Smart Working

Smart Buildings and the Future of Work

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1. Introduction

The way companies work has been transformed over the past decade as the confluence of new ideas, technological innovation and the entrance of new generations into the workforce has upended longstanding approaches to work and the workplace. Traditional models of workplace design that focused on cost reduction and efficiency are being rapidly superseded by more dynamic, agile models that aim to increase productivity, collaboration and wellbeing.

As the role of the workplace changes, so do the kinds of buildings that companies look to locate in. More mindful of the benefits that particular buildings offer, firms are increasingly discerning about the kinds of sites they select. For most companies, buildings need to provide more than the traditional lease – they need to help them attract the best talent, support business aims and energise and inspire their staff.

Smart buildings do all of these things, and more. Leveraging cutting-edge technologies, such as the Internet of Things, Big Data and intelligent software, smart buildings enhance the experience of occupants, and create more attractive and desirable places to work. In a smart building, building systems sustain optimal levels of performance, helping to make them highly energy efficient; the experience of building users is personalised to their individual preferences; and real-time data is captured on the performance of the building and its work spaces.

This report sets out the advantages that smart buildings offer to occupiers and developers of commercial real estate. It identifies key technological enablers and shows how smart buildings will transform work, the workplace and the urban landscape over the next few years. Furthermore, it lays out a set of practical steps that developers can follow to realise the vision for smart buildings.

The emergence of smart buildings is about to fundamentally reshape the way modern buildings are designed, built and operated. This report shows how developers can position themselves to benefit from the changes taking place.

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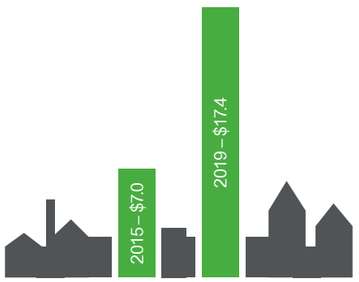
2. Executive Summary

Emerging technologies such as the Internet of Things (IoT), Big Data and intelligent Building Management Systems (iBMS) are fundamentally changing how modern buildings are designed, built and operated.

At the same time, the way buildings are used by occupiers is being transformed as competitive pressures and new ways of working create demands for different types of space. Increasingly, companies are looking to locate to buildings that are flexible and adaptive, that help them attract the best talent, that offer excellent user experience and that are simple and efficient to run.

Enter the smart building. Smart buildings are those that utilise cutting-edge technology to enhance the experience of occupants, sustain optimal levels of performance and reduce the costs of building operations. In a smart building, different technology systems work together to make the building highly efficient, flexible and a more attractive and desirable place to work.

Investment in smart building systems has grown considerably over the last few years. Global spending on smart building systems reached $7.0 (£5.8) billion in 2015. By 2019, this figure is projected to reach $17.4 (£14.4) billion.[1]



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Assessing Building Intelligence: The Activ8 Model of Smart Buildings

While occupiers and developers of commercial real estate are increasingly aware of smart buildings, understandings and definitions of the different aspects of building intelligence differ widely. This reports sets out a new, outcome-orientated model for assessing how smart a building truly is.

The Activ8 model details eight outcomes that can be used to understand the benefits of building intelligence.

1. **Insightful.** Smart buildings provide actionable insights into how a building is operating. In a smart building, real-time data is reported and used to inform decisions on building operations. Portfolio managers can see their operations across the globe and compare performance, giving them actionable insight on how to drive efficiencies and improvements.

2. **Sustainable.** Smart buildings enable facilities managers to easily monitor and control the performance of the buildings against their sustainability strategies. Combined with appropriate supply and demand energy management strategies, many smart buildings are even net-positive, creating more energy than they consume.

3. **Flexible.** Smart buildings are better able to accommodate agile, dynamic models of work, such as activity-based working, by allowing spaces to be easily re-configured. This enables the workplace to adapt to technological advances and changing business requirements more easily.

4. **Experiential.** Office users have greater control over their environment in a smart building, allowing them to tailor comfort levels to their personal preference.

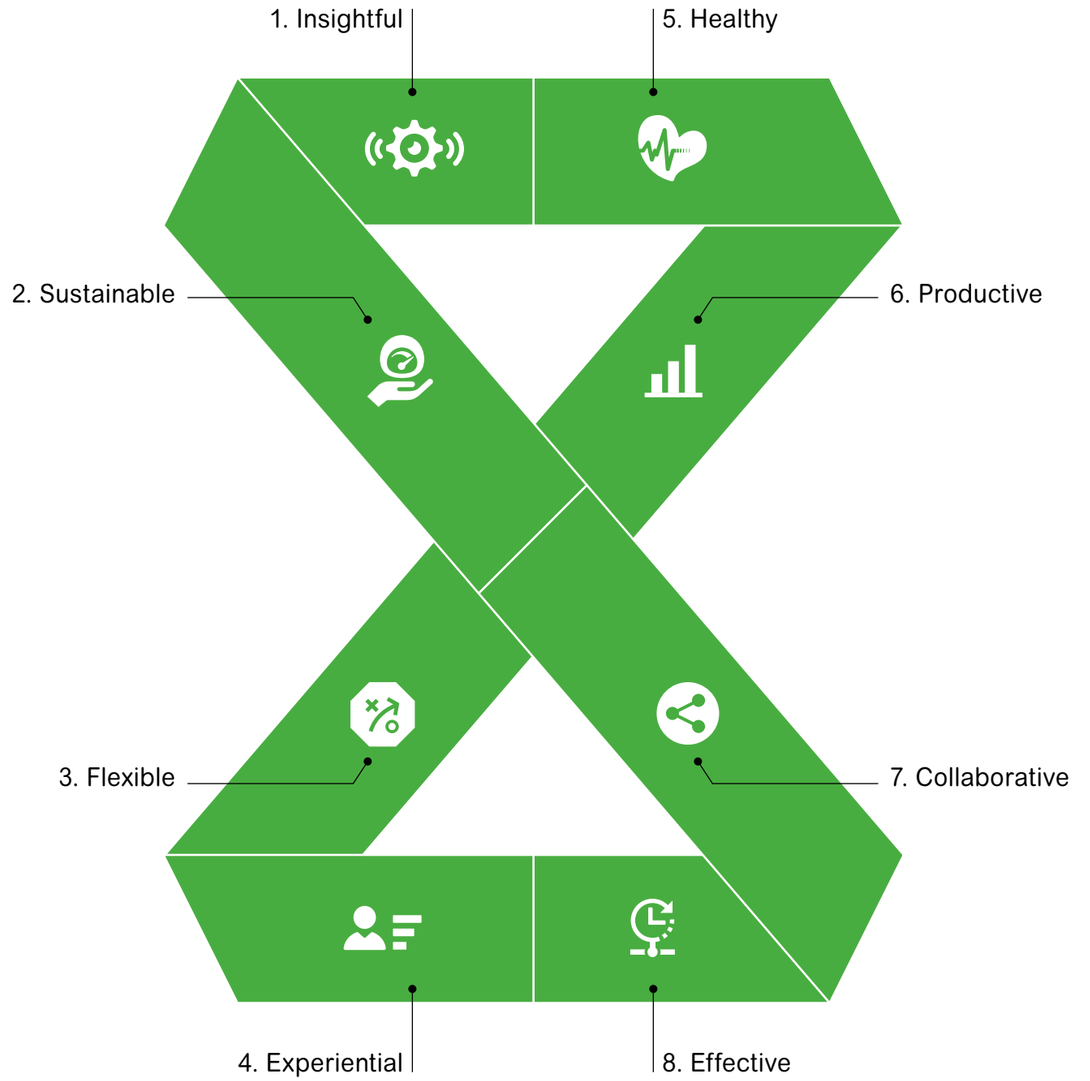
5. **Healthy.** Smart buildings contribute to a healthy environment and provide technology that can facilitate and measure wellbeing, helping to reduce the costs of sickness and absenteeism.

6. **Productive.** Smart buildings facilitate better, more efficient use of space and environments that enable companies to get more out of their staff.

7. **Collaborative.** Through advanced use of data and analytics, smart buildings are able to encourage interactions, knowledge sharing and improve business performance.

8. **Effective.** Smart buildings meet the needs of their stakeholders and transform a company's real estate into an enabler of business growth.

Together, the components of the Activ8 model represent a set of criteria for developers and occupiers to use when designing, specifying and procuring smart building technology.



The Smart Advantage

This report demonstrates that a smart building offers considerable advantages over a conventional one for developers, landlords and occupiers of commercial real estate.

Smart Assets
In a smart building, intelligent energy management solutions can be deployed to optimise the performance of building systems and carefully manage energy consumption, enabling smart buildings to achieve high levels of energy efficiency. Onsite energy production, advanced analytics software and new types of intelligent building materials even allow some smart buildings to be net suppliers of energy to national grids, rather than mere consumers.

Huge volumes of data produced by building systems and sensors can be analysed by smart building software to provide actionable intelligence on building performance. Building managers are then better able to make informed decisions on the operations of a building, or schedule pre-configured outcomes based on their desired model of operation. The continual monitoring of data produced by building systems also enables advanced detection and diagnostics of faults, and allows a building to sustain a high level of performance across its entire lifecycle.

Advanced security technologies, like facial recognition and video analytics, can be easily integrated into a smart building to ensure the safety of building occupants and users. These sorts of technologies can then work alongside other building systems to deliver a more holistic concept of security. For example, upon identifying an intruder, a smart building can redirect security cameras, engage control systems to prevent building access and direct security personnel to the threat.

Smart Workplaces
For businesses, there are considerable strategic advantages to working in a smart building, including better business performance, improved workforce wellbeing and a better working experience for their employees.

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Data captured by a range of workplace sensors can report the occupancy of workplaces in real time, measure how effectively the space is being used and enable better decision-making by heads of real estate and facilities managers.

Moreover, new analytics techniques are being pioneered that can correlate data captured in work environments with overall business performance. ‘Social physics’, the practice of using vast datasets from smartphones, wearables and workplace sensors to gauge how people interact and share ideas, has been used to demonstrate the effectiveness of workplace design on individual performance, speed to market and sales growth.

Workplace sensors in a smart building can also be used by companies to measure their organisational health, while also giving office users greater control over their working environment. Data on indoor air quality, light and noise levels and levels of physical activity can all be assessed by smart building sensors, which companies can use to make positive interventions that improve health and wellbeing outcomes.

Smart Buildings, Smart Cities

Smart buildings are the enabler of smart cities, cities that use data to generate and realise efficiencies in the provision of services or improve the wellbeing of the urban population. Smart buildings engineered to use energy more efficiently, for example, can generate vast savings in the running of urban infrastructure.

A multitude of technologies has been deployed as part of efforts to create smart cities. In Singapore, IoT and other technologies have been deployed to ease the flow of congestion, monitor the workings of streetlights and measure the cleanliness of public places. In China, spending on the government’s expansive smart cities programme is expected to reach $16 billion by 2024.[2]

Real estate developers can play a leading role in the creation of smart cities. At Songdo International Business Park in South Korea, real estate developer, Gale International, has demonstrated that investments in smart technology can help developers transform how urban services are delivered to occupiers and other building users. Creating clusters of smart buildings that can exchange information between each other will expedite the creation of smart cities and allow developers to redevelop the urban landscape.

Delivering a smart building – Seven Steps to Achieve Smart

1. **Choose smart from the start.** Smart buildings with the best outcomes are born from conception. Although not impossible, introducing smart after a building’s strategic development stage can incur more costs than needed, delay projects and reduce the benefits for all stakeholders.

2. **Procure smart and challenge the state as quo.** Identify experts that can help sell your concept to key stakeholders and work with your consultants to drive smart choices of technology, gain cost certainty and keep your chosen solutions on track.

3. **Don’t forget the basics.** Power demand and supply, an iBMS and resilient building systems that interconnect can save time, manage risk, deliver cost efficiency and lifecycle value. The most commercially attractive buildings are those where the lights do not go out and the systems are open to updating and improvement.

4. **Be as smart as your building needs to be.** Focus on the technologies and base build inclusions that deliver tangible benefits for each building and deliver the concept of operation that is needed but allow for future innovation and improvement.

