LTIMindtree

Whitepaper

Smart Spaces:
IoT-led Smart Building Transformation

Table of Contents

1. Synopsis

1.1 Smart Buildings

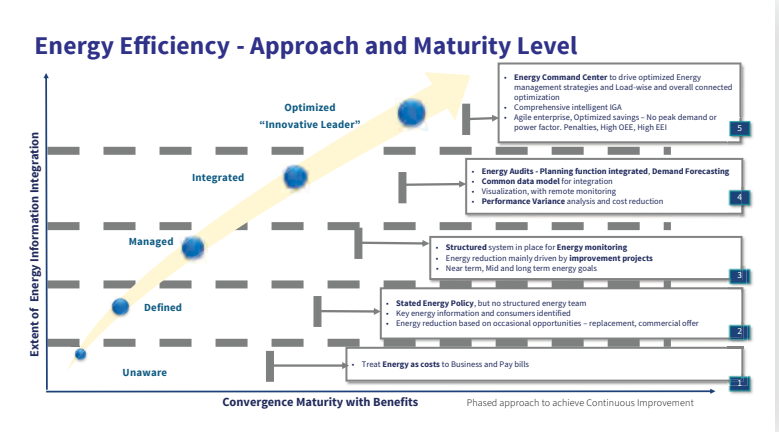
For years, advancements in building science have been focused on the physical and tangible aspects, such as architectural aesthetics, structural integrity, mechanical components, and building materials. Though these factors shall be permanently constant, there are new benchmarks when it comes to creating modern structures that will perform to greater standards and expectations. Nowadays, a building's digital infrastructure—the embedded information and operational technology network that powers its daily functions—holds as much importance as its physical infrastructure.

For the past two to three decades, digital transformation has been revolutionizing buildings, much like it has transformed several aspects of human experience in the past. The current era is inclined towards sustainably designed, digitally enabled buildings with intelligence that deliver operational excellence and unrivaled user experience.

However, the definition of smart buildings has been changing over the years. With the continuous refinement, history, current digital transformation, futuristic intelligence, and smart buildings can be characterized by the inbuilt robust and resilient digital infrastructure to connect seamlessly to their sensors, assets, systems, and people. It dynamically processes operational data to provide greater insights and intuitive experiences to various personas, thereby constantly learning and adapting to dynamic stimuli from various systems and sources that are both internal and external.

2. Significance of Total Digital Transformation in Today's Buildings

Many MNCs, industries, and infrastructure and property management companies have a strong commitment towards Sustainable Development Goals (SDG) goals, tackling climate change, and implementing environmental initiatives that address the main impact areas in carbon management such as CSR goals for efficient energy and water conservation, waste management, and decarbonization and sustainability measures to reduce negative impact on the environment.



Organizations are at different maturity levels in terms of realizing total building performance and sustainability in their transition towards a low-carbon economy. In terms of evolving smart building technology, there is a need to find the scope and means to leverage operational excellence of facilities and connected buildings with a holistic vision, and enhance occupant experience and well-being at all times, to realize organization-wide sustainability goals.

2.2 Market Prospects

The smart building market space has gained momentum with the global urge towards sustainable development in buildings, as they are major consumers of energy, water, and other resources, major sources of emissions and effluents posing global challenges of climate change, pollution, pandemics, etc.

Fortune Business Insights' report classifies the Smart building market across industries based on key criteria, with the market being bifurcated into solutions and services components. The Smart building market is also segmented by application into residential, commercial, and industrial categories. In terms of solutions, the building infrastructure management sub-segment accounted for a 32.9% share in 2020. This is attributable to rising challenges in maintaining large commercial buildings at operational cost, including parking, smart water management systems, elevators and escalators. As a result of these factors, it is anticipated that the segment will experience growth in the upcoming years. The market is segmented into North America, Europe, Asia Pacific, the Middle East and Africa, and Latin America based on its geographical presence. Investments in green building projects are expected to drive the dominance of North America in the market. Due to the growing population in India and China, Asia Pacific is expected to hold a substantial market share. Furthermore, the market is expected to flourish due to the swift urbanization and increasing infrastructure development in the region.

It is estimated that the smart building market will grow to USD 265 billion by 2028.

2.3 Business Challenges of Today's Campuses

Buildings and superstructures across different geographies and industries are constructed at different times, with varied objectives, needs, principles, and technologies that keep evolving. With myriad facilities, sub-systems, assets, edge components, and technologies, it is incumbent to converge them as connected facilities to operate at benchmarked indices.

