Nusantara
National Capital
Authority

Nusantara's Smart Building Guideline

Green and Digital Transformation
Nusantara Capital Authority

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National Capital
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CIRCULAR LETTER
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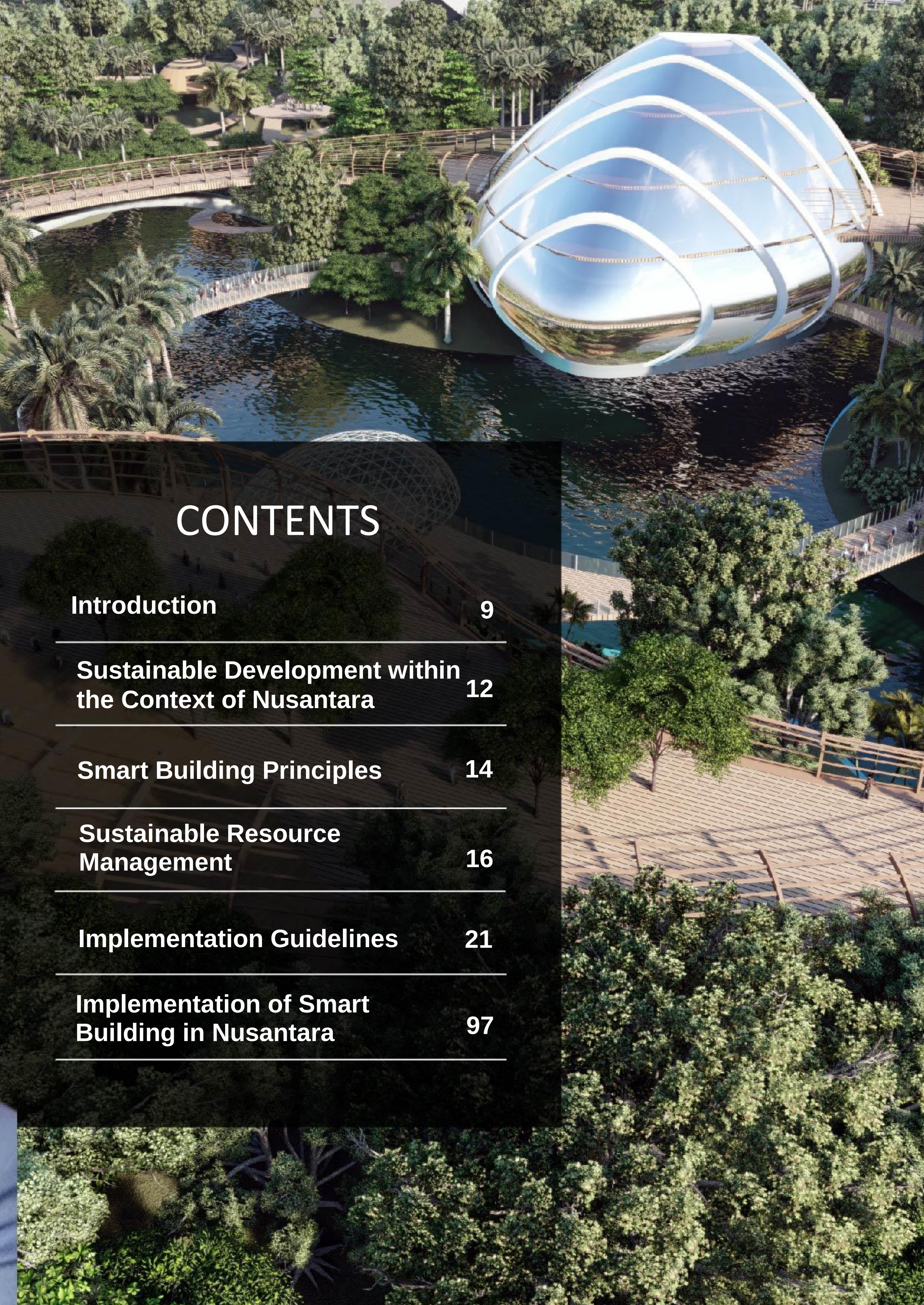
ABOUT
GUIDELINE FOR THE DEVELOPMENT OF SMART BUILDINGS
IN THE NUSANTARA CAPITAL CITY

APPENDIX
NUSANTARA'S SMART BUILDING GUIDELINE

"Nusantara's Smart Building Guideline" is the official translation of Circular Letter Nomor: 009/SE/Kepala-Otorita IKN/VIII/2023



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Green and Digital Transformation

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This guideline is the result of the in-house production of the Deputy for Green and Digital Transformation of the Nusantara Capital Authority, which is an accumulation of learning and research that has been carried out over the past 10 years by the team of authors at Universitas Indonesia. Before the smart building guideline book was published, a Focus Group Discussion was held at Le Meridien Hotel Jakarta on June 9-10, 2023 and involved more than 50 institutions from various related ministries including the Ministry of Health, Ministry of Communication and Information, Ministry of Transportation, Ministry of Environment and Forestry, Ministry of Finance, Ministry of Energy and Human Resources, academics from 9 universities, practitioners and construction companies and technology providers from within and outside the country.

FOREWORDS

Developing a city and its infrastructure is arguably one of the main drivers of economic growth. New city development can form the backbone of an economy, as they provide social and economic benefits to the society. The economic role and significance of city development must consider other dimensions of sustainable development, particularly its environmental aspects. Thus, the development of modern cities enables competitive advantage in the global economy and contributes to a nation's economic and social growth.

Nusantara Capital City will be planned as green open space where 65% is a protected area and 10% is for food production and the rest, the development area will consist of various zones of mixed-use and neighbourhood. On top of that, Nusantara will be utilized as a clean energy source and mobilization within Nusantara will be heavily accomplished by public transportation.

The creation of a new city requires careful preparation in terms of planning and project implementation. Well-prepared technical, financial, and good governance frameworks need to be in place before the construction of a new city can be carried out. Implementing accountable and prudent good governance in the development process is among the important factors in the construction of a new capital city's mega project. Based on the presidential regulation on the master plan of Nusantara, we then develop a more detailed plan as shown in this guideline.

Smart city development aims to produce a resilient and sustainable city by producing better city services, from improvements in transportation, energy, and water resources to waste disposal and health services. Smart cities can improve a city's ability to use natural resources efficiently, make public transportation more attractive, and further provide data to planners and decision makers to allow them to allocate resources appropriately. In other words, the smart city concept contributes to the formation of a high-quality, healthy, and regenerative built environment that is modelled on a circular economy and has an overall positive impact on the environment.

Science and technology development plays a significant role in achieving sustainable development by improving the efficiency and effectiveness of new and more long-lasting ways of building and living. Investments in green technology, more streamlined and targeted processes, safer materials, and improved performances and outcomes are some of the results of such development. Technological advances in utilizing renewable energy resources, building urban water systems and sustainable public infrastructure, and producing environmentally friendly materials and products are among the pathways along which technology will significantly contribute to sustainable new smart city development.

Bambang Susantono
Chairman of Nusantara Capital City Authority

FOREWORDS

As technology advances at an unprecedented pace, our buildings are transforming into intelligent, connected entities capable of improving how we live, work, and interact with our surroundings. The concept of smart buildings has received a lot of traction in recent years as businesses and governments have realized how revolutionary these cutting-edge buildings may make the way we plan, develop, use, and maintain our built environment.

The demand for comfort, efficiency, and sustainability is growing, and smart buildings are emerging as a robust solution to address the challenges caused by the inadequate supply of these demands. In this book, we go into the topic of smart buildings to offer a thorough guide that covers the terminology, background, elements, and technological approaches used in these innovative buildings.

We start by delving into the definition of smart buildings, moving beyond the buzzword to comprehend the essential elements that develop a building as smart. We look at the numerous aspects of smart buildings and how they fit into the larger picture of smart cities, where connectivity and data-driven decision-making are changing the look of metropolitan areas.

Next, we explore the components of smart buildings, revealing the essential elements that serve as the foundation of these intelligent structures. From advanced sensors and controls to energy-efficient systems, we explore the inner workings of smart buildings, emphasizing how these components work to maximize building performance, improve user experience, and reduce environmental impact.

However, what truly distinguishes smart buildings are the innovative technological solutions that enable their transformation. In this book, we present an in-depth examination of the advanced technologies driving smart building growth. We investigate the role of these technologies in enabling buildings with intelligence and connection, ranging from artificial intelligence (AI) and machine learning (ML) to the Internet of Things (IoT) and big data analytics.

This book results from extensive research, expert insights, and practical recommendations to guide industry experts, policymakers, and stakeholders in navigating the fascinating world of smart buildings. It is a comprehensive resource that can help architects, engineers, facility managers, and urban planners understand, develop, and execute smart building solutions that are user-centric, efficient, and sustainable.

"Smart Building Guidelines" is aimed to encourage the implementation of smart buildings that contributes to the growth of sustainable and intelligent built environments. I hope you can join us on this transformative journey as we uncover the potential of smart buildings and shape the future of our cities.

Mohammed Ali Berawi
Deputy for Green and Digital Transformation
Nusantara Capital City Authority

Executive Summary

A smart city is an approach that utilizes advances in information and communication technology, urban data management, and digital technology to plan and manage core urban functions in an efficient, innovative, inclusive, and resilient manner. Based on technological priorities, smart buildings are a component that is expected to be present at the beginning of Nusantara Capital City. Therefore, this guideline is established as a standard for smart building planning in the Nusantara region. With the application of the features in this guideline, it is expected that all buildings in Nusantara can optimally achieve their performance goals. The application of smart buildings is one of the supporters of Nusantara Capital City’s vision, namely 'World City for All' through sustainable development in the **energy, water, waste, environment & biodiversity, economy, tourism, security, and technology** sectors. Smart buildings have 6 principles namely **automation, multi-functionality, adaptability, interactivity, inclusivity, and efficiency**. Smart buildings are equipped with a range of features that allow for greater energy efficiency, convenience, and safety. Each feature in a smart building must fulfil the following functional requirements and specifications.

