Building Intelligence: Applying Artificial Intelligence to Revolutionise the Built Environment

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Abstract

Buildings account for nearly 40% of the world's greenhouse gas emissions (Global Status Report for Buildings and Construction 2019 – Analysis - IEA) and there is no decarbonising our future without decarbonising buildings. AI has a key role to play in getting to net-zero building operations through efficiency, electrification, and digitalisation. This report by the Sustainable Markets Initiative's Buildings Task Force explores the applications of AI in the built environment, and the principles that need to be upheld to responsibly revolutionise the way we design, construct, use and maintain our buildings.

Introduction

While Artificial Intelligence (AI) has been used in business for decades[1], its widespread adoption in consumer and infrastructure applications is more recent. In 2024, the market for AI in Smart Buildings and Infrastructure is valued at $41.4 billion and is expected to be worth around $359 billion by 2034[2]. This growth is fuelled by advances in core technologies, such as faster processing power and lower data storage costs, that have made AI more scalable and accessible.

Professionals in the built environment are increasingly using AI not just to automate routine tasks but as a collaborative tool throughout the entire building lifecycle, from concept and design to long-term operation and maintenance. By aggregating data across building portfolios, AI enables buildings to respond dynamically to real-time conditions, transforming connectivity and functionality.

The rise of AI in smart buildings is largely driven by the need to boost efficiency and sustainability in the face of rapid urbanisation. AI supports proactive, sustainable building management by reducing energy consumption and maintenance costs, while also enhancing safety and security through advanced surveillance and anomaly detection.

This report aims to serve as a useful source of information for practitioners with regards to relevant AI applications and opportunities for the built environment industry.

Acknowledgements

TRANE TECHNOLOGIES

Johnson Controls

Foster + Partners

[1] Leveraging AI in Business: 3 Real-World Examples

[2] AI in Smart Buildings and Infrastructure Market Size | CAGR of 24%

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AI Definitions and Systems in the Built Environment

Artificial Intelligence (AI) is increasingly permeating the built environment, enabling new ways of designing, constructing, operating, and maintaining buildings. However, its definition and scope are often misunderstood or overly broad. This section clarifies what constitutes AI, the various types and systems associated with it, and their relevance to the built environment.

At its core, AI refers to computer systems capable of performing tasks that traditionally require human intelligence. This includes functions such as learning, reasoning, problem-solving, perception, and language understanding. However, not all software or automation is considered AI.

What *is* classed as AI:

- Systems that can learn from data (e.g., machine learning models predicting energy use).
- Tools that adapt over time without explicit reprogramming (e.g., predictive maintenance systems).
- Generative models that create novel outputs (e.g., floorplans, simulations).
- Intelligent agents that interact autonomously with their environments (e.g., smart heating, ventilation, and air conditioning (HVAC) controllers adjusting based on occupancy).

What *is not* classed as AI:

- Rule-based systems with hardcoded logic (e.g., simple if-then BMS scripts).
- Static dashboards or manual control systems.
- Predefined templates or configurations that lack adaptive capabilities.

The distinction lies in adaptivity and autonomy; true AI systems learn and evolve based on data or environmental feedback.

AI in the Built Environment

Smart buildings apply AI technologies to enable real-time control of systems such as lighting, HVAC, and security, using inputs from IoT sensors, digital twins and external data such as weather data (real-time and predictions), utility tariff structures, and grid emission rates, to continuously optimise building performance. These AI-enabled systems analyse vast and complex datasets to automate tasks, generate predictive insights, and support informed decision-making across all stages of the building lifecycle – from design and construction to operation, maintenance, and eventual decommissioning or reuse. In more advanced implementations, AI has the ability to autonomously control building systems, requiring little to no human supervision to manage and optimise building performance in real time.

AI supports long-term strategic objectives, such as reducing embodied and operational carbon, enhancing resilience, and enabling adaptive reuse and circularity within the built environment.

Types and Categories of AI and Related Systems

To better understand how AI applies to the built environment, we categorise AI into three interconnected layers: 1) core paradigms, 2) deployment models, and 3) domain-specific applications and systems.

1. Core AI paradigms

These are the fundamental models and techniques that underpin AI capabilities.

Category	**Description**
Machine Learning (ML)	Algorithms that learn patterns from data to make predictions or decisions without being explicitly programmed. Subtypes include supervised and unsupervised learning.
Deep Learning (Neural Networks)	A subset of ML that uses multi-layered neural networks to model complex patterns in data. Particularly powerful in image recognition, speech processing, and sensor data analysis.
Generative AI	AI models that create new content, such as images, designs, text, or simulations. Useful in generative design, layout planning, or documentation.
Large Language Models (LLMs)	A class of generative AI trained on vast text datasets to understand and generate human-like language. Used in conversational agents, design documentation, and knowledge retrieval.
Reinforcement Learning (RL)	A type of ML where an agent learns to make sequential decisions by receiving feedback (rewards/penalties) from its environment. Applied in dynamic control systems, such as HVAC optimisation.
Natural Language Processing (NLP)	Enables machines to understand, interpret, and generate human language. Used in voice assistants, chatbots, and querying building data through natural language.
Computer Vision	Allows machines to interpret and process visual data. Commonly used in construction monitoring, people counting, safety inspections, and spatial analytics.
Agentic AI	AI systems designed to autonomously pursue goals and make decisions over time, often interacting with users or environments iteratively. Enables intelligent building agents, adaptive design tools, or operational assistants.
Multi-Agent Systems (MAS) or Self-Organising Agent Networks	Systems composed of multiple autonomous agents that interact, collaborate, or compete to achieve local or global goals. These agents may self-organise, adapt to environmental changes, and coordinate in decentralised ways.