- Total building performance, energy and water efficiency, and sustainability: There is a need for a single system to monitor the total building performance and facility-wide sustainability quotients, apart from an integrated platform to monitor the performance and control all the sub-systems of the building, without the need to switch over to different Building Management Systems (BMS), local Human Machine Interfaces (HMIs), etc.
- Central unified system at enterprise level: At the enterprise level, organizations lack an eagle-eye view of all the facilities across the country and globe for planning and ESG reporting.
- Decentralized decisions - Systems thinking: There is a need for all the facilities, systems, sub-systems, assets, and processes to be intelligent and autonomous to deliver optimal asset-level,

plant-level, building-level, and enterprise-level efficiency. There is a strong need for optimization from every asset's level to the overall system in order to positively impact the operation cost, downtime, maintenance expenditures, and planned Opex costs with inter-connected operations.

3. The IoT Way to Future-ready Smart Buildings

Living Building: In simple words, it is a building that is adaptive, learning, ever-transforming with intelligence responds to dynamic system changes at optimal efficiency, and takes care of occupants' health and safety, all on its own.

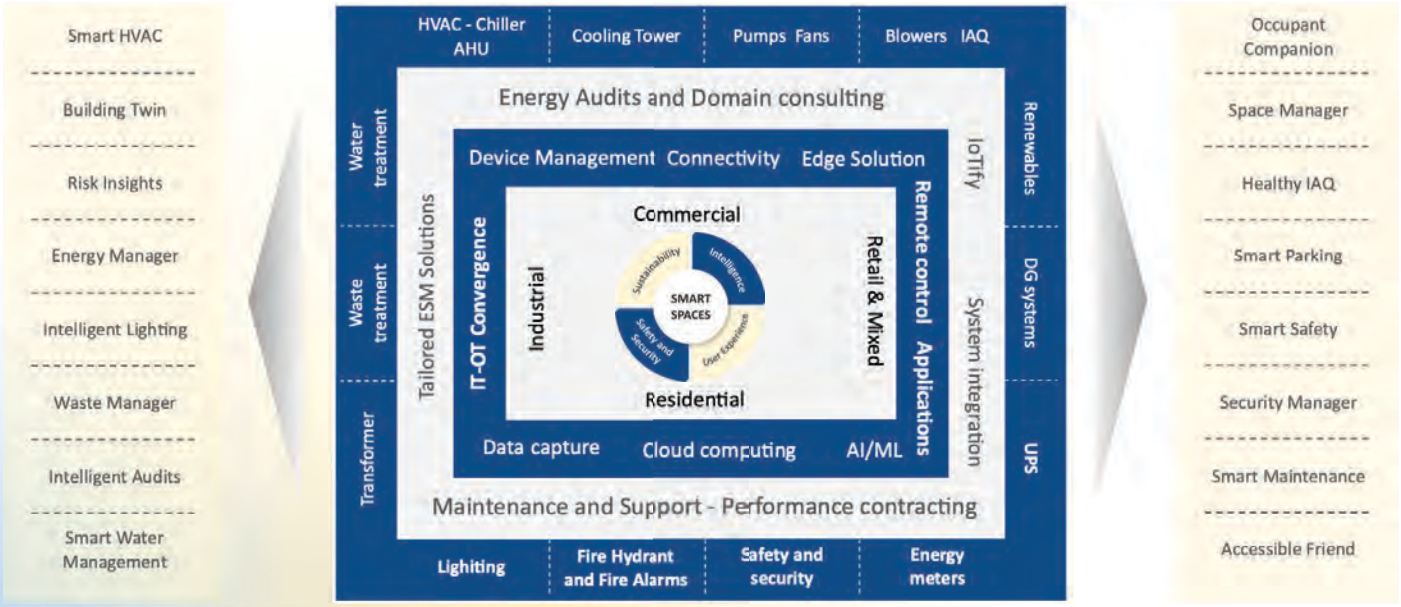
According to Global Market Insights, the global smart building market was valued at USD 67.6 billion in 2021 and is expected to grow to USD 328.62 billion by 2029, while exhibiting a CAGR of 22.2% between 2021 with 2029.