BASIC REQUIREMENTS • Integrated Building Management System • Control Room and Data Center • Fiber-to-the Room (FTTR) • Digital Twin	**COMMUNICATION SYSTEM** • Intercom System • Audio Visual & Digital Signage
RESOURCE SYSTEM • Smart Water Management • Smart Drinking Water Fountain • Smart Waste Chute • Smart Bin • Smart Restroom	**SECURITY SYSTEM** • Intelligent Video Surveillance • Smart Locking System • Virtual Gates • Occupancy Monitoring
ACCESS CONTROL SYSTEM • Touchless Access Control • Visitor Management	**LIGHTING SYSTEM** • Smart Lighting System
ENERGY SYSTEM • Automatic Meter Readers • Automatic Sub-meter Readers • Electricity Load Balancing • Public Electric Vehicle Charging Stations	**MOBILITY SYSTEM** • Smart Escalator and Auto walk • Smart Elevator • Smart Parking System
SAFETY SYSTEM • Active Disaster Response System • Smart Fire Suppression System • Emergency Button • Fire Safety Device Maintenance • Animal Hazard Protection	**HVAC SYSTEM** • Air Quality Monitoring • Air Conditioning System • Air Purification and Filter Monitoring • Demand Controlled Ventilation • Climate Detection System

Table 1. System Integration Matrix

SYSTEM	Access Control	Communication	Energy	HVAC	Lighting	Mobility	Resource	Safety	Security
Access Control		☑	☐	☑	☑	☑	☑	☐	☑
Communication	☑		☐	☑	☐	☑	☐	☑	☑
Energy	☐	☐		☑	☑	☑	☑	☐	☑
HVAC	☑	☑	☑		☐	☑	☑	☑	☑
Lighting	☑	☐	☑	☐		☑	☑	☑	☑
Mobility	☑	☑	☑	☑	☑		☐	☐	☑
Resource	☑	☐	☑	☑	☑	☐		☐	☑
Safety	☐	☑	☐	☑	☑	☐	☐		☑
Security	☑	☑	☑	☑	☑	☑	☑	☑	

The table above shows the integration between systems in a smart building. Integration between systems in smart buildings must be done carefully and planned by considering the needs and objectives of building use, namely energy efficiency, increased productivity, increased occupant comfort and safety.

The implementation of smart building in Nusantara consists of several stages to ensure the achievement of performance target, from building planning and design, performance review, system implementation, and performance evaluation.

1. Introduction

1.1 Background

Law No. 3 of 2022 has decreed that Indonesia's capital city will move from Jakarta to the Nusantara, located in East Kalimantan. The development plan of the Nusantara Capital City is described in Presidential Regulation Number 63 of 2022 concerning the Master Plan for the Nusantara Capital City. In the regulation, it is explained that the basic principles of developing the capital city area combine three concepts of urban development, namely forest city, sponge city, and smart city.

A smart city is an approach that utilizes advances in information and communication technology, urban data management, and digital technology to plan and manage core urban functions in an efficient, innovative, inclusive, and resilient manner. Based on technological priorities, smart buildings are a component that is expected to be present at the beginning of Nusantara Capital City. Plus, President Jokowi has emphasized that on Indonesia's Independence Day in 2024, a flag ceremony will be held with a complete city ecosystem, including office and residential buildings of course. So, building designs that include smart features are important from the planning phase.

The application of smart buildings has begun in Indonesia, such as parking systems with sensors, surveillance with CCTV, automatic lighting systems, and others. However, the understanding of the smart building concept is still different from one building to another. In Indonesia, there is no policy or standard that specifically explains smart buildings. Therefore, this guideline is established as a standard for smart building planning in the Nusantara Capital City region. With the application of the features in this guideline, it is expected that all buildings in Nusantara can optimally achieve their performance goals.

1.2 Limitations of this Guideline

- This guideline only regulates the design of building towers
- This guide is not universally applicable, as it is dependent on specific conditions, functions, and locations. It is not a substitute for accurate calculations and modelling by the design team.
- The effectiveness of the design methods and systems outlined in this guide will be determined by the design, implementation, and operation of the relevant systems.

1.3 Why Smart Building?

According to IEA data from 2021, building operations account for 30% of global final energy consumption and 27% of total energy sector emissions [28]. Therefore, the building sector has a vital role to play in responding to the climate emergency. Engineers in the construction world are starting to conceptualize more environmentally friendly buildings such as green buildings and sustainable buildings.

Many studies have proven that the condition of buildings greatly affects the productivity of the people who move in them. Indoor environmental quality, such as air and lighting conditions, can affect human health and comfort. Therefore, the condition of building occupants is also starting to become a major concern in building design [29].

This smart building guideline was developed to promote building practices within Nusantara that take into account, not only the impact of buildings on the environment, but also on the well-being of their occupants with the help of the latest technology.

The application of the smart building concept offers many advantages including:

- Optimize energy use and minimize energy waste, thereby reducing operating costs and helping to protect the environment.
- Air quality can be better monitored and regulated, improving the health and comfort of building occupants.
- Equipped with better security and safety systems, such as CCTV monitoring systems, fire sensors, and alarm systems, so as to help protect building occupants.
- With the right use of technology, smart buildings can help reduce building operational and maintenance costs.
- Smart buildings can be connected to other systems, such as public transportation and urban infrastructure, helping to reduce traffic congestion and improve transportation efficiency.
- Improve the productivity and well-being of building occupants by providing a better environment to work or live in.
- Provide a better and more efficient user experience in the use of building facilities and services.

1.4 Is Smart Building More Expensive?

The perception that smart buildings cost more than conventional buildings is not necessarily true. The initial cost of implementing technology for smart buildings can indeed increase building costs by up to 25%. However, with the application of these technologies, building operational costs can decrease to 38% [8]. In addition, there are many other financial benefits that come from implementing smart building concepts such as increasing occupant productivity, increasing building asset value, and reducing carbon tax costs.

1.5 Smart Building Study Cases

JTC Summit, Singapore

JTC Summit is a smart office building in Singapore's Jurong Lake district. The 31-story building incorporates a network of approximately 60,000 sensors to collect various building systems data. By using open digital platform, they are able to merge various technologies, such as smart energy, building management, and robot delivery services, into a single platform. The building's owners are able to see data virtually via the building's digital twin to help them in decision making regarding energy use, system malfunction, remotely unlocking gates in real time. In addition, the building is equipped with robots that are capable of delivering packages, detecting maintenance problems, and conducting security patrols throughout its corridors [40].

Source: streetdirectory.com

Source: conferences-uk.org.uk

The Crystal, London

The Crystal is a sustainable urban development center in London that is considered to be one of the most sustainable buildings in the world. The building was opened in 2012 and was designed by Siemens as a showcase for sustainable technology and urban planning. The building is designed to be highly energy efficient, with features such as triple-glazed windows, a high-performance building envelope, and a rooftop solar array that generates electricity. A number of smart control systems manage its energy use through building management systems and an integrated energy management system that tracks and analyzes energy use in real-time [27].

The Edge, Amsterdam

The Edge Amsterdam is considered one of the most intelligent and sustainable buildings in the world. The building is located in the Zuidas business district of Amsterdam, Netherlands and was completed in 2015. It was designed by the architectural firm PLP Architecture and built by OVG Real Estate. The building is equipped with over 28.000 sensors to monitor lighting, temperature, humidity, and other factors, resulting in a 70% reduction in energy consumption. A significant amount of its energy is provided by over 4.000 solar panels on the roof of the building. The building is equipped with an indoor climate control system, smart lighting system, and smart parking system. The building collects data on several metrics and analyzes them to make informed decisions about the building operations and management [2].

Source: urbanland.uli.org

2. Sustainable Development Within the Context of Nusantara

One of Nusantara's main goals in achieving the vision of a 'World City for All' is to develop sustainable cities in the world. Nusantara is designed to be a pioneer in sustainable cities and is expected to become a model for other regions in Indonesia. The master plan for the Nusantara capital city, as stated in Presidential Regulation 63 of 2022, describes sustainable development as follows.

2.1 Energy

All energy infrastructure is gradually directed towards using 100 percent renewable energy by 2045 throughout the Nusantara Capital City region. Renewable energy sources are produced through hydroelectric power plants, solar farms, rooftop solar panels, floating solar panels, bioenergy, and other potentials such as green hydrogen.

Specifically in the building infrastructure, the key performance indexes (KPI) in 4.2 with topic low carbon emission for the Nusantara Capital City is 60% energy savings for energy conservation in buildings. In the transportation sector, the use of electric vehicles and the development of supporting infrastructure are also part of the renewable energy development strategy in the Nusantara Capital City region as part of efforts to achieve the Net Zero Emission target.

2.2 Water

The sponge city concept is applied in the Nusantara Capital City, as stated in the masterplan part 3.1.2.2, to restore and maintain the natural cycle of water which has changed due to changes in function and land cover. The sponge city concept is implemented in an integrated manner at the smallest to urban settlement scale to slow down and restrain the flow of water, harvest rainwater, and increase the absorption of rainwater into the ground.

Buildings in Nusantara are conceptualized to be flood-resistant using in-place rainwater retention features, porous surfaces, and green roofs to hold and filter water before discharge. Technology also plays an important role in sustainable water management on a city or building scale.

2.3 Waste

Nusantara's KPI in point 5 with topic circular and tough for the waste sector is 60% recycling of solid waste by 2045 in sub point 2 (5.2) and 100% of waste water will be treated through a treatment system by 2035 in sub point 3 (5.3). Both targets are achieved by the development of facilities and infrastructure as well as the management of integrated waste and wastewater management systems from upstream to downstream by applying circular principles.

2.4 Environment & Biodiversity

Nusantara's development concept as a forest city is a nature-based solution. The concept of a forest city is a realization of the concept of a sustainable city by maintaining, managing, and restoring forest ecosystems to anticipate various social and environmental changes. The application of forest city has advantages in economic, social, and environmental aspects, which include increasing biodiversity, maintaining water and air quality, and overcoming climate change.

2.5 Economic

Referring to President Regulation No. 63 of 2022 (Nusantara's master plan) where the smart city aims to become an Economic Superhub. In order to achieve the GDP projection of 13900 - 14700 per capita in 2045 for the smart city, one of the requirements is the implementation of smart buildings to support 6 components of 6 industrial clusters and 2 enablers. Economically, the development of smart buildings would be much more effective compared to conventional buildings. By calculation, it can reduce costs by 50% and even more depending on the desired PEB (Pre-Engineered Buildings) and BEC (Business Environment and Concepts). Additionally, maintenance will be more efficient, coupled with guaranteed connectivity between smart buildings, which will accelerate economic circulation.

2.6 Tourism

Referring to President Regulation No. 63 of 2022 part 3.2.2.5, the development of ecotourism in Nusantara Capital City is centered around the natural environment and/or traditional culture. The concept of ecotourism aims to minimize negative impacts on the natural environment and socio-culture. Nusantara can become a unique destination through the development of a sustainable ecotourism identity that meets ecological, socio-cultural and economic criteria. Nusantara's KPI in point 5 with topic circular and tough for the waste sector is 60% recycling of solid waste by 2045 in sub point 2 (5.2) and 100% of waste water will be treated through a treatment system by 2035 in sub point 3 (5.3). Both targets are achieved by the development of facilities and infrastructure as well as the management of integrated waste and wastewater management systems from upstream to downstream by applying circular principles.