2. AI deployment models & architectures

These define how and where AI is implemented and accessed.

Category	Description
Edge AI / Embedded AI	AI that runs locally on devices (e.g., sensors or controllers) without needing continuous cloud connectivity. Reduces latency and supports real-time responsiveness.
Cloud-Based AI	Centralised models that require connectivity to external servers or platforms. Typically used for complex computation, large-scale analytics, and model training.

3. Domain applications and systems in the built environment

These are components of practical, system-level implementations of AI across the building lifecycle.

Category	Description
Digital Twins	Dynamic, data-driven digital replicas of buildings or infrastructure. Used for simulation, monitoring, and optimisation of performance across the asset lifecycle.
Building Management Systems (BMS) / Building Automation Systems (BAS)	Centralised platforms that monitor and control building systems. Enhanced with AI to optimise energy use, detect faults, and automate responses.
Building Information Modelling (BIM)	A structured digital model of a building's geometry, systems, and data. Becomes AI-enabled when integrated with simulation, analytics, or generative design tools.
IoT Devices	Sensors, meters, and actuators that collect and transmit real-time data. Serve as a data backbone for AI applications such as occupancy sensing, indoor air quality monitoring, and predictive maintenance.
Predictive Maintenance	AI systems that analyse equipment behaviour to predict and pre-empt failures. Reduces downtime and lifecycle costs of building systems.
Construction Automation & Monitoring	Use of AI-driven robotics, drones, and vision systems to track progress, ensure safety compliance, and improve accuracy during the construction phase.
Commissioning & Energy Performance Gap Analysis	AI-enhanced tools that continuously verify system performance and identify discrepancies between design expectations and operational outcomes.
Occupant Interaction Systems	Interfaces like chatbots, voice assistants, and personalised comfort apps that use AI to improve user experience and engagement within buildings.
Virtual Building Engineer/ AI Building Agents	An intelligent, software-based system that uses AI to manage, monitor, and optimise various operations within a building – acting like a digital facilities

Category	Description
	engineer, operating 24/7 with access to telemetry data, workorder and asset information, field service management systems, equipment manuals, parts data, and more.

Interplay of Systems

These systems do not exist in isolation. For instance, AI-powered digital twins rely on BIM data, real-time IoT inputs, and ML models to reflect and predict building performance. BMS systems can become intelligent platforms when integrated with AI that interprets sensor data and automates control. In combination, these technologies support a shift from static, reactive buildings to adaptive, predictive, and performance-optimised environments.

Data as the Foundation

AI's effectiveness in the built environment hinges entirely on the quality and availability of data. Timely, clean, well-organised, and properly tagged data is essential for accurate predictions, meaningful automation, and reliable system behaviour. Yet, this remains one of the greatest challenges in our industry, where siloed systems, inconsistent data standards, and legacy infrastructure often hinder AI integration. Without trustworthy data from sources like BIM, IoT sensors, and BMS, even the most advanced AI models cannot deliver actionable insights or real value.

AI Application Opportunities: Use Cases & Case Studies

Artificial Intelligence is rapidly transforming how buildings are designed, constructed, and operated with a strong emphasis on sustainability. By integrating AI at every phase (from initial design and material selection, through construction management, to ongoing building operations), we can significantly reduce environmental impact, optimise energy efficiency, and extend asset lifecycles.

This section explores practical AI applications that enable smarter decision-making, resource conservation, and enhanced performance, driving the built environment toward a more sustainable and resilient future.

Concept and feasibility

AI to inform decisions that minimise environmental impact from the start:

- Site analysis using geospatial AI to assess solar potential, wind patterns, flood risks, and ecological sensitivity.
- Predictive modelling of carbon footprint, life-cycle costs, and energy performance using historical and real-time data.
- Generative design tools for sustainable site layouts and massing options based on objectives like daylight access or passive ventilation.

Design Phase

AI to create efficient, low-carbon design with minimised energy and material use:

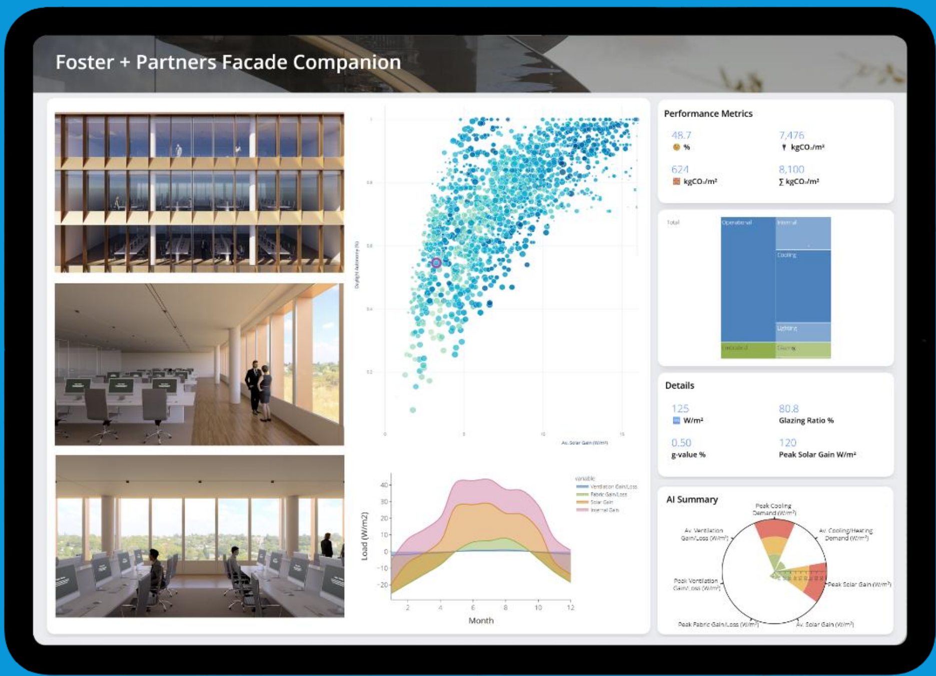
- Generative architecture that optimises materials, energy performance, and daylight use.
- Simulation-driven design using AI to speed up analysis of thermal performance, glare, airflow, and energy demand.
- Material optimisation using AI to select low-carbon, local, or recyclable materials.
- BIM and AI integration for clash detection and efficient systems layout to reduce waste.

Foster + Partners' Façade Companion

AI Visualisation, Data Comprehension, and Analysis

Foster and Partners is a global studio for sustainable architecture, urbanism, engineering and design, founded by Norman Foster in 1967. Foster and Partners' AI driven Façade Companion aims to assist architects to quickly and efficiently make informed design decisions. Façade design has been steered towards performance optimisation, which values 'efficiency' above lifecycle carbon, aesthetic, or economic factors. This narrow approach often produces untenable solutions that might work well in simulations but are practically unachievable.

It is vital to understand the impact that façade design decisions have on aspects of a building – such as embodied carbon, mechanical and electrical design, sustainability certification, environmental performance, natural ventilation, view quality, material specification, natural ventilation, structural engineering, symbolic and aesthetic affect.



The Façade Companion aims to empower architects to make informed decisions on the multidisciplinary impacts of the building design by quantifying design options quickly and efficiently. Projects often contain hundreds to thousands of design combinations that makes it impractical to produce visual renders and calculations for all combinations.

Foster + Partners

The Façade Companion solves this problem through:

1. **AI visualisation and analysis:** to rapidly produce high quality renders on request. Enabling architects to explore and identify the suitability of façade strategies for the orientation, massing, and climate.
2. **Multifactor evaluation:** Considers aspects such as embodied carbon, operational carbon, views out, materiality, aesthetics, climactic suitability, human comfort and heating/cooling loads.
3. **Machine learning:** Identifies trends and important features in successful designs. Using the Façade Companion these trends and characteristics can be projected, visualised and compared.
4. **Real-time data analysis:** Simplifies complex plots and large datasets, communicating them effectively to technical and nontechnical users. This is achieved by using methods that identify the key features that contribute to the success of a design approach.

Pre-construction

AI to reduce embodied carbon and waste before breaking ground:

- AI-driven procurement to select green-certified vendors and materials based on carbon impact or circular economy credentials.
- Smart scheduling to reduce equipment idling and onsite energy use.
- Permitting assistance using AI to ensure sustainability codes (e.g., LEED, BREEAM) are met.

Construction

AI to minimise construction waste, lower fuel consumption, and reduced emissions:

- Computer vision for tracking material usage and waste on-site.
- AI-powered robotics for precision construction and minimising material loss.
- Predictive maintenance of construction equipment to reduce emissions and energy waste.
- Supply chain optimisation for just-in-time delivery to reduce overstocking and spoilage.

Commissioning

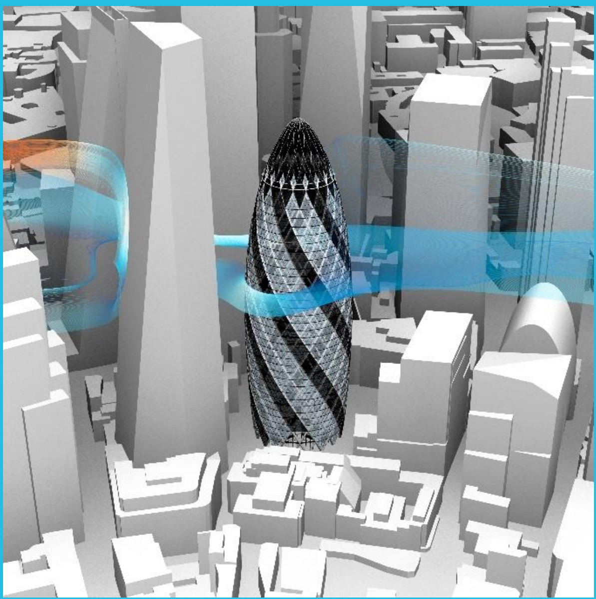
AI to enable smooth handover with sustainable operations built-in from day one:

- Machine learning algorithms to calibrate systems (HVAC, lighting, etc.) for optimal energy use.
- Anomaly detection during test phases to identify inefficiencies or faulty installations early.
- Digital twins to simulate and optimise building operations before occupancy.

