The Law Society

Smart buildings

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Contents

List of abbreviations

AI	Artificial intelligence
API	Application programming interface
APPI	Act on the Protection of Personal Information (Japan)
AR	Augmented reality
BaaS	Buildings-as-a-service
BCA	Building and Construction Authority (Singapore)
BCIs	Brain-computer interfaces
BIM	Building information modelling
BMS	Building management systems
BRE	Building Research Establishment
BREEAM	BRE Environmental Assessment Method
CAGR	Compound annual growth rate
CHP	Combined heat and power
CPS	Cyber-physical system
EnEV	Energy Saving Ordinance (Germany)
GDP	Gross domestic product
GDPR	General Data Protection Regulation
HD	High-definition
HVAC	Heating, ventilation and air conditioning
ICT	Information and communications technology
IoT	Internet of Things
IP	Intellectual property
ISO	International Organisation for Standardisation
LEED	Leadership in Energy and Environmental Design
MEES	Minimum energy efficiency standards
METI	Ministry of Economy, Trade and Industry (Japan)
NDA	Non-disclosure agreement
OECD	Organisation for Economic Co-operation and Development
PDPA	Personal Data Protection Act (Singapore)
PIPL	Personal Information Protection Law (China)
PPL	Protection of Privacy Law (Israel)
UIM	Urban information modelling
VR	Virtual reality

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1. Introduction

In today's fast-changing world, artificial intelligence (AI) and the Internet of Things (IoT) are transforming industries globally. In the area of smart buildings, AI and IoT are changing how properties are designed, built, and managed. For property lawyers, understanding this new landscape — including issues around privacy and liability — is essential to give clients good advice and ensure legal compliance in a changing market.

Smart building management is just one of several AI-driven trends shaping the commercial property sector. However, while intelligent buildings may be the future, so are cyber threats to these systems. Current discussions about the future of smart and autonomous buildings cover the role of connectivity, system compatibility, security, and resilience. These debates also consider the human role in the technology of intelligent buildings.

Before exploring the details of AI and IoT in smart buildings, it's important to define these terms clearly.

1.1 Definitions

- **Artificial intelligence (AI)** is a branch of computer science that aims to create systems capable of performing tasks that would normally require human intelligence. These tasks include learning from experience, understanding natural language, recognising patterns, solving problems and making decisions. AI can be categorised as either narrow, meaning it is designed and trained for a particular task, or general, which is capable of understanding, learning and applying knowledge across a broad range of tasks at the level of a human being. AI technologies are now part of our everyday lives, integrated into a variety of sectors such as healthcare, finance, transportation and entertainment. AI systems have the potential to impact society greatly by improving efficiency and effectiveness, creating new opportunities and tackling large-scale challenges. However, they also raise important ethical and societal considerations that need to be addressed.
- The **Internet of Things (IoT)** refers to the network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators and connectivity which enable these objects to connect and exchange data. Each thing is uniquely identifiable through its embedded computing system but can inter-operate within the existing internet infrastructure. IoT provides the opportunity to seamlessly integrate and act on data from a variety of sources, ultimately improving efficiency, decision-making and utility for the end-user.
- A **smart building** is a structure that uses automated processes and technology to control the building's operations, including heating, ventilation, air conditioning, lighting, security and other systems. A smart building uses sensors, actuators and microchips to collect data and manage it according to the building's functions and services. This infrastructure helps owners, operators and facility managers improve asset reliability and performance, reduce energy use, optimise

how space is used and minimise the environmental impact of buildings. Smart buildings can communicate with the grid to optimise energy consumption and contribute to grid resilience. They can also provide additional benefits to the occupants, enhancing their comfort, productivity and wellbeing.

Smart buildings offer several appealing features: convenience (like remote control and monitoring via smartphones), intelligent automation and control (such as learning and predicting user habits, smart scheduling), and improved energy efficiency. These buildings are connected, allowing them to communicate with each other, with the power grid, with utilities, with energy storage, with occupants and with other smart devices.

The terms "intelligent," "smart," and "sustainable" buildings are often used interchangeably, leading to confusion. Ghaffarianhoseini et al. (2018) explain that while green and sustainable buildings — supported by green building councils globally — focus on environmental, social, and economic aspects (as seen in certifications like LEED and BREEAM), intelligent and smart features have not been as fully integrated into these frameworks.

In 2014, Buckman, Mayfield, and Beck defined smart buildings as those that bring together intelligence, management, control, materials, and construction in a unified system, designed to adapt to priorities like energy efficiency, durability, and occupant comfort (2014: 98).

However, nearly a decade later, this definition needs updating to account for major technological advances and changing priorities. Increased connectivity in building systems brings significant cybersecurity risks, requiring strong defences against cyber threats. Today's smart buildings need a broader definition that includes advanced technology, sustainability, human-centered design, connectivity, data use, and compliance with regulations and ethics.

A smart building in 2025 might be described as an autonomous, adaptive system that responds to its environment and occupants through integrated AI, IoT, and renewable energy technologies. Operating with minimal human intervention, it optimises energy use, sustainability, and comfort, continuously learning and evolving to improve user well-being and productivity. Its design allows extensive data access, insights, and automated decisions that enhance building performance.

1.2 Importance of AI and IoT in the context of smart buildings and property law

The integration of AI and IoT technologies in smart buildings has major implications for property developers, owners and occupants. These technologies allow buildings to adapt and respond to changing environments. From predictive maintenance and energy optimisation to personalised experiences and improved security, AI and IoT offer a wide range of possibilities. However, these opportunities also bring unique legal challenges that require careful attention and strategic advice, affecting professionals in property, data, and privacy law, among others.

Looking ahead, smart buildings will likely evolve even further, driven by constant innovation and the expanding capabilities of AI and sensing systems. In the future, buildings may not only anticipate occupants' needs but also adapt to external factors like climate change, urbanisation, and new regulations. From self-diagnosing structural issues to managing interactions between different systems, smart buildings have the potential to redefine living and working spaces. But on the downside, these buildings could worsen inequality, increase surveillance, and raise social justice issues (Sharma et al. 2023; Zajko 2022), merging property law concerns with broader societal questions about the cities and homes of the future.

For property lawyers, this emerging landscape presents both challenges and opportunities. As experts in a digital and connected world, lawyers will need to adapt their practices to address the new legal issues created by AI and IoT in smart buildings. This means managing complex issues like data privacy, cybersecurity and liability, while perhaps even creating new legal frameworks that support innovation in property design, construction, leasing, buying, selling, and management, all while protecting the rights of all involved.

1.3 Purpose and scope of this report

This report looks at the intersection of AI, IoT technologies and smart buildings in the property law sector. Its main goal is to give property lawyers and relevant stakeholders insights into the current landscape, emerging trends, and future outlook of AI and IoT in smart buildings. By exploring technology adoption, regulations, and real-world applications — as well as how these may evolve over the coming decades — the report aims to help professionals manage the growing complexities of smart building development, operation, and management.

The Law Society's foresight function is committed to helping legal professionals and policymakers prepare for future changes in the legal field. By analysing emerging trends, technology advances, and societal shifts, it supports strategies to keep the legal profession resilient and adaptable. Using tools like horizon scanning, futures wheels, and scenario planning, we aim to provide insights that guide policy, inform regulatory changes and help members prepare for future challenges and opportunities.

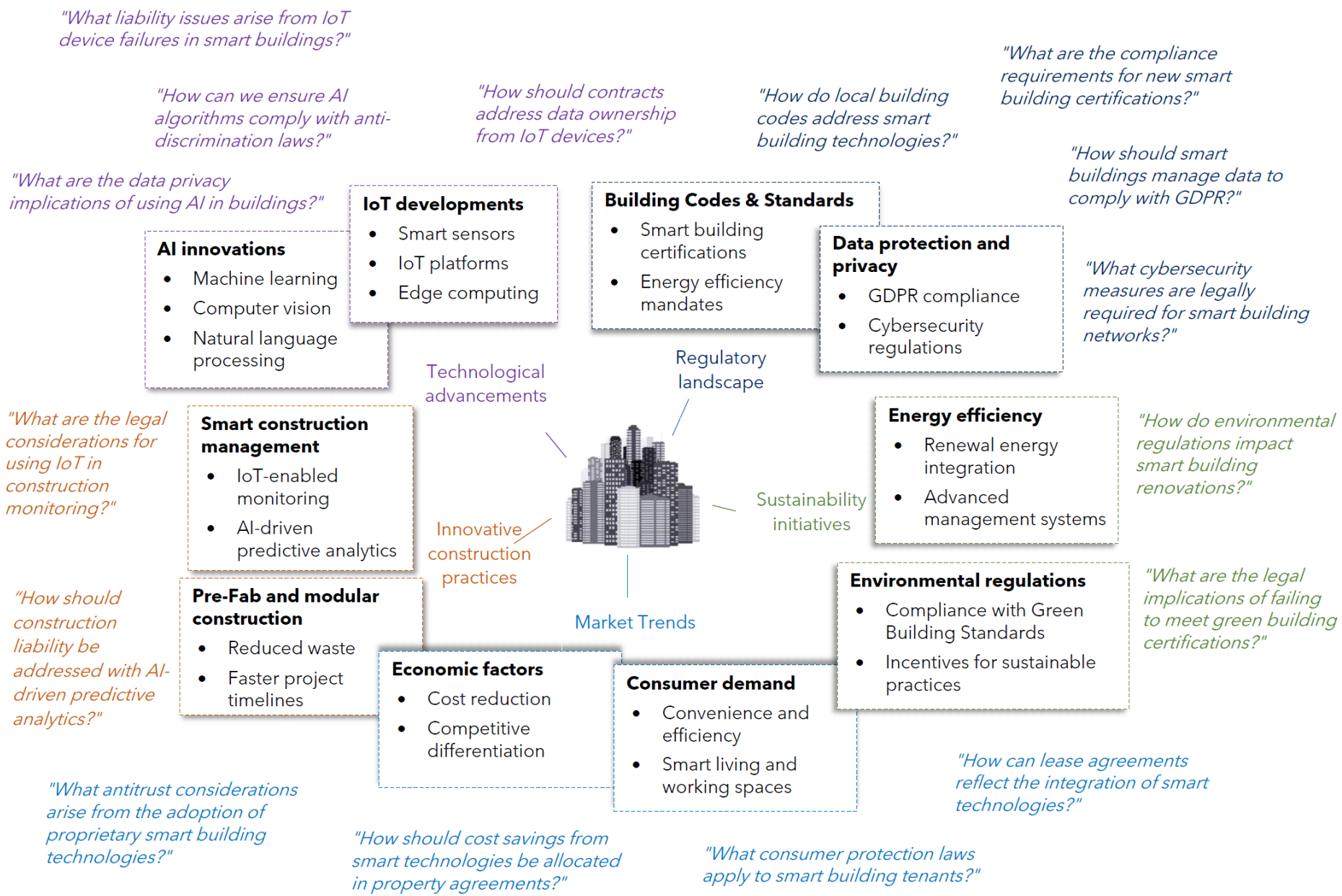
This report uses foresight methods like horizon scanning, system mapping and futures tools to capture the complex nature of smart building technologies and their impact. Horizon scanning identifies emerging trends and disruptions in the sector, while system mapping helps us understand how different trends interact in smart building ecosystems. The report includes boxes of questions to encourage readers to think broadly about the future opportunities and challenges of smart buildings in the property law sector.