2.7 Technology

Nusantara's KPI in point 7 with topic comfortable and efficient in technology in the subpoint 2 (7.2) contains 100% connectivity digital and technology, information, and communication for all citizens and business. The utilization of technological advances in the development of Nusantara is implemented in the smart city concept. The emergence of various innovations in improving environmental sustainability and improving the welfare of the community is a parameter for the successful implementation of this concept. In the sustainable aspect, technology has the benefit of better environmental quality by reducing greenhouse gas emissions, water wastage, and waste generation. The smart city concept in the Nusantara Capital City Region is categorized into 6 (six) domains, namely governance, natural resources and energy, living, transportation and mobility, industry and human resources, and built environment and infrastructure.

3. Smart Building Principles

3.1 Automation

A smart building should be able to utilize advanced technology for the purpose of managing and improving building systems. The integration of various building systems, along with the monitoring of building conditions through sensors, and the use of automation and data analytics are key principles of smart building automation. By automating and centralizing building management, smart building automation can lead to lower energy usage, increased efficiency, and an enhanced user experience [13].

3.2 Multi-functionality

A smart building should be able to serve various purposes and adapt to changing user requirements. This principle involves integrating various building systems and technologies such as heating, ventilation, and air conditioning, lighting, and security to create a versatile and adaptable building environment. The primary aim of smart building multifunctionality is to optimize the use of building space and resources, minimize expenses, and enhance user satisfaction. By designing buildings that can perform multiple functions and cater to various users' needs, smart building multifunctionality can boost building sustainability and value [45].

3.3 Adaptability

A smart building should be able to learn, predict and satisfy the needs of users and the stress from the external environment. Integration between different aspects in the building gathers information internally and externally from a range of sources. Smart buildings utilize this information to prepare the building for a particular event before the event has happened. For example, sensors and smart control in air conditioning systems can be used to detect and respond to changes in air quality and other environmental factors. A smart building should be able to adapt its operations and physical form for these events to increase energy efficiency, occupant’s comfort and productivity [9].

3.4 Interactivity

The systems in a smart building should be able to interact and communicate with one other as well as with building occupants. Advanced sensors and control systems that can detect changes in occupancy, temperature, lighting, and other aspects can be used to create interactivity. This enables real-time communication between a smart building and its residents. A smart building, for instance, may recognize when a room is empty and automatically switch off the lights. Building inhabitants can utilize a smartphone app as a communication platform to modify the lighting, temperature, and other systems as needed. With demand response programs, interactivity can improve occupant security and safety, comfort and productivity, and energy efficiency [33]. The system should also be open platform so that it is open to future technological developments.

3.5 Efficiency

A smart building should be able to increase energy, time, and costs in several ways. Real-time data can inform decision-making, streamlining building operations to help building managers. Predictive maintenance through the use of sensors and data analytics can prevent major maintenance issues and further save time and cost on repairs. Automated systems can also improve efficiency by reducing the time required for manual adjustments. Improved productivity and retention rates, leading to cost savings, can also be achieved by improving occupant experience through personalized settings. This can be implemented to all building systems to, not only to increase efficiency, but also create a more sustainable and comfortable environment for occupants [12].

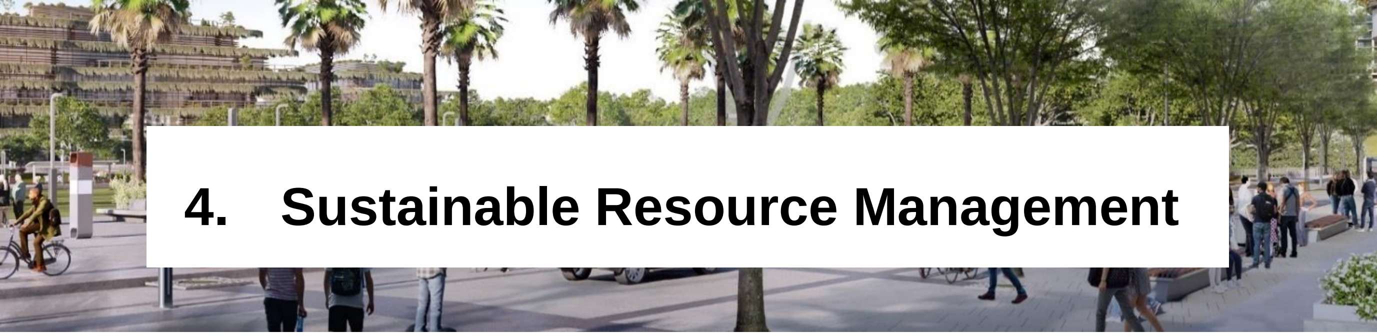
3.6 Inclusivity

Designing, creating, and operating smart buildings in a way that is inclusive, equitable, and accessible to everyone, regardless of their skills or impairments, is known as inclusivity. Smart buildings should be made accessible and useful by everyone, regardless of their age, size, ability, or disability. This entails following accessibility guidelines, offering inclusive technology, and interacting with the neighborhood to learn about the requirements and tastes of various user groups.

3.7 Green Building

The principle of green building is one of the main foundations in planning the smart building concept. Regulations regarding green buildings in Indonesia have been regulated in the Minister of Public Works Regulation No. 21 of 2021 concerning Green Building Performance Assessment. The principles are:

- Site management
- Energy use efficiency
- Water use efficiency
- Indoor air quality
- Use of environmentally friendly materials
- Waste management
- Wastewater management



4. Sustainable Resource Management

4.1 Energy Management

Managing energy is important to smart buildings in Nusantara because it uses the most modern technology to make efficiency & reduce energy consumption and carbon emissions. The ways that energy systems can be managed sustainably:

- **Renewable Energy Sources**
  The integration of renewable energy sources like solar panels, wind turbines, and geothermal systems into the building's energy infrastructure can help reduce reliance on fossil fuels and decrease carbon emissions. This not only makes the building more sustainable but also saves costs in the long run.

- **Energy Efficient HVAC Systems**
  Heating, ventilation, and air conditioning (HVAC) systems are among the most significant energy consumers in a building. Smart buildings can use energy-efficient HVAC systems that are designed to optimize energy consumption and reduce waste. For instance, using smart thermostats that can adjust the temperature based on occupancy or outside temperature can reduce energy consumption.

- **Efficient Lighting Systems**
  Smart buildings can implement efficient lighting systems that use motion sensors and timers to turn off lights in unoccupied areas. This helps reduce energy consumption and also prolongs the lifespan of lighting systems.

- **Energy Storage Systems**
  Energy storage systems like batteries can store excess energy generated by renewable energy sources or during off-peak hours for later use when the demand for energy is high. This helps reduce peak-hour energy demand and also ensures a reliable and continuous energy supply.

- **Energy Management Systems (EMS)**
  Energy management systems (EMS) can help monitor, manage and optimize the energy consumption of a smart building. This system integrates with the building's various energy systems and provides data-driven insights and recommendations for reducing energy consumption and increasing efficiency.

- **Monitoring and Analytics**
  Smart buildings can incorporate sensors and monitoring systems to collect and analyze energy data. By analyzing this data, building managers can identify areas of high energy consumption and optimize energy consumption in real-time.

4.2 Air Management

The air management system is an important aspect for smart building as people spend 90% of their time indoor. Therefore, following are some ways to manage air systems sustainably in a smart building:

- **Efficient Ventilation Systems**
  A smart building can implement efficient ventilation systems that can reduce energy consumption and improve indoor air quality. The ventilation system can use sensors to control the amount of outdoor air brought into the building based on occupancy levels. This ensures that the ventilation system operates only when neccessary thus reducing energy consumption.

- **Air Quality Monitoring**
  Smart buildings can use sensors to monitor indoor and outdoor air quality, including humidity, temperature, carbon dioxide, and volatile organic compounds (VOCs). Monitoring and analyzing this data can help identify sources of indoor air pollution and take necessary actions to improve air quality.

- **Air Purification Systems**
  Air purification systems, such as air filters, can help remove pollutants and allergens from the air, improving indoor air quality. These systems can be integrated with the building's HVAC system to ensure optimal air quality and energy efficiency.

- **Proper Maintenance and Cleaning**
  Regular maintenance and cleaning of air systems, including HVAC systems and air filters, can help improve air quality and reduce energy consumption. Dirty filters and ducts can impede airflow, forcing HVAC systems to work harder to circulate air, resulting in increased energy consumption.

4.3 Water Management

Sustainable resource management of water systems is a crucial aspect of a smart building, as it helps reduce water consumption, minimize water waste, and conserve natural resources. So, following some ways to implement sustainable resource management in water systems in a smart building:

- **Rainwater Harvesting**
  Capturing and utilizing rainwater as a water source can reduce health and environmental impacts, reduce runoff and provide economic benefits to building users.

- **Water Recycling**
  Grey water is domestic wastewater that comes from the results of daily household activities such as bathing and washing, excluding toilets. Grey water can be treated and redistributed to toilets and urinals for flushing and irrigation purposes.

- **Efficient Plumbing Fixtures**
  Smart buildings can incorporate water-efficient plumbing fixtures such as low-flow toilets, faucets, and showerheads. These fixtures can help reduce water consumption without compromising performance.

- **Water Monitoring and Analytics**
  Smart buildings can use sensors to monitor water consumption and identify areas of high consumption. By analyzing this data, building managers can identify inefficiencies and implement corrective measures.

- **Leak Detection Systems**
  Smart buildings can incorporate leak detection systems to identify and address leaks in real-time. These systems can use sensors to detect leaks and notify building managers before they become major issues.

- **Smart Irrigation Systems**
  Smart buildings can use sensors and weather data to optimize irrigation systems. This can help reduce water waste and ensure that irrigation occurs only when necessary.

- **Proper Maintenance and Cleaning**
  Regular maintenance and cleaning of water systems, including plumbing fixtures and irrigation systems, can help improve efficiency and reduce water waste. Dirty fixtures and clogged pipes can impede water flow, resulting in increased water consumption.

4.4 Economic

Sustainable resource management is not only about environmental conservation, but it also includes economic sustainability. Smart buildings can implement various strategies to achieve economic sustainability while promoting environmental conservation.

- **Energy Efficiency**
  Smart buildings can implement energy-efficient strategies such as using efficient HVAC systems, lighting systems, and appliances. This can help reduce energy consumption, which can lead to significant cost savings in the long run.

- **Renewable Energy**
  Smart buildings can incorporate renewable energy systems such as solar panels, wind turbines, and geothermal systems. This can help reduce energy costs, and in some cases, generate revenue by selling excess energy back to the grid.

- **Demand Response Programs**
  Smart buildings can participate in demand response programs that incentivize energy reduction during periods of peak demand. This can help reduce energy costs by avoiding high-demand charges.

- **Smart Metering**
  Smart buildings can install smart metering systems that can track energy and water consumption in real-time. This can help identify areas of high consumption, optimize energy usage, and minimize costs.