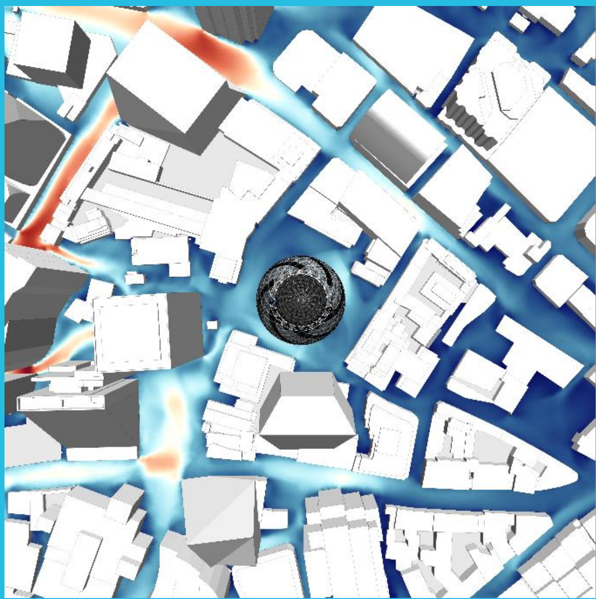
Predictive Computational Fluid Dynamics Analysis

Simulation Driven Design - Predicting Wind Flow for Design

Computational Fluid Dynamics (CFD) simulates air flow around buildings at high resolution, allowing predictions of street-level ventilation and wind comfort. However, the substantial computation time traditional CFD requires is often a bottleneck within the fast pace of concept development. To overcome this, Foster and Partners used a neural network model based on residual Convolutional Neural Networks (CNNs), trained on thousands of CFD simulations, to predict flows in real-time, providing immediate feedback during the early design phase.



CFD airflow around 30 St Mary Axe



AI CFD predicted street level wind speed

AI CFD tools unlock the ability to rapidly test, compare, and optimise architectural concepts without waiting for traditional CFD simulations. This allows architects and urban designers to incorporate wind analysis as part of an interactive design loop - encouraging climate-responsive and performance-driven solutions.

Integrated into common design tools, this AI-powered approach supports creativity, while promoting sustainability, offering an intuitive bridge between environmental analysis and spatial thinking.

Foster + Partners

Autonomous AI technology for commercial HVAC

BrainBox AI helped Dollar Tree save 7,980,916 kWh and $1,028,159 in one year

BrainBox AI, a Canadian climatech firm recently acquired by Trane Technologies in January 2025, has helped Dollar Tree, a Fortune 500American discount retailer, deploy its autonomous HVAC technology in over 600 stores across 18 US states with a focus on energy optimisation and carbon emissions reduction[3].

By leveraging the seamless integration of on-premises servers with the cloud, BrainBox AI rapidly scaled its deployment without additional Capex investments.

Within just two months, 400 sites were live and operating autonomously. Each piece of HVAC equipment was precisely labelled with industry-standard nomenclature, while BrainBox AI's extensive algorithm library was virtually tested at every store to select the optimal configuration for maximum performance.

Powered by the data extracted from Dollar Tree's BMS, combined with external data sets such as weather forecasts, BrainBox AI's autonomous HVAC optimisation solution effectively transformed energy usage patterns across hundreds of its stores. This resulted in reduced energy consumption, portfolio-wide visibility, and greater data-driven decision-making, reducing unnecessary technician dispatches and saving thousands per avoided trip.

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[3] Dollar Tree unlocks major energy and emissions savings with BrainBox AI

Operations and Maintenance

AI for long-term reductions in operational carbon and energy costs:

- Predictive energy management using AI and IoT sensors to optimise HVAC, lighting, and equipment use in real-time.
- Smart maintenance predicting when systems need service to extend life and reduce downtime.
- Occupant behaviour analysis to fine-tune energy and resource consumption.
- AI-powered BMS for continuous learning and automated sustainability improvements.

ARIA

BrainBox AI, a Trane Technologies company, recently launched the Virtual Building Engineer (powered by Generative AI), ARIA[4]. ARIA harnesses the power of advanced large language models (LLMs) and draws on data from across an entire building portfolio to give facility management teams immediate access to critical insights – via conversational interactions, similar to technologies such as ChatGPT.

ARIA has been expertly trained on countless scenarios and vast amounts of data specifically related to HVAC equipment, building management systems, and any external sources that may affect a building's energy and emissions. Additionally, it has access to the most recent data available on the internet.

This fusion allows ARIA to offer real-time, AI-driven insights on energy and emissions alongside advanced conversational and information retrieval features.

