference-room availability and scheduling, can proactively reduce HVAC need, ramping down when a room is vacant and increasing in proportion to the number of occupants. And ambient-light detection, in addition to adapting color and spectrum over the course of the day, can be used to proactively dim artificial lighting when sufficient sunlight is present. The resulting reductions have a substantial impact on recurring energy savings, and provide a significant lead-in for connected-building ROI.

5. Successful players will pursue end-to- end solutions

To deliver on these experiences, building- infrastructure players will need to establish end-to- end solutions. Players will need to reevaluate their capabilities, their position along the value chain, and their approach to the market, and they will need to stake a defensible, sustainable position amid a complex landscape of choices. Critical among these choices is the identification of "how to play" in a connectivity-defined era.

Traditionally, these players have chosen which parts of the hardware offering they needed to own and develop in-house, and which they simply needed to access through suppliers to create a compelling product line. Yet connectivity is adding new layers to the technology stack—sensors, software platforms, applications, and services are now required. With this in mind, infrastructure players must make some new decisions, with "facilitation" approaches becoming critical in new parts of the stack. Ecosystems and partnerships are likely to drive success in these new software-defined layers, enabling these companies to create end-to-end products, access multiple building systems, develop compelling user interfaces, and continuously expand the range of use-case offerings (Exhibit 5).

In addition to facilitation, players must identify which sections of the stack to own, either by developing them in-house or acquiring them.

Two control points are beginning to emerge: the hardware infrastructure, given its position as host for sensors and connectivity, and the software platform, since it serves as the gateway to value-added applications and services (Exhibit 6). Ownership of one or both is likely to provide a foundation for capturing an outsize share of value when forming an end-to-end product offering.

Exhibit 5: Winning players will need to stake a defensible, sustainable position among a complex set of decisions