- **Building Automation Systems**
  Smart buildings can incorporate building automation systems that can monitor and control building systems such as HVAC, lighting, and security systems. This can help optimize energy usage, reduce costs, and improve occupant comfort.

- **Life-Cycle Cost Analysis**
  Smart buildings can use life-cycle cost analysis to evaluate the cost-effectiveness of different sustainability measures. This can help prioritize investments that provide the greatest long-term economic benefits.

4.5 Technology

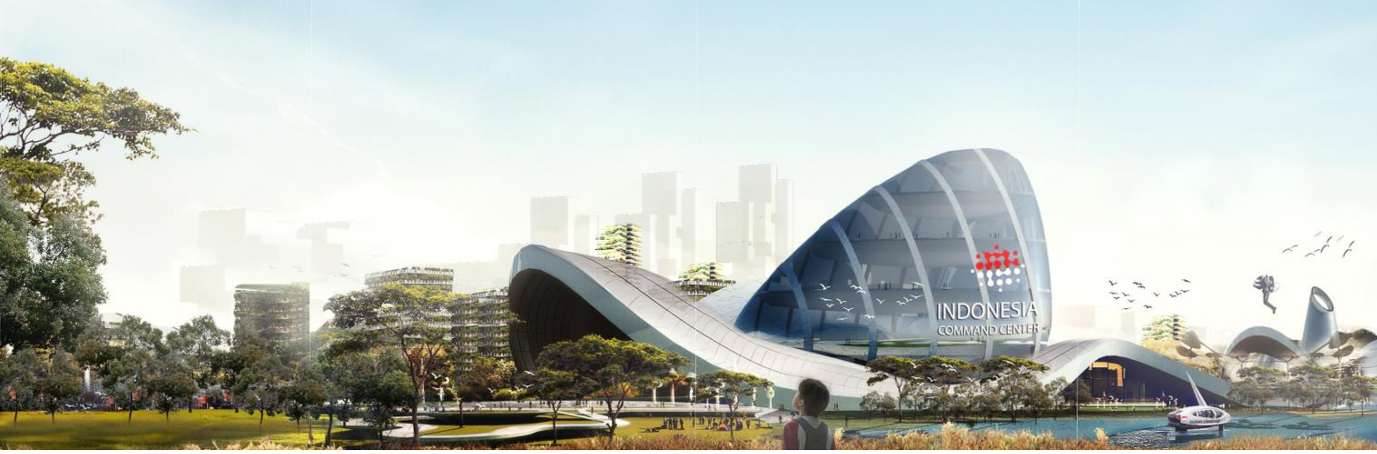
Sustainable resource management in technology systems of smart buildings involves the implementation of efficient and effective technologies that reduce energy and resource consumption, minimize waste, and promote sustainability. Here are some ways to implement technology in the sustainable resource management smart building in Nusantara New Capital City:

- **Virtualization and Cloud Computing**
  Virtualization and cloud computing can help reduce the need for physical infrastructure and equipment, leading to a reduction in energy usage, waste, and costs.

- **Smart Monitoring and Analytics**
  Smart monitoring and analytics systems can help optimize energy usage and identify areas of waste and inefficiency in technology systems. This can help reduce energy waste and promote sustainability in the operation of the building's technology systems.

- **Automation Decision Making**
  Automation decision making in smart buildings involves the use of sensors and data analysis to make real-time decisions about the operation of various building systems. By using automation decision making in smart buildings, for example machine learning and artificial intelligence, businesses and organizations can reduce their environmental impact while also improving efficiency and reducing costs. However, it is important to ensure that these systems are designed and implemented in a sustainable and responsible way.

By implementing these strategies, smart buildings can promote sustainable resource management in technology systems, reduce the environmental impact of the building, and improve the overall sustainability of the technology systems. It is important to consider sustainability as part of the overall technology strategy and promote sustainable practices throughout the lifecycle of the building's technology systems.



5. Implementation Guidelines

Smart buildings are equipped with a range of features that allow for greater energy efficiency, convenience, and safety. Each feature in a smart building must fulfill the following functional requirements and specifications.

5.1 Basic Requirements

5.1.1 Integrated Building Management System

Smart buildings have emerged as pioneers of efficiency and sustainability, with Integrated Building Management Systems at their core. The Integrated Building Management System is a framework that governs communication and limitless control among various building systems. One crucial layer within the Integrated Building Management System is the Automation Layer, where Building Automation Systems take the lead.

The Automation Layer serves as the nerve center of smart buildings, integrating various controllers, panels, and adapters that seamlessly connect and regulate all interconnected systems. Advanced sensor and actuator networks facilitate this complex interaction, ensuring optimal functionality and resource utilization.

Building automation systems are crucial in enabling the Automation Layer to function effectively. Gateways connect various smart building systems in the Field Application Layer, which includes HVAC systems, energy systems, lighting systems, resource systems, mobility systems, communication systems, access control systems, security systems, and safety systems.

Aligning various interconnected systems in smart buildings using Integrated Building Management Systems will enhance efficiency and lay the foundation for a more environmentally friendly, responsive, and future-ready built environment. With technological advancements, the potential of smart buildings and their contribution to sustainable living will continue to evolve, revolutionizing how we inhabit and interact with the environment.

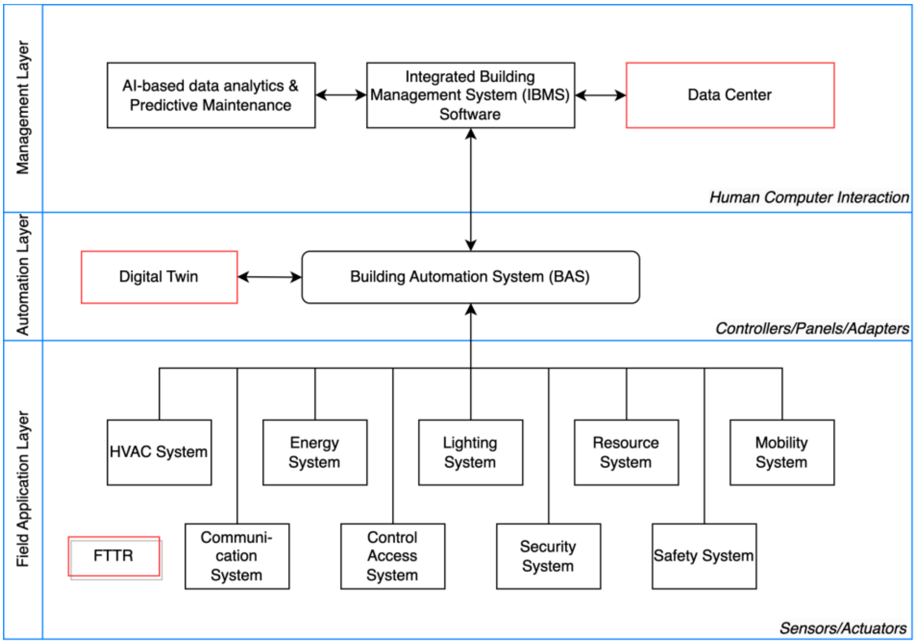


Figure 1. Integrated Smart Building Management System

Functional Requirement	
Integration [1]	The system must be able to integrate all systems and devices in the building.
Building Automation [1]	The system must be able to control various systems and devices within the building.
Data analysis [1]	The system must have data analysis capabilities that can provide insight into building performance and identify areas for improvement. This will enable operators to make informed decisions and optimize building performance over time.
Compliance and Data Security [1]	Systems must comply with applicable data security regulations and standards to protect sensitive data related to building operations.

[1] Mandatory for buildings and landed houses, [2] Mandatory for buildings and recommended for landed houses, [3] Recommended for buildings and landed houses

Reference Standard	
ISO 16484	Building automation and control systems
ISO 27001:2022	Information security, cybersecurity, privacy protection
ISO 27010:2015	Information security controls for cloud services
ANSI/ASHRAE Standard 135-2020	A Data Communication Protocol for Building Automation and Control Networks
Others	and other applicable regulations or standards

5.1.2 Control Room and Data Center

A data center is a specialized facility that houses and manages computer systems, servers, network equipment and other critical infrastructure components for storing, processing and managing large amounts of data. The data center is the central hub for an organization's IT operations and hosts a variety of hardware and software resources that support various applications, services, and business processes.

A control room is a centralized facility designed to monitor and manage complex systems, processes or operations in real-time.

Functional Requirements	
Real-time monitoring and control [2]	The control room must be equipped with the necessary sensors and control systems to monitor and control all the building systems in real-time. This will enable the operators to quickly identify and resolve any issues that may arise
Integration with building systems [2]	The control room must be able to integrate with all the building systems, including HVAC, lighting, security, and energy management systems. This will allow the operators to control and manage all the systems from a central location
User-friendly interface [2]	The control room must have a user-friendly interface that is easy to navigate and understand. This will allow the operators to quickly access the information they need and take appropriate action
Alerting and notification [2]	The control room must be equipped with an alerting and notification system that can quickly inform the operators of any issues or malfunctions in the building systems. This will allow the operators to take immediate action and prevent any potential damage or downtime
Energy management [2]	The control room must have a robust energy management system that can monitor and optimize the building's energy consumption. This will help reduce energy costs and minimize the building's carbon footprint.
Data analytics [2]	The control room must be equipped with a data analytics and reporting system that can provide insights into the building's performance and identify areas for improvement. This will allow the operators to make informed decisions and optimize the building's performance over time
Data reporting [2]	The control room must have a robust security and access control system to ensure that only authorized personnel have access to the building systems. This will help prevent unauthorized access and protect the building from potential security threats.
Security and access control [2]	The control room should have a data backup and recovery system in anticipation of an emergency or cyber hazard.
Data Backup and Recovery [2]	The control room must be equipped with the necessary sensors and control systems to monitor and control all the building systems in real-time. This will enable the operators to quickly identify and resolve any issues that may arise

Hardware	Software
○ UPS (Uninterruptible Power Supply) ○ HVAC and Security ○ Storage ○ Server ○ Advance monitor ○ Power Backup ○ Cooling Machine ○ CCTV ○ Fire extinguisher	○ System Operation Server ○ Database Management System ○ Web Server ○ Server Virtualization ○ Monitoring Tools and Dashboard ○ Backup and Recovery Tools ○ Remote Access Software ○ Security Software

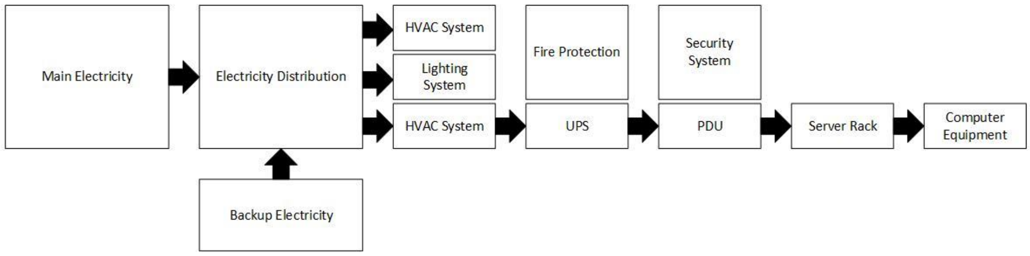


Figure 2. Control Room and Data Center

Reference Standard	
Minister of Public Works and Housing Regulation Number 21 of 2021	Green Building Performance Assessment
SNI 8799:2019	Information Technology - Data Center
SNI 7512:2008	Information Technology - Security Engineering - Information security incident management
SNI 19-7013-2004	Data Center Building Security Requirements
TIA 942-B	*Telecommunications Infrastructure Standard for Data Centers*
ISO/IEC 22237	*Information technology – Data Centre Facilities and Infrastructures*
ISO 27001:2022	*Information security, cybersecurity, privacy protection*
ISO 27010:2015	*Information security controls for cloud services*
ISO 11064	*Ergonomic Design of Control Centres*
ISO/IEC 30134-1	*Information technology - Data centres - Key performance indicators - Part 1: Overview and general requirements*
Lainnya	And other applicable regulations or standards

5.1.3 Fiber-to-the-Room (FTTR)

FTTR (Fiber to The Room) is a telecommunications infrastructure concept that involves deploying fiber optic cables directly to individual rooms or living areas within a building or facility. In the FTTR architecture, fiber-optic connectivity extends into the end-user space, providing high-speed, high-bandwidth communication services directly to each individual location.