The journey to fully realising AI and IoT in smart buildings requires collaboration, foresight and a strong understanding of the changing legal landscape. This report does not offer answers; rather, it explores key topics, offering insights and questions to guide understanding and discussion. Property

lawyers have a crucial role in shaping the future of smart buildings, contributing to a more sustainable, efficient and fair built environment for future generations.

Figure 1 on the following page shows the outcome of a foresight workshop to identify the main trends and impacts of smart buildings (2024/2030) and some of the associated legal questions arising.

Figure 1: Trends impacting smart buildings from 2024 to 2030, and associated legal questions

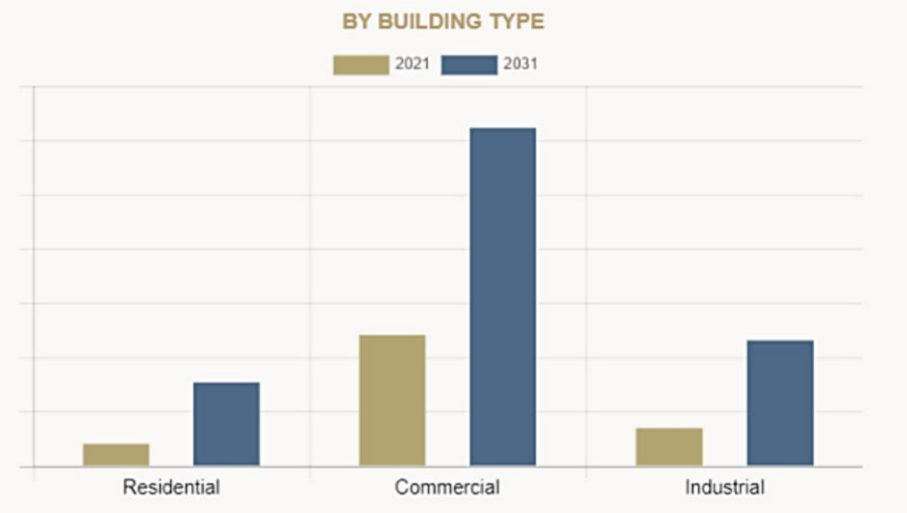


2. Current landscape of smart buildings

Smart buildings have emerged as a cornerstone of modern urban development, harnessing cutting-edge technologies to optimise efficiency, sustainability and occupant comfort. From commercial office spaces to residential complexes, the proliferation of smart building technologies is reshaping the way we design, construct and manage built environments. Figure 4 shows examples of uses.

The global smart building market size was valued at $69.80 billion in 2021 and is projected to reach $201.16 billion by 2030, growing at a compound annual growth rate (CAGR) of 11.3% from 2022 to 2031 (Allied Market Research 2024).

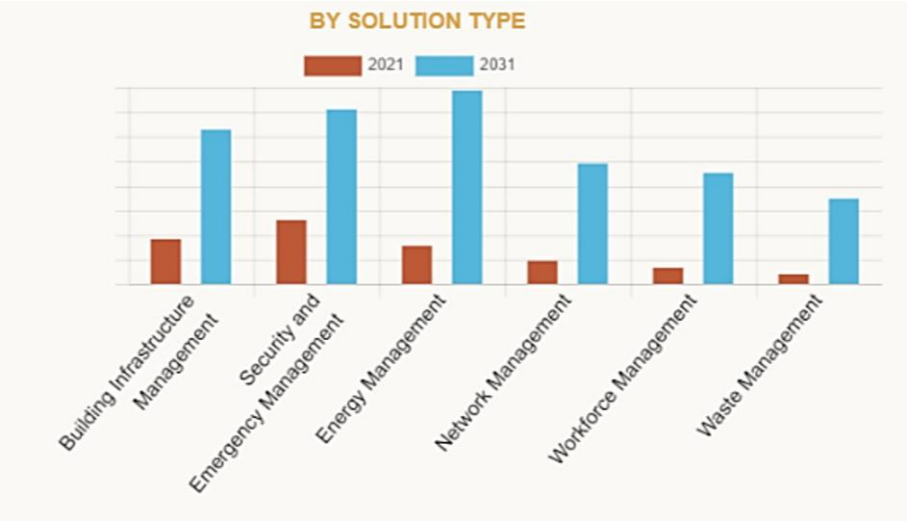
Figure 2: Smart building market by building type 2021 versus 2031
(Source: www.alliedmarketresearch.com/smart-building-market-A00682)



The commercial segment is expected to garner the highest market share owing to a higher need for smart building systems in commercial buildings for large-scale control and management of resources.

Source: www.alliedmarketresearch.com/smart-building-market-A00682

Figure 3: Smart building market by solution type 2021 versus 2031
(Source: www.alliedmarketresearch.com/smart-building-market-A00682)

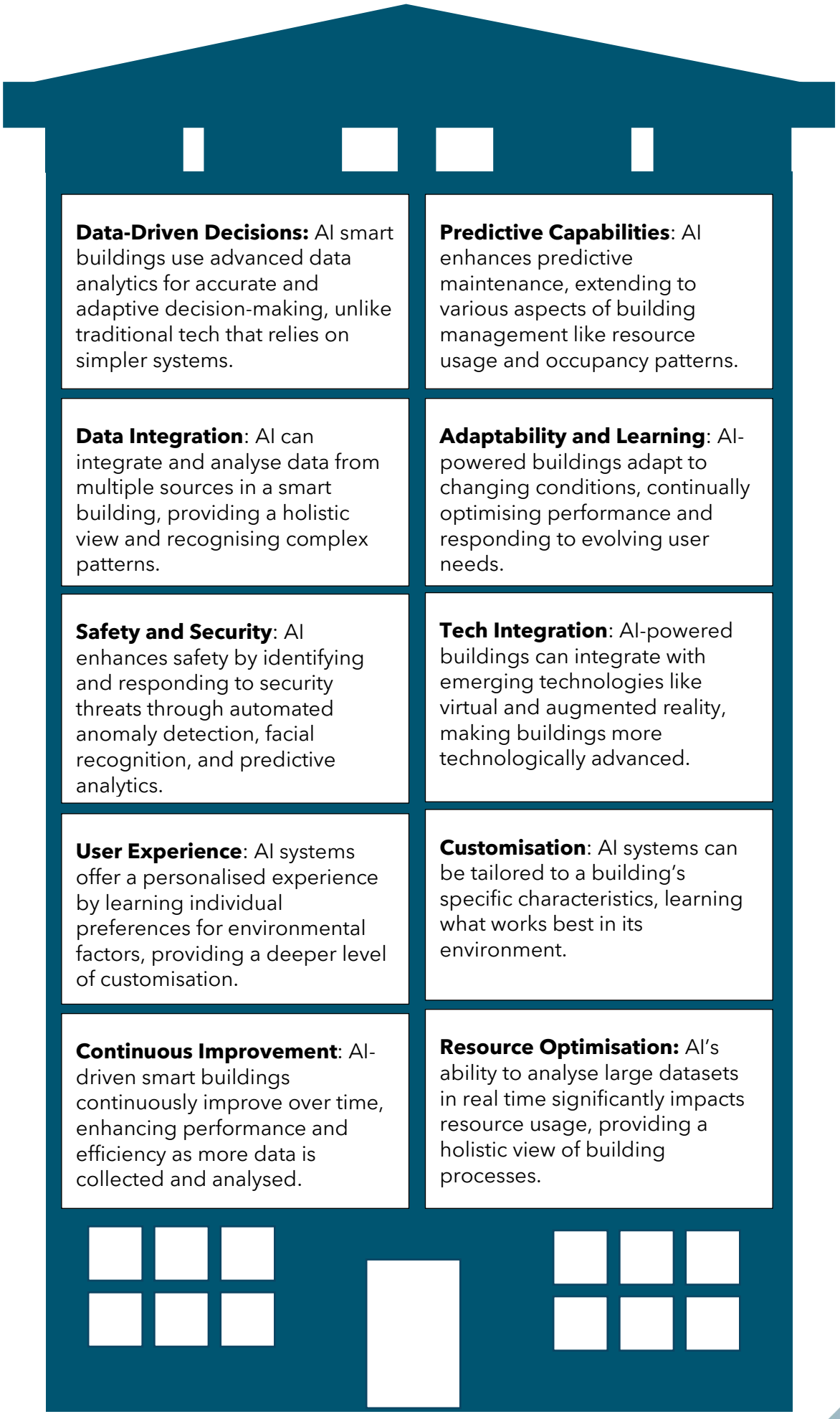


The security and emergency management segment is expected to garner the highest market share in the nearer term owing to the growing demand for smart building and perimeter security solutions.

Source: www.alliedmarketresearch.com/smart-building-market-A00682

Swedish smart building research firm Memoori tracked how IoT has transformed smart building automation and control in recent years, offering significant new opportunities to improve the efficiency of buildings and raise employee productivity, as well as helping to stimulate the development of innovative new services. Memoori forecasts revealed Asia-Pacific as the largest market adopting IoT in buildings, representing 36% of the global market by 2022. North America followed in market size, but was expected to decline in overall global importance from 30.9% in 2017 to 27.7% by 2022 (Tomás 2020: 3).

Figure 4: Examples of the ways in which AI and IoT are used in smart buildings



When smart buildings, artificial intelligence (AI) and the Internet of Things (IoT) work together:

1. **Energy efficiency**: AI can use data from IoT devices to optimise energy use, automatically adjusting lighting and temperature based on occupancy and time of day.
2. **Predictive maintenance**: IoT sensors can monitor building systems, like HVAC or elevators. AI can analyse this data to predict possible issues, allowing maintenance before problems arise.
3. **Security**: AI can analyse video feeds from IoT security cameras in real time to spot suspicious activity. It can also recognise occupants and automatically grant them access.
4. **Personalised comfort**: IoT devices can gather data on individual preferences, like favourite temperatures or lighting. AI can then adjust the environment based on who is present.
5. **Space utilisation**: IoT sensors can track which areas are used at different times. AI can use this data to optimise space, scheduling cleaning or maintenance when areas are typically empty.
6. **Disaster response**: In a disaster like a fire or earthquake, IoT sensors can give real-time data on the situation. AI can use this data to guide people to safety and inform emergency responders.