5. **Dealing with data.** Focus on the data that is needed for reporting – efficiency, business improvement and performance – and ensure that your technology partner or integrator is aligned to this.

6. **Don’t rule out your lifecycle.** Understand the relationship between CapEx and OpEx choices. Smart base build technology will open the door to smart facilities maintenance which can be far more cost effective and drive ROI and system optimisation at the most detailed level.

7. **Choose a strong smart partner.** Partners that share and manage risk and reward equally, have clear experience in delivering smart, promote leading alliances with other technology players, and work regularly with the contractual chain in partnerships, are key.

3. The Changing Role of Corporate Real Estate

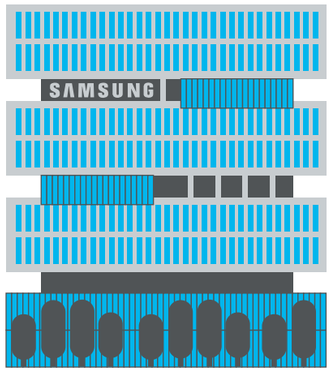
The way businesses use their office space has transformed over the last few years. Whereas in the past firms tended to look at their real estate as an intractable though necessary cost of doing business, they now appreciate how investments in their workplaces can support business aims and help them attract the best talent.

3.1 The Workplace of the Future

By providing employees with the right environment, tools and facilities to work more productively, a company's work environment can become a catalyst for innovation and growth. As more companies have realised this, they have started to put more thought into the design of their work environments. Traditional models of workplace design that attempt to pack as many desks into an office as possible are being superseded by more dynamic, agile models that focus on collaboration and knowledge sharing.

Activity-Based Working (ABW) is an approach to office design in which employees do not 'own' a desk, but make a transition between a number of different settings for work according to the tasks they are doing. As employees are not tied to any particular space in an ABW environment, there are more opportunities for staff to interact and mingle.

In some cases, entire buildings are even being designed to encourage chance encounters in the hope that this will lead to the development of new ideas. Samsung, for its North American HQ in San Jose, worked with architect, NBBJ, to create a workplace that would encourage collaboration between employees. NBBJ leveraged insights from psychology and neuroscience to model how different building designs would impact the



number of interactions employees would experience over a working day. The final design, a doughnut-shaped building with a glass façade, provides visibility between floors, allowing someone on one floor to see another colleague up to two floors away. Building 20, a recently opened facility on Facebook's Menlo Park campus in California, is the largest open plan office in the world, where employees can meet and interact with each other in one large contiguous space.

Increasingly, companies with multiple business units are co-locating them in fewer locations to encourage collaboration and break down silos. Specialist incubator and accelerator spaces, where employees can work on new projects and ideas alongside start-ups, partner companies and outside experts are also becoming more common.

3.1.1 Attracting the Best Talent

Firms are increasingly aware of the role their workplaces play in attracting and retaining the best people. According to data from Oxford Economics, the average cost of replacing an employee is around £30,000, with most of this due to lost output while the new employee is brought up to speed.[3] Taking into account the value of a leaving employee's knowledge, reputation and relationship with clients, some studies put the total cost of losing an employee at 1.5 times an annual salary.[4] Given that the cost of replacing staff heavily outweighs the cost of office space, many companies now view investments in the quality of their workplaces as a cost-effective way of retaining top talent.

The increasing interconnectedness between talent and workplace strategies has made companies more discerning about the locations they select. While low-cost, out-of-town office locations were once seen as an effective way of controlling real estate costs, they are now being shunned in favour of central business districts and urban talent hotspots that allow employers to tap into deeper pools of talent. Innovation districts, such as TechCity in London, 22@ in Barcelona and Silicon Alley in New York, are emerging in cities with a high concentration of young tech talent and a vibrant ecosystem of start-up businesses. Identifying and securing space in these sorts of locations is becoming vital to sourcing top talent.

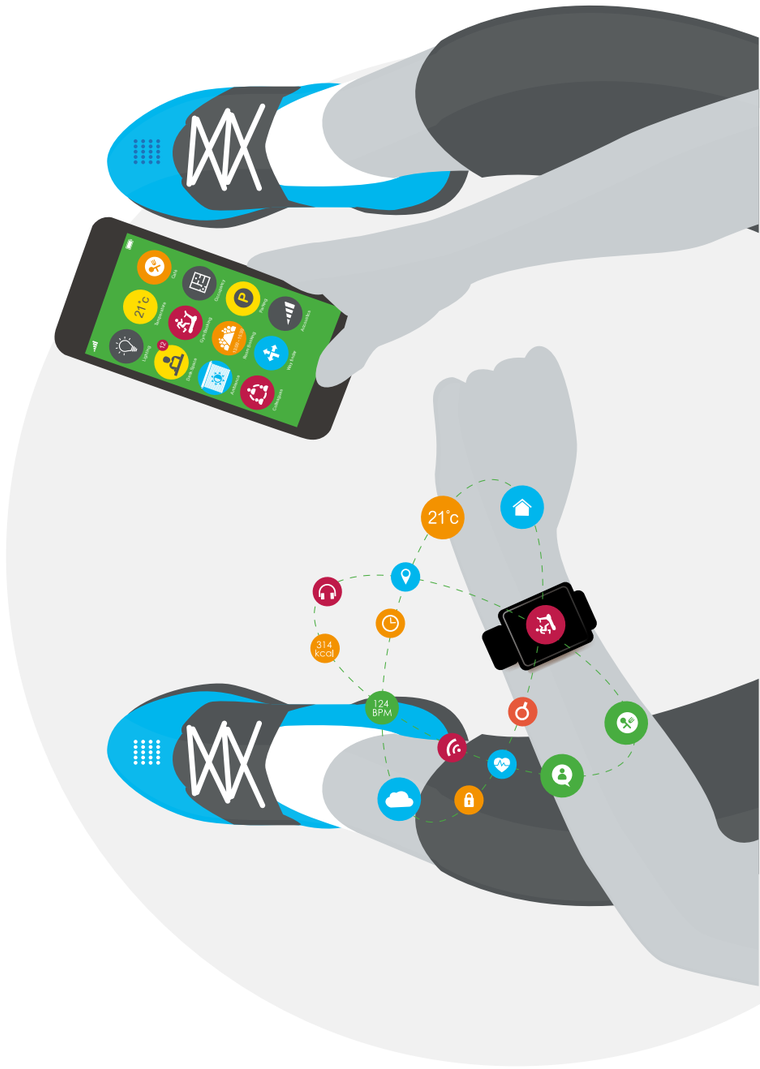
3.1.2 Wellness and Amenities

The competition for talent will become more intense as growth in the global labour market slows down. Between 2015 and 2030, the world's working age demographic will only grow at half the pace it did between 2000 and 2015.[5] In the UK and other developed economies, demand for talent will outstrip the growth in supply. This will not only drive the costs of talent up, but also lead companies to invest further in their workplaces so they can appeal to the best people.

In the technology sector, where talent shortages have already started to emerge, it is common to see workplaces kitted out with gyms, wellness and fitness centres, as well as games and music rooms. These types of spaces will become standard features of offices in other sectors as firms find themselves having to compete harder to source and retain top talent.

As the costs of talent increase, it is even more important that firms create environments that maximise the output of their staff. Wellness initiatives that reduce the amount of sick days employees take can significantly increase business performance. According to estimates by PwC, absenteeism through sickness costs UK businesses £29 billion per year.[6] Improving access to natural light, healthy food and an environment that promotes movement are playing a more significant role in workplace design due to their impact on absenteeism and staff turnover.

This increased focus on employee wellbeing has led to the development of a WELL Building Standard, a certification that rates buildings on seven different criteria related to health and wellbeing, including indoor air quality, access to natural light and how much a building's design encourages physical activity.[7] As wellness becomes more important to large occupiers, WELL and similar standards are likely to be incorporated into occupiers' selection criteria for new sites.



3.1.3 Intergenerational Working

Running parallel to slower growth in the global labour market will be profound changes to the composition of workforces. The share of older workers will increase significantly: by 2030, over 20% of the global workforce will be above the age of 55.[8] The number of those over the age of 65 will almost double in number over the next 20 years, with many of these over-65s continuing to participate in the workforce.[9] At the other end of the age scale, companies will continue to need to source younger employees with the technical and digital skills upon which they are increasingly reliant.

More generations will, therefore, soon be working side by side in the workplace than at any time in history. In this context, companies will not only need to create workplaces that can accommodate the physical and cognitive demands of a more varied workforce, but also invest in programmes that can keep older workers engaged for longer.

3.1.4 Agile Workplaces and Flexible Real Estate

As companies increase the share of their footprints in cities and invest more in creating spaces that inspire and energise their employees, they will have to find innovative ways to secure the most value from their workplaces. Models of workplace design based on non-assigned seating, such as ABW, allow companies to unlock significant space savings by freeing up under-occupied space while also providing office users a choice of settings from which to work. By overturning the idea that every employee 'owns' a desk, even when they are not in the office, firms are able to create highly efficient offices and better manage the costs of locating closer to the centre of cities.

Flexible locations, such as co-working spaces and serviced offices, are also becoming an increasingly important part of real estate strategies as companies look to scale their space commitments more dynamically, rather than locking themselves into long leases. WeWork, a co-working space provider with over 140 locations in 34 cities, is experiencing strong growth in demand from large corporates. Of the company's 80,000 members, 14% is employed by companies with more than 500 employees.

Companies are increasingly aware of the competitive advantages that can be secured from adopting a well-considered workplace and real estate strategy. This shift has changed the types of work environments firms create, and the kinds of buildings to which they opt to locate. The office was previously considered a dumb container for work, with people commuting to buildings where they spend most of their day behind a desk. Now these assumptions are being challenged. Buildings are becoming fluid workplaces, with agile work driving a more efficient use of space, higher productivity and better performance.

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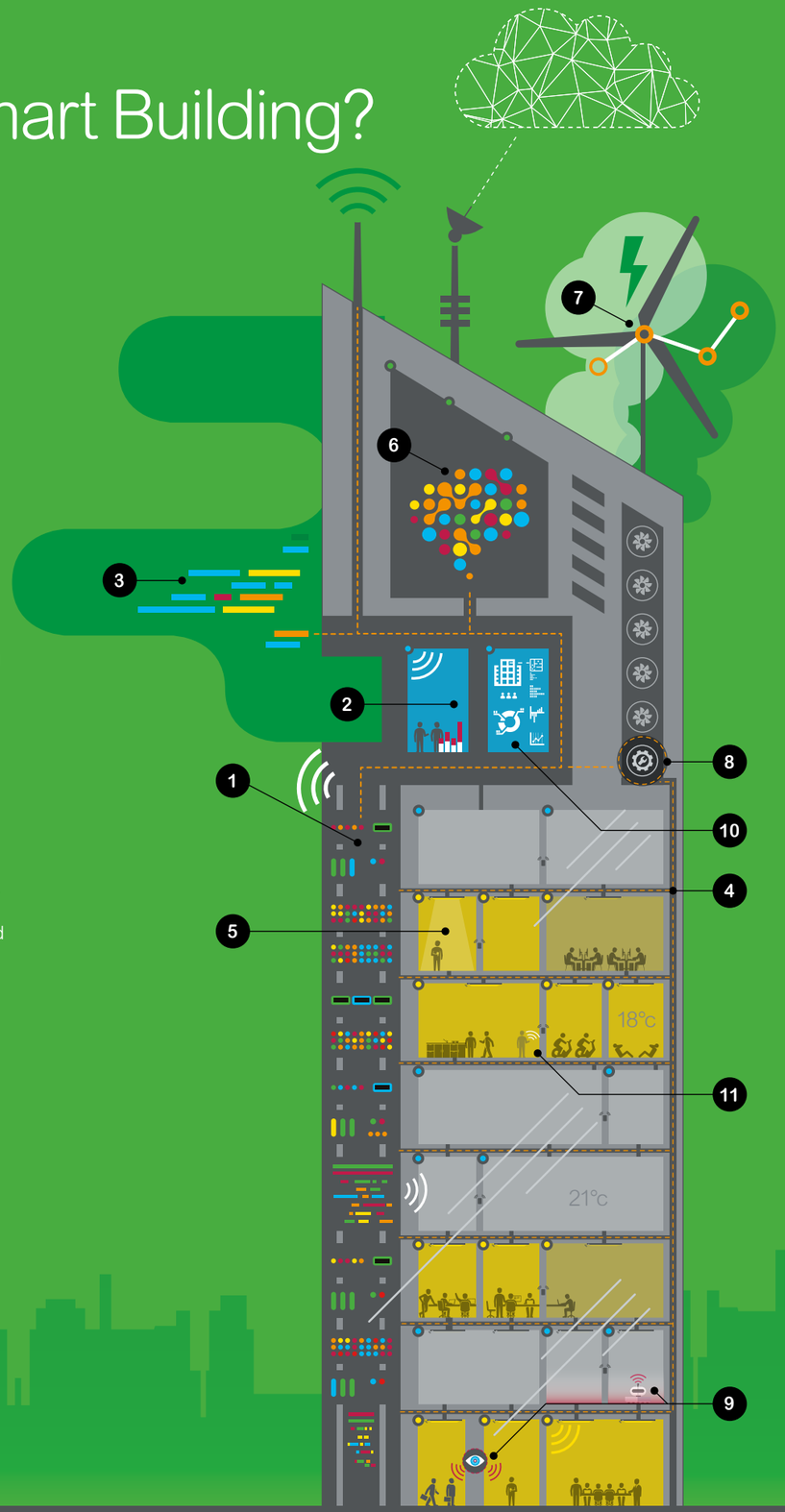
What's a Smart Building?