Functional Requirements	
High-speed internet connectivity [1]	The main purpose of FTTR is to provide fast and reliable internet connectivity to every room in the building. The network must be able to support high-bandwidth applications such as video streaming, online gaming, and video conferencing
Scalability [2]	FTTR should be designed to support future network growth and expansion, as more users and devices are added to the system
Reliability [1]	Networks should be designed with redundancy and *failover* mechanisms to ensure uninterrupted connectivity even in the event of fiber or equipment failure
Security [1]	FTTR networks must be secure to prevent unauthorized access and protect user data from cyber threats
Compatibility [1]	The network must be compatible with a wide range of devices and operating systems, including smartphones, laptops, tablets, and smart home devices
Management [1]	FTTR networks should be easy to manage and monitor, with tools and software for network administrators to troubleshoot and optimize performance
Cost-effectiveness [1]	FTTR networks should be designed to minimize costs, with efficient installation and maintenance procedures, and energy-efficient equipment and technology
Hardware	**Software**
○ Optical receiver ○ Network equipment ○ Fiber cable ○ Media conversion	○ Guest Wi-Fi Management Software ○ Network Management Software ○ Billing and Revenue Management Software ○ Fiber Optic Test and Analysis Software

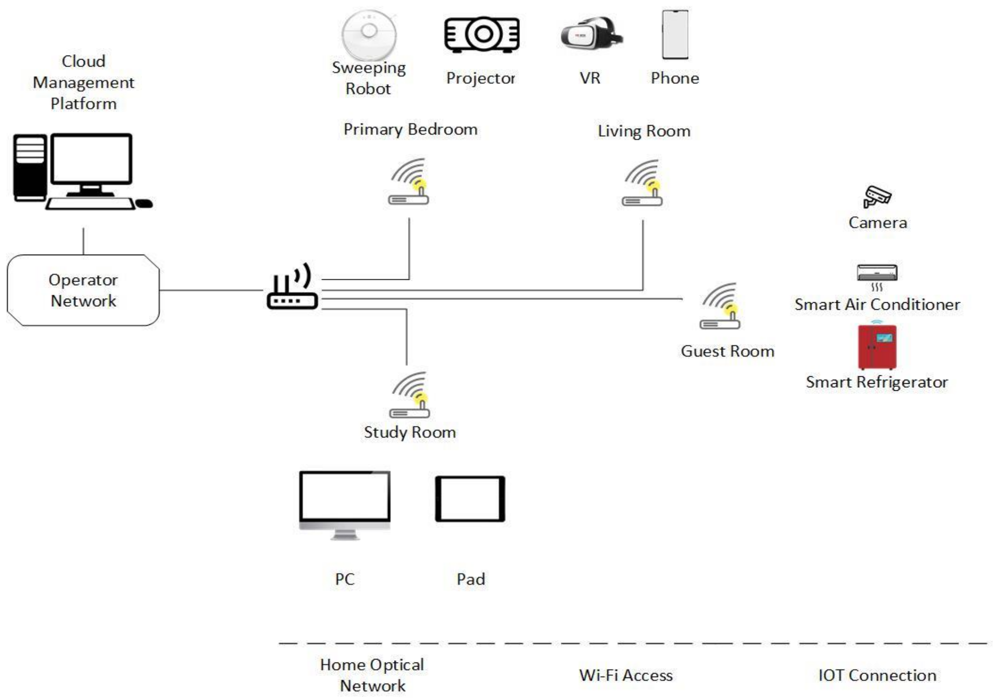


Figure 3. Fiber-to-the-Room (FTTR) System

Reference Standard	
ISO 33.180	Fibre Optic Communication
ISO 20780:2018	Space systems — Fiber optic components — Design and verification requirements
IEEE 802.11	Wireless LAN Standards
IEEE 802.3	Ethernet
ISO 14302	Space systems — Electromagnetic compatibility requirements
ISO 27001:2022	Information security, cybersecurity, privacy protection
ISO/IEC 29794-5-1:2022	FTTR network topology
ISO/IEC 14763-3:2019	Information technology - Implementation and operation of customer premises cabling - Part 3: Testing of optical fibre cabling
Others	and other applicable regulations or standards

5.1.4 *Digital Twin*

Digital Twin refers to a virtual representation of a physical object, system or process, which is a digital replica that reflects the real world in real-time, capturing its physical and behavioral characteristics. This technology combines multiple data sources, such as sensors, IoT devices, and simulations, to create dynamic, interactive models that reflect the current state and behavior of the physical entities they represent.

<table>
<tr><th colspan="2">Functional Requirements</th></tr>
<tr><td>Accurate representation [2]</td><td>The digital twin must provide an accurate representation of the physical asset or system, including its geometry, behavior, and interactions with other systems.</td></tr>
<tr><td>Real-time data [2]</td><td>The digital twin must be updated in real-time with data from sensors, devices, and other sources to reflect the current state of the physical asset or system.</td></tr>
<tr><td>Visualization [2]</td><td>The digital twin must provide visualizations that enable users to interact with and explore the virtual replica of the physical asset or system.</td></tr>
<tr><td>Analysis and simulation [2]</td><td>The digital twin must support analysis and simulation capabilities, such as predictive maintenance, energy optimization, and fault detection, to help optimize the performance of the physical asset or system.</td></tr>
<tr><td>Integration [2]</td><td>The digital twin must be able to integrate with other systems and platforms, such as building management systems or manufacturing control systems, to enable seamless data exchange and interoperability.</td></tr>
<tr><td>Security and privacy [2]</td><td>The digital twin must be designed with security and privacy in mind, with measures in place to protect against unauthorized access and data breaches.</td></tr>
<tr><td>Scalability [2]</td><td>The digital twin must be scalable to support large and complex assets or systems, and be able to handle increasing amounts of data and users over time.</td></tr>
<tr><th>Hardware</th><th>Software</th></tr>
<tr><td>○ AR (Augmentation Reality) Devices
○ VR (Virtual Reality) Devices
○ Computer</td><td>○ Digital twin software
○ Augmentation and virtual reality software</td></tr>
</table>

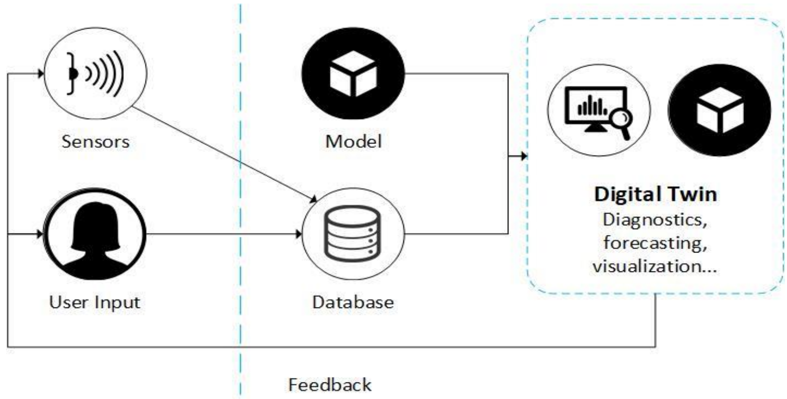


Figure 4. Digital Twin System

Reference Standard	
ISO 16739	Digital twin framework for manufacturing
ISO 23247	The Digital Twin framework for manufacturing.
ITU-T F.746.10	Developed by the International Telecommunication Union
SNI 7512:2008	Information Technology - Security Engineering - Information security incident management
ISO 27001:2022	Information security, cybersecurity, privacy protection
IPC-2551	International Standard for Digital Twin
IEEE P3144	Standards for the Twin Digital Maturity Model and Assessment Methodology in Industry
Others	and other applicable regulations or standards

5.2 Access Control System

5.2.1 Touchless Access Control

Touchless Access Control is a security system or technology that allows access to a specific area or facility without requiring physical contact with a device or surface.