2.1 Examples of existing AI and IoT applications in smart buildings

AI and IoT applications are already changing how smart buildings work and interact with their surroundings. For example, AI-powered predictive maintenance systems use sensor data from building equipment to anticipate and prevent possible issues, reducing downtime and maintenance costs.

IoT-enabled smart thermostats and lighting systems adjust based on occupancy and outside conditions, optimising energy use while keeping occupants comfortable.

AI-driven security systems use facial recognition and behaviour analysis to improve building security and control access, reducing risks and enhancing safety. A smart home security system is an automated network of connected devices designed to protect the home. In 2023, the global smart home security market was valued at $25.55 billion, with projections to grow to $93.14 billion by 2032. According to Dream Casa, in 2022, 72% of millennials said they would pay more for a property already equipped with smart home systems (Fortune Business Insights 2024).

Brain-Box AI

brainboxai.com/en/

Brain-Box AI, a Canadian company, specialises in autonomous building technology. Its technology combines deep learning, cloud computing and autonomous decision-making to create buildings that operate on their own, 24/7. The company reports that it has installed this technology in over 15 million square feet of commercial space across 15 cities. In each building, the HVAC system runs independently and in real time, achieving up to a 25% reduction in energy costs and a 20–40% reduction in carbon footprint.

Sidewalk Labs

In 2019, Sidewalk Labs LLC, a Google subsidiary focused on urban planning, proposed a smart city project for Toronto's Quayside neighbourhood. The project promised social and environmental benefits like affordable housing, improved public transit and sustainability. However, to access affordable housing, residents would need to share extensive personal data due to the project's high level of data collection.

Environmental goals would be reached not only through design but by tracking and influencing residents' energy and water use. However, detailed data on water and energy use could be sold to companies to market products and services to residents. Within 18 months of the project's launch, the Canadian Civil Liberties Association called it a "non-consensual, state-authorised mass capture of Canadians' personal information" (Walker 2022).

Due to concerns over privacy, the people of Toronto ultimately rejected the project. Many felt the privacy protections were inadequate and insisted that any data collected be stored on Canadian servers to reduce the risk of US government surveillance. This example shows the importance of agreements that reflect community values and the need for strong privacy protections in smart city projects.

The Edge

edge.tech/buildings/the-edge

The Edge in Amsterdam marks a new direction in real estate, with buildings that produce more energy than they use. Completed in 2015, the building is designed for both function and user experience and is often called “the smartest building in the world.” It has systems that improve office comfort and efficiency.

Employees use a smartphone app to manage schedules, access facilities, and find parking and workspaces. The building adjusts lighting and temperature based on individual preferences throughout the day. Meetings are held under a “digital ceiling” with 28,000 sensors that control motion, light, temperature, and humidity. This setup, managed through central dashboards, is expected to pay for itself within eight years.

The Edge is a sustainability leader, earning a 98.4% rating from BREEAM for its green design. More than just a workplace, it is a connected ecosystem created with Deloitte’s help, showcasing the best of modern office design with its integrated data and user-focused approach.

One Angel Square

In 2009, the Co-op began building a new 400,000-square-foot, 16-storey head office in Manchester to offer a modern workspace with flexible options for staff. The building, known as “One Angel Square,” was developed by BAM Construction and Engineering, with 3DReid as architects and Buro Happold as structural engineers. It achieved the highest-ever BREEAM rating, earning the prestigious “Outstanding” status.

One Angel Square is powered by a biodiesel co-generation plant using rapeseed oil to produce electricity and heat. The building uses natural resources efficiently, drawing solar heat, natural ventilation through its double-skin façade, adiabatic cooling, rainwater harvesting, greywater recycling, and recycling of waste heat. Its combined heat and power (CHP) system is central to reducing carbon emissions, allowing the Co-op to manage most of its own heat and power needs.

Extensive use of 3D technology and AI supported the design, from coordinating engineering and architectural elements to creating energy models. This technology also helped create animations to show design ideas to the client and construction team. One Angel Square was part of a climate change study funded by the Technology Strategy Board, which assessed the building’s resilience to future climate conditions, like overheating and flooding. BRE awarded a unique innovation credit to recognise the team's leadership in this area at the time.

2.2 Adoption of AI and IoT in the property sector

The use of artificial intelligence (AI) and the Internet of Things (IoT) in the property sector has been growing steadily. This trend is driven by the need to improve efficiency, cut costs, and increase tenant satisfaction.

The COVID-19 pandemic highlighted the need for technology that supports remote monitoring, touchless access control and managing indoor air quality. This has sped up the adoption of AI and IoT in property development. We expect to see ongoing investment and innovation in smart building technologies, driven by rising consumer expectations, regulatory requirements, and industry standards.

Reasons for adoption

- **Better operational efficiency:** This is one of the main reasons for using smart building technology. IoT sensors and AI can monitor and analyse building systems in real time. This helps with proactive maintenance, energy savings, and better management of resources.
- **Cost savings:** Smart building technology can save a lot of money by reducing energy use, predicting maintenance needs, and using space more effectively. By using IoT and AI, building owners can find inefficiencies and apply specific solutions to cut operational costs.
- **Better tenant experience:** Features like automated climate control, smart lighting, and personalised workspace settings help keep tenants happy and encourage them to stay.
- **Environmental sustainability:** Smart buildings help create a more sustainable environment by using energy efficiently, reducing waste, and following green building practices.

Reasons for non-adoption

- **Cost barriers:** The high initial costs of installing IoT and AI technologies in existing buildings can be a major obstacle for some property owners. The uncertainty about whether these investments will pay off can also discourage them from pursuing smart building solutions.
- **Complexity and integration challenges:** Combining IoT sensors, AI systems and existing building systems can be technically difficult. The lack of standards for compatibility and concerns about data security and privacy can make adoption harder, especially for property owners who may not have much technical knowledge.
- **Legacy infrastructure:** Older buildings with outdated systems may have a hard time being upgraded to include IoT and AI technologies. Retrofitting these buildings can be expensive and disruptive, making it a less viable option for some property owners.
- **Regulatory compliance:** Property owners may face challenges related to regulations about data privacy, cybersecurity, and building codes. They need to navigate complicated legal requirements and ensure they comply with relevant laws, which can add to the complexity and uncertainty of adopting these technologies.

2.3 Regulatory frameworks and standards governing smart buildings

While there are no regulations specific to AI in buildings, there are several regulations and guidelines that apply to AI in general, which would also cover its use in smart buildings.

- **United States:** In 2023, President Biden signed an executive order on AI, which calls for increased transparency and new standards. The National Institute of Standards and Technology proposed a framework that categorises AI types and uses based on the level of risk they present. Each sector and agency is expected to implement this framework, yet with possible variations (Ryan-Mosley, Heikkilä, and Yang 2024).
- **European Union:** In March 2024, the EU adopted the Artificial Intelligence Act (AI Act https://artificialintelligenceact.eu/), which is the world's first comprehensive AI law. It imposes the strictest rules on the riskiest AI models to ensure they are safe and uphold fundamental rights in the EU. Regulations like the General Data Protection Regulation (GDPR) set high standards for how personal data is collected, processed, and stored in smart buildings, promoting privacy and responsible data management (www.hfsresearch.com/research/emerging-regulations-global-ai-landscape/).
- **Global guidelines:** The AI regulations being discussed align with key principles set by the OECD and endorsed by the G20, which include respect for human rights, sustainability, transparency, and effective risk management (Ryan-Mosley, Heikkilä, and Yang 2024). For example, the International Organisation for Standardisation (ISO) has developed the ISO 37101 standard for sustainable community development, which offers a framework for integrating smart building technologies into broader urban sustainability efforts (https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/ai/ey-the-artificial-intelligence-ai-global-regulatory-landscape-v7.pdf?download).

These regulations and guidelines aim to ensure that AI systems, including those in smart buildings, are safe, transparent and respect fundamental rights. As AI technology continues to advance, it is likely that more specific regulations will emerge to address its use across various sectors, including smart buildings.

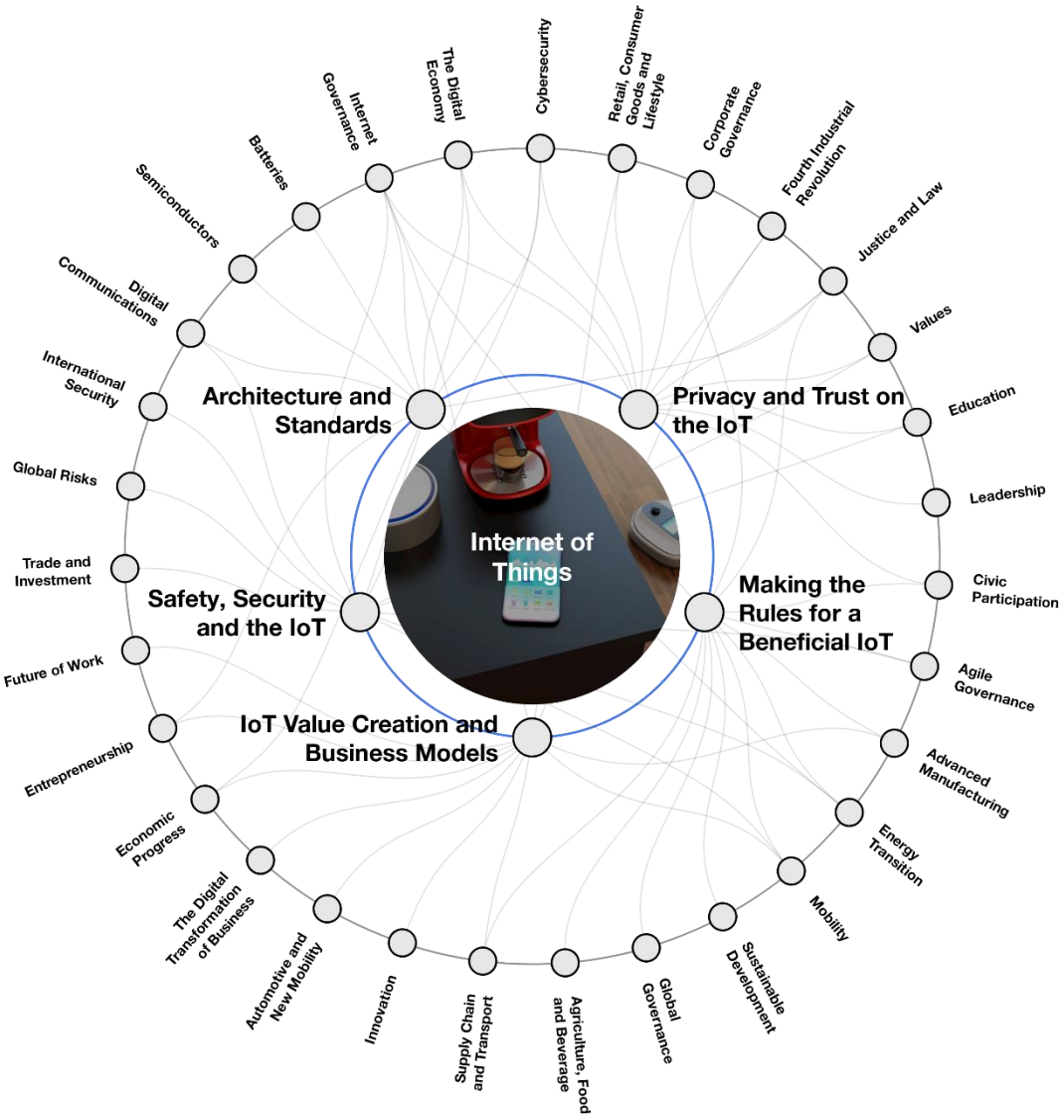
Effective governance structures in this context will require collaboration between private and public sectors, as well as support for promoting e-governance and ICT-enabled governance, leading to better strategic planning (Al Waer et al. 2014; Ojasalo and Tähtinen 2017).