3.1 Towards a New Building Transformation Journey

A broad spectrum of today's automated buildings lies mostly in a semi-transformed state with local intelligence of facility-level monitoring and controls that are in silos. A smart building refers to a space or construction that automatically regulates a building's operations while ensuring occupants' safety and comfort. IoT-driven building management systems, augmented reality, and artificial intelligence are some of the mechanisms that are used in a smart building to achieve two major objectives - operational excellence and enhanced user experience and safety. These connected buildings help different personas, viz., building owners, operators, facility managers, CSR leads, and property managers, to improve asset reliability and performance, reduce energy consumption, optimize space, and minimize the environmental impact of buildings.

To achieve an autonomous, transformed, and sustainable state, not limited to understanding just assets and building systems, the smart building should act as a Digital Twin of the built environment ecosystem, designed with complex interactions – from assets, processes, events, people, places, and things to their very relationships. The system should make the ecosystem more agile and capable to respond to real-time changes, break down silos of discrete devices and business systems, and provide a centralized view.

The solution should be customer-centric to cater to the utmost business needs in every dimension, with a domain-rich database that powers robust ML engines to control integrated building operations at optimal performance and deliver an intuitive user experience. The IoT-driven solution must bring buildings to life with intelligence, inter-connected operations with a central brain, act at the edge, and deliver optimal efficiency and enhanced user experience. It should provide central insights to all personas, and the required information in a consumable manner for informed decisions and efficient operations.



A smart building solution should be built on the four core values of sustainability, intelligence, safety and security, and user experience. It must cater to different customer categories, viz., commercial (office, institutions, healthcare, etc.), industrial (shopfloors, factories, warehouses, etc.), residential and retail, and mixed developments. The architecture should be scalable and robust, encompassing all available IT-OT convergences. It must ensure device management with connectivity to field sensors, PLCs, BMS, legacy systems, BIM, controllers, HMIs, industrial gateways and edge controllers, onboarding assets, data acquisition and processing, analytics, AI/ML, and visualizations, and report to the end user. Above all, the domain rule engines that power up all the layers to make the solution future-proof have to be considered. This can be channelized by leveraging industrial knowledge with Greenmark practices and international building codes at each and every unit of the entire system. Understanding global SDG goals, transforming them into organizations' energy policies, and conducting initial to investment-grade audits to come up with an end-to-end solution can be the holistic approach.

3.2 Smart Building Components

Smart building solutions can be classified into three broad categories based on their impact zones, namely energy and cost optimization, enhanced user experience, and type of vertical. Solutions can be curated for each category and built upon the core framework, depending on the impact.

Smart Spaces and components

- LTI Smart Campus program's vision is to modernize the campus experience while leveraging it to drive Energy and operational efficiency
- Bringing all functional, operational systems, and, business analytics into one platform with next-gen technologies
- Key focal point is to deliver an amazing, intuitive user experience that is innate and persona-centric
- The solution is built to be Modular, adaptive, Flexible and intelligent
- In a broad horizon, we have classified the solution into 3 components based on the user group and services as Smart Facility, Smart Habitat, Smart Factory.

Smart Facility

Enabling Intelligent Building Systems that are connected and operate at optimal Energy Efficiency, ensuring highest reliability with real-time monitoring and advanced analytics

Smart Habitat

Transforming User experience to serve the needs of today's and tomorrow's campuses. It can improve three important factors: experience, efficiency, and productivity.

Smart Industry

With the advent of Industry 4.0, design of future-proof solution visualize and realize the automated processes, monitor, optimize and initiate workflows and offer many more innovative practices that digital natives are accustomed to.

3.3 Empowering Users with Actionable Insights and Operational Excellence:

In order to deeply understand intricately built environments, digital replicas of these environments are created – essentially, building digital twins. This can be an immersive model of the space or simply a powerful digital representation of various assets, processes, people, events, and their interactions. IoT platforms enable the capacity to combine both physical and digital worlds together, accelerating building and business transformation that leverages an intuitive user experience.

It is reported that a majority of solution providers with a digital twin strategy perceive it as an integral part of their smart building IoT framework. In practical scenarios, modeling an entire built environ-ment ecosystem is complex and challenging as it would involve consolidating all the aspects. Howev-er, smart building solutions of today have powerful applications that combine siloed data across built environments that bring the twin models to life, and deliver actionable insights. With IoT enabling the entire lifecycle, the building blocks of a holistic smart building solution can be created, with each functional unit as an integrated feature. It is required and desirable that these key building blocks are part of the smart building solution.