Functional Requirements	
Authentication [2]	The touchless access control system must be able to authenticate the user's identity through various means, such as facial recognition, iris scanning, or voice recognition.
Access control [2]	The system must be able to grant or deny access to the user based on their authentication status and the level of access granted.
Physical access [2]	The touchless access control system must be able to control physical access to areas or equipment, such as doors, elevators, or turnstiles, without requiring the user to touch any surfaces.
Remote access [2]	The system must be able to provide remote access to users, such as via mobile devices or other wireless technologies.
Temperature Checking [3]	The system must be able to monitor visitors body temperature to track visitor's health condition and to protect others.
Integration [2]	The touchless access control system must be integrated with other building automation systems, including HVAC, CCTV, and alarm systems.
User management [2]	The system must have a user management interface for adding, modifying, and deleting users, as well as assigning access levels and permissions.
Scalability [2]	The touchless access control system must be scalable to adapt to changes in user volume, new access points, and evolving security requirements

Hardware	Software
○ Biometric Sensor ○ Motion Sensor ○ Bluetooth-enabled locks ○ RFID cards and readers ○ Automatic doors/gates	○ Biometric software ○ Mobile apps ○ RFID card management ○ Access control management software ○ Visitor management software

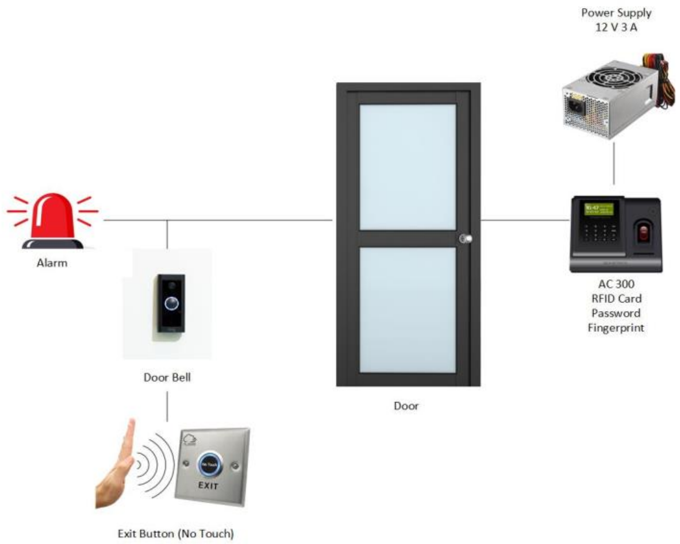


Figure 5. Touchless Access Control System

Reference Standard	
IEC 60839-11-1 dan -11-2	Electronic Access Control Systems and Application Guidelines
ISO/IEC 19794-6:2019	Information technology - Biometric data interchange formats - Part 6: Iris image data
ISO/IEC 19794-5:2011	Information technology - Biometric data interchange formats - Part 5: Face image data
ISO 16484	Building automation and control systems
ISO 27001:2022	Information security, cybersecurity, privacy protection
IEEE 2410-2020	Standard for Biometrics Open Protocol Extended Frameworks (OPEN)
ISO 27001:2022	Information security, cybersecurity, privacy protection
Others	and other applicable regulations or standards

5.2.2 Visitor Management

Visitor management is a systematic and efficient management of visitors, guests and individuals entering or leaving a building or facility, which involves the use of advanced technology and integrated systems to streamline the process of welcoming, monitoring and controlling visitor access to the venue.

Functional Requirements	
Mobile check-in [3]	The system ought to have a mobile check-in feature that enables guests to sign up beforehand using a mobile app or website.
Real-time tracking [2]	The system must be capable of following guests around the building in real-time, giving hosts or security personnel precise location data.
Predictive analytics [2]	The system ought to make use of predictive analytics to foresee visitor traffic and offer insights for building management, such as optimizing staffing levels or modifying HVAC settings.
Personalization [3]	Depending on the visitor's preferences, the system must be able to tailor the experience they have while they are there, for example, by pointing them in the direction of meeting spaces they prefer or recommending amenities close by.
Environmental controls [2]	Depending on the volume of visitors and the occupancy levels, the system must be able to modify the lighting, temperature, and other environmental elements.
Reporting [2]	The system must be able to generate reports on user activity, access attempts, and system events for audit and compliance purposes.
Integration [2]	To improve building performance and efficiency, the system must be able to integrate with other smart building technologies, including IoT sensors, smart lighting, and energy management systems.

Hardware	Software
○ Camera	○ Visitor management software ○ Building automation systems ○ Mobile apps

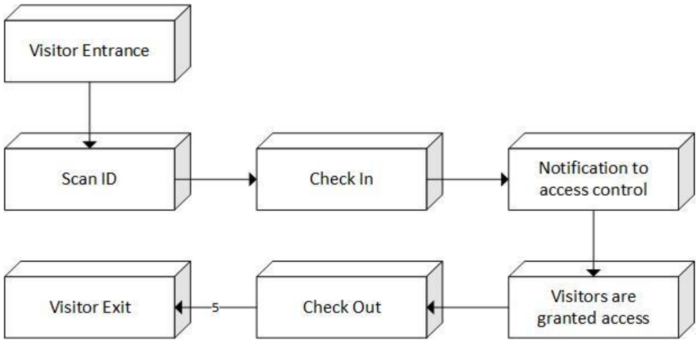


Figure 6. Visitor Management System

Reference Standard	
ISO 14762	Information technology — Functional safety requirements for Home and Building Electronic Systems (HBES)
ISO 16484	Building automation and control systems
IEC 60839-11-1 dan -11-2	Electronic Access Control Systems and Application Guidelines
ISO/IEC 19794-6:2019	Information technology - Biometric data interchange formats - Part 6: Iris image data
ISO/IEC 19794-5:2011	Information technology - Biometric data interchange formats - Part 5: Face image data
ISO 27001:2022	Information security, cybersecurity, privacy protection
Others	and other applicable regulations or standards

5.3 Communication System

5.3.1 Intercom System

The intercom system is an internal communication system that allows users or building occupants to communicate by voice or video with other people in the building, designed to facilitate communication between building occupants or between users and security or administrative officers without having to move from their place.

Functional Requirements	
Remote access [2]	The smart intercom system must be accessible remotely, allowing users to answer calls and grant access from their mobile devices or computers.
Video Intercom [3]	The system must have a video intercom feature that allows users to see and speak with visitors before granting access.
Access control [2]	The system must be able to grant or deny access to visitors based on user authorization levels and visitor permissions.
Visitor management [2]	The system must be integrated with visitor management systems to streamline the visitor check-in process and provide accurate visitor information to users.
Two-way communication [2]	The system must support two-way communication between users and visitors with video quality and clear audio.
Integration [2]	The smart intercom system must be integrated with other smart building technologies, such as security cameras, access control systems, and building automation systems.
Mobile app [3]	Users must be allowed to answer calls, receive notifications, and manage access control settings through mobile apps from their mobile devices.
Customizeable settings [2]	The system must be customizable, allowing users to adjust settings such as microphone sensitivity, camera quality, and access control rules.

Hardware	Software
○ Video and audio intercom system	○ Building automation system ○ Visitor management system ○ Intercom software ○ Mobile apps

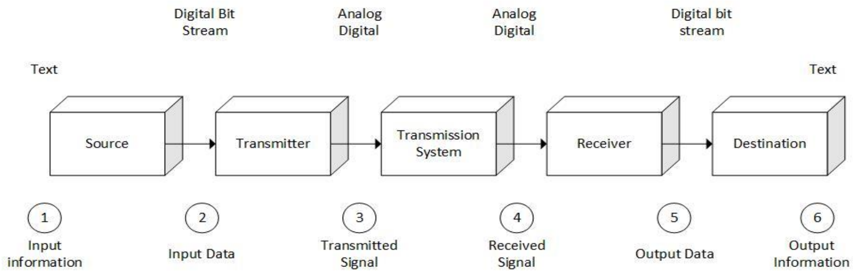


Figure 7. Intercom System

Reference Standard	
DS/EN 62820	Building intercom system
TIA-570	Residential Telecommunications Infrastructure Standard
ISO 14762	Information technology — Functional safety requirements for Home and Building Electronic Systems (HBES)
ISO 27001:2022	Information security, cybersecurity, privacy protection
Others	And other applicable regulations or standards

5.3.2 Audio Visual & Digital Signage

Audio Visual & Digital Signage is a technology system that enables the display of information, images and other multimedia content in an interactive and attractive digital form, and can be integrated with other systems, such as security systems or building management systems.

Functional Requirements	
Centralized control [2]	The system must have a centralized control panel that allows users to manage and monitor all audiovisual and digital signage components from one control system.
Customizable content [2]	The system must allow users to create or display custom content such as graphics, videos, or announcements, on digital signage displays.
Real-time updates [2]	The system must be able to provide real-time updates on building events, schedules, or emergency notifications through digital signage displays.
Interactive features [2]	The system must support interactive features, such as touch screens or motion sensors, to enhance user engagement and promote building interactivity.
Accessibility [2]	The system must adhere to accessibility guidelines, such as offering text-to-speech features or larger fonts for users who are blind or visually handicapped.
Integration [2]	To maximize building performance and efficiency, the smart AV and digital building signage system must be able to integrate with other smart building technologies, such as occupancy sensors or energy management systems.
Analytics [2]	In order to give information for content improvement, the system must provide analytics on user involvement, such as the quantity of interactions or clicks on digital signage displays.
Personalization [3]	The system must be able to personalize the user experience based on individual preferences, such as displaying personalized content or adjusting display settings.
Multilingual support [2]	The system must provide multilingual support, including signage and audio cues in different languages to accommodate visitors from diverse backgrounds.

Hardware	Software
○ Screen display ○ Media player ○ Camera ○ Sensor ○ Power distribution system ○ Communication infrastructure	○ Real-time voice transcription and translation ○ Interactive display features

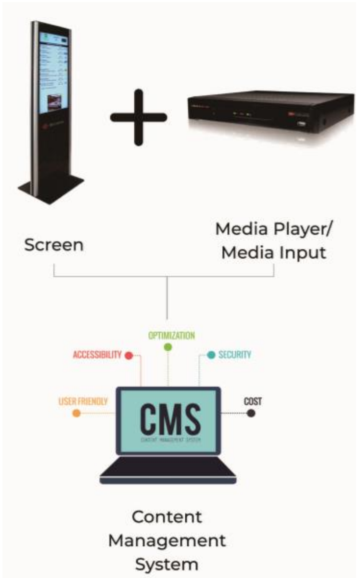


Figure 8. Audio Visual and Digital Signage

Reference Standard	
ISO 2846	Graphic technology
ISO/IEC 23488:2022	Information technology — Computer graphics, image processing and environment data representation — Object/environmental representation for image-based rendering in virtual/mixed and augmented reality (VR/MAR)
ISO 17049:2013	Accessible design — Application of braille on signage, equipment and appliances
ISO 27001:2022	Information security, cybersecurity, privacy protection
ISO 27010:2015	Information security controls for sharing data
IEC 62443-4-1	Secure product development lifecycle requirements
Others	And other applicable regulations or standards

5.4 Energy System

5.4.1 Automatic Meter Readers

Automatic Meter Reader is a technology system used to automate the collection and monitoring of data on energy usage, such as electricity, water or gas, that occurs inside certain buildings or facilities, by utilizing sensor technology and remote communication to automatically collect data from various meters measurements installed in the building.

Functional Requirements	
Automatic meter reading [1]	The system must automatically read and record the data of the meter, so that the personnel of the electricity company does not have to read the meter manually.
Real-time data [1]	The system must provide real-time data on energy usage and other metrics so that users can monitor and adjust energy usage in real time.
Remote access [2]	The system must be remotely accessible so users can monitor meter activity and energy usage from their mobile devices or computers.
Integration [1]	The smart meter reader system must be able to integrate with other smart building technologies, such as energy management systems or HVAC controls, to optimize building performance and efficiency.
Analytics [1]	The system must provide analytics on energy use, such as peak usage times or energy-saving opportunities, to provide insights for energy optimization.
Customizable alerts [1]	The system must allow users to set up customizable alerts for abnormal energy usage or meter readings, to notify them of potential issues.
Compatibility [1]	The system must be compatible with existing meters and support multiple communication protocols, such as cellular or Wi-Fi, to accommodate different building configurations.
Scalability [2]	The system must be scalable to accommodate changes in building occupancy, user volume, and evolving energy management needs.
Maintenance [1]	The system must have maintenance features in place, such as reporting and tracking meter issues or requesting repairs, to ensure accurate and reliable meter readings.
Security [1]	The system must prioritize security by implementing appropriate data protection measures and secure access controls to prevent unauthorized access or breach.