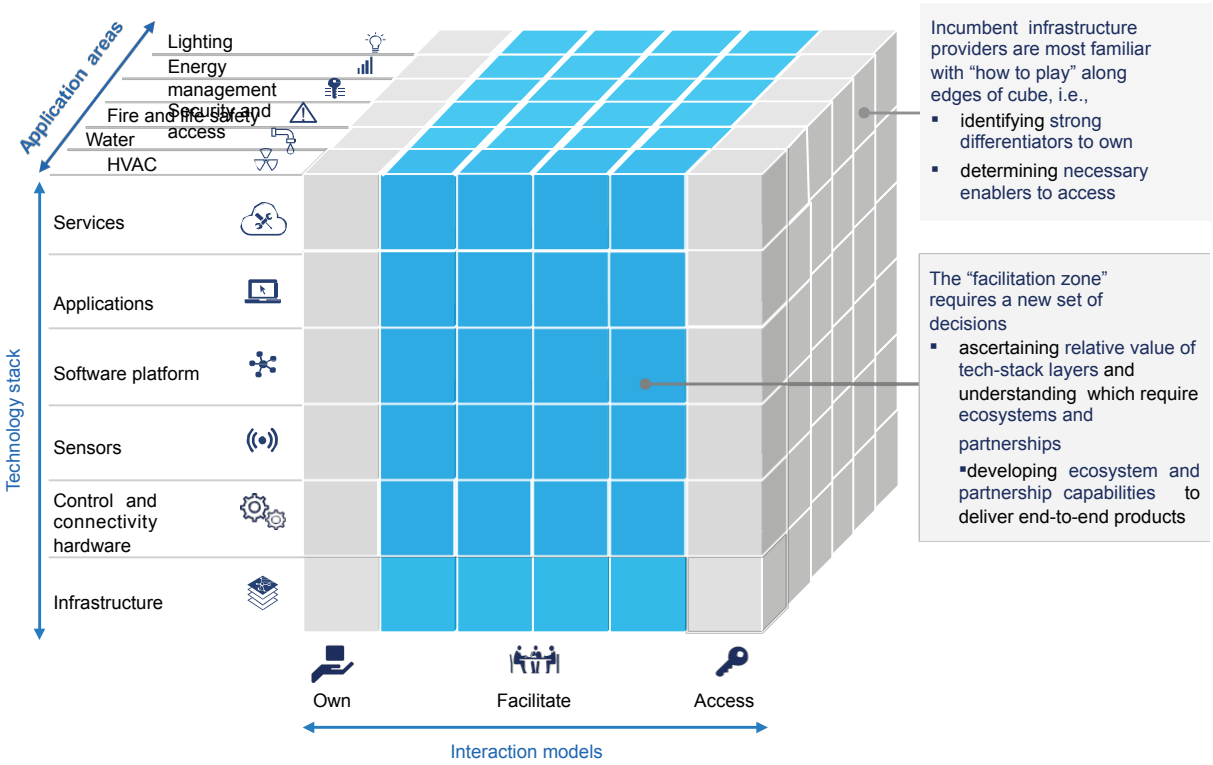
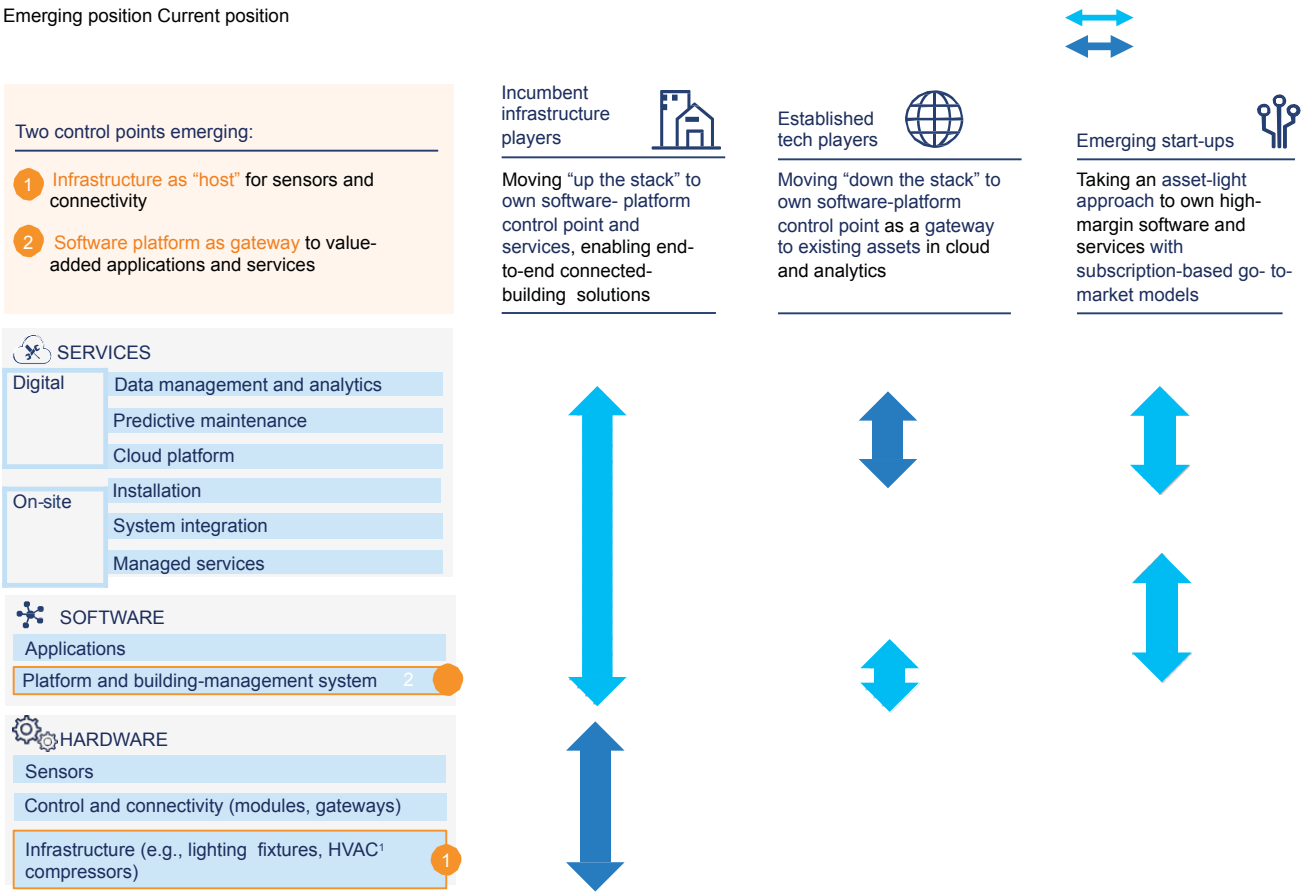


Exhibit 6: Ownership of one or more control points is critical for 'full stack' success



[1] Heating, ventilation, and air - conditioning.

All players will need to stake a defensible, sustainable position about where to play and how to play within the connected-building space.

Incumbent building-infrastructure players are in an advantageous position; they already own the hardware-infrastructure control point and should look to move up the stack to offer an end-to-end connected solution. Established technology players, currently focused on cloud-services offerings, should evaluate down-the-stack moves to own the software-platform control point given its status as a gateway to additional value. And start-ups, currently emphasizing solutions for specific use cases, will need to establish themselves early as part of a strong software-platform ecosystem to ensure pull with end customers.