- **Reporting:** ARIA lets you instantly access, download, and share your building's data.
- **Fault detection & diagnostics:** ARIA pinpoints issues, identifies root causes, prioritises repairs, and minimises downtime.
- **Building control & execution:** Assign ARIA simple building management tasks like adjusting your HVAC schedules and setpoints.
- **Data visualisation:** ARIA pulls from your live dashboards to help you better understand your building's data.
- **Decision-making:** ARIA provides real-time insights and recommendations for smarter building decisions.
- **Predictive maintenance:** ARIA prioritises your alarms and sends them straight to you, allowing you to anticipate future problems.

ARIA grows more intuitive with each interaction, meaning the more you use it, the better it gets at forecasting your needs, pre-empting maintenance or equipment issues, and suggesting optimisations.

[4] ARIA: Your building AI Engineer

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Central Utility Plant Optimisation

Central Utility Plant Optimisation (CUPO) is an AI solution to automatically optimise and dispatch equipment in central utility plants. Using data-driven models and mathematical programming, the algorithm determines the set of equipment and corresponding operating points that meet current loads at minimum cost or energy consumption. These decisions can then be displayed to plant operators for advisory purposes, or they can automatically be sent to the BMS for implementation. This process is repeated every 15 minutes to ensure maximum system efficiency in response to changing conditions.

The main benefit of CUPO is that it can account for thousands of data points simultaneously while making its decisions. Some of the key trade-offs are as follows:

- How individual equipment efficiency varies with load and weather
- How downstream equipment is impacted by upstream equipment
- How energy use of primary equipment (e.g., chillers and boilers) balances with that of auxiliary equipment (e.g., cooling towers and pumps)
- How equipment switching must be limited to avoid stability problems
- How thermal energy storage tanks can be used to decouple production and consumption
- How peak demand charges compare to time-varying use charges for electricity

Especially in complex plants where human operators can't account for every variable, AI can improve performance by reducing energy consumption and cost, reducing equipment wear due to consistent operation, and improving operator productivity provided by automated dispatches.

Johnson Controls' OpenBlue CUPO solution[5]: University Campus (US)

Johnson Controls' OpenBlue CUPO solution[1] was installed to manage a new state-of-the-art central energy facility on a university campus in the United States. Replacing an aging fossil-fuel-based combined heat and power plant, the new facility uses grid-sourced electricity to produce hot and chilled water, including large heat-recovery heat pumps and thermal energy storage for both hot and cold water. The optimisation solution managed the complex trade-offs imposed by time-varying loads and utility prices, providing better and more consistent outcomes compared to manual operation.

Results:

- $500,000 per year (10%) in cost savings
- 17% reduction in peak energy demand
- 68% reduction in campus greenhouse gas emissions
- 15% reduction in domestic water use

[5] OpenBlue Central Utility Plant | Johnson Controls

Johnson Controls

Data Centre (UK)

Johnson Controls' OpenBlue CUPO was added on top of an already well-tuned cooling system serving a large data centre in the United Kingdom. The system includes five sub-plants (each with a chiller, cooling tower, and heat exchanger) serving four data halls, and it must be air-gapped to meet privacy and cybersecurity requirements. The optimisation solution was able to maintain operational stability and automated dispatch for the cooling system while also reducing energy use.

Results:

- £38,000 in annual energy cost savings
- 10% improvement in Power Usage Effectiveness (PUE), a comparison of total energy used to the energy used by computing equipment in a data centre
- 350,000 kWh reduced annual energy use
- 8% improvement in plant efficiency

Hospital (US)

Johnson Controls' OpenBlue CUPO solution was deployed alongside upgraded chillers, controls, and building automation system at a hospital in the United States. Uninterrupted supply of hot and chilled water is critical for patient care, so reliability is key. By optimising chiller utilisation and automating dispatch, the solution provided greater peace of mind with reduced system downtime and fewer unexpected repairs.

Results:

- $681,000 per year in cost savings
- 69% reduction in natural gas usage
- Enhanced decision-making and resource management

Johnson Controls

Renovation and End of Life

AI for circular construction and extending building life responsibly:

- Building diagnostics to determine whether retrofitting or reuse is more sustainable.
- Material tracking with AI to identify components for reuse or recycling (circular economy).
- Deconstruction planning using AI to minimise demolition waste and maximise salvageable materials.

Barriers to development and deployment of AI

While AI offers transformative potential in the built environment by enabling significant energy and emissions reductions (between 20-40% according to Smart Building International[6]), its practical deployment is often hindered by a range of challenges across technical infrastructure like interoperability of systems, high compliance, and lack of data standardisation. Addressing these barriers is essential to unlocking the full benefits of AI across the building lifecycle.

Data and Infrastructure Challenges

Availability and standardisation of data

The lack of standardised data formats and ontologies across systems significantly limits AI interoperability. AI solutions often require data normalisation and mapping before use, which is time-consuming and prone to error. Initiatives like Project Haystack[7] and BRICK Schema[8] aim to create standardised and consistent semantic models for building data, but industry-wide adoption is still limited.