Hardware	Software
○ Smart electric meter ○ Smart gas meter ○ Smart current sensor ○ Smart voltage sensor	○ Energy management software ○ Building automation software ○ Data analytics software ○ Visualization software

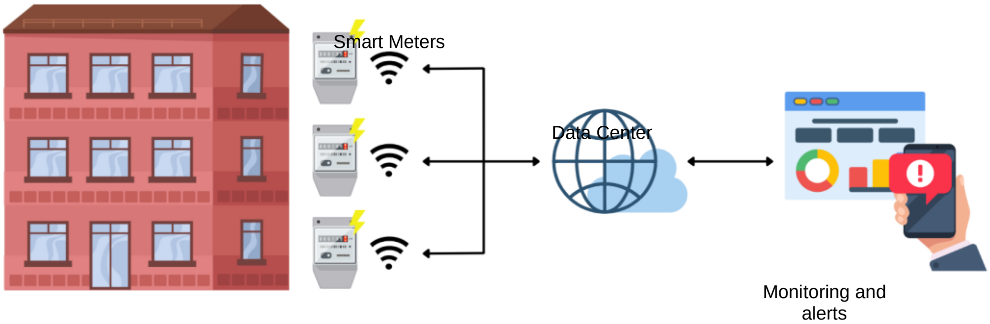


Figure 9. Automatic Meter Readers

Reference Standard	
Minister of Public Works and Housing Regulation Number 21 of 2021	Green Building Performance Assessment
SNI 62053	Electric Meter Equipment
ISO 16484	Building automation and control systems
Others	and other applicable regulations or standards

5.4.2 Automatic Sub-meter Readers

Automatic Sub-meter Reader is an automatic system used to monitor and measure electricity consumption specifically at the sub-meter level inside a building that is installed on a certain circuit or device, such as electronic equipment, lighting, heating systems, air conditioning, and others, which has a separate electrical load from the main meter of the building. Automatic Sub-meter readers work automatically and in real-time to collect energy consumption data from sub-meters installed at various locations in the building.

Functional Requirements	
Automated meter reading [3]	The system must automatically read and record sub-meter data, eliminating the need for manual meter reading by building management or tenants.
Real-time data [3]	The system must provide real-time data on energy usage and other sub-meter readings, allowing users to monitor and adjust energy usage in real-time.
Granular monitoring [3]	The system must provide granular monitoring of energy usage for individual tenants or sub-zones, to help identify energy-saving opportunities and allocate energy costs accurately.
Integration [3]	The smart sub-meter reader system must be able to integrate with other smart building technologies, such as energy management systems or billing software, to optimize building performance and efficiency.
Analytics [3]	The system must provide analytics on energy usage, such as peak usage times or energy-saving opportunities, to provide insights for energy optimization and cost reduction.
Customizable alerts [3]	The system must allow users to set up customizable alerts for abnormal energy usage or meter readings, to notify them of potential issues or opportunities for cost reduction.
Scalability [3]	The system must be scalable to accommodate changes in building occupancy, user volume, and evolving energy management needs.
Maintenance [3]	The system must have maintenance features in place, such as reporting and tracking sub-meter issues or requesting repairs, to ensure accurate and reliable sub-meter readings.

Hardware	Software
○ Smart sub-meter ○ Data concentrator ○ Communication Infrastructure	○ Energy management software ○ Building automation system ○ Cloud-based platforms

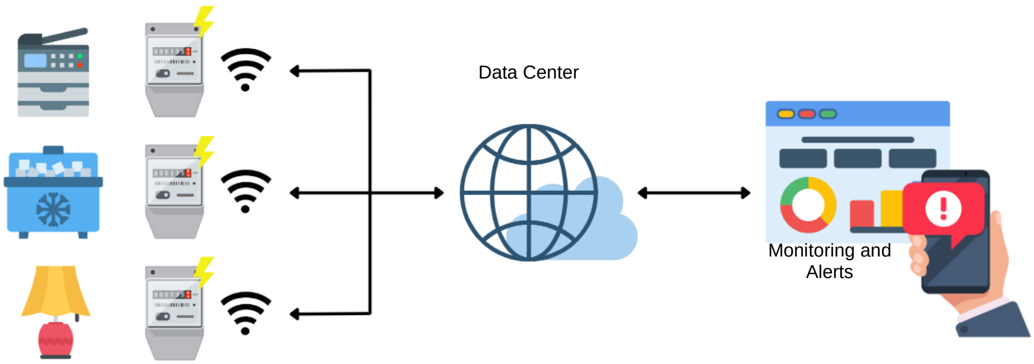


Figure 10. Automatic Sub-meter Readers

Reference Standard	
Minister of Public Works and Housing Regulation Number 21 of 2021	Green Building Performance Assessment
SNI 62053	Electric Meter Equipment
ISO 16484	Building automation and control systems
Others	and other applicable regulations or standards

5.4.3 Electricity Load Balancing

Electrical Load Balancing is a technique used to ensure a balanced distribution of electrical loads throughout a building's electrical system, which aims to avoid load imbalances between various electrical circuits or devices in a building, thus preventing overloading on one circuit or device and optimizing efficient use of power.

Functional Requirements	
Real-time monitoring [1]	The system must provide real-time monitoring of electricity demand and supply, allowing for quick adjustments to load balancing.
Automatic load balancing [1]	The system must automatically balance the electrical load of the building or building, ensuring efficient distribution of energy consumption.
Load shedding [1]	The system must be able to automatically shed non-critical loads during peak periods to prevent system overload and ensure a stable power supply.
Predictive analytics [1]	The system must use predictive analysis to predict future demand and adjust load balancing accordingly to optimize energy consumption and minimize costs.
Integration [1]	The load balancing system must be able to integrate with other smart building technologies, such as HVAC controls or lighting systems, to optimize building performance and efficiency.
Scalability [2]	The system must be scalable according to changes in building occupancy, number of users and changing energy management needs.
Energy storage [2]	The load balancing system must be capable of incorporating energy storage solutions such as batteries or other storage systems to store excess energy during periods of low demand and release it during periods of peak demand.
Renewable energy integration [2]	The system must be able to integrate with renewable energy sources such as solar panels or wind turbines to optimize energy consumption and reduce dependence on the grid.
Fault detection [1]	The system must be able to detect faults or anomalies in the load balancing process and alert building management or maintenance for quick resolution.
Security [1]	The system must prioritize security by implementing appropriate data protection measures and secure access control measures to prevent unauthorized access or unauthorized modification of load balancing information.

Hardware	Software
○ Smart meter ○ Power management system ○ Energy storage system	○ Energy management software ○ Building automation system ○ Cloud-based platforms

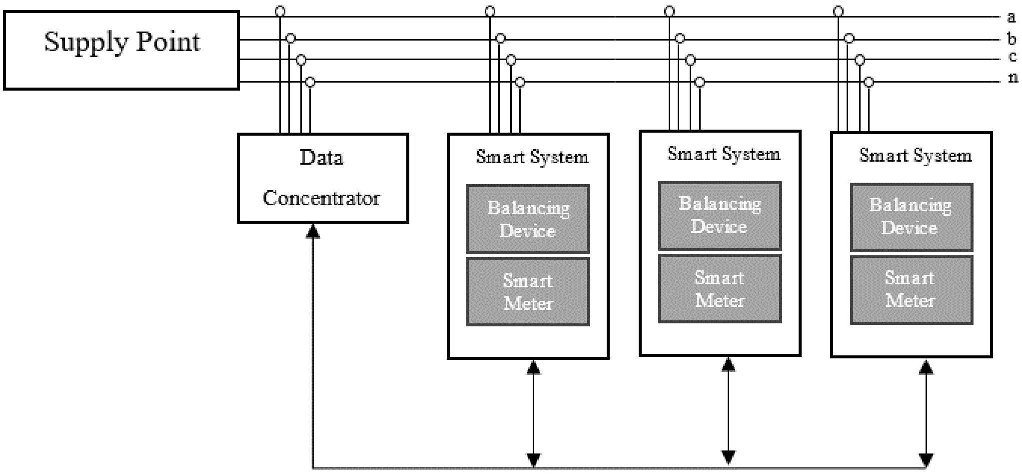


Figure 11. Electricity Load Balancing

Reference Standard	
Minister of Public Works and Housing Regulation Number 21 of 2021	Green Building Performance Assessment
SNI 6390-2020	Energy conservation of building air conditioning systems
SNI 6197-2020	Energy conservation in lighting systems
SNI 62053	Electric Meter Equipment
ISO 16484	Building automation and control systems
ISO 23045:2008	Building environment design — Guidelines to assess energy efficiency of new buildings
Others	and other applicable regulations or standards

5.4.4 Public Electric Vehicle Charging Stations

Public Electric Vehicle Charging Stations are facilities designed to recharge electric vehicle batteries in general, which can be used by the public with the aim of providing accessible and reliable infrastructure.

Functional Requirements	
Fast charging [3]	The system should have sufficient energy output so that it can charge electric vehicles quickly.
Compatibility [2]	The system should support various charging standards to ensure the system can serve different types of electric vehicles.
User-friendly user interface [3]	The system should have a user-friendly user interface that allows property managers or maintenance workers to easily monitor and control the system. It also increases user comfort in operating the system.
Renewable energy integration [2]	The system should be able to integrate with renewable energy sources such as solar panels or wind turbines to optimize energy consumption and reduce dependence on the grid.
Maintenance [2]	The system should have maintenance features, such as testing and inspection schedules, to ensure that the system is working and coded correctly.
Real-time data [2]	The system should provide real-time data on energy usage and other metrics so that users can monitor and adjust energy usage in real time.
Remote access [2]	The system should be remotely accessible so that users can monitor meter activity and energy usage from their mobile devices or computers.
Security [2]	The system should prioritize security by implementing appropriate data protection measures and secure access controls to prevent breaches or unauthorized access.
Customizable alerts [2]	The system should allow users to set customizable alerts for users or building management, to notify them of potential emergencies and prompt action.
More than one charging port [2]	The system must have more than one charging port to simultaneously accommodate multiple vehicle charging.