Smart Building Technologies

1. **The Internet of Things (IoT).** Thousands of sensors and other connected devices are embedded into the fabric of the building and exchanging information over the Internet.

2. **Predictive Analytics.** Using data from IoT devices, intelligent software forecasts how the building and its different systems will perform throughout their lifecycles.

3. **Open Standards Architecture.** All connected devices are speaking the same language, allowing them to 'talk' to each other and exchange information.

4. **Next Generation Power.** Building fixtures and fittings – such as the lighting, information screens and security cameras – are powered through Ethernet cables, allowing the building to monitor their performance.

5. **Smart Lighting.** Sensors embedded into the building's lights detect building users, who can adjust light levels via an app.

6. **Intelligent Building Management System (iBMS).** Functioning like the building's brain, the iBMS connects to all systems and devices and then takes informed decisions to improve the building's operations.

A Smart Asset

7. **Greener Buildings.** By carefully monitoring the usage of electricity and water, the building optimises the performance of its different systems and is highly energy efficient.

8. **Actionable Intelligence.** Intelligent software monitoring the performance of every building device detects faults, schedules maintenance and sustains optimal levels of performance.

9. **Smarter Security.** Technologies like robotics, video analytics and advanced access controls keep building users safe.

A Smart Workplace

10. **Data in the Workplace.** Data on the occupancy of different workspaces is captured and reported in real time, allowing the building's manager to identify spaces where an intervention is needed.

11. **Getting Smart About Wellness.** Sensors and wearables report on how the working environment is supporting the wellbeing and productivity of building users.

12. **Enhancing Employee Experience.** Using an app, building users are able to locate colleagues, control their environment and access building information.

4. The Smart Building

As the role of corporate real estate changes, the types of buildings that companies occupy are changing too. A greater appreciation of the contribution that the workplace can make to business success has made firms more discerning about the kinds of sites they select, and more mindful of the benefits that particular buildings offer.

Increasingly, occupiers are opting for buildings that provide more than the traditional lease, support talent attraction, offer excellent user experience and are simple and efficient to run.

Enter the smart building. Smart buildings are those in which different technology systems work together to reduce the costs of operations and enhance the experience of occupants. Smart buildings are more efficient, flexible and adaptive, making them more attractive and desirable places to work. In contrast to earlier notions of the 'intelligent building' that arose in the 1980s and focused on narrow concepts of operations, today's smart buildings deliver far greater benefits and a complete concept of operations for developers, landlords and occupiers of commercial real estate.

Rising interest in smart buildings from occupiers and developers of commercial real estate space has seen investment in the space reach $7.0 (£5.8) billion in 2015. By 2019, IDC forecasts that spending on smart buildings will exceed $17.4 (£14.4) billion.[10]

4.1 The Activ8 Model of Smart Buildings

In the interviews conducted as part of this research, there was no single or consistent definition or criteria as to what constitutes a smart building. However, there was a general recognition that assessments of a building's smartness should be done by examining the benefits it produces for its landlords and tenants.

This reports sets out a new, outcome-orientated model for assessing building intelligence. The Activ8 model details eight outcomes that developers and occupiers of commercial real estate can use to understand the benefits of smart buildings.

1. **Insightful.** Smart buildings provide actionable insights into how a building is operating. In a smart building, real-time data is reported and used to inform decisions on building operations. Portfolio managers can see their operations across the globe and compare performance, giving them actionable insight on how to drive efficiencies and improvements.

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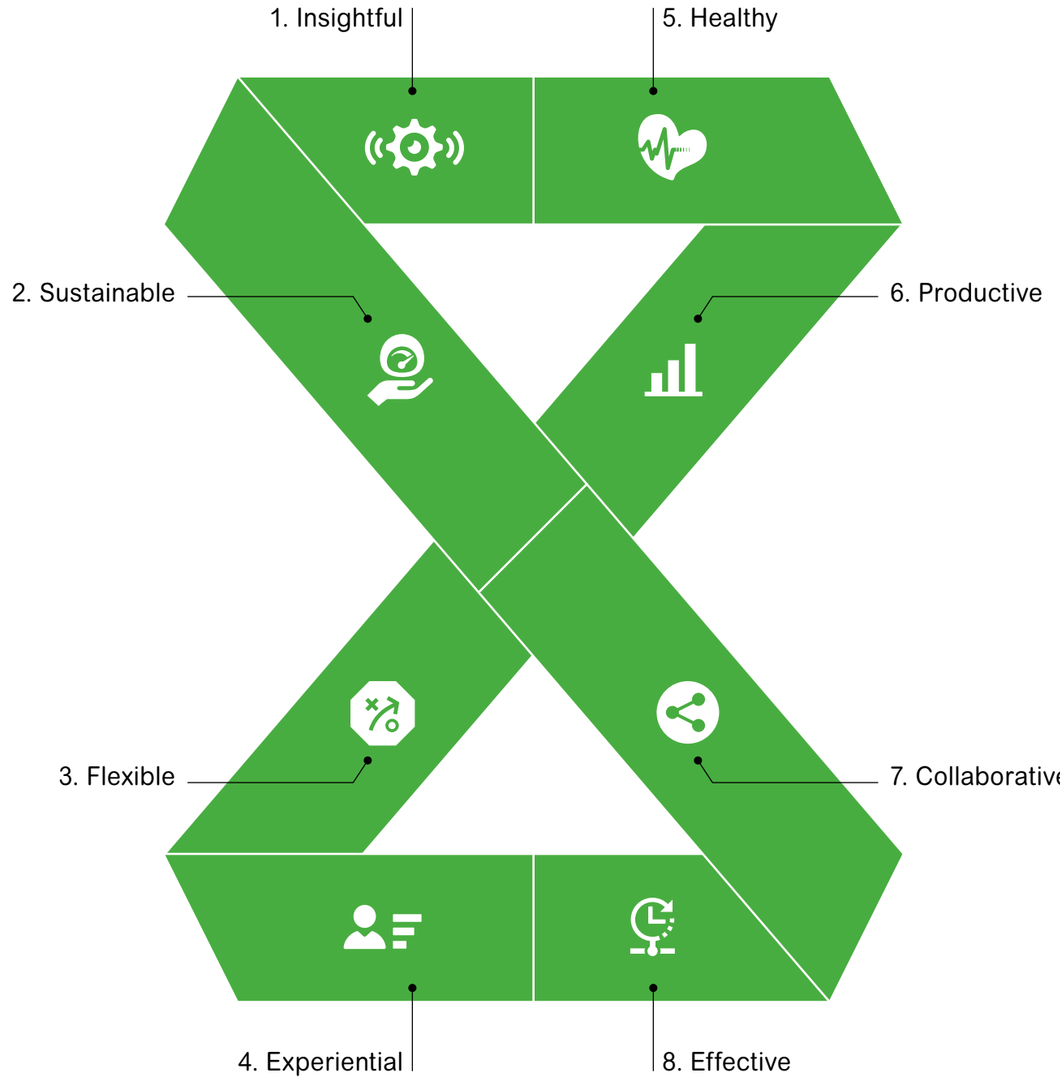


4.2 The Technological Enablers of Smart Buildings

Leveraging the latest technology is essential to realising the Activ8 benefits set out above. Emerging technologies, such as IoT, the next generation of intelligent Building Management Systems (iBMS) and new device protocols, are fundamentally changing how buildings are designed, built and operated.
As a technology consultant at a major engineering firm we spoke to as part of this research said, "the technology has overtaken our expectations – creating use cases for smart buildings that we hadn't previously imagined." Developers of real estate need to understand these technologies and what impact they will have on workplaces and buildings.

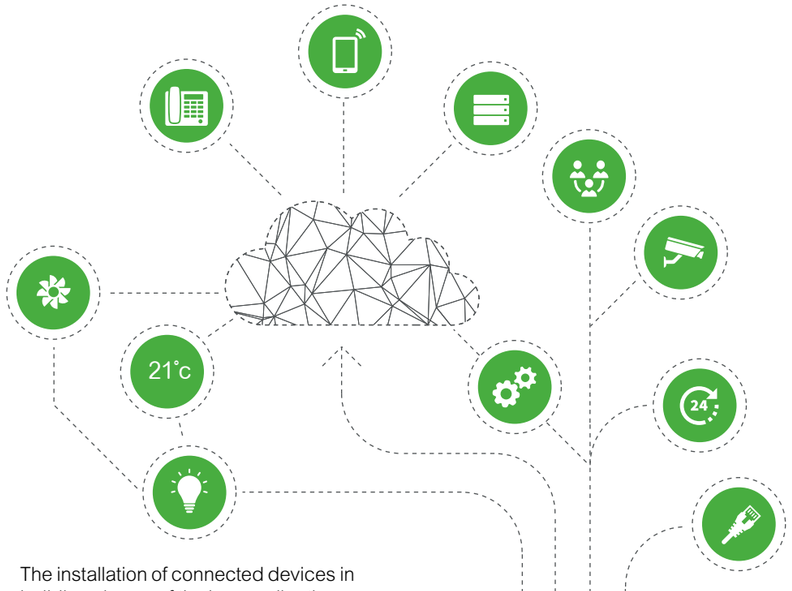
As a technology consultant at a major engineering firm we spoke to as part of this research said, "the technology has overtaken our expectations – creating use cases for smart buildings that we hadn't previously imagined."

4.2.1 The Internet of Things

IoT is the term used to describe a world in which devices are sensor-enabled, connected and able to share information about their current state and environment over the Internet. Sensors in cars, oil pipes, energy meters and wearable devices are all part of the expanding IoT ecosystem, which already connects billions of devices. Gartner estimates that by 2020, there will be 21 billion connected IoT devices – up from 900 million in 2009.[11]

IoT devices are being used by businesses to automate decision-making, increase efficiency and reduce operating costs. General Electric is using sensors to remotely monitor the performance of its jet engines allowing the firm to detect and deal with minor faults before they become major ones. In buildings, similar sensors for managing the performance of building systems are starting to be installed.

Combined with faster connectivity and advances in cloud computing, IoT has the potential to transform how businesses operate. By 2025, The McKinsey Global Institute forecasts that applications of IoT technologies will have an economic impact worth potentially $11 trillion to the global economy.[12]



The installation of connected devices in buildings is one of the key applications of IoT technology. Sensors that detect the presence of a person, light levels and humidity are already being installed in new developments. The Edge, a 40,000m2 office building in Amsterdam, is by many accounts the world's smartest building. 28,000 sensors track the movement of people through the building.[13] The office buildings of the near future will have hundreds of thousands of sensors installed, monitoring everything from the performance of individual light fittings to the health and wellbeing of employees.