BMS readiness

Advanced AI-based solutions in buildings require high-quality data from sensors (e.g., flow and energy meters, occupancy detectors), but many sites skip installing these sensors during construction to reduce costs. Even when sensors are installed, they may not be mapped in the BMS, or have historical data logged. Ensuring sensors are installed, mapped, trended and integrated at new sites is key to unlock the full benefits of AI.

Energy demand of AI and data centres

While AI is often deployed to improve energy efficiency within buildings, its own computational infrastructure can significantly increase global energy consumption. Data centres currently account for roughly 1.5% of global electricity use (around 415 TWh in 2024), and are projected to nearly double to about 945 TWh by 2030[9]. Energy efficient solutions are necessary. Cooling data centres can consume some 50% of data centre energy. Technologies like Johnson Controls' YVAM chiller are changing that, delivering cooling with 40% less energy needed and zero water consumption. If these technologies are paired with low-carbon and renewable energy systems, AI can scale sustainably.

[6] AI Adoption Slowed by EU Smart Building Regulations | Smart Building International
[7] Project Haystack
[8] Brick: A Uniform Metadata Schema for Buildings
[9] Energy demand from AI – Energy and AI – Analysis - IEA

Operational and Human Factors

Skilled Labour Shortages and User Acceptance

There is a gap between AI system capabilities and the skill sets of typical facilities personnel. Without adequate training and change management, even the best AI solutions can be underutilised or misused. Bridging this gap requires investment in upskilling, as well as designing AI interfaces that are intuitive and user-friendly.

Integration and Governance

System Integration and Legacy Infrastructure

AI implementation often requires seamless integration with existing BMS, BIM, or IoT systems. However, buildings typically operate a mix of legacy and modern technologies, making interoperability a key barrier. Standardised APIs, open-source middleware, and modular AI architectures can help reduce friction in integration.

Ethics, Bias, and Governance

As AI begins to influence critical decisions, such as energy allocation, comfort optimisation, or predictive maintenance. It raises ethical concerns around bias, accountability, and decision-making authority. Questions arise, such as: Who is responsible if an AI-driven system fails? How do we ensure algorithms do not favour certain users or outcomes unintentionally?

Policy and Regulation

As Artificial Intelligence becomes increasingly embedded in the built environment infrastructure across the EU, several laws establish requirements to ensure the safety and accountability of AI systems. These include distinct categories of obligations: product liability regulations such as the EU Product Liability Directive; cybersecurity frameworks like the EU Cybersecurity Act and the Cyber Resilience Act, which aim to protect AI and IoT systems in buildings from digital threats; and data privacy rules under the EU General Data Protection Regulation (GDPR), which impose transparency requirements and mandate clear communication about how AI systems process data or when AI is being used. While this robust existing legal framework ensures comprehensive oversight, it also results in high compliance costs. The introduction of additional AI-specific legislation at the EU level may further contribute to regulatory uncertainty.

European Union

The European Union has taken a leading role in establishing a legal framework for AI through the EU Artificial Intelligence Act (Regulation (EU) 2024/1689), the world's first comprehensive regulation on AI. Provisionally agreed upon in 2024 and expected to come into force gradually by 2026, it classifies AI systems by risk level and imposes obligations accordingly, with the strictest controls placed on high-risk and unacceptable-use applications. The four risk levels established are:

- **Unacceptable risk**: banned outright (e.g., real-time biometric surveillance in public spaces).
- **High risk:** stringent requirements—transparency, human oversight, conformity assessments, record-keeping (e.g., AI in critical infrastructure, workplace safety).
- **Limited risk**: transparency obligations, such as informing users when interacting with AI-generated content.
- **Minimal risk**: largely unregulated.
    - Includes specific rules for general-purpose AI (GPAI); transparency for open-source models, additional evaluations for high-capability systems.
    - Non-compliance can result in hefty penalties: up to €35 million or 7% of global turnover.
    - Enforcement is via a new governance structure including the European Artificial Intelligence Board and national authorities.

This includes AI used in critical infrastructure, biometric surveillance, and employment decisions. The Act includes mandatory transparency, data governance, and human oversight requirements, backed by enforceable penalties. It sets a global benchmark and is already influencing policy debates in other regions.

- **European AI Office:** established to supervise GPAI compliance, including via a Code of Practice for transparency, copyright, and safety (published July 2025). GPAI obligations begin on 2 August 2025, with enforcement set to start 2 August 2026; models released before August 2025 must comply by August 2027.

High-Risk AI providers must conduct risk assessments at EU level, maintain documentation, conformity testing and human oversight regulations. EU think thanks including CEPS and Bruegel estimate that these requirements could lead to estimated cost increases of 17% to 25% for companies developing high-risk AI systems.

Overall, the EU AI Act has drawn both praise and criticism. Consequently, the EU is currently reviewing its AI policy and will seek to better integrate AI data and cybersecurity policies in a streamlined approach to be addressed in an upcoming AI omnibus.

United States

The United States have opted for a lighter touch approach.

U.S. AI governance continues to rely heavily on voluntary guidelines and agency-specific oversight, such as the National Institute of Standards and Technology's (NIST) AI Risk Management Framework and the Federal Trade Commission's role in regulating deceptive AI practices. Some states (e.g., California and Illinois) have begun implementing their own rules for AI and automated decision-making.