Global insights

A central unified system at an enterprise level that provides global insights of all the properties across geographies, equipping leaders in terms of goal setting, measuring and controlling the progress towards these goals, planning and effectiveness, and ensuring decentralized decisions and systems thinking at every level. This dashboard provides an eagle-eye view of all the connected smart facilities to monitor, track, control, plan organization-wide sustainability and energy goals. Being aligned to global Sustainable Development Goals would be a quintessential component

Sustainability insights:

With sustainability being the core, the performance of all connected buildings across the globe needs to be monitored with respect to primary factors such as energy efficiency and savings, carbon footprint, green power quotient, water balance, waste management, and Reduce-Reuse-Recycle practices, which are aligned to organizations' sustainability, energy, and global Sustainable Development Goals. Apart from this, tracking air and water quality, emissions and effluent control, and CSR health and respective carbon sequestration helps in keeping up with compliances.

Building specific insights:

A facility-wide command center acting as a single system to monitor, track, and control the total building performance and sustainability at site, with an integrated platform to monitor the performance and control all the sub-systems of the building without the need to switch over to different BMS, local HMIs, other individual systems, etc. The definition, design of control, and inter-connected operations positively impacts the operation cost, downtime, maintenance expenditures, and planned operational expenditure.

Energy management system:

Energy management across all industries is an evergreen requirement and challenge for sustained optimization. Thus, a smart building's primary requirement would be ensuring a standalone console of the entire energy management in the load and supply side, and block and floor level consumption, providing actionable Insights with configurable trends, historical data, and analytics.

It shall provide an overview of the health of power sources and backup systems with performance metrics like Diesel Generator Health and UPS Performance. It also provides the metrics of on-site renewables such as rooftop solar plants, green power purchased, and the overall energy consumption trends, energy savings realized, demand forecast, and alerts and notification systems

HVAC Management:

HVAC systems are the most critical, complex, and omnipresent building assets that are major consumers of energy in buildings. A Smart HVAC management system encompasses the management, optimization of cooling or heating systems, and all mechanical ventilations at the building, apart from providing insights on individual system performance viz. chiller plant efficiency, chilled water and condenser water pumps performance, cooling tower, energy consumed, cooling load demand and forecast, powered by ML engines.

Smart Safety and Security:

Managing safety and security in a building's perimeters is not only a need from Facilities to safeguard occupants, but a compliance. Hence, it is an essential component that overlaps in the segments of efficient operations and user experience. Safety and security metrics can be monitored, analyzed, and alerts can be provided in near real-time for better risk insights.

Asset Performance & Smart Maintenance:

Modern buildings are not just structures but complexes with interconnected operations of their assets like chillers, air handlers, blowers, diesel generators, power back-up systems, fire hydrant systems, and many more. Optimal building performance can be achieved by optimizing all of these systems. Hence, smart buildings require central platforms for monitoring, tracking, and optimizing the performance of all their connected assets. Adding to that, AI/ML models with domain-enriched rule engines can aid predictive analytics at asset and plant level, with a profound database of maintenance planning, operational data, and technical factors. This helps predict the Remaining Useful Life and Health Index of assets and plants. Furthermore, integration with alerts and notification systems will enhance operations.

Water Management:

Smart building solutions need to ensure positive water balance by monitoring water consumption across every load, optimizing water usage and efficiency through water-efficient fittings, metering, leak management, and managing the quality

Waste Management:

A Smart IoT-enabled waste management solution is required for monitoring, segregating, and recycling daily waste. AI-powered forecast on waste statistics will further help reduce and reuse the waste generated, thus monitoring, and controlling emission and effluents.

Building and CSR Plantations Health:

Smart building solutions need ensure positive water balance by monitoring water consumption across every load, optimizing water usage and efficiency through water-efficient fittings, metering, leak management and managing the quality

Air Quality Monitoring:

IoT-powered solutions for real-time monitoring, and comparison of buildings' indoor, outdoor, and respective geographic data, to maintain a healthy environment.