3. Trends shaping the future of smart buildings

Several trends are set to influence the future of AI in smart buildings, driven by the merging of new technologies, changes in the market and shifting societal priorities. This section examines these trends and their effects on how smart buildings are designed, built, managed and made sustainable.

The trends wheel (Figure 5) illustrates some key factors affecting IoT, as well as the broader impacts they may have. These factors range from safety and security to architectural standards and extend to important topics such as energy supplies, social values, the digital economy, the future of work, civic engagement and the digital transformation of businesses, among others.

Figure 5: The trends wheel



3.1 Market trends

This section highlights important market trends that are shaping the property landscape, focusing on cyclical dynamics, regional differences and the varied impacts on different types of properties. Understanding these trends is essential as they are influenced by economic conditions, government policies and demographic changes. The section also emphasises the increasing importance of sustainability, especially through the lens of the circular economy and resilient cities, as well as the ethical responsibilities associated with integrating AI and other technologies in the property market. Together, these factors are reshaping strategies and operations in the industry, presenting both challenges and opportunities.

- **Cyclical dynamics**: The property market goes through cycles influenced by economic factors like interest rates, employment levels, and GDP growth. The balance of supply and demand significantly affects property prices and availability.

- **Regional variances**: Property markets show regional differences influenced by local economic growth, infrastructure projects and demographic changes.

- **Property types**: Different types of properties, like commercial (offices, retail, industrial) and residential, behave differently in terms of investment strategies and market dynamics, as seen during the COVID-19 pandemic.

- **Economic conditions**: Interest rates, inflation and GDP growth greatly influence property markets. Lower interest rates can encourage borrowing for property purchases, increasing demand.

- **Government policies**: Changes in regulations, tax incentives and housing policies significantly affect the property market. Initiatives that promote homeownership or encourage commercial development can boost market activity.

- **Demographics**: Population growth, migration patterns and changes in household structures influence property demand. For instance, the rise of remote work has shifted preferences towards larger residential spaces and suburban areas.

- **Circular economy and resilient cities**: The move toward circular cities is crucial for sustainability, requiring changes in urban design and resource management. Initiatives like the Circular Cities Declaration highlight the need for smart networking, intelligent operations and citizen engagement to achieve climate neutrality and promote circular resource flows.

- **Policy benchmarks and ethical responsibility**: Ethical considerations are vital for the responsible development and use of AI in smart buildings. Trustworthy AI, backed by strong regulatory frameworks and ethical guidelines, encourages innovation while protecting societal values and human rights. Policy initiatives such as the European Green Deal and

Global AI Strategy are important steps toward advancing responsible AI development and use.

The idea of smart buildings has been evolving for decades, starting with simple automated heating and cooling controls in the 1970s and 1980s. These early systems paved the way for more advanced controls in the 1990s, which included lighting control and basic sensor networks. The early 2000s saw the rise of radio frequency identification (RFID) technology for inventory management and access control, coinciding with the development of cloud storage solutions. This set the stage for the rapid growth of IoT technology in the 2010s, marking a significant shift in how smart buildings operate.

As IoT devices have become more common and connectivity has improved, the integration of smart building technologies has expanded. This allows various systems and devices to work together, enhancing data collection and remote monitoring. Advances in cloud computing, sensor technologies and data analytics have further increased the intelligence and responsiveness of building systems. The most significant recent development has been the integration of AI, machine learning and advanced analytics into these systems.

As these technological advancements continue to converge, they are profoundly impacting how buildings are designed and constructed. The integration of AI and IoT is not just improving the functionality of smart buildings; it is fundamentally changing how they are conceived, built, and managed.

3.2 Impact of AI and IoT on building design and construction

The integration of AI and IoT is transforming every stage of the building lifecycle. In the design phase, AI-powered generative design tools help architects and engineers optimise building layouts, materials and systems for better performance, efficiency and sustainability. Additionally, IoT-enabled construction equipment and drones improve safety, productivity and quality control at job sites. AI-driven predictive analytics enhance scheduling, resource allocation and risk management.

Gregory Dial, executive vice president of corporate and market strategy at JMA Wireless, highlighted that 5G technology, combined with private network capabilities and increased computing power at the edge of the network, will begin to automate essential operations.

Innovative examples like Metaverse City and virtual reality (VR) technologies showcase the transformative potential of digital twins and AI in building and city planning. These technologies allow for real-time collaboration, better decision-making and simulation, which improve project transparency, efficiency and stakeholder engagement. AI applications and digital twins are creating a significant shift in the construction sector, offering new opportunities for sustainable design and urban planning. The integration of AI and urban information modelling (UIM) is particularly promising, as it enables detailed modelling of urban operations and smart city infrastructure.

3.3 Role of sustainability and energy efficiency in shaping smart building trends

With increasing concerns about climate change and resource depletion, sustainability and energy efficiency are becoming major factors in smart building trends. Building owners and operators are placing more importance on green building certifications, energy performance standards, and sustainable design principles in their projects. AI and IoT technologies play a crucial role in reaching these goals, helping buildings optimise energy use, lower carbon emissions, and improve indoor environmental quality.

The potential for sustainable innovation in smart buildings is extensive and diverse. As governments, businesses and consumers work harder to fight climate change and reach net-zero carbon emissions, we expect a continued emphasis on sustainability and energy efficiency in the design, construction and operation of smart buildings. This focus will likely lead to even more innovation and investment in this rapidly growing sector.

4. Challenges and opportunities

Transactions and interactions on digital networks do more than just share information; they also create data about those transactions and interactions. This presents both challenges and opportunities regarding how this data is used in smart buildings and what it could mean legally.

4.1 Challenges

Privacy

As sensors and data collection become more common, privacy issues are a significant concern. Greg Corlis from KPMG US points out that "giving every single employee or visitor to a building a badge that can track their movements… I think the biggest challenge right now is that people just aren't comfortable with providing that level of detail on their movement and activities on the property" (Tomás 2020a: 6).

It is essential to collect and use data in ways that respect the privacy of those in the building. The same information that helps manage smart buildings can also give hackers new powers if they access it. For instance, occupancy sensors can indicate when someone leaves their home, which could lead to illegal surveillance or even property damage.

Experts recommend that IoT devices should be designed with privacy protections in mind, including rights like data deletion and the right to be forgotten. However, with companies possibly holding vast amounts of user data, there is a temptation to sell this information to third parties, which raises ethical and legal issues.

Interoperability

There are numerous standards and protocols for IoT devices, making it challenging to connect different devices and systems. Other technical issues include unsecured application programming interfaces (APIs), device software that has too many permissions and ensuring that networks can manage the large amounts of data generated. To improve resilience, it is important to divide the network of connected devices, use strong usernames and passwords and apply multifactor authentication for systems hosted in the cloud.

Security

While AI and IoT can improve building security, they also create new vulnerabilities. If these systems are not properly protected, hackers could take control of them. The large amounts of data collected from many interconnected devices increase the risk of security breaches, including data leaks and hacking threats. As technology develops rapidly, existing security measures often struggle to keep up, making them inadequate for IoT applications. This data can reveal a lot about individuals' movements, preferences and activities, making strong data protection essential.

Cost

Implementing AI and IoT in buildings can be expensive. This includes the cost of the devices themselves, as well as the cost of integrating them into existing systems.

Complexity and liability

Managing and maintaining a building with many interconnected devices and systems can be complicated and requires advanced technical skills. Security risks also raise questions about who is responsible if something goes wrong. If hackers exploit IoT devices and cause real harm, it can be unclear whether the user, the service provider, or someone else is liable.

Brittle and hackable cities

Data does not just exist on its own; it is shaped by many factors, including technical knowledge, public opinion, ethical issues, regulations and funding. These factors influence what types of data are produced and how they are managed, leading to concerns about the politics of urban data, the role of technology in governance and the potential risks of creating cities that are vulnerable to hacking or malfunctioning. Additionally, there is a growing worry about the idea of a “panoptic city,” where constant surveillance threatens people's privacy.

Training and contingency plans

To ensure the security of smart buildings, it is crucial to incorporate best cybersecurity practices when deploying equipment and training building managers. Having contingency plans is also important for times when smart building systems are down. These plans should focus on protecting sensitive data, keeping networks strong and using secure authentication methods to prevent unauthorised access.

The future of AI in smart buildings depends on overcoming these challenges to create secure, private and reliable environments for users. While integrating AI and IoT into smart buildings poses some significant difficulties, it also offers many opportunities. By tackling issues related to data management, security and privacy, stakeholders can unlock many advantages that improve the functionality, efficiency and sustainability of smart buildings.

4.2 Opportunities

Energy efficiency

AI and IoT can greatly enhance energy efficiency in buildings. By examining data from sensors and making smart decisions, these technologies can optimise how heating, cooling and lighting systems are used.

Enhanced data analytics and predictive maintenance

One of the biggest opportunities is using the large amounts of data created by smart buildings. Advanced data analysis can offer valuable insights into how buildings operate. By forecasting when equipment might break down and planning maintenance ahead of time, building managers can minimise downtime, increase the lifespan of assets and lower operating costs. This data-focused strategy can also improve energy efficiency, cutting costs and lessening environmental impact.

Improved security solutions

AI and IoT can improve building security. For instance, AI can review video footage to spot suspicious behaviour, while IoT devices can manage who has access to the building. The risks of data breaches and security threats also create chances for innovation in cybersecurity. Creating advanced security solutions designed specifically for smart buildings can lead to new business opportunities. These solutions might include AI-based systems to detect threats, advanced encryption techniques and strong authentication methods. Companies that focus on cybersecurity for smart buildings can succeed in this growing market by providing services to protect against complex cyber threats.