4.2.1.1 The Internet of Things and Predictive Analytics

The real promise of IoT is that data captured by connected devices could be used to not just report the performance of various devices and information about their environment, but accurately forecast conditions into the future. Using data from sensors, for example, Schneider Electric's weather prediction software provides forecast data to the company's building management software, which then regulates building operations according to these forecasts.

Growing volumes of data from IoT sensors are expediting the development of new types of computing that will further transform building operations. Neural networks, for instance, are an emerging technology that use networks of interconnected processing units arranged to mimic the makeup of the human brain. Software running on a neural network can identify patterns and trends in large sets of historical data to learn to anticipate future events. By analysing data from building sensors, and combining this with external data, specialist neural software could predict how many building users will be present on a given day, and optimise services accordingly.

DeepMind, a company specialising in applications of neural networks that was acquired by Google in 2014, recently announced that it had cut the amount of electricity needed to cool Google's datacentres by 40% through delegating power management to its neural network.[14] Elsewhere, IBM Watson, IBM's cognitive artificial intelligence system, is now being used in the real estate industry to analyse vast sets of data to improve building operations. IBM has partnered with facilities services provider ISS to enable Watson to analyse data from millions of sensors installed in ISS-managed buildings. ISS will be able to use this data to optimise its services and understand how people are using its sites.[15]

One key application of neural networks is in natural language processing, enabling software to understand and respond to commands spoken in natural language. As this technology improves it will enable the rise of virtual concierges in buildings that users can interact with as they do today with Apple's Siri or Google's Assistant. These virtual concierges could be employed to help building users track down colleagues, book meeting rooms or control the working environment.

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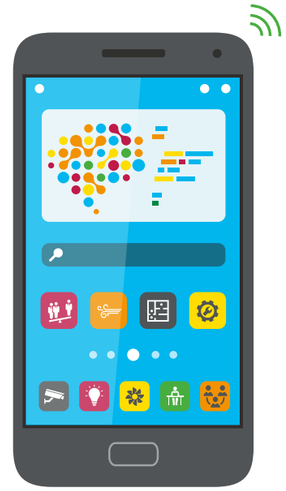

4.2.2 Intelligent Building Management Systems

Smart buildings are powered by the next generation of iBMS. In many of today's office buildings, existing BMS only support the operation of critical plant systems. All other systems, such as those controlling lighting, security and safety, are regulated by their own subset of controllers, supervisor panels and applications, each with their own support networks.

An iBMS, by contrast, connects to all building systems and services over an Internet Protocol (IP) network. This allows an iBMS to function like the operating system of a building, with data from individual systems and devices transmitted back to the iBMS. Using this data, an iBMS can make informed decisions and actions that improve the operation of the building. Data from occupancy sensors, for instance, could be fed into an iBMS to allow it to identify vacant parts of the building where ventilation and lighting systems can be turned off.

Operational efficiencies generated by the iBMS can significantly reduce running costs in areas such as utility consumption, management overhead and building adaptations. Furthermore, iBMS control software provides a simple, visual solution that brings all building systems together on one user interface, allowing building managers to monitor, adjust and reconfigure devices on lighting, security, HVAC, elevator, power and other building systems as needed.

4.2.3 Open Standards Architecture

One of the major inhibitors to the adoption of smart building technology has been the lack of interoperability between different building systems. Currently the makers of these building control systems have begun to adopt open protocols, such as LonWorks or ASHRAE's open-source BACnet, that allow all systems to communicate in a common protocol language. These common protocol languages define the arrangements under which devices and systems interact and communicate with each other.

Open protocol systems can be programmed by asset managers to pre-configure certain outcomes, ('if system x does this, then system y should take the output data and process it in this way'). For example, if a security system were to identify an intruder, the iBMS could be programmed to redirect cameras, engage control systems to prevent access to parts of the building and direct security personnel to the threat.

One key advantage of open standards architecture and open protocol systems is that they enable the integration of new devices, IoT sensors and systems, as long as these devices also communicate using an open protocol language. A building that adopts open architecture standards is, therefore, effectively 'future-proofed', as new functions and devices can be easily installed when enabling technologies are developed. Furthermore, open standards enable the use of powerful software solutions that can link data from multiple locations to drive efficiency across an entire real estate portfolio.

4.2.4 Next Generation Power Systems

New standards for cabling are being implemented in smart buildings to allow more effective information exchange. Power over Ethernet (PoE) is an electrical standard that can be used to transmit 60w of electrical power and data over Ethernet cabling. Lighting systems, desktop phones and CCTV cameras can all be powered using PoE. In the near future, it is possible that wall-mounted display screens and even personal devices could be powered by the technology.

One of the key advantages of PoE is that it enables the monitoring and control of power consumption at the device level, meaning that individual devices can be remotely controlled or shut down when not in use.

In lighting systems, PoE also enables the deployment of other communication and location-based technologies on top of lighting. Information transmitted over invisible light can be interpreted by a smartphone camera, pairing the device with an individual light fitting. This then enables building users to adjust lighting levels to their preferred level via an app. Alternatively, the location of a device could be monitor through its communication with multiple light fittings, giving building users access to services like wayfinding based on their location.

4.3 Smart Buildings – A Day in the Life

As new applications of smart building systems and IoT technologies are developed, the advantages that smart buildings offer over conventional ones are growing in number. Investing in smart building technologies offers a number of benefits for building users, occupiers and landlords.

Building Users. When users arrive at a smart building, facial recognition technology means they do not have to use entry cards to access the building. Security systems recognise them and open the access gates automatically. As they move through the building, temperature and lighting settings automatically adjust to their desired level. Services, such as booking a meeting space, ordering lunch or locating colleagues working in other parts of the building, are all available through a smartphone application. Through analysing corporate databases, the building also knows what employees are working on, alerting users that colleagues or specialists in their network are working nearby.

Heads of Real Estate. Real time data on building utilisation provides CRE professionals with detailed measures of how efficiently the space is being used. This data is then used by intelligent software to recommend design interventions that will make the space more efficient, such as resizing the meeting rooms according to the size of the meetings that are actually taking place. Wearable devices capture rich insights into who talks to whom, and what impact this is having on business performance. Data on the wellness and physical activity of employees captured from wearables and sensors in the office furniture provides a comprehensive measure of organisational health, helping to reduce the costs of sick days and absenteeism.

Building Owners. Data from the building allows building owners to compare the performance of their buildings against corporate objectives. Smart technologies that enable buildings to be net contributors of energy, rather than consumers, positively contribute to occupiers' sustainability goals. By providing real-time reports on occupancy, the building gives owners informed insight so they can adapt their strategy based on the evolution of the real estate requirements.

Building Management. Tactical and operational decisions on the operation of the building are taken by algorithms as part the iBMS, allowing the building manager to take a more hands-off approach and look after several sites remotely. By analysing data provided by individual building systems and sensors, the iBMS optimises the workings of the building to reduce operating expenditure, run more sustainably and enhance the experience of occupants. Advanced cause and effect modelling means the building can respond dynamically to changes in usage. The performance of every individual building device is carefully monitored and controlled by the iBMS, allowing it to identify any issues and automatically schedule maintenance when needed.

5. A Smart Asset

Smart buildings offer considerable advantages to real estate developers, landlords and tenants. Intelligent energy management solutions employed in smart buildings can enable them to be net suppliers of energy to national grids, rather than merely to consumers. Implementing these solutions will allow buildings to reach de-carbonisation targets and ensure that the supply of energy keeps pace with demand. Actionable intelligence provided by building systems means that a smart building's iBMS can detect malfunctioning equipment or wasteful practices, reducing running and maintenance costs. Smart security technologies, like facial recognition and video analytics, allow the building to identify users and keep occupants safe.

5.1 Greener Buildings

Smart buildings are highly energy efficient, using technology to carefully monitor and optimise the usage of electricity and water. In order to keep electricity grids functioning and achieve ambitious de-carbonisation targets set out by national governments, smart buildings will be vital.

Europe and North America are supported by an ageing national electricity infrastructure that requires significant investment to meet rising demand, putting pressure on utilities companies to eke out operational efficiencies or find better ways of supplying energy. Alongside this, legislative targets to reduce carbon emissions requiring electricity companies to source a specific portion of their energy sales from clean sources within a fixed time-frame have been adopted in at least 67 countries.[16] The European Union, for instance, has set a goal to generate 20% of energy from renewable sources by 2020.
Meeting these challenges will require the creation of a smart electricity grid that can use data on energy consumption to realise efficiencies and improve the reliability of supply. In a smart grid, connected energy meters, appliances and sensors are used to give utility companies data on energy usage habits. This data can then be used to balance power generation with energy usage and generate operational savings. GB Smart Grid estimates that £19 billion of savings could be achieved from upgrading the existing network to a smart grid in the UK alone.[17]

The smart grid, however, relies on smart buildings. Buildings account for around 40% of total energy consumption and 36% of overall carbon emissions.[18]
In the United States, commercial real estate consumes at least $179 billion of energy every year.[19] Without investments in improving the energy efficiency of buildings, achieving a more efficient, less carbon-dependent electricity infrastructure will be impossible. Developers of commercial real estate are finding themselves under

The European Union, for instance, has set a goal to generate 20% of energy from renewable sources by 2020.

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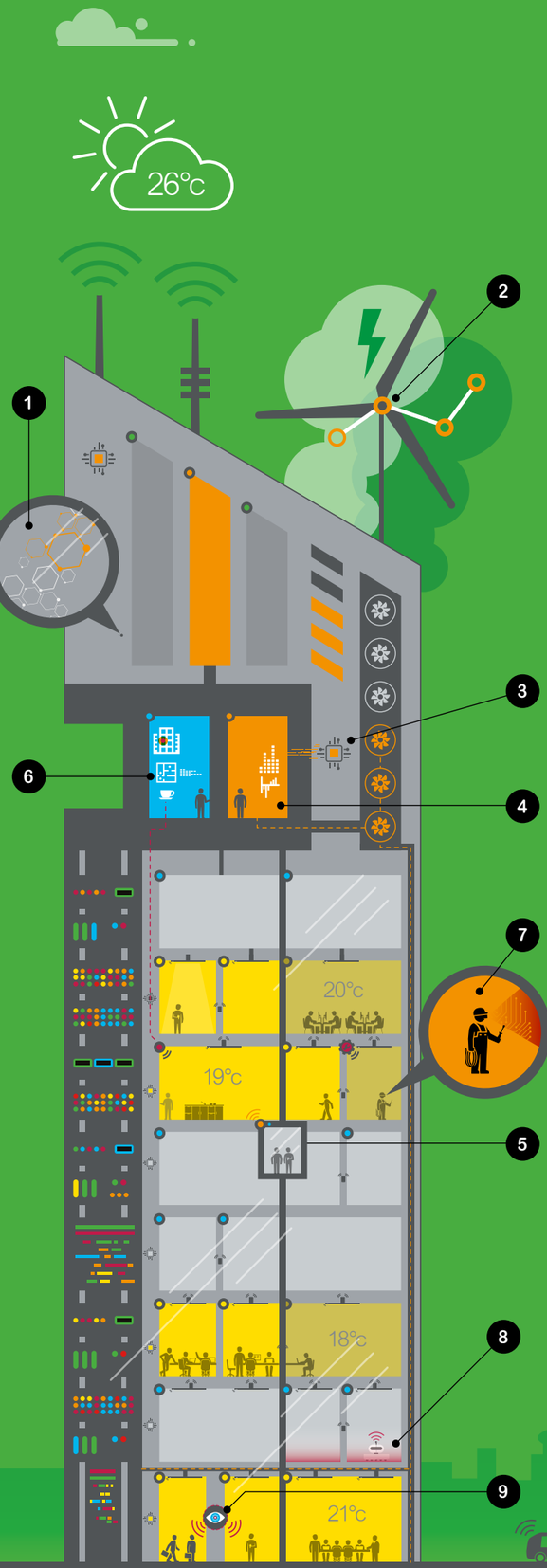
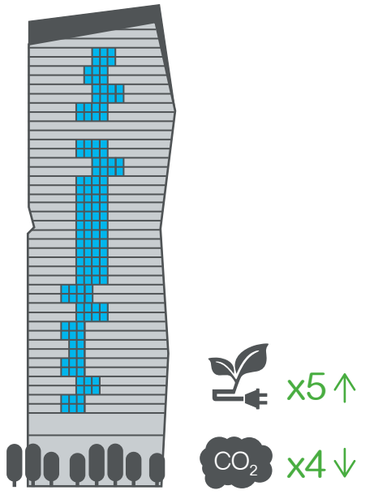


A Smart Asset

1. **Smart Materials.** Technologies like bio-reactive facades and nanotechnology make the building much stronger and energy efficient.
2. **Power Generation.** Onsite energy production makes the building a net contributor of energy to the national grid, rather than merely a consumer.
3. **Environmental Sensors.** Sensors measure levels of ambient light and adjust the building's lighting levels accordingly.
4. **Energy Management.** Software analyses and predicts the consumption and costs of energy, and then optimises the performance of the HVAC systems to increase efficiency.
5. **Connected Lifts.** Sensors measure the motor temperature, shaft alignment, cab speed and door functioning of the building's lifts, helping to identify when maintenance might be needed.
6. **Intelligent FM.** Sensors highlight to the building manager when bathrooms need cleaning, coffee machines need refilling, or lightbulbs need changing.
7. **Smart Servicing.** Service personnel use Augmented Reality (AR) to access information on faulty equipment concealed behind building fixtures.
8. **Robotics.** Robot security guards patrol the building at night to locate potential intruders.
9. **Facial Recognition.** Video analytics is used to identify individual building users and visitors, who then receive a personalised experience.