Enhanced User Experience:

While all of the above solutions are from the point of view of facility management, smart buildings need to address and serve a myriad of personas right from Facility, Management, Leadership, and Building Users. A building can be a 'Smart Habitat' in a true sense by ensuring occupant health and well-being, safety, security, comfort and forecast and planning, when integrated with building operation and performance. A few services empowering users are space management, central virtual bookings, smart parking, navigation, wayfinding, smart cafeterias, smart transport solutions, and many more

Space Utilization

- Monitor desk usage in real time
- Report Room and Area Usage
- Show correlations and deviations on usage plans
- Detect and Show free desks on a floor
- Identify seasonal, and weekly variations
- Resource Management
- Access Management

Building Energy Profile

- Monitor Energy (including Solar) and Water –Sustainability View
- Assets, Alerts & Diagnostics
- Indoor Air Quality

Wayfinding (Internal / External)

- Buildings / Indoor and outdoor Wayfinding
- Integration with Visitor Management system
- Locate free desks and workspaces
- Locate nearby free meeting rooms or cafeteria

Smart Parking

- App based system – availability, location
- Car Dongle recognition
- Visitor Management System integration
- Occupancy planning integration
- Number plate recognition
- Pay as you go, auto-Invoicing

Virtual Campus

- 'Virtual Campus' App with interactive features
- User Friendly App / Portal for all access, requests, navigation, information, etc

Alerts & Notifications

- Receive notifications related to queues, security, events, promotions, and more
- Intelligent Bots

Customized Workspaces

- Sensors identify patterns in workspace usage
- Monitor staff behaviors help design more com-fortable workspaces

Food, Restaurants, Queue Management

- Food courts current menu and availability
- Current queue at food counters
- Order Food for express pickup

Safety & Security

- Video Analytics : Recognizing People
- Measuring people flows
- Measuring crowd density
- Monitoring Vehicles
- Electrical, Fire Safety information on App

4. The Three-tier Architecture

An architecture has to be robust, scalable, and powerful to support this expanding solution. Ideally, this is a three-tier architecture consisting of Edge, Cloud, and Enterprise layers. The business flow is: Edge devices connected to field assets for capturing the sensor, controller, and IT-OT data, which gets sent to the cloud tier where the data pipeline should be built to acquire, process, analyze, and advise, and finally pass the actionable insights to the third tier of the enterprise.

The solution and individual components should be designed on a Digital Twin-based architecture, and built to be scaled and customized to cater to customers across industries and for any business challenge pertaining to smart buildings transformation.

5. Benefits of Smart Buildings Transformation

The advantages and benefits Smart buildings are multifold:

- Global insights empower leaders with current trends, operational expenditure, and forecast of multiple buildings across geographies
- Facility-wide insights for energy and operating cost savings
- Optimization of major load segments like HVAC, comprising chillers, AHUs, and lighting loads for enhanced energy efficiency and cost savings
- AI/ML-powered smart maintenance that enables reduced downtime, maintenance expenditures, repair costs, production losses, occupant discomfort
- Higher reliability and stable Opex
- Improved productivity in workspaces with better indoor environmental quality and occupants' care, ensuring the right balance with data privacy
- Sustainability compliances to national and international building codes, ensuring environment-friendly operations
- Helps ensure a greener future through de-carbonization and water positivity

6. Conclusion

With unlimited potential for human intelligence and unparalleled digital growth, it is evident that smart buildings are reaching their peak. A report states that a human being, on average, spends 90% of their lifetime inside a building. This resonates with the fact that almost 40% of energy and resource consumption and emissions are accounted for by buildings. With uncontrolled energy gaps, emissions, and pollution on one side and remarkable advancements in technologies like IoT, cloud, and data sciences on the other, appropriate remediation and incentivization by government and regulatory bodies and adoption by the industry and corporate leadership will help tie both ends for a sustainable built environment.

In this journey towards realizing smart building goals, LTIMindtree's holistic smart building system can help you become a technology leader in the smart building space, thus taking you to the future, faster. Contact us to know more.

7. Author

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With 12+ years of experience in smart building management, sustainability, energy auditing, Greenmark consulting, IoT, automation, and agile delivery, Sivapreeta is a smart building and sustainability leader who heads the Smart Building competency at LTIMindtree. She also leads the CoE for the Industry 4.0 Practice and has designed and delivered multiple innovations in intelligent building spaces, sustainability, computer vision, analytics, smart maintenance, fleet management, plant production performance etc.

Reviewer

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Rex has 23+ years of industry experience across manufacturing, banking, travel and logistics domains. He is experienced in implementing multiple digital transformation programs, including DW/BI, analytics, and IoT platforms across cloud and edge for global clients. As a Senior Principal of Enterprise Architecture, Industry 4.0 at LTIMindtree, he helps customers with their innovation journeys across cutting-edge technology spaces like AR/VR, digital twins, etc.

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