Privacy-focused design

Creating IoT devices and systems that focus on privacy can help companies stand out in the market. Devices that prioritise user privacy, have clear data management practices and give users control over their data can build trust and gain a competitive advantage. This approach matches the increasing consumer awareness and demand for privacy and data protection, providing a unique selling point for manufacturers and service providers.

New business models

The growth of AI and IoT in smart buildings opens up new possibilities for innovative business models. For example, companies can provide buildings-as-a-service (BaaS), where they handle and improve building operations for owners. This can involve energy management, predictive maintenance and security services, creating a complete solution that uses advanced technologies. Additionally, shared ownership and co-investment platforms can make it easier for more people to invest in and benefit from smart building projects.

Regulatory and legal services

The changing rules and regulations regarding smart buildings present opportunities for lawyers to specialise in this area. Property lawyers can gain expertise in understanding the complexities of AI, IoT and data protection laws, helping clients ensure compliance and reduce risks. They can also assist in writing contracts for shared ownership arrangements, managing governance issues and resolving disputes, providing essential support to those involved in smart building projects.

Sustainable and green building practices

AI and IoT technologies can help improve sustainable building practices. Smart buildings can save energy, cut down on waste and make occupants more comfortable, all of which support sustainability goals. Companies that focus on using these technologies to promote green building practices can take advantage of the increasing demand for environmentally friendly solutions. This includes creating AI-driven energy management systems, smart heating and cooling systems and other technologies that support sustainability.

Resilience and emergency preparedness

Creating systems that improve the resilience and emergency preparedness of smart buildings is another promising area. AI can help monitor and respond to emergencies, like fires or natural disasters, more effectively. By using AI-driven emergency response systems, building managers can keep occupants safe and reduce damage. This feature can be a major selling point for smart buildings, especially in areas that are at high risk for natural disasters.

Opportunities in education and training

As the smart building industry expands, there is a growing need for education and training programmes to help professionals gain the skills they need. Universities and training organisations can create specialised courses focused on the legal aspects of smart building technologies, cybersecurity, data analytics and regulatory compliance. This can help prepare a skilled workforce ready to meet the demands of this evolving market.

Innovation in interoperability

Interoperability is a major challenge in smart buildings because devices from different manufacturers need to work together smoothly. Innovators can create platforms and protocols that improve this communication, helping different systems function efficiently together. This would make it easier for building managers to integrate technologies and provide a better experience for occupants.

4.3 What might this all mean for property lawyers?

The rise of AI and IoT in smart buildings is transforming commercial and residential property, bringing new challenges and opportunities for property lawyers. As Nicholas Stello, senior vice president of IT at Vornado Realty Trust, remarked: “We’ve seen a growing trend over the years where a prospective tenant would inquire about cell coverage … There’s no doubt that there exists a correlation between a property’s technology offerings and the successful execution of a lease” (Tomás 2020a: 9). This trend has grown, especially after COVID-19, as more people work remotely and need reliable digital infrastructure.

Greg Corlis, managing director for emerging technologies and national IoT leader at KPMG US, highlighted another significant trend: “We’re starting to see a significant uptick in clients asking to move forward with smart building initiatives. Definitely any new building that is being built needs to be built from the ground up as a smart building” (Tomás 2020a: 3).

As smart building initiatives become more prevalent, property lawyers will be required to navigate the complex regulations that come with these innovations. This involves staying informed about the evolving legal frameworks governing AI, blockchain and IoT technologies, and ensuring compliance to protect clients’ interests in these advanced property investments, developments and transactions.

The property sector is also acknowledging that building owners are responsible for ensuring connectivity and data security. Integrating AI and IoT technologies presents both technical challenges and legal liabilities. Building owners and managers need to understand how these technologies can help attract and keep commercial clients. For property lawyers, engaging with technological integration, understanding regulatory challenges, specialising in shared ownership models and committing to ongoing learning will be essential to stay competitive in the fast-changing world of smart building transactions.

Key areas of focus for property lawyers

1. **Embrace technology**: Property lawyers will need to actively incorporate new technologies into their practices. Understanding AI, blockchain and virtual platforms is essential to make processes smoother and provide better legal services for property transactions. This includes using technology to automate contract reviews, facilitate digital signatures and speed up transactions to enhance client experiences. Lawyers can also improve their advisory roles by offering insights based on data, creating new legal frameworks for emerging technologies and ensuring strong cybersecurity to protect client information.
2. **Navigate regulations**: It is vital for lawyers to stay updated on changing regulations. Keeping an eye on the laws surrounding AI, IoT, blockchain and data security will help them ensure compliance, manage risks and protect their clients' interests in technology-related smart building transactions.
3. **Specialise in shared ownership**: With the growth of shared ownership and co-investment models in smart building projects, lawyers have an opportunity to specialise in drafting associated contracts and handling the legal complexities involved. The contracts must protect the rights of all stakeholders, address issues related to governance and profit-sharing, and ensure legal security in collaborative smart property ventures.
4. **Continuous learning**: Ongoing education is important for staying competitive. Lawyers should keep up with new technologies, legal changes, and market trends to provide well-informed advice, foresee potential challenges and manage the complexities of property transactions in this evolving landscape.

5. **Online property marketplaces**: Online property marketplaces are making it easier to find and lease smart buildings equipped with advanced IoT devices and AI features. Property lawyers need to ensure that lease agreements comply with the law, respect privacy regulations regarding data collected by smart building systems and handle any legal issues related to the use of AI in property transactions.
6. **Crowdfunding for property**: Crowdfunding platforms are becoming important for financing innovative projects that develop or upgrade buildings with smart technologies. For lawyers, this means navigating the legal complexities of crowdfunding regulations, ensuring compliance with securities laws, protecting investors and meeting disclosure requirements. They also play a key role in drafting contracts and agreements to manage risks and ensure the success of smart building projects.
7. **Tech-driven property platforms**: Platforms like RealtyTech Hub (in the US) are changing how smart buildings are marketed, sold and managed. These platforms use AI, augmented reality (AR) and virtual reality (VR) to provide immersive virtual tours, predictive analytics and simplified transaction processes through digital signatures, smart contracts and automated workflows. Lawyers who adapt to these technologies can ensure compliance with digital contract laws and privacy regulations and address legal issues related to the use of AI, AR, and VR in property transactions.

4.4 Legal considerations relating to data privacy, security and liability

Navigating the legal issues around data privacy, security, and liability in smart buildings requires a thorough and proactive strategy. Property lawyers need to keep up with the latest regulations, security measures and technological developments to provide effective advice to their clients. By addressing these legal factors and asking important questions, the property sector can better prepare for the challenges and opportunities that come with using AI and IoT technologies.

Data privacy

One of the main legal issues related to smart buildings is protecting personal data. With many sensors and connected devices constantly gathering information about people's movements, preferences and activities, there is a greater risk of privacy violations. The General Data Protection Regulation (GDPR) in Europe, which is enforced in the UK through the Data Protection Act 2018, establishes strict standards for how data is collected, processed and stored. Property managers and AI service providers must follow these regulations by putting strong data protection measures in place.

Questions to consider:

- How can lawyers help to ensure property managers' compliance with the GDPR while leveraging AI and IoT for building optimisation?

- What steps should be taken to anonymise data to protect individual privacy while still benefiting from the insights provided by AI analytics?
- How can property lawyers advise clients to implement privacy measures that will remain effective as data protection laws evolve and new technologies emerge?
- What long-term strategies should be in place to ensure continuous compliance with international data privacy standards as buildings become more interconnected globally?
- With data being stored in various jurisdictions, how can property lawyers navigate the complexities of cross-border data regulations and ensure their clients' compliance?
- What strategies should be employed to manage the risks associated with international data transfers and storage in the context of smart buildings?

Security

The security of data collected and processed by AI and IoT systems in smart buildings is a major concern. Because these systems are interconnected, they are vulnerable to cyber-attacks, which can result in unauthorised access, data breaches and even manipulation of building controls. To reduce these risks, it is important to use advanced encryption, secure authentication methods and conduct regular security audits. Additionally, as AI and IoT technologies are integrated into buildings, it is crucial to continuously monitor and update security protocols to stay ahead of changing cyber threats.

Questions to consider:

- What legal responsibilities do property owners have in preventing and responding to cyber-attacks on smart building systems?
- How can liability be distributed among various stakeholders, including device manufacturers, service providers and building owners, in the event of a security breach?
- With the rise of AI-driven cyber-attacks, what proactive steps can be taken to predict and mitigate future security threats to smart buildings?
- How can property lawyers ensure that their clients are not only compliant with current security standards but are also prepared for future regulatory changes?

Liability

The issue of liability in smart buildings is complex and involves questions about who is responsible for data breaches, system failures and any harm caused by AI and IoT technologies. When technology fails or is hacked, it can be difficult to determine who is liable—whether it is the user, the service provider, or someone else. For example, if a hacker breaks into a building's security system

and causes physical damage or injuries, there may be legal disputes over who is responsible for the incident.

Questions to consider:

- In cases of AI system failures resulting in property damage or personal injury, how should liability be apportioned between developers, property owners and users?
- In the event of a cyber-attack on a smart building, who should be held accountable: the technology provider, the building owner or another party?
- What legal frameworks are needed to address the complexities of liability in smart buildings, especially when multiple parties are involved in the operation and maintenance of AI and IoT systems?
- In a highly interconnected building ecosystem, how should liability be determined if a failure in one smart system cascades to affect other systems, leading to widespread damage?
- What legal frameworks need to be established to address liability issues related to autonomous decision-making by AI systems in smart buildings?
- How can property lawyers draft contracts to clearly delineate responsibilities and liabilities in the complex ecosystem of smart building technologies?

4.5 Intellectual property rights and ownership issues relating to AI and IoT

The use of AI and IoT technologies in buildings introduces many questions about intellectual property (IP) rights and ownership. As buildings become smarter and more connected, the development and management of these new technologies can create complicated legal challenges for property lawyers.

Intellectual property rights in AI and IoT

AI and IoT technologies in buildings involve various types of intellectual property (IP), such as patents, copyrights, trademarks and trade secrets. Each of these plays a role in protecting innovations related to AI and IoT.

- **Patents:** New AI algorithms and IoT devices can be patented, granting exclusive rights to their creators or those they assign these rights to. However, because technology advances quickly, the traditional patent process may lag, potentially leading to disputes over who invented something first and issues of infringement.
- **Copyright:** The software and data produced by AI and IoT systems can be protected by copyright law. This includes the code, user interfaces and even the data sets used to train AI.

Determining who owns these copyrights can be complex, especially when several parties work together on a project.

- **Trade secrets:** Many innovations in AI and IoT are based on proprietary information kept secret. To protect these trade secrets, strong security measures and contracts like non-disclosure agreements (NDAs) are essential.
- **Trademarks:** Branding for AI and IoT products and services requires trademark protection. As smart buildings become more common, it is vital for companies to establish and defend their trademarks to stand out in the market.