Primary energy consumption at Majunga Tower is less than 80kWh PE/M2/year, which is five times more efficient than other office blocks. The building's total carbon footprint is four times lower than the average for other nearby office buildings.

more scrutiny from governments to invest in energy-efficient buildings. New York, Boston, Philadelphia and other major American cities have established building energy benchmarks ordinances requiring thousands of commercial buildings to track and publically report their energy consumption. In the EU, Directive 2010/31 promotes the ultimate goal of ensuring that all new buildings are nearly zero-energy buildings by 2020, to produce almost as much energy onsite as they consume.

There are considerable gains to be achieved in terms of energy consumption in buildings through better management of how building systems are run and managed. Damper systems in buildings are designed to provide cool outside air, rather than relying on chillers or compressors. In many buildings it is common, however, for chillers and compressors to continue to operate even on cool days when outside air could be used, despite this being highly inefficient.

Furthermore, smart buildings that are highly energy efficient offer developers, landlords and tenants a number of other hard benefits. In a seminal study by the World Green Building Council, these buildings were found to command significant rent premiums and higher sale prices, had greatly reduced energy costs and contributed to better rates of staff retention for tenants.[20] Furthermore, by using energy more efficiently, smart buildings positively contribute to corporate social responsibility targets.

A number of exemplary, highly energy-efficient smart buildings have been completed in the last few years. Majunga Tower, a 70,000 sq.m. office tower is situated in the heart of the La Défense district of Paris. The building, owned by Unibail-Rodamco, has an iBMS which brings together the control and management of the building's energy distribution, HVAC, lighting and blinds to improve building performance. Primary energy consumption at Majunga Tower is less than 80kWh PE/M2/year, which is five times more efficient than other office blocks. The building's total carbon footprint is four times lower than the average for other nearby office buildings.[21]

Al Bahar Towers in Abu Dhabi also uses an iBMS to achieve high levels of energy efficiency, despite being situated in a climate where temperatures regularly exceed 100 degrees Fahrenheit. The building features an intelligent façade that reacts to the movement of the sun to limit solar gain and glare, helping to reduce the use of the HVAC system.[22] The head office of the Cooperative Group is situated in One Angel Square in Manchester. The 50,000 sq.m. office building is one of Europe's most sustainable office buildings, rated 'Outstanding' on the Building Research Establishment Environmental Assessment Methodology (BREEAM) scale. The building has its own source of heat and power generation onsite, allowing it to give back surplus energy to the UK's electricity grid.[23]

It is not just new developments like these that can employ smart building technology to improve energy efficiency. IoT sensors can be employed in existing sites to significantly lower operating expenses and energy consumption. American telecoms firm AT&T, for instance, retrofitted 240 of its offices, garages and call centres with sensors built by Enlightened, a California-based provider of lighting and energy management systems. The sensors optimise lighting according to the levels of ambient light to save energy. AT&T now saves $8 million on its energy bill and expects to save a further $200 million over the next ten years as the sensors are introduced in more facilities.[24]

Analytics software can also be used to monitor and control energy consumption. Building Optimisation, a solution from Schneider Electric, interacts with building control systems to analyse and predict the consumption and costs of energy, as well as the comfort needs of the building occupants. Data from weather reports, rate tariffs and demand response events can be included to further optimise the performance of HVAC systems automatically.[25]

New types of building façades and materials allow further energy efficiencies to be achieved. BIQ House in Hamburg has a bio-reactive façade that generates hot water using glass panels filled with microalgae. Developments in nanotechnology could impact the properties of building materials by allowing modification at the molecular level. Types of concrete have already been developed using this method that are many times lighter and stronger than traditional concrete. In the future, the same technique may be able to make building materials more thermally efficient.

Case Study: Majunga Tower

Situated in La Défense, a business district on the outskirts of Paris, Majunga Tower is a 195m office building owned by Unibail-Rodamco. The design of the building helps to set it apart from the monolithic design of other office towers – its façade comprises three vertical strips that offer outdoor spaces on every floor and 2000m2 of terraces and gardens around the base of the building.

Since its inception, Majunga Tower has aimed to enable its occupants to reduce energy consumption and the size of their carbon footprint. A single network links the building's energy distribution, HVAC, lighting and blind controls, allowing the monitoring and optimisation of energy consumption. Primary energy consumption at Majunga Tower is less than 80kWh PE/M2/year, five times more efficient than a typical office block. Its carbon footprint is also four times lower than the average for a building on the outskirts of Paris.

Majunga Tower is also equipped with Workplace Efficiency, a Schneider Electric system that measures the occupancy of spaces to make work environments more comfortable and productive. The system connects to a network of radio frequency sensors that captures data on how efficiently spaces are being used. This data is fed into a smartphone app that allows building users to view which workstations and meeting rooms are available. Building users can use the app to control the lighting, temperature and blinds, thereby adjusting the work environment to their own comfort preference.

5.2 Actionable Intelligence

Smart buildings provide huge volumes of data on the performance of building systems and services. Using specialist software, analysis of this data makes them easier to manage and maintain.

In a smart building, building managers are provided with control software that gives them a simple, visual solution to manage all systems on one interface. This software can be accessed remotely, allowing portfolio owners to manage multiple properties from a single location.

Continual monitoring of all building systems ensures that high levels of performance can be maintained across a building's life cycle. In any building, the operation of one building system inevitably has consequences for another. One component or system that deviates from optimal performance may cause other elements to overcompensate or begin to underperform. Consequently, it is common for a routine commissioning to take place every five years so that systems can be recalibrated and returned to optimal performance. In a smart building, however, the continual monitoring of operations allows the building to sustain high levels of performance at all times.

EcoStruxure™ Building Operation, a Schneider Electric solution, is a software platform that integrates the data collected from multiple building systems to report a smart building's energy, process and resource performance.[26] Schneider Electric's Building Analytics solution monitors the workings of building systems and components and uses artificial intelligence to detect any faults, potential inefficiencies or energy-saving opportunities. At one facility, the software detected that a preheating coil and a cooling coil were operating simultaneously. This insight enabled the service technician to pinpoint and repair a leaking chilled water value, leading to a cost avoidance of €46,000 (£40,000) per year and a positive return on investment within one month.[27]

The bathrooms at Dubai Airport have been fitted with sensors that report when bathrooms are experiencing high volumes of traffic and need cleaning. This enables better scheduling of cleaning rotas, helping to save time, supplies, staff and energy.

IoT devices can further enable the detection of system faults and the avoidance of costly breakdowns. To better schedule maintenance and repairs, lift-maker ThyssenKrupp Elevators partnered with CGI and Microsoft to deploy an IoT solution which monitors the performance of the company's lifts. Embedded sensors measuring everything from motor temperature to shaft alignment, cab speed and door function have now been installed. This data is fed into machine learning algorithms, which can predict when maintenance will be required. The system has helped ThyssenKrupp Elevators, which runs 1.1 million lifts worldwide, and its customers reduce expenditure on repairs and servicing.[28]

Efficiencies in the management and operation of buildings can be achieved through the deployment of smart sensors. The bathrooms at Dubai Airport have been fitted with sensors that report when bathrooms are experiencing high volumes of traffic and need cleaning. This enables better scheduling of cleaning rotas, helping to save time, supplies, staff and energy.[29]

For servicing technicians, methods for overlaying digital displays of smart building components onto the real world using Augmented Reality (AR) can be used to aid maintenance and identify faulty equipment. When combined with Building Information Modelling (BIM), the standard for designing buildings using detailed, digital representations of their component parts, AR displays allow technicians to access detailed models of components via a tablet or pair of smart glasses. Inspections or quality controls can use BIM AR to check the performance of components concealed behind other fixtures, further assisting facilities operations and smart maintenance.

5.3 Smarter Security

Late night visitors to The Edge in Amsterdam may encounter a security guard shuffling along the building's corridors. But unlike security personnel in other buildings, the ones at The Edge are not human, they are knee-high robots that come out at night to autonomously patrol the office building. These machines can identify and challenge potential intruders, and are one example of the security benefits that smart buildings can offer to landlords and tenants.

In addition to robotics, a number of other advanced security systems are arriving on the market that can be easily implemented in a smart building. Smart cards that use Radio-Frequency Identification (RFID) technology, for instance, can be used to capture the location and movements of individual building users. Near Field Communication (NFC) technology (used in contactless payment apps like Apple Pay) can be used to allow building users to enter the building using their smartphones.

Facial recognition technology, an area that has advanced considerably in recent years, can be used to identify banned persons or record exactly who is in the building at a given point in time. It can also be employed to soften the visitor arrival and check-in process. The reception staff in a smart building could be alerted to returning guests and important persons, providing personal details to a reception's display screen and notifying their host of the guest's arrival as they approach the building.

Case Study: Le Hive

Le Hive is the international headquarters of Schneider Electric. Located 10km west of Paris, the 35,000m2 building is home to 1,800 employees spread across seven floors. Le Hive, short for Hall de l'Innovation et Vitrine de l'Energie, is a showcase for Schneider Electric's smart building technology.

All building systems at Le Hive are integrated into the same system architecture, which means they can all be monitored and controlled by the iBMS. The efficient running of building systems ensures that Le Hive is one of the world's most energy-efficient buildings – its average energy consumption per m2 is 78kWh PE/M2/year, a 47% reduction from when the building was first occupied. Le Hive was also the world's first building to be rated 'Outstanding' by BREEAM.

Critical to the success of Le Hive is the optimisation of the building's occupancy rate and the surface area rented out. Schneider's Workplace Efficiency solution, which measures the occupancy of the building using RFID sensors installed in the holders of building users' identification badges, is used to report the occupancy of the building in real time. Schneider Electric uses this data to understand the surface area of Le Hive that is actually used and assess the difference between the predicted occupancy and actual use.

Smart buildings can also leverage video analytics software to analyse security surveillance data and flag up any potential incidents to security personnel in real time. Sophisticated video analytics solution can detect unauthorised access to a prohibited area, abandoned baggage that may require investigation, or a person who is injured and requires help. In buildings with large numbers of surveillance streams, it is impossible for security personnel to monitor and detect all incoming security issues. Intelligent video analytics solutions enable developers of commercial real estate to ensure the security of their buildings.

Security is an increasingly important topic for businesses, which are more aware than ever of the threat of industrial espionage and information theft. Developers who can offer prospective tenants comprehensive physical security through investing in smart security solutions can make their spaces more desirable and command considerable rental premiums.

6. A Smart Workplace

Operational gains are only part of what makes a smart building attractive for potential tenants. There are considerable strategic advantages to working in a smart building, including better business performance, improved workforce wellbeing and a better working experience for individual employees. As IoT and sensor technologies develop, businesses are increasingly able to link the performance of their real estate more closely with business outcomes.