6. New business models will be needed to capture value in software and digital services Hardware has traditionally served as the primary revenue driver for building-infrastructure players. Yet legacy hardware-based business models are unlikely to suffice in the connected era, since much of the intellectual property, feature set, and differentiation lies in the software and digital services portions of the stack. Infrastructure players will therefore need to explore new

monetization approaches to capture this value. Although the industry has many technical and commercial dynamics in play, early signs point to three potential constructs:

Conventional product-based. Players offer connectivity as a product. Connectivity hardware and software components are either sold individually, or, in the case of existing infrastructure players, provided at low or no charge in order to generate pull-through for the base infrastructure hardware. Customers incur greater upfront cost, although this can typically be capitalized. Substantial time can pass between the bids and proposals phase on a project and actual installation, equipment commissioning and first use, however. At least a year is typical for smaller renovation projects and two or more years for new construction, during which significant evolution of connectivity technology and use cases is likely to occur, presenting challenges for value-based pricing and software update agreements.

Subscription-oriented. Connectivity hardware is sold as a product, while software and services are monetized through a subscription-based platform. Customers license software and subscribe to specific use cases. Background analytics, cloud hosting, and user interfaces as well as updates and support are provided throughout the subscription period. Pricing scales with the number of system nodes deployed across a building. Infrastructure players benefit from a recurring, “asset lite” revenue stream with strong staying power once hardware is installed, and customers gain access to new features and use cases over the life of the system.

Connectivity-as-a-service. End-to-end solutions are monetized through a subscription model, including all hardware, software, and services for connectivity-enabled use cases. Customers avoid up-front hardware and software costs; they are instead covered on a recurring operational-expense basis. Sensors and controls are provided, maintained, and upgraded as part of the subscription, with the infrastructure for all functionality in place but only unlocked upon a subscription to each use case. Although the up-front hardware cost is minimized to encourage customer adoption, infrastructure players bear more risk, since hardware is difficult to remove in the event of nonpayment.

Among these business models, both subscription- oriented and connectivity-as-a-service approaches are beginning to take hold, outpacing a product- based approach in early adoption. Yet building infrastructure players continue to experiment with different constructs, and the industry is unlikely to adopt only one model going forward. Depending on the overall pull for each use case and the ability to quantify ROI over the long run, the likely evolution could take many paths. Furthermore, successful players will need to tailor their monetization approach according to the value created by each offering, the distinct needs of each building type, and the infrastructure domain or technology stack layers in which they have a sustainable advantage.

Next steps for infrastructure players

Building-infrastructure players won't win by standing still. It's time to move forward by developing the capabilities, partnerships, and ecosystems needed to succeed in the new age of connectivity, where constant technological advances will transform the environment in which we work.
Companies will need to consider several issues as they forge ahead, but three are paramount:

Where to compete. When deciding where to compete, players need to look at both infrastructure domains and application areas. They should select use cases that best build upon their current hardware or software capabilities, generate the most value for building occupants and end users, and provide a sustainable competitive advantage.

How to compete. Companies should be working now to establish ecosystems around their products and developing relationships with potential partners that will be critical to filling in the gaps for an effective end-to-end solution. Existing building-infrastructure providers should be moving up the stack, while technology players looking to build out their share in the space should move down. It's also important for players to take a fresh look at their market approach and begin establishing relationships with potential end customers at senior levels, who are best positioned to evaluate the overall return on investment. Players should also aggressively reduce hardware costs in parallel to demonstrating compelling value from use cases, and then establish subscription-based monetization models for use cases that share in this value. For instance, a lighting player might charge only a small premium to add sensors to a lighting-fixture package, which would thereby enable connected-use-case subscriptions to be offered long term.

When to compete. Now is the time to act. Waiting is unlikely to be rewarded—many businesses only undertake substantial renovations or construction projects once in a decade, and the first connectivity wave, expected to separate leaders from everyone else, has launched. Although the industry may eventually converge on a set of universal standards to help drive adoption and collaboration, winners will not stand idle. Customers are indexing heavily on early proof points when evaluating vendors, and players should therefore focus on compelling solutions that enable them to rapidly establish a foothold.

While connectivity represents a substantial opportunity for both incumbent infrastructure companies and new tech-focused entrants, they need to act quickly. Many players are already attempting to establish themselves as leaders in the connected- building space, so competitors that delay may never regain their lost ground. No single approach is right for every potential player, but those that follow the strategies outlined here will obtain universal benefits. Will your company be among this group?