Questions to consider:

- How can property lawyers advise clients to effectively protect their AI and IoT innovations through patents, copyrights and trade secrets in a rapidly evolving technological landscape?
- What proactive measures can be taken to mitigate the risk of IP infringement in smart building projects?
- How can property lawyers structure licensing agreements to ensure fair and equitable distribution of IP rights among all stakeholders in smart building projects?
- What are the potential legal pitfalls in joint development agreements for AI and IoT technologies, and how can they be avoided?
- How can IP agreements be drafted to remain relevant and enforceable in the face of rapid technological advancements and changing legal standards?
- What clauses should be included in contracts to address potential future disputes over IP ownership and usage rights?
- How can property lawyers ensure that their clients' AI and IoT technologies comply with evolving IP regulations and standards, both domestically and internationally?
- What role should property lawyers play in shaping future IP regulations to better accommodate the unique challenges of AI and IoT in smart buildings?

Ownership issues in AI and IoT

Ownership of AI and IoT technologies in smart buildings can be complicated because many different parties are involved. Developers, property owners, technology providers and users might all have conflicting claims to ownership and control over these technologies.

- **Joint ownership:** Often, AI and IoT technologies are created through partnerships between various organisations. Figuring out who owns what and how to share IP rights can lead to disagreements, so it is important to have clear contracts in place.
- **Licensing and usage rights:** Property owners and managers need to negotiate licensing agreements to use AI and IoT technologies in their buildings. These agreements should clearly outline how the technologies can be used, including any limitations on modifications, sublicensing and how long the licence lasts.
- **Data ownership:** The large amounts of data produced by AI and IoT systems in smart buildings raise important questions about who owns this data. There must be clear policies that specify who owns the data, how it can be used and the rights of different parties to access and profit from this data.

Questions to consider:

- Who truly owns the data generated by AI and IoT systems in smart buildings, and how can this ownership be clearly defined and enforced?
- What legal frameworks need to be established to balance the commercial interests in data monetisation with the privacy rights of building occupants?

4.6 Regulatory compliance and risk management in smart buildings

The use of AI and IoT technologies in smart buildings creates a complicated environment for following regulations and managing risks. As buildings become more advanced and connected, property lawyers will need to deal with various legal and regulatory requirements to ensure compliance and reduce risks. This section looks at important areas of regulatory compliance and risk management related to smart buildings and encourages property lawyers to think critically about the future.

- **Data privacy and security:** The large amounts of data generated by AI and IoT devices in smart buildings raise serious privacy and security issues. Laws like the GDPR in Europe and the Data Protection Act in the UK have strict rules about how data is collected, stored and processed. Complying with these regulations requires strong data protection measures, such as encryption, anonymisation and secure storage. Building operators also need to be transparent with occupants about how their data is used and get their consent where necessary.
- **Building codes and standards:** Smart buildings must follow national and local building codes and standards, which often include requirements for energy efficiency, safety and

accessibility. These codes are continually updated to include new technologies and sustainability practices. Property lawyers must ensure that smart building projects meet all relevant codes and standards from the design phase through to construction and operation.

- **Health and safety regulations:** AI and IoT technologies can improve safety in buildings through advanced monitoring and automation. However, they can also introduce new risks, such as cybersecurity threats and possible system failures. Complying with health and safety regulations means implementing effective risk management strategies, conducting regular system tests and making sure building occupants are well-informed about the use and safety of these technologies.

- **Environmental regulations:** Sustainability is a key aspect of smart buildings, with regulations often requiring energy efficiency, water conservation and waste reduction. Property lawyers face environmental regulations to ensure that smart building projects not only meet current standards but also anticipate future regulatory changes aimed at promoting sustainability.

Questions to consider:

- How can property lawyers help clients balance the drive for innovation in smart building technologies with the need to comply with stringent regulatory requirements?
- What are the potential legal ramifications of failing to comply with new and emerging regulations related to AI and IoT in smart buildings?
- How should property lawyers address the ethical implications of pervasive data collection and surveillance in smart buildings?
- What role should property lawyers play in advocating for regulatory frameworks that protect individual privacy while promoting technological advancement?
- How can property lawyers develop legal strategies that remain relevant and effective as technology continues to evolve?
- What measures can be taken to ensure that smart building projects are not only compliant today but also adaptable to future regulatory changes and technological advancements?
- How can property lawyers anticipate and influence future regulatory developments in AI and IoT to better protect their clients' interests?
- What strategies can be employed to ensure continuous compliance with rapidly evolving data privacy and security regulations?

Risk management strategies

Cybersecurity: Because smart buildings are interconnected, they can be vulnerable to cyber-attacks. To manage these risks effectively, it is important to implement strong cybersecurity measures like firewalls, intrusion detection systems and regular security audits. Property lawyers should collaborate with cybersecurity experts to create comprehensive security policies and plans for responding to incidents.

Liability management: Figuring out who is liable in smart buildings can be complicated, especially when multiple parties are involved. It is essential to have clear contracts that outline each party's responsibilities and liabilities. Property lawyers need to ensure that these liability clauses are strong and provide enough protection for their clients in case of technology failures or cyber incidents.

Insurance: Insurance coverage for smart buildings should be thoroughly reviewed and updated to reflect the unique risks tied to AI and IoT technologies. This could include coverage for cyber incidents, technology failures, and data breaches. Property lawyers should work closely with insurance providers to customise policies that adequately protect their clients' interests.

5. International comparisons

The use of AI in smart buildings is changing the property sector around the world. Different countries are adopting AI technologies to varying degrees, influenced by their specific regulations, technological progress and market demands. This section compares the use of AI in smart buildings internationally; specifically in:

- the United States
- the United Kingdom
- Germany
- Japan
- China
- Singapore
- Dubai
- Russia
- Israel

Table 1 has a breakdown of the (i) technological implementation; (ii) regulatory environment; and (iii) challenges of each country.

All featured countries see the potential of AI to improve energy efficiency, predict maintenance needs and enhance occupant comfort, although the level of recognition varies. Data privacy and regulatory compliance are challenges that all countries face, but the complexity differs from one place to another. The US and the UK lead in technology but struggle with fragmented regulations and high costs. Germany emphasises sustainability and the integration of Building Information Modelling (BIM) within strong regulatory frameworks. Japan uses AI to improve disaster resilience, given its geographical challenges, while Singapore's Smart Nation initiative positions it as a leader in incorporating AI into smart buildings, backed by progressive regulations.

While each country faces its own challenges, they also offer unique innovations that shape the global landscape of smart buildings.

Table 1: The use of AI in smart buildings internationally

Country	Technological implementation	Regulatory environment	Challenges
United States	The United States leads in integrating AI with IoT for comprehensive building management systems. AI applications include advanced HVAC systems, predictive maintenance and energy management. Companies like Google and Microsoft are pioneering AI-powered building management solutions, using machine learning algorithms to optimise energy use and reduce operational costs.	Regulations like the Energy Star program and incentives for green buildings encourage the adoption of AI technologies. However, data privacy laws vary by state, creating a complex landscape for AI deployment in smart buildings.	The fragmented regulatory environment and high costs of implementation are significant barriers. Privacy concerns and the need for standardised protocols are ongoing issues.
United Kingdom	The UK focuses on sustainability and energy efficiency, with AI being used to enhance building performance and occupant comfort. Smart buildings in the UK employ AI for real-time energy monitoring and adaptive learning to improve energy efficiency.	The UK government supports smart building initiatives through policies like the Building Regulations and the Minimum Energy Efficiency Standards (MEES). The GDPR impacts how data is collected and used, ensuring stringent data privacy standards.	Compliance with the GDPR adds complexity to AI implementations. The high initial cost of technology adoption and the need for skilled professionals are also barriers.

Germany	Germany emphasises the integration of AI with building information modelling (BIM) for the construction and management of smart buildings. AI is extensively used for predictive maintenance and optimising energy use, aligned with Germany's strong focus on sustainability.	Regulations like the Energy Saving Ordinance (EnEV) and incentives for green building certifications support the adoption of AI technologies. Data protection laws are strict, influenced by the GDPR, ensuring robust privacy and security measures.	High regulatory standards and costs associated with implementing AI technologies can be restrictive. There is a need for more skilled workers in the AI and construction sectors.
Japan Sources: www.mdpi.com/2076-3417/11/2/763 www.aspi.org.au/report/big-data-china-and-battle-privacy	Japan utilises AI in smart buildings primarily for disaster resilience, energy efficiency and enhancing the quality of life for occupants. AI-driven systems are used to predict and respond to natural disasters, an essential feature given Japan's vulnerability to earthquakes and tsunamis.	Japanese regulations promote smart and sustainable building practices, with policies like the Act on the Rational Use of Energy. Data protection laws, while stringent, are supportive of AI advancements in smart buildings. Japan's AI regulation emphasises a human-centric approach, with guidelines for ethical AI implementation. The Ministry of Economy, Trade and Industry (METI) has developed governance guidelines to ensure AI systems are fair, transparent and accountable. Japan's Act on the Protection of Personal Information (APPI)	The ageing population poses a challenge in terms of both workforce and the design of AI systems that cater to elderly occupants. High implementation costs and maintaining data privacy are ongoing issues. Other challenges include standardisation and interoperability issues, as well as cultural attitudes towards business risk. Limited data availability and the need for robust data privacy standards also pose significant hurdles.