6.1 Data in the Workplace

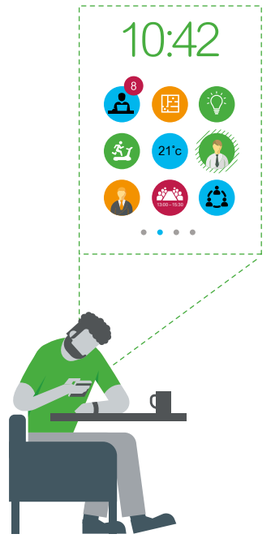
Rising real estate costs have led companies to seek as much value from their office space as possible. Activity Based Working and other agile models of workplace design in which employees share workspaces have allowed companies to unlock significant space savings without compromising the quality of their work environments.

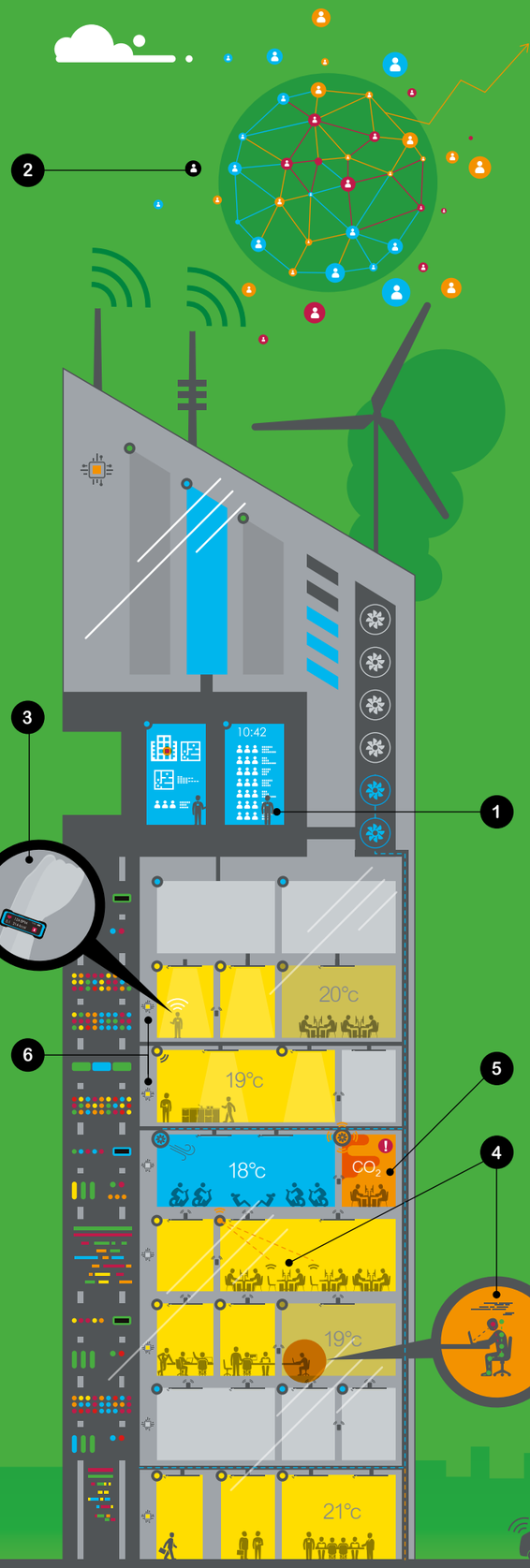
To truly use their offices efficiently, however, companies need to understand where space is under-utilised and what this means for real estate requirements in the future. Traditionally, companies have gathered this data as they approach a lease expiry or relocation exercise. Now, smart building technologies are enabling companies to capture data on the occupancy of their locations in real time and scale their commitments more dynamically.

Sensors that gauge how effectively companies are using their space are becoming increasingly widespread in the workplace. Condeco, a company that makes meeting-room booking software, has launched a suite of sensors for measuring the occupancy of desks and meeting spaces. Jooxter, a French start-up company, has developed a Bluetooth Low Energy (BLE) sensor that monitors the movement of staff around a workplace via a smartphone application.[30] Similar BLE technologies can provide a number of location-based services, such as tracking arrival and building entry.

Now, smart building technologies are enabling companies to capture data on the occupancy of their locations in real time and scale their commitments more dynamically.

Sophisticated utilisation sensors can even capture data on office usage and interact with smart building systems to optimise space performance. Workplace Efficiency (WPE) is a solution developed by Schneider Eclectic that monitors building occupancy to support the effective use of ABW environments. The solution uses a network of connected sensors and anonymous RFID tags inserted into the badge holders of building users. These tags transmit information to the sensors, allowing the real-time usage of different spaces to be reported and visualised. The iBMS in a smart building is able to use this data to optimise lighting and temperature levels according to the number of people in a space or the preferences of individual building users.





A Smart Workplace

1. **Real Time Occupancy.** Sensors and wearables are used to measure the occupancy of workstations in real time, and observe the movement of people across space.
2. **Sociometrics.** Rich data about how people interact, who they work with and what they're working on reveal how the building is driving business success.
3. **Fitness Tracking.** Wearable fitness trackers show how healthy the organisation is.
4. **Connected Furniture.** Sensors in seating coach building users on their sitting habits and posture to prevent them developing musculoskeletal problems.
5. **Air Quality.** Levels of CO_2 are constantly measured, with the HVAC systems responding to levels that might impact building users' productivity or concentration.
6. **Lighting and Heating.** Temperature and light levels of the building automatically adapt to the individual preferences of users.
7. **App-enabled.** Building users are able to identify spaces to work, reserve meeting spaces and even locate colleagues via a smartphone application.

Techniques for correlating the interactions that take place in an office with the development of new products and ideas are a fast-growing area of scientific research.

The next generation of workplace sensors does not just measure the use of physical space, but can link it to business performance. Techniques for correlating the interactions that take place in an office with the development of new products and ideas are a fast-growing area of scientific research. Alex 'Sandy' Pentland at MIT has pioneered 'social physics', the practise of using vast sets of data captured from smartphone app and wearables to gauge how people interact and share ideas. Sociometric badges, a wearable badge developed at MIT, can record where an employee goes in an office, who they interact with and the tone and nature of these interactions.

Data captured from sociometric badges have allowed Pentland and his colleagues to show that interactions taking place in an office can explain business successes. In a study with a pharmaceuticals company, data from sociometric badges identified a positive correlation between cross-team interactions and higher sales volumes. The company then used this data to justify installing a large canteen facility and replace its existing coffee points with bigger units shared between more employees. Following the redesign, sales rose by $200 million dollars more than proving the business case for the upgrades to its office.[31]

At an IT company that sold bespoke server configurations to enterprise clients, data captured by sociometric badges was able to show that the performance of the firm's engineers was heavily influenced by the amount of time they spent interacting with one of four experts, who spent much of their time advising colleagues. This data helped the company understand the potential risks that could arise from one of these experts leaving the business.[32]

When these sorts of wearable technologies become suitable for ongoing deployments, it will change the way workplaces are designed. Heads of real estate will be able to correlate the interactions and activities that take place within their workplaces with strategic metrics, such as bottom line, number of new product launches or staff turnover.

Business outcomes could even be shaped by machine learning algorithms leveraging sociometric data. Data could be analysed to enable the building to identify two employees with similar professional interests or project histories, and facilitate an interaction between them. Design interventions could be recommended that would maximise the productivity of staff, based on rich insights gathered on their working habits. A smart building can then have a significant and measurable impact on business performance.

6.2 Getting Smart about Wellness

The impact of workplace design on the physical and mental wellbeing of employees is increasingly well understood. With salaries and benefits comprising around 90% of the operating costs of any typical large business, even modest increases in productivity arising from better working environments can have a significant impact on the bottom line.

Recent scientific research has been able to demonstrate that higher levels of physical activity can lead to more effective employees. Consequently, companies are starting to weigh up how their workplaces can encourage movement and combat sedentary lifestyles. Gartner estimates that 10,000 companies gave fitness trackers to their staff in 2014.[33] Jawbone, a maker of wearable fitness devices, has launched Up for Groups, a corporate wellness programme that gives firms data on the physical activity of different teams.[34] One major accounting firm has trialled giving its employees fitness bands that capture data on their physical activity, which they can then use to better understand their health habits.

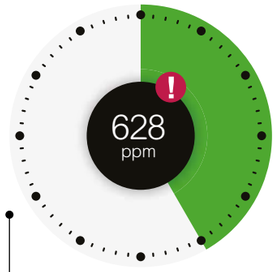
Sensors are also coming to the market which help prevent back, neck and muscle pain, a major cause of absenteeism. According to the UK's Office for National Statistics, 30 million work days were lost in 2013 due to musculoskeletal problems.[35] Steelcase, a manufacturer of office furniture, unveiled a version of its Gesture chair in 2015 which monitors the posture and sitting position of users.

The quality of indoor air can also impact the productivity and wellbeing of building users. High levels of CO2 have been shown to impact feelings of tiredness and decision-making in a number of studies. Research has found that CO2 at levels as low as 600 parts per million (ppm) can have a significantly detrimental impact on individual performance, despite this figure being well below the normally accepted level of 1000 ppm.[36] Smart building sensors, such as those deployed at The Edge, can detect and measure levels of CO2, allowing the iBMS to adjust HVAC settings accordingly.

Smart building systems and sensors, which both capture the data and optimise the environment, allow companies to realise productivity gains through enhancing the wellness of employees.

Natural ventilation or mixed-mode conditioning has also been shown to bring a number of benefits. Research compiled by Carnegie Mellon identified significant savings on health costs, HVAC energy and productivity gains from natural or mixed ventilation. Another study found that short-term sick leave in buildings ventilated by an outdoor air supply rate of 24 litres per second (l/s) was 35% lower than in buildings with rates of 12 l/s. The value of the increased ventilation was estimated to be worth $400 per employee per year.[37]

What gets measured gets managed. Through monitoring the quality of the work environment and the activity of those who use it, companies can better understand how their workspace is helping (or harming) the wellbeing of their people. Smart building systems and sensors, which both capture the data and optimise the environment, allow companies to realise productivity gains through enhancing the wellness of employees.



The quality of indoor air can also impact the productivity and wellbeing of building users. High levels of CO2 have been shown to impact feelings of tiredness and decision-making in a number of studies.

6.3 Enhancing Employee Experience

The quality of a company's workplace is increasingly key in its ability to attract and retain the best people. As the competition for talent intensifies, it is imperative that companies provide high quality work environments that match the workstyles and expectations of potential recruits.

Smart buildings can positively contribute to talent strategies by enhancing the experience of employees. According to the CEO of a large property management company interviewed as part of this research, smart buildings offer the possibility of "markets of one in the workplace" with individual users able to adjust the lighting and temperature settings of their workspace according to their individual preferences. Buildings users at Majunga Tower, for instance, can control lighting, temperature and blinds from a smartphone app. Preferences follow a user around the building, optimising the environment as they go from one space to another. As the workforce ages, workplaces will have to accommodate comfort needs that differ significantly across different generations. Letting users set their own light and temperature preferences will, therefore, be essential.

Workplace apps will develop as the key interface between building users and smart buildings in which they work, allowing them to access a range of services via a single app. Tracking the usage of space in real time allows the building to identify available spaces to work and provide information to employees allowing them to use an app to find a desk or book a meeting room. At The Edge, building users can find working spaces, reserve meeting spaces and even locate their colleagues using the building's app. Other services, such as ordering food and beverages, checking the availability of car parking spaces, and scheduling classes in the building's gym, could also be available via an app, with all the relevant data being provided by a smart building's iBMS.

Employees who experience these sorts of benefits at one building will start to expect them at others. Adoption by some companies of technology to improve the experience of employees will trigger a domino effect that will ultimately lead to more widespread implementation. Smart buildings that allow environmental control and enable intelligent workplace apps will then become a key part of workplace and real estate strategies.

Case Study: The Edge

Completed in May 2015, The Edge is a 40,000m2 multi-tenant, Class A office building conceived by OVG Real Estate, a Dutch property developer, in partnership with professional services firm Deloitte, who are the building's primary occupant. The Edge was designed according the principles of agile working, with smart building technologies employed to create a highly efficient, flexible and productive workspace.