Canada

In Canada, there have been a number of voluntary initiatives to promote safe and responsible AI, notably the Voluntary Code of Conduct on the Responsible Development and Management of Advanced Generative AI Systems, released in 2023.

Recommendations

To fully realise AI's potential in the built environment, coordinated action is required across technical, operational, and regulatory domains. We recommend the following priorities to overcome current challenges and accelerate responsible AI adoption:

Adopt Responsible AI Principles

By embedding transparency, privacy, security, fairness, and accountability into AI programs, organisations can innovate responsibly and sustainably in a rapidly evolving landscape. For users to adopt and rely on AI responsibly:

- They must **trust** that the system is fair, secure, and transparent.
- They need **control** over their data and decisions.
- They deserve **accountability** from the humans and organisations behind AI to protect privacy and maintain robust security.
- And they benefit from **ethical and responsible design** that respects both utility and individual dignity.

AI should be continuously monitored and improved through regular audit of performance, security, and ethical impact.

Use AI for Supervisory Control and FDD

Most equipment in buildings is operated by dedicated controllers, each with a clear responsibility and a means to achieve it. Thus, instead of replacing the low-level controls, AI systems should supervise control systems by optimising setpoints or making configuration changes. This structure allows the AI to focus on higher-level objectives and ensures that the building can continue to operate (albeit less efficiently) if connection to the AI is interrupted or needs to be temporarily disabled. Interfacing with existing setpoints also improves scalability for these solutions.

Apply Agentic AI to Improve Productivity

Although not a panacea, generative AI does provide a new opportunity to connect disparate systems and automate manual tasks. By building multiple agents, each specialising in a specific set of tasks or systems, these capabilities can be made available to users as an intuitive natural-language interface. For example, a building manager might ask why a particular room is too hot. In response to that question, an FDD agent could assess recent rule-based faults to find the cause, a service manager agent could automatically create a work order to fix the malfunctioning equipment, and a BMS agent could temporarily override that zone's setpoint to minimise impact on nearby rooms.

Select the Right Algorithms and Prioritise Data-Efficiency

Clearly AI holds great promise to decarbonize buildings and drive sustainability in the built environment. Of course, as with all AI applications, choosing the right model is important to achieve desired outcome at minimum energy consumption and cost. Beyond model simplicity, investing in data-efficient AI techniques can further reduce environmental impact. One promising approach is the use of Neural Ordinary Differential Equations (Neural ODEs)[10]. Neural ODEs combine neural networks with the structure of traditional differential equations, enabling models to learn system dynamics over time using far less data.

Enabling Conditions for AI Integration in Buildings

To support the widespread integration of AI in buildings, public funding and industry actions are essential. Governments should incentivise smart retrofitting through grants or tax incentives that promote the adoption of AI-driven energy and performance upgrades, particularly in older or underperforming buildings. Building sector professionals also require targeted upskilling programs to ensure the workforce is equipped with the knowledge and skills necessary to work effectively with emerging AI technologies.

To build trust and accountability, it is critical that AI systems used in building operations adhere to minimum explainability standards, making their decision-making processes transparent to stakeholders. In parallel, regulatory sandboxes should be established to allow AI tools to be tested in live environments under controlled conditions – creating space for innovation while generating insights that can inform future regulation and best practices.

[10] Neural ODEs: Pioneering AI predictions for buildings

Conclusion

In recent years, Artificial Intelligence has evidenced its potential applications in the built environment, and is poised to enable significant improvements in service processes, industry productivity and business operations.

The built environment is characterised by complex, interconnected systems and evolving operational demands. AI technologies offer powerful tools to address several persistent industry challenges:

- **Complexity management**: AI can optimise across multiple interdependent systems (HVAC, lighting, occupancy) simultaneously.
- **Risk reduction**: AI can forecast equipment failure, enabling predictive maintenance and reducing unplanned downtime.
- **Waste reduction**: through pattern recognition, AI minimises material waste in construction planning and operations.
- **Budget & schedule control**: AI-enabled project analytics improve cost forecasting and flag potential delays earlier.
- **Labour deficits**: AI supports automation of routine monitoring and reporting, allowing skilled labour to focus on high-value tasks.

As leaders and practitioners in the built environment, members of the Sustainable Markets Initiative Buildings Task Force are uniquely positioned to shape how AI is adopted and applied across the industry. To harness AI's potential responsibly and effectively, the Sustainable Markets Initiative Buildings Task Force endeavours to:

- Champion ethical and transparent AI practices that prioritise safety, privacy, and sustainability.
- Invest in capacity building, ensuring teams are equipped with the knowledge and skills to use AI tools wisely.
- Collaborate across disciplines and organisations to share best practices, align on standards, and ensure interoperability.

References

1. Leveraging AI in Business: 3 Real-World Examples
2. AI in Smart Buildings and Infrastructure Market Size | CAGR of 24%
3. Dollar Tree unlocks major energy and emissions savings with BrainBox AI
4. ARIA: Your building AI Engineer
5. OpenBlue Central Utility Plant | Johnson Controls
6. AI Adoption Slowed by EU Smart Building Regulations | Smart Building International
7. Project Haystack
8. Brick: A Uniform Metadata Schema for Buildings
9. Energy demand from AI – Energy and AI – Analysis - IEA
10. Neural ODEs: Pioneering AI predictions for buildings

Glossary of terms

Agentic AI: AI systems that operate autonomously, take initiative, and pursue goals with minimal human input.