		is the primary legislation governing data privacy, ensuring that personal data is handled securely and transparently.	
China Sources: www.mdpi.com/2076-3417/11/2/763 www.aspi.org.au/report/big-data-china-and-battle-privacy www.globenewswire.com/en/news-release/2021/08/11/2278554/28124/en/Worldwide-Smart-Buildings-AI-Machine-Learning-in-Smart-Commercial-Buildings-Industry-to-2025-Impact-Analysis-of-COVID-19.html	China is rapidly urbanising and is using AI in smart buildings to manage this growth sustainably. AI technologies are integrated into smart buildings through advanced sensors, big data and building management systems (BMSs) to enhance energy efficiency and automation. Public-private partnerships and state-led initiatives drive the development of smart city infrastructure, incorporating AI, 5G and IoT. The benefits of improved urban living are driving the adoption of AI in smart buildings.	China has a comprehensive regulatory framework for AI, including the Interim Measures for the Management of Generative AI Services. The regulatory approach is top-down, with significant involvement from central government agencies. China has implemented the Personal Information Protection Law (PIPL), which sets stringent requirements for data collection, storage and processing. The Cybersecurity Law and Data Security Law also play crucial roles in regulating data privacy, emphasising the protection of personal information and critical data.	Despite these regulations, there are concerns about the extent of state surveillance and the sharing of data between private companies and government authorities. The enforcement of privacy laws can be inconsistent, leading to potential gaps in data protection. China faces challenges in terms of regulatory complexities and the need for large-scale funding. Key challenges include cybersecurity risks, lack of infrastructure and insufficient funds. There is also a lack of trust in AI and IoT technologies among the public.
Singapore	Singapore is at the forefront of smart city initiatives, with AI in smart buildings being integral to the Smart Nation vision. AI is used for	The Building and Construction Authority (BCA) promotes AI and smart technologies through initiatives like the Green Mark	Balancing rapid technological adoption with stringent data privacy regulations is a challenge. High costs and the need for continuous

	comprehensive energy management, smart security systems and enhancing occupant experience through personalised services.	Scheme. Data protection is governed by the Personal Data Protection Act (PDPA), which supports innovative uses of AI while ensuring privacy.	technological upgrades are barriers to widespread AI adoption.
Dubai Sources: www.mdpi.com/2076-3417/11/2/763 www.aspi.org.au/report/big-data-china-and-battle-privacy https://outsideinsight.com/insights/ai-in-dubai-how-the-worlds-smartest-city-is-embracing-data/ https://wired.me/technology/ai-safety-how-the-uae-commits-to-it/	In recent years, the UAE has seen a significant rise in the development of smart buildings. Dubai leverages AI in smart buildings through initiatives like the Dubai AI Lab and the Dubai Centre for Artificial Intelligence, focusing on integrating AI into government services and city infrastructure. AI technologies are also used for intelligent traffic management, smart energy grids and public safety enhancements. The UAE recognises the immense potential of smart buildings, with ambitious government initiatives like the Dubai 2040 Smart City vision driving widespread adoption.	The UAE has introduced regulations for AI activities, requiring businesses to obtain approvals from relevant authorities. Dubai has established AI ethics guidelines to ensure responsible and ethical AI development. Dubai has established the Dubai Data Law, which provides a framework for data categorisation and governance, aiming to protect personal data from misuse. The Smart Dubai initiative includes robust data protection measures, encryption protocols and anonymisation techniques to ensure data security.	Data security, cost implications and user adoption are major challenges for AI implementation in smart buildings. Ensuring ethical use of AI and maintaining public trust are also critical issues. Balancing innovation with privacy concerns remains a challenge, as the city continues to push the boundaries of AI and smart technology, while ensuring public trust in AI systems and maintaining transparency in data handling practices are ongoing priorities.
Russia	In Russia, AI technologies are extensively used in smart buildings, particularly in Moscow. The city has	The Russian government has implemented regulations to protect personal data, such as the Federal Law on Personal	Despite these measures, there are ongoing concerns about the lack of regulation and oversight, particularly

Sources: www.mos.ru/en/news/item/130409073/ https://link.springer.com/article/10.1007/s10796-020-10044-1	implemented over 80 AI-based digital projects, including smart cameras, traffic control systems and building management systems (BMSs) that enhance energy efficiency and automate routine operations. These technologies help in real-time monitoring and decision-making, improving the overall efficiency of urban management.	Data (No. 152-FZ). This law mandates that personal data must be processed with the consent of the data subject and outlines strict requirements for data storage and protection. Russia has established a comprehensive regulatory framework for AI. The government approved the Concept for the Regulation of AI and Robotics in 2020, which aims to balance technological development with citizen safety and rights. This includes creating legal standards, identifying barriers to AI development and establishing a national system for standardisation and conformity assessment.	with the expansion of technologies like facial recognition. In 2024, the primary challenges include the impact of international sanctions, which limit access to advanced technologies and talent. Additionally, there is a significant brain drain, with many skilled professionals leaving the country. The integration of AI in smart buildings also faces hurdles related to data security and privacy, and the reluctance of local officials to fully embrace digitalisation.
Israel Sources: https://link.springer.com/article/10.1007/s10796-020-10044-1	Israel is a leader in AI innovation, with a strong focus on integrating AI into smart buildings. Smart buildings in Israel leverage cutting-edge technologies to safeguard data privacy. This includes the use of secure IoT devices, advanced encryption	Israel's regulatory framework for AI is guided by the National AI Program, which emphasises ethical and responsible AI use. The government has released a comprehensive policy document outlining principles for AI regulation, focusing on transparency, fairness and human-centric AI	Despite its advancements, Israel faces challenges such as data security and privacy concerns, especially with the integration of AI and IoT in smart buildings. The country also deals with workforce constraints, as a significant portion of its tech workforce serves in the military reserves. Additionally, maintaining a

	methods and privacy-preserving data analytics. The country's National AI Program supports the development of AI technologies across various sectors, including smart buildings. AI is used for optimising energy efficiency, predictive maintenance and enhancing building design through advanced simulations.	development. This approach ensures that AI technologies are developed and deployed in a manner that respects fundamental rights and public interests. Israel's data protection laws are robust, with the Protection of Privacy Law (PPL) being a key piece of legislation. This law sets out comprehensive guidelines for the collection, processing and storage of personal data, ensuring that privacy rights are protected. Occupants of smart buildings are informed about the types of data being collected and the associated privacy risks. Efforts are made to ensure that data collection processes are transparent and that users have control over their personal information.	balance between rapid technological innovation and ethical considerations remains a critical challenge.

6. Future outlook

This section looks ahead at how AI and IoT could influence smart buildings and the legal field. It discusses potential changes and innovations in the property sector and presents brief scenarios of how AI could impact legal practices in buildings in the coming decades. The section also suggests what property lawyers may need to focus on.

6.1 Future scenarios: legal cases involving smart buildings

These snapshot scenarios were created in a foresight workshop using futures methods. The scenarios illustrate the complex legal landscape that smart buildings might trigger in the future, highlighting the need for robust legal frameworks and ethical considerations in the development and deployment of smart technologies in the property sector.

The following hypothetical cases explore issues ranging from data privacy and cybersecurity to liability for system failures and accessibility concerns.

Case 1: Jones v. TechHabitat (2025)

In 2025, a landmark case, *Jones* v. *TechHabitat*, brought data privacy to the forefront of smart building litigation. The claimant, Aleesha Jones, filed a lawsuit against TechHabitat, a smart building management company, alleging that her personal data was collected and used without her consent. Jones claimed that the AI systems in her apartment building tracked her movements, preferences and interactions, creating detailed profiles that were then sold to third-party advertisers. The court ruled in favour of Jones, stressing that residents must give clear, explicit consent before their personal data can be collected and used. This case set a new standard for stricter privacy rules and transparency for smart building operators, but it also raised worries about how to keep track of less visible data trading happening on the dark web.

Case 2: State of New York v. SecureSmart Systems (2028)

In 2028, the State of New York brought a case against SecureSmart Systems, a company that provides AI-driven security solutions for commercial buildings. The case was triggered by a serious data breach that exposed sensitive information of thousands of occupants across several buildings. The breach was linked to weaknesses in SecureSmart's AI security system. The court ruled that SecureSmart was responsible for not having enough cybersecurity measures in place and for failing to quickly fix known vulnerabilities. This case highlighted the need for strong cybersecurity protocols and led to stricter regulations aimed at protecting data in smart buildings. It also raised concerns about cybersecurity insurance as breaches become more frequent. Legal questions emerged about how much coverage is appropriate, what responsibilities insured parties have and how insurers can encourage better cybersecurity practices.

Case 3: GreenTech v. City of San Francisco (2029)

GreenTech, a company focused on eco-friendly smart building technologies, installed a new energy management system called EcoFlow in several public buildings in San Francisco. This system optimises energy use by adjusting lighting, heating and cooling based on how many people are in the building and the weather conditions. In 2029, San Francisco experienced a severe heatwave, and EcoFlow's algorithms prioritised energy savings over occupant comfort. This resulted in dangerously high temperatures inside some buildings, leading to several occupants suffering from heat-related illnesses, including one fatality.

The City of San Francisco sued GreenTech for negligence and wrongful death, claiming that EcoFlow's programming failed to consider extreme weather conditions and did not prioritise the safety of the people inside the buildings. The court found GreenTech responsible for the incident, and emphasised the need to design smart systems with fail-safes to protect against extreme weather. As a result, GreenTech was required to compensate the victim's family and update EcoFlow to include emergency protocols that prioritise occupant safety during extreme weather.

As AI systems become more independent in making decisions, determining who is liable when something goes wrong can get complicated. Questions arise about responsibility: If an AI decision leads to physical harm, is it the developers, the company using the AI, or the AI itself that is responsible?

Case 4: Patel v. FutureSpace Corp (2032)

The Patel v. FutureSpace Corp case in 2032 addressed the problem of AI bias in managing smart buildings. Pratik Patel, an office worker, claimed that the AI system controlling workplace amenities and resource allocation showed bias by favouring certain employees based on data linked to their age and job level. The court found FutureSpace Corp responsible for using an AI system that supported discriminatory practices, violating employment and anti-discrimination laws. This case brought attention to the ethical and legal issues surrounding AI bias and led to demands for stricter auditing and oversight of AI algorithms used in smart buildings.

Case 5: People v. Quantum Residences (2040)

Quantum Residences, a luxury smart apartment building in New York City, features advanced AI systems that handle everything from climate control to security. The building's AI, called Q-Guard, uses facial recognition and behavioural analytics to monitor residents and visitors. In 2040, a resident named Alex Johnson was mistakenly detained by Q-Guard after the AI wrongly identified him as a wanted criminal due to a glitch in the facial recognition software that used outdated data. Johnson filed a lawsuit against Quantum Residences for false imprisonment and emotional distress.

The case, People v. Quantum Residences, raises important questions about who is responsible for the actions of AI systems and what building operators must do. The court ruled in favour of Johnson, stating that Quantum Residences did not ensure the accuracy and reliability of its AI system. The ruling highlights the need for regular updates and audits of AI systems to avoid such mistakes.

Quantum Residences was ordered to pay a significant amount in damages to Johnson and to improve oversight of its AI systems.

By 2040, there may be strict legal requirements for the accuracy, timeliness, and reliability of data used by AI systems. This could include mandatory protocols for regular data updates, audits and the use of real-time data to prevent errors like the one that caused Johnson's wrongful detention. As AI systems like Q-Guard become more independent, there may be discussions about whether these systems should be given some form of legal status. This would involve figuring out how much accountability AI systems have for their actions without their operators being responsible. Legal frameworks might need to clarify if AI systems can be sued directly and what kinds of penalties or corrective actions can be applied to them.

Governments might also create certification processes for AI systems used in important infrastructure. This could lead to legal questions about the standards for certification, how to revoke certification, and the liability of the organisations that certify these systems.

6.2 Gaps in the future of the law?

The following potential future scenarios, created from our horizon scanning analysis and foresight workshop, suggest areas that current laws might struggle to address.

AI-driven decision-making in smart buildings

Scenario: In 2050, a smart building's AI system decides on its own to evict a tenant based on predictions about their future behaviour that might be disruptive. The tenant, who has not done anything wrong yet, challenges the eviction.