There are 28,000 sensors at The Edge, measuring everything from the occupancy of workstations to the cleanliness of bathrooms. Super-efficient LED panels built by Philips, for instance, are powered using Ethernet cables and packed with sensors that measure motion, light, temperature, humidity, and air quality. SmartStruxure, an iBMS built by Schneider Electric, analyses the data produced by the building's sensors, actuators and valves to optimise the operation of the building.

Through its use of technology, The Edge is among the world's most energy-efficient buildings. The building's entire south façade is fitted with solar panels, allowing the building to produce more energy than it consumes. A subterranean aquifer dug 130m beneath the building stores warm water in the summer and releases it when it is needed in the winter. Over 180 energy meters have been installed around The Edge, with all the data fed back to the building management system. These innovations secured the highest score ever awarded by the Building Research Establishment (BRE), 98.36%, and a BREEAM certification of 'Outstanding'.

Smart sensors are also used in The Edge to improve the day-to-day running of the building. Hand dryers in the bathroom have embedded sensors that capture data on usage, alerting facilities staff when cleaning is required. Coffee machines can even report when they need to be refilled. Easy-to-use dashboards allow the building's facilities managers to review and analyse all the data, and make information-based decisions to enhance building operations and improve the experience of occupants.

Employees based at The Edge can interact with building systems via a smartphone app, which they can use to find a space to work or track down a colleague. The app knows the lighting and temperature preferences of individual building users, allowing it to tweak the environment accordingly. For those who drive to work, entrance to the employee garage is automated: when they arrive, a camera takes a photo of their licence plate, matches it to their employment record, and raises the entrance gate.

The Edge has received global recognition as one of the world's smartest buildings, and OGV Real Estate intends to incorporate many of its features into subsequent developments.

7. From Smart Buildings to Smart Cities

The Jurong Lake District in Singapore is a testbed for all sorts of technologies that could change the way people live and work in cities. Over 1,000 IoT sensors have been deployed in the precinct to monitor everything from the flow of traffic to the operation of streetlights.

New data hubs, called Above Ground Boxes, provide power and fibre-connectivity at the street level, and connects all the sensors. A system devised by local university Temasek Polytechnic and ZWEEC Analytics autonomously measures the cleanliness of public areas using advanced video analytics and smart bins. Driverless buggies built in partnership by the National University of Singapore and the Singapore-MIT Alliance for Research and Technology (SMART) ferry people around.[38]

The experiments taking place in Singapore and other similar deployments of IoT and intelligent technologies, are part of a wider effort to create smart cities that can use data to generate and realise efficiencies in the running of urban infrastructure or improve the wellbeing of the urban population.

According to forecasts by the United Nations, the number of people living in cities is set to grow by 380 million people by 2020. In the developing countries of Asia and Africa, where the majority of urban population growth will take place, creating smart cities is seen as key to meeting the challenges presented by fast-expanding cities. China alone accounts for 40% of global spending on smart cities, with projections showing that it will spend $16 billion on smart cities programmes by 2024. The government of India has announced plans to develop 100 smart cities and intends to spend $7.3 billion on its smart cities programme within the next three years. Globally, Frost and Sullivan estimate that the smart city space will be worth $1.565 trillion by 2020.[39]

7.1 Smart Buildings as the Driver of Smart Cities

Without smart buildings, however, cities cannot become smart. The impact of many smart cities programmes has ultimately been stifled due to overlooking the role of buildings as the enabler of smart cities. It is impossible, for instance, for cities to use energy more efficiently if buildings have not been re-engineering to support this objective. Most smart city initiatives have also been top-down programmes led by municipal governments or local councils. However, to create a truly smart city, a broad range of stakeholders has to be aligned, including owners and developers of commercial real estate.

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Developers, particularly those of large estates, can play a leading role in the creation of smart cities. Songdo is a smart city initiative being constructed on 600 hectares of reclaimed land located 35 miles west of Seoul in South Korea. Real estate developer, Gale International, is building the Songdo International Business Park. Fibre connections were laid prior to construction to future-proof the site and will enable a range of services to prospective tenants. Gale has partnered with Cisco to spin out u-Life Solutions, which will provide IoT backbone and iBMS for Songdo's buildings. The 14,000 residential units on the site have been installed with a bespoke telepresence system that residents can use to interact with city administrators. Gale is also working with a Korean start-up incubator to pilot new smart services around the development.[40]

The creation of smart cities will begin with clusters of smart buildings that can exchange information between each other. Smart cities will then be able to link different buildings and clusters, and optimise the delivery of city services accordingly.

Real estate developers should not wait for governments to take the lead in building smart cities: through creating smart buildings, they have the opportunity to redevelop the urban landscape on their own.

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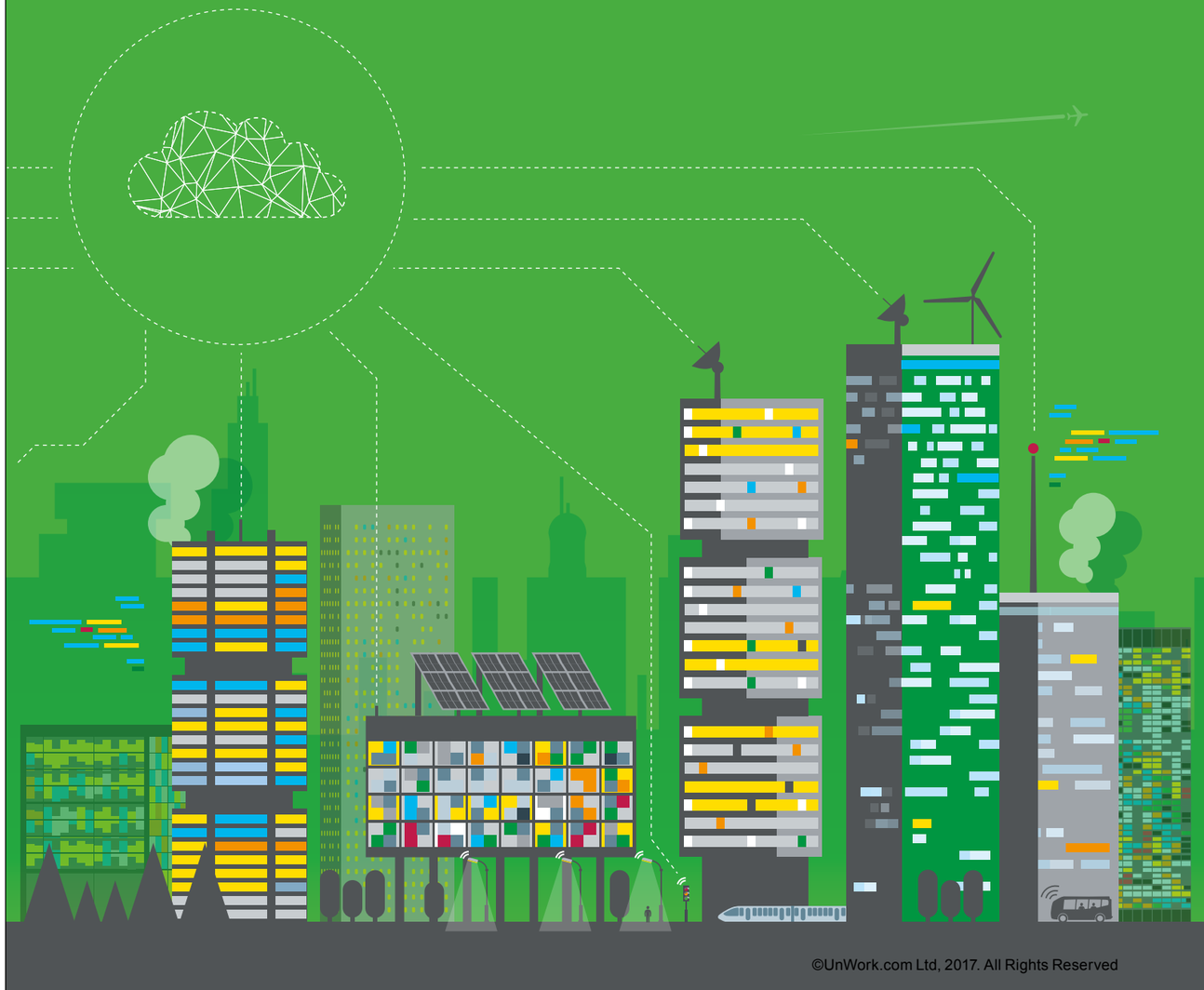


8. Creating a Smart Building

Smart buildings can only deliver the benefits set out in this report when they are specified, procured and commissioned properly. Developers and investors who overlook critical requirements in the design and construction of their buildings risk being left with buildings that do not perform as intended or an asset that exposes them and their tenants to grave security risks.

Companies who use smart technologies in their workplace need to understand the implications of using data to measure the performance of their employees, and put in place practices that make it clear how this data will be used.

8.1 Procurement

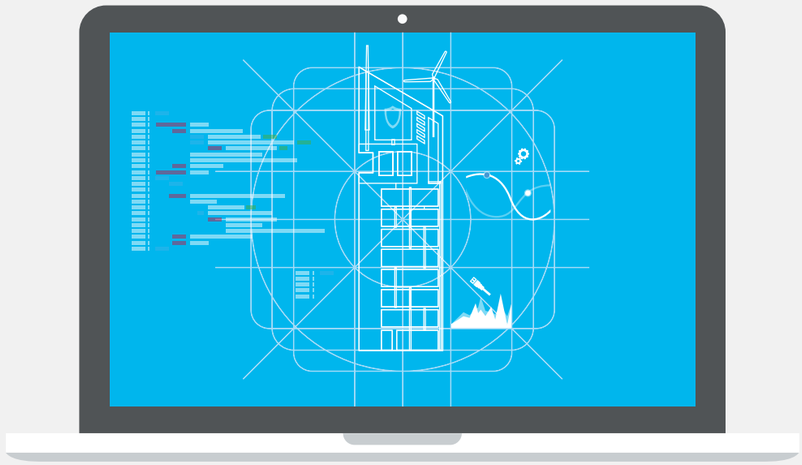
Throughout the interviews that were undertaken as part of this research, there was a recognition that a new approach to building procurement was needed to realise the benefits that smart buildings offer. A common complaint among the developers we spoke to was that reliance on the traditional procurement route led to smart building systems being de-specified through value engineering and the delivery of buildings that failed to deliver on their performance goals. To create a truly smart building, developers of real estate need to first articulate their concept of operations and articulate what outcomes they intend to achieve from their building. This needs to be stated in the form of a clear vision that all stakeholders can align to and are incentivised to achieve. The Activ8 outcomes identified in this report provide a robust starting point for thinking about how a smart building can deliver significant value for both developers and consumers of commercial real estate.

Smart building specialists need to be engaged during the strategic development stage. The reason that many buildings fail to meet developers' expectations or deliver on the promise of smart buildings is that construction often proceeds to near completion before considerable thought is given to building intelligence. Certain fundamental requirements must be incorporated early in the planning process and a smart building strategy and brief need to be established. This includes open systems architecture, open protocol product selection and IP compliance for the purpose of data transfer.

Planned integration of enterprise business services and procurement of building technologies must be undertaken in accordance with clearly-defined performance goals. Deviation from the requirements should not be tolerated. A common point of failure in developing a smart building occurs when value engineering results in fundamental principles being compromised. This can have disastrous effects on both the operation of the building and its lifecycle costs.

It is often assumed that constructing and commissioning a smart building is inherently more costly than a conventional building due to the added complexities presented by emerging technologies and their impact on building systems. In fact, there is the potential for capital expenditure to be reduced or cut by integrating building systems. The use of a common infrastructure enables savings from the reduction of multiple independent system networks that exist in a conventional building.

As more companies begin to see the benefits of locating in a smart building over a dumb one, it will be essential that developers have the expertise and knowledge to create smart real estate. Developers who move first to incorporate smart building strategies into their future developments will be able to increase the desirability of their locations and a rise in the value of their properties.



Certain fundamental requirements must be incorporated early in the planning process and a smart building strategy and brief need to be established. This includes open systems architecture, open protocol product selection and IP compliance for the purpose of data transfer.