APIs (Application Programming Interfaces): Protocols that allow different software applications to communicate and share data or functionality.

Artificial Intelligence (AI): A broad field focused on creating machines capable of tasks requiring human-like intelligence, such as learning and decision-making.

BREEAM (Building Research Establishment Environmental Assessment Method): A method for assessing, rating, and certifying the sustainability of buildings.

Building Energy Management Systems (BEMS): Systems that monitor and optimise a building's energy use, often integrated with BMS.

Building Information Modelling (BIM): A digital representation of a building's features, used across its lifecycle for design, construction, and management.

Building Management Systems (BMS) / Building Automation Systems (BAS): Centralised systems that control and monitor building services like HVAC, lighting, and security.

Central Utility Plant Optimisation (CUPO): The use of AI or analytics to improve efficiency in central heating, cooling, and power systems.

Computational Fluid Dynamics (CFD): Simulation methods used to model airflow, temperature, and fluid dynamics in buildings.

Computer Vision: A subfield of AI focused on interpreting visual information from images or video.

Convolutional Neural Networks (CNNs): A deep learning model especially effective in processing visual data.

Data Protection Impact Assessments (DPIAs): Assessments that identify and mitigate privacy risks in systems that process personal data.

Deep Learning (Neural Networks): A machine learning approach using multi-layered networks to learn from complex data sets.

Energy Performance of Buildings Directive (EPBD): EU legislation aimed at improving energy efficiency and promoting NZEB standards.

FDD (Fault Detection and Diagnostics): Systems that detect and diagnose faults in building operations to improve performance.

General-Purpose AI (GPAI): AI systems designed to perform a wide range of tasks rather than being application-specific.

Generative Adversarial Network (GAN): A model where two neural networks compete to generate realistic synthetic data.

Generative AI: AI that creates new content (text, images, etc.) from learned data patterns.

GPUs (Graphics Processing Units): Hardware that accelerates AI computations by processing large data in parallel.

Heating, Ventilation, and Air Conditioning (HVAC): Systems that regulate indoor temperature, air quality, and airflow.

IoT Devices (Internet of Things Devices): Internet-connected devices embedded with sensors for data collection and automation.

Large Language Models (LLMs): AI models trained on vast text data to generate or understand human language.

LEED (Leadership in Energy and Environmental Design): A global certification program for assessing sustainable building practices.

Machine Learning (ML): A type of AI where systems improve their performance based on data, without explicit programming.

Multi-Agent Systems (MAS): Decentralised systems with multiple autonomous agents collaborating to solve problems.

National Institute of Standards and Technology (NIST): U.S. agency that develops standards for technology, cybersecurity, and AI.

Natural Language Processing (NLP): AI methods that help machines understand, interpret, and generate human language.

Neural Ordinary Differential Equations (Neural ODEs): AI models that use differential equations to represent continuous changes in dynamic systems.

NZEB Standards (Nearly Zero-Energy Building): Building codes requiring very low energy use, offset by renewable energy.

PUE (Power Usage Effectiveness): A measure of data centre efficiency, calculated as total energy divided by energy used by IT equipment.

Reinforcement Learning (RL): A learning method where an agent improves performance through trial and error, guided by rewards.

Sustainable
Markets
Initiative

About the Sustainable Markets Initiative (SMI)

Founded by His Majesty King Charles III, then The Prince of Wales, in 2020, the Sustainable Markets Initiative is seen as the world's 'go-to' private sector organisation for sustainable transition. Its ten year mandate (2020-2030), the Terra Carta, provides an ambitious roadmap for the private sector to accelerate a sustainable future. In 2023, the SMI launched the complementary Astra Carta which seeks to ensure the sustainability of the growing space economy, including leveraging space-based technologies to improve sustainability on Earth.

The Sustainable Markets Initiative is a unique global CEO-led network focused on actionable delivery. It operates across 20+ real economy industries and financial services communities as well as at country and regional councils. Recognising the interdependencies for transition and supply chains across industries and borders, the SMI enables CEO action through global cross cutting Pathfinders and Lighthouse Projects.

About the SMI Sustainable Buildings Task Force

The Sustainable Buildings Task Force, one of its Industry Transition Hubs, is comprised of global CEOs from throughout the buildings industry working together to accelerate the delivery of net zero buildings. The Sustainable Buildings Task Force supports the overall SMI mission to speed the world's transition to a sustainable future by engaging and challenging public, private, and philanthropic sectors to bring economic value, in harmony with social and environmental sustainability.

The SMI Sustainable Buildings Task Force recognises its role in accelerating the delivery of sustainable buildings that reduce operating costs and create long-term commercial value. Together, the members are united by a common ambition to harness the power of technology and drive partnerships and policy decisions that enable the adoption of sustainable building solutions and promote a more efficient, cost-effective built environment.