Legal Gap: Current laws do not fully cover the ethical and legal issues related to AI taking pre-emptive actions based on predictions. Important questions arise regarding due process, potential discrimination, and the tenant's right to privacy that need to be addressed.

Bio-integrated smart buildings

Scenario: By 2050, smart buildings are equipped with bio-sensors that continuously monitor residents' health and can even administer medication or treatments on their own. A resident suffers a bad reaction to one of these automated treatments.

Legal Gap: Current medical malpractice and liability laws might not address the unique challenges of autonomous medical actions by non-human systems. It would be difficult to determine who is accountable and how to ensure residents give informed consent in such cases.

Digital twin disputes

Scenario: By 2050, smart buildings use digital twins—virtual replicas of the physical building—to improve maintenance and operations. A resident disputes charges, claiming that the data in the digital twin was tampered with, leading to unfair utility and service costs.

Legal Gap: Current laws do not cover the accuracy and reliability of digital twins. New legal frameworks would be needed to set standards for data integrity in digital twins and to handle disputes over virtual building representations.

Autonomous security systems

Scenario: In 2060, a smart building's security system relies on drones and robots for rule enforcement. During an incident, a security drone injures a resident while attempting to detain them for a minor infraction.

Legal Gap: Current laws on the use of force and personal injury may not fully cover autonomous systems. Establishing liability and defining acceptable use of force by non-human agents would be challenging.

Data sovereignty and cross-border data flows

Scenario: By 2065, smart buildings across different countries are interconnected, sharing data globally to optimise energy use. A dispute emerges when one country's data privacy laws conflict with another's data-sharing practices.

Legal Gap: Existing international data privacy laws may be inadequate for the complexities of cross-border data flows in interconnected smart buildings. Developing global standards and resolving jurisdictional conflicts will be essential.

These scenarios underscore the need for adaptable legal frameworks to keep pace with technological advances. Collaboration among technologists, lawmakers, and ethicists will be crucial to ensure future innovations are legally sound and beneficial.

6.3 Emerging roles for property lawyers?

In the future, property lawyers could take on roles that are significantly different from those of today's professionals, adapting to the evolving technological landscape and the complexities of smart buildings. Here are some emerging roles lawyers might be required to play:

- **Techno-legal architects**: Lawyers may work with engineers to embed legal compliance within smart building technologies from the design phase, ensuring systems are both legally sound and ethically aligned.

- **AI Ethics advisers**: As AI becomes central to smart buildings, these advisers would ensure AI systems uphold ethical standards, human rights, and privacy, navigating complex moral and accountability issues.
- **Cybersecurity legal experts**: With cyber threats on the rise, specialists in cybersecurity property law could develop and enforce protective regulations, manage data breach cases, and ensure perpetrators are held accountable.
- **Data privacy advocates**: Focused on privacy rights, these lawyers would ensure data collection complies with privacy laws, advocate for residents' rights, and educate the public on safeguarding personal data.
- **Sustainability compliance officers**: These lawyers would guide smart buildings in adhering to environmental standards, championing sustainable practices to reduce environmental impact and align with climate change goals.
- **Digital twin regulators**: Lawyers in this role would oversee digital twins, ensuring these virtual representations are accurate, ethical, and resistant to manipulation.
- **Human-Machine interaction lawyers**: Specialists in this area would address legal concerns related to resident-AI interactions, safeguarding human rights and ensuring transparency in how AI systems operate within smart buildings.

These roles illustrate how the legal field may evolve, calling for cross-disciplinary expertise to address the ethical, technical, and regulatory challenges presented by future smart buildings.

6.4 Longer horizon skillsets for property lawyers?

Questions to consider:

- On the longer horizon, as technologies like quantum computing and advanced AI become mainstream, how will they impact the legal landscape of smart buildings?
- What new legal challenges might arise and how can property lawyers prepare for them?

As the property sector evolves through rapid technological advancements, property lawyers must prepare for a future where innovations, including quantum computing, virtual reality (VR) and neurotechnology, may significantly impact property transactions and building management. These emerging technologies demand a new set of skills and knowledge, enabling lawyers to navigate complex legal landscapes, anticipate future challenges and provide innovative solutions. This section takes a longer horizon approach to explore the competencies property lawyers may need to stay ahead in an increasingly dynamic, technologically driven industry. While this looks speculatively some 10 years ahead, there are skills in this list already beginning to shape service offerings in pioneering law practices.

Quantum computing law

Skillset: Understanding the principles of quantum computing, particularly its implications for data security, encryption, and intellectual property.

Knowledge Area: Lawyers need to grasp how quantum computing may break traditional encryption methods and the resulting legal ramifications of quantum data processing, including privacy concerns and the protection of sensitive information.

Neuro-legal expertise

Skillset: Knowledge of neuroscience and its intersection with law, focusing on how AI interfaces with human cognition and behaviour.

Knowledge Area: This includes the legal implications of brain-computer interfaces (BCIs) utilised in smart buildings for controlling environments or enhancing human capabilities, especially regarding consent and personal autonomy.

Synthetic biology and bioethics

Skillset: Expertise in synthetic biology, especially as it relates to bio-integrated smart buildings employing living organisms for energy production, waste management or structural integrity.

Knowledge Area: Lawyers must navigate the ethical and legal challenges of integrating living systems with built environments, ensuring compliance with health, safety, and environmental regulations.

Holographic and virtual reality law

Skillset: Proficiency in the legal aspects of holographic and virtual reality technologies, particularly as they are used in smart buildings for communication, entertainment, and work.

Knowledge Area: Understanding intellectual property rights, privacy issues, and liability in virtual environments, including the legal implications of user-generated content and virtual interactions.

AI and machine learning engineering

Skillset: Basic programming and machine learning skills to understand the development and functioning of AI systems.

Knowledge Area: A hands-on understanding of AI algorithms allows lawyers to assess issues related to bias, transparency, and accountability effectively, enabling them to advocate for fair and responsible AI use in property management.

Cyber-physical systems security

Skillset: Knowledge of cyber-physical systems (CPSs) that integrate computing, networking, and physical processes.

Knowledge Area: Understanding the security vulnerabilities of CPSs in smart buildings is essential for developing legal frameworks that protect against cyber-physical attacks and establishing liability in the event of breaches.

Environmental and climate science

Skillset: Expertise in environmental science and climate change to address the sustainability challenges posed by smart buildings.

Knowledge Area: Lawyers should understand the environmental impact of smart building technologies and develop legal strategies that promote sustainability, compliance with environmental regulations, and support for green initiatives.

Ethical hacking and penetration testing

Skillset: Skills in ethical hacking and penetration testing to identify and mitigate security vulnerabilities in smart building systems.

Knowledge Area: Understanding the legal boundaries of ethical hacking is vital for developing regulations that ensure the security of smart buildings while protecting consumer rights.

Blockchain and smart contracts

Skillset: Proficiency in blockchain technology and the application of smart contracts for automating legal agreements in smart buildings.

Knowledge Area: Lawyers need to understand how blockchain can enhance transparency and security in transactions and operations within smart buildings, including the implications for contract enforcement and dispute resolution.

By developing one or more of these competencies, property lawyers will be well-equipped to address the challenges and opportunities presented by an increasingly dynamic and technologically driven industry.

The future of smart buildings is set to be marked by a new age of intense connectivity, intelligence, and independence. With advancements in AI-powered algorithms, these buildings will not only react to the needs of the people living and working in them but also anticipate and adapt to those needs and changes in their environment.

We expect to see a surge in autonomous systems and robotic assistants within smart buildings, enhancing human capabilities and making operations more efficient in areas like facility management and hospitality. The merging of AI, IoT and robotics will blur the lines between the physical and digital worlds, transforming buildings into dynamic, responsive entities that learn and evolve with the preferences and needs of their occupants. These buildings will essentially become 'living and breathing' cyber-physical systems.

The growing variety of sensor technologies will lead to a seamless integration of buildings into our daily lives. New ways to interact with these smart systems—using sound, voice, or touch—will become commonplace. Future commercial buildings will require diverse services, such as high-definition video, edge computing, and enhanced networking, with 5G-enabled services likely incorporating service robots. Moreover, buildings that generate excess energy may be able to sell that energy back to the grid or to other buildings.

The clustering of smart buildings hints at the development of smart cities, which have adopted information and communication technology (ICT) as a foundational strategy. These cities will embed digital infrastructure and systems into their urban environments, utilising them for both entrepreneurial and regulatory purposes. Scholars have used various terms to describe this evolution, including 'wired cities' (Dutton et al. 1987), 'cyber cities' (Graham and Marvin 1999), 'digital cities' (Ishida and Isbister 2000), 'intelligent cities' (Komninos 2009), 'smart cities' (Hollands 2008), and 'sentient cities' (Shepard 2011). Each term reflects the ongoing transformation of urban spaces through technology.

Conclusion

The integration of AI and the Internet of Things in smart buildings is changing the property sector in significant ways. It promises to improve efficiency, sustainability and the experiences of users. Market trends are pushing these developments, emphasising the importance of connectivity, data insights and environmental responsibility. However, these advancements also bring serious legal challenges, including protecting data privacy and security, navigating complex regulations and safeguarding intellectual property rights. Property lawyers play a crucial role in this evolving landscape, needing to keep up with technological changes and adapt their skills to create strong legal frameworks for smart building transactions.

Looking ahead, the future of smart buildings is full of potential but also complex challenges. The fast pace of technological change requires proactive risk management and the creation of strong legal structures. Lawyers will need to address issues related to liability, ownership of data and the ethical concerns that arise from integrating AI and IoT. Additionally, new technologies like quantum computing and virtual reality will introduce fresh challenges and opportunities that could change the legal landscape in unexpected ways.

As we consider the future, it is clear that AI, IoT, and smart buildings will significantly reshape the property sector. By staying ahead of future developments and building expertise in these technologies, property lawyers can become essential guides in this transformative era. The insights and challenging questions raised in this report aim to prepare legal professionals for the changing landscape, ensuring they remain key players in the advancement of smart buildings.

At the same time, smart cities face the challenge of balancing global capital with local communities, as well as diverse populations and governance structures. The focus on collecting and analysing data from smart buildings for informed policymaking, alongside tech-driven governance, holds the potential for empowering citizens and driving economic growth. However, it also raises important social justice issues. Addressing these challenges will require inclusive engagement processes that acknowledge and reconcile the varied values and priorities of different stakeholders.

The rise of AI and IoT in smart buildings is likely to create new business models and revenue opportunities, encouraging innovation and entrepreneurship within the property sector. Concepts like subscription services, predictive leasing, digital twins and blockchain transactions are just a few examples of the innovations on the horizon. However, these opportunities come with specific legal considerations and challenges that will require property lawyers to engage proactively and strategically to ensure the sustainable and ethical development of smart building technologies.

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