8.2 Cyber Security

The security of any Internet-connected device can never be completely guaranteed. “Smart buildings”, according to a partner at a property developer interviewed as part of this research, “could be de-railed by poor cyber security”. With more connected devices installed in workplaces and greater dependencies between different building systems, the security of these devices is paramount. Poorly encrypted smart lighting systems can leak a network’s administrative password, connected printers can be spied on to steal documents, and the processing power of any smart device can be hijacked to send spam emails or mine cryptocurrencies. Many IoT devices, especially inexpensive consumer and smart home products, have been shipped without adequate security protocols. According to a study by Hewlett Packard, as much as 70% of IoT devices may be insecure.[41]

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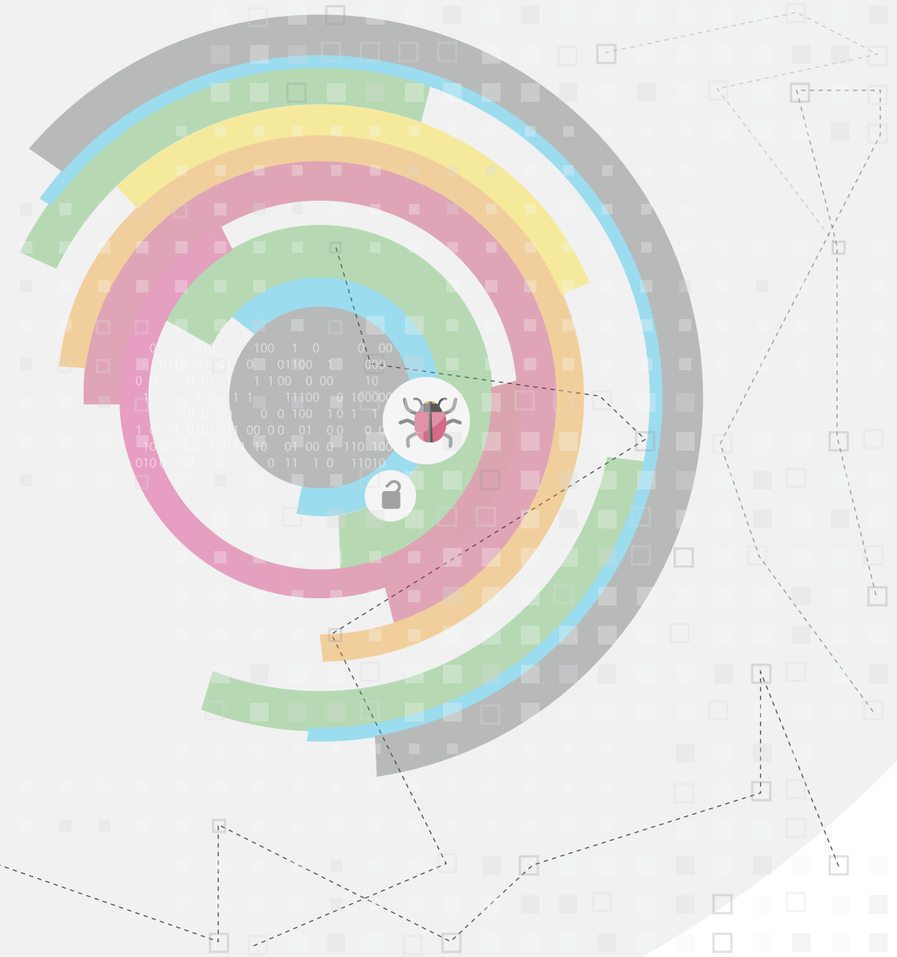
The networking of different building systems means that they are only as secure as the weakest device on the network. An iBMS is networked with IoT sensors, data centres, remote access servers and utilities through open protocols, exposing them to greater security vulnerabilities. Hackers could exploit these for malicious purposes or even shut building systems down until a ransom is paid. Furthermore, there is no clear precedent for who is ultimately responsible for any security breaches arising from insecure technology. Landlords might even find themselves liable for damages if a tenant is hacked through their smart building systems.

Developers and landlords can, however, mitigate the risks of breaches through putting in place a number of security procedures. Default passwords, for instance, on any devices should be changed as soon as they are initialised. Risks assessments should be undertaken to determine the relative risk of the individual field bus networks running in an iBMS, and firewalls used to secure different parts of the network where appropriate. Physical access ports, such as USB and IP ports, that are not being used should be disabled to prevent the inadvertent loading of malicious software onto networked devices.

With more connected devices installed in workplaces and greater dependencies between different building systems, the security of these devices is paramount.

Ultimately, no system can ever be wholly secure. Building managers should aim to stay one step ahead of any potential hackers through putting robust security procedures in place and ensuring that all building systems use best-in-class security protocols. Device manufacturers are starting to offer financial rewards to people who can identify security flaws in their products. It is possible that building owners in the future may start doing the same.



8.3 Data Privacy

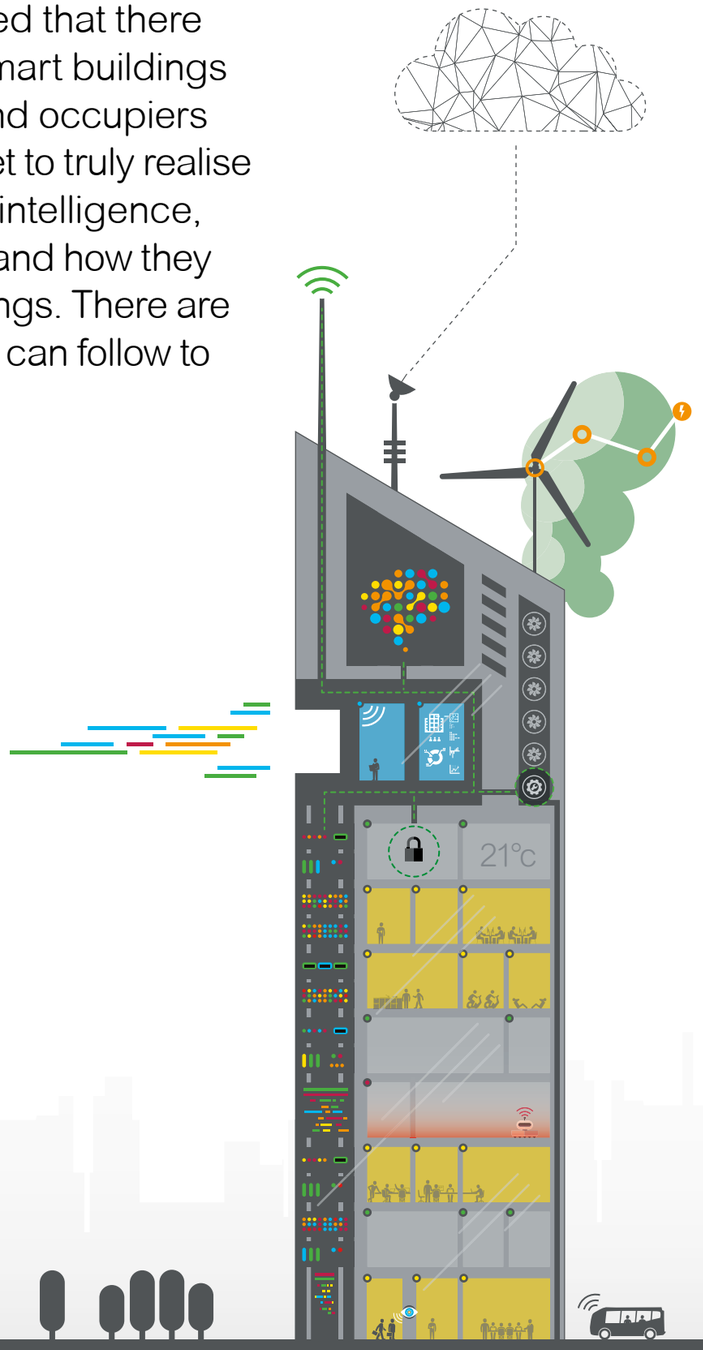
IoT devices allow the monitoring of all kinds of metrics relating to the performance of a building and of the people who use it. This data, however, presents building and business managers with both opportunities and challenges. Operational efficiencies and real improvements in business performance can be achieved through capturing building data, but this must be balanced with ensuring the privacy of building users. Smart technology has made it possible to track where people are in a building, who they talk to and how active they are. As more applications of IoT technologies are developed, new ways of tracking and measuring performance at an individual level will become possible.

Companies who fail to develop clear data policies that articulate why they are collecting certain types of information, and how they are using it, risk damaging their reputation and ability to attract the best people.

Yet just because new kinds of data can be captured, does not mean they should be. Not everything that can be measured is actually interesting or analytically useful. Firms need to identify what their objective is in capturing data from their workplaces, and communicate this clearly to their employees. Companies who fail to develop clear data policies that articulate why they are collecting certain types of information, and how they are using it, risk damaging their reputation and ability to attract the best people.

9. Conclusion: 7 Steps to Achieve Smart

This report has demonstrated that there are significant benefits to smart buildings for developers, landlords and occupiers of commercial real estate. Yet to truly realise the advantages of building intelligence, developers need to understand how they can create truly smart buildings. There are seven steps that developers can follow to achieve smart:



Delivering a smart building – Seven Steps to Achieve Smart

1 **Choose smart from the start.** Smart buildings with the best outcomes are born from conception. Although not impossible, introducing smart after a building's strategic development stage can incur more costs than needed, delay projects and reduce the benefits for all stakeholders.

2 **Procure smart and challenge the state as quo.** Identify experts that can help sell your concept to key stakeholders and work with your consultants to drive smart choices of technology, gain cost certainty and keep your chosen solutions on track.

3 **Don't forget the basics.** Power demand and supply, an iBMS and resilient building systems that interconnect can save time, manage risk, deliver cost efficiency and lifecycle value. The most commercially attractive buildings are those where the lights do not go out and the systems are open to updating and improvement.

4 **Be as smart as your building needs to be.** Focus on the technologies and base build inclusions that deliver tangible benefits for each building and deliver the concept of operation that is needed but allow for future innovation and improvement.

5 **Dealing with data.** Focus on the data that is needed for reporting – efficiency, business improvement and performance – and ensure that your technology partner or integrator is aligned to this.

6 **Don't rule out your lifecycle.** Understand the relationship between CapEx and OpEx choices. Smart base build technology will open the door to smart facilities maintenance which can be far more cost effective and drive ROI and system optimisation at the most detailed level.

7 **Choose a strong smart partner.** Partners that share and manage risk and reward equally, have clear experience in delivering smart, promote leading alliances with other technology players, and work regularly with the contractual chain in partnerships, are key.

10. About Unwork

The Future of Work

We specialise in creating the business case for new ways of working, challenging the established patterns of work and enabling businesses to understand the opportunity presented by agile working and alternative ways to organise work.

We focus on all aspects of the future of work where people, place and technology meet. We are particularly interested in ABW, change management and understanding the technology enablers required.

We believe there are seven key forces shaping the future of work, which we use to create a vision of the future of work for our clients:

Culture – demographics and intergenerational working

People – psychology and behaviour, company culture and workstyles

ICT – technology, connectivity and collaboration

Transport – travel and the city

Sustainability – community and innovation

Brand – creating a narrative that links organisation and workplace

Real estate – property and workplace.

We focus our research and consultancy on these key areas:

- Agile working – meeting new business imperatives – new types of working
- ABW
- Expectations of the next generation
- New technology cost
- People and productivity
- Insight and innovation
- Sustainability
- Language and behaviour.

We believe that work can only be properly understood as being the confluence of people, technology and place. We provide unrivalled knowledge of global innovation in work and the workplace.

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11. About Schneider Electric

Schneider Electric is the global specialist in energy management and automation. With revenues of €25 billion in FY2016.

Schneider Electric is the global specialist in energy management and automation. With revenues of €25 billion in FY2016, our 160,000+ employees serve customers in over 100 countries, helping them to manage their energy and process in ways that are safe, reliable, efficient and sustainable. From the simplest of switches to complex operational systems, our technology, software and services improve the way our customers manage and automate their operations. Our connected technologies reshape industries, transform cities and enrich lives.

At Schneider Electric, we call this **Life Is On**.

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