Hardware	Software
○ Charging station ○ Control panel ○ Authentication system ○ Payment system ○ Internet connection	○ Charging management system ○ User interface ○ Monitoring system ○ Integration with other energy systems ○ Power loading algorithm

Reference Standard	
Minister of Public Works and Housing Regulation Number 21 of 2021	Green Building Performance Assessment
Minister of Energy and Mineral Resources Regulation Number 1 of 2023	Provision of Electric Charging Infrastructure for Battery-based Electric Motor Vehicles
ISO 15118	Road vehicles – Vehicle to grid communication interface
IEEE 1547-2018	Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces
IEC 61851	Electric vehicle conductive charging system
Others	and other applicable regulations or standards

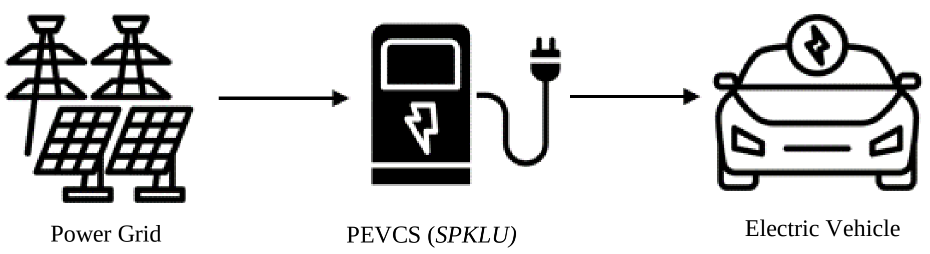


Figure 12. Public Electric Vehicle Charging Station

5.5 Safety System

5.5.1 Active Disaster Response System

Active Disaster Response System is a technology used to provide a fast and efficient response in dealing with emergency or disaster situations with the help of artificial intelligence, Internet of Things (IoT), and integration with related parties.

Functional Requirements	
Sensor and monitoring system [2]	The system must include a network of sensors and monitoring devices that detect changes in temperature, humidity, air quality and the presence of smoke, gas and other hazards.
Alert system [2]	The system must be able to quickly alert building occupants and emergency responders when a potential threat is detected. This could include audible alarms, visual alerts, and/or automated notifications to smartphones or other devices.
Communication system [3]	The system must provide a reliable communication channel for building occupants and emergency responders to communicate with each other and coordinate response efforts.
Automatic shut-off system [2]	The system must automatically shut-off systems for utilities such as gas, water, and electricity in case of emergency situations.
Automated emergency lighting [2]	The system must include automatic emergency lighting that turns on in the event of a power outage or other emergency situation.
Remote access to building controls [2]	The system must provide remote access to building controls, such as HVAC systems and elevators, to enable building managers and emergency responders to adjust settings as needed.
Real-time data analysis [2]	The system must include machine learning and artificial intelligence algorithms to analyze data from sensors and devices in real-time to identify patterns and anomalies that may indicate potential threats.
Disaster recovery system [2]	The system must have a disaster recovery plan in place to ensure that critical data and systems can be quickly restored in case of a disaster.
Integration [2]	The system must be integrated with other systems in order to maintain the safety of building occupants
Manual override [2]	The system must be able to be controlled manually when there is an automatic system failure in the event of a disaster.

Hardware	Software
○ Sensors and detectors ○ Alarms and alerts ○ Communication devices ○ Control devices ○ Data storage devices	○ Disaster response software ○ Alert management software ○ Data analysis software ○ Remote access software ○ User interface software ○ Building management system

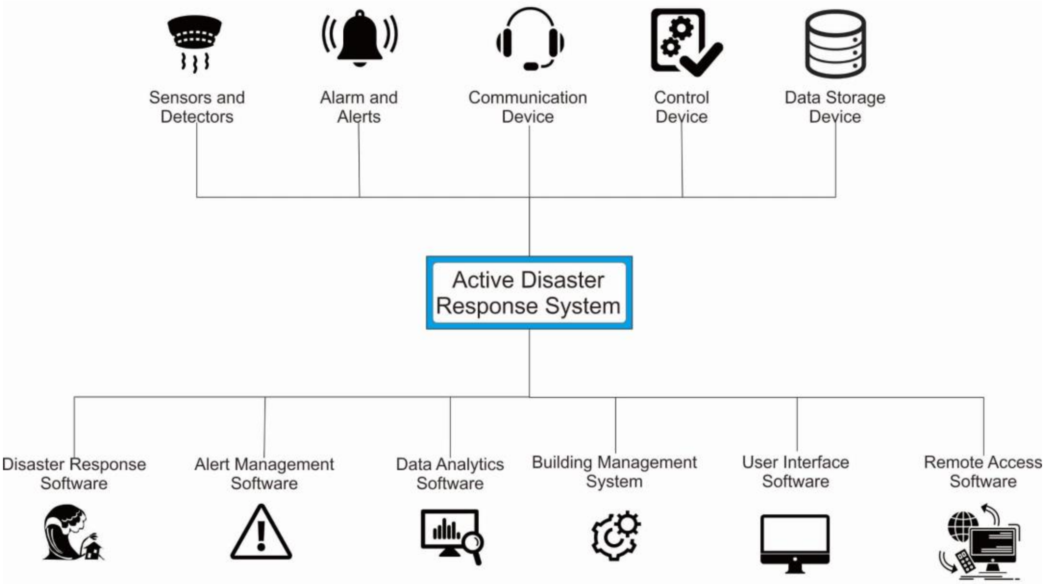


Figure 13. Active Disaster Response System

Reference Standard	
ISO 22329	Security and Resilience – Emergency management
ISO 16484	Building automation and control systems
ISO 8201:2017	Alarm systems
ISO 30061:2007	Emergency lighting
ISO 20414:2020	Fire safety engineering — Verification and validation protocol for building fire evacuation models
SNI 8840	Early warning system
SNI ISO 22320-2012	Public safety - Emergency management - Requirements for incident handling (ISO 22320:2011, IDT)
Others	And other applicable regulations or standards

5.5.2 Smart Fire Suppression System

Smart Fire Suppression System is a technology used to detect, track and respond to fires quickly and efficiently with the help of Internet of Things (IoT) devices and integration with other building systems.

Functional Requirements	
Real-time monitoring [1]	The system must enable real-time monitoring of the building or facility for potential fire hazards or outbreaks of fires.
Automatic fire suppression [2]	The system must automatically detect and extinguish fires using sprinklers or other fire suppression methods to minimize damage and protect passengers.
Alert system [1]	The system must be able to quickly alert building occupants and emergency responders when a potential fire threat is detected. This could include audible alarms, visual alerts, and/or automated notifications to smartphones or other devices.
Integration [2]	To optimize building safety and efficiency, a fire suppression system must be able to integrate with other smart building technologies, such as smoke detectors.
Scalability [2]	The system must be scalable according to building occupancy, number of users and changing security requirements.
Redundancy [2]	The system must have redundant parts, such as multiple water sources or backup power sources, to ensure reliable operation in case of failure or emergency.
Maintenance [1]	The system must have maintenance features, such as testing and inspection schedules, to ensure that the system is working and coded correctly.
User-friendly user interface [2]	The system must have a user-friendly user interface that allows property managers or maintenance workers to easily monitor and control the system.
Customizable alerts [3]	The system must allow users to set custom alerts for potential fires or system failures, notify them of potential problems, and act quickly.

Hardware	Software
○ Temperature sensor ○ Smoke sensor ○ Flow sensor ○ Water supply and pump ○ Sprinkler head ○ Fire extinguisher	○ Building Automation System (BAS) ○ Fire Alarm and Control Software ○ Fire Suppression and Control Software

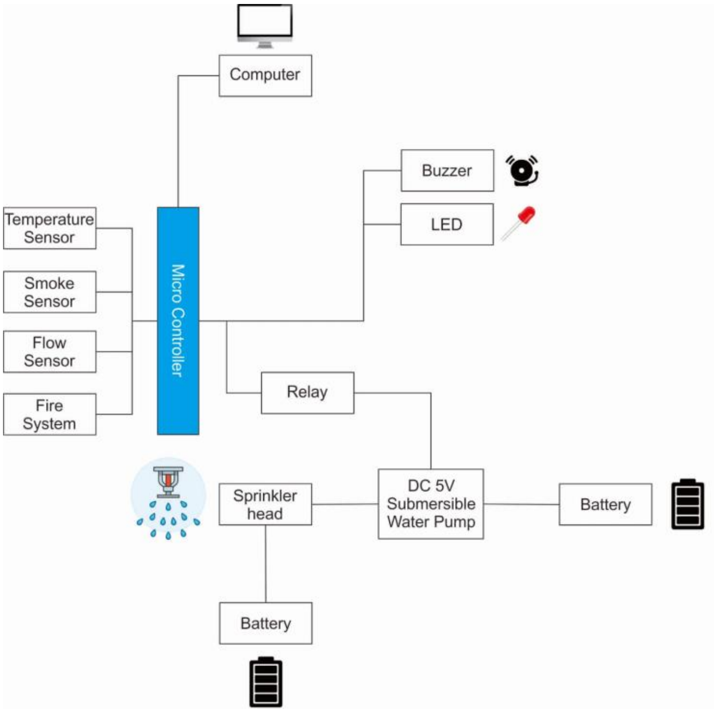


Figure 14. Smart Fire Supression System

Reference Standard	
ISO 7240	Fire detection and alarm systems
ISO 8201:2017	Alarm systems
ISO 30061:2007	Emergency lighting
ISO 16484	Building automation and control systems
ISO 20414:2020	Fire safety engineering — Verification and validation protocol for building fire evacuation models
ISO 16738:2009	Fire-safety engineering — Technical information on methods for evaluating behaviour and movement of people
SNI 03-6571-2001	Sistem pengendali asap kebakaran pada bangunan gedung
SNI 03-3985-2000	Procedures for planning, installation, and testing of fire detection and alarm systems for fire prevention in buildings.
SNI 03-3987-1995	Procedures for planning, installation of light fire extinguishers for fire prevention in houses and buildings.
SNI ISO 22320-2012	Public safety - Emergency management - Requirements for incident handling (ISO 22320:2011, IDT)
Others	And other applicable regulations or standards

5.5.3 Emergency Button

Emergency Button is a technology designed to provide quick assistance and emergency response in situations that threaten the life or safety of a person through integration with relevant parties.

Functional Requirements	
Quick response [2]	The system must provide quick response in case of emergencies, allowing occupants to quickly and easily request assistance.
Integration [2]	The emergency button system must be able to integrate with other smart building technologies, such as security cameras or access control systems, to optimize building safety and efficiency.
Scalability [2]	The system must be scalable to accommodate changes in building occupancy, user volume, and evolving safety requirements.
Location tracking [2]	The system must be able to track the location of the emergency button activation, to facilitate quick response and efficient allocation of resources.
Customizable alerts [3]	The system must allow users to set up customizable alerts for emergency response teams or building management, to notify them of potential emergencies and prompt action.
User-friendly interface [2]	The system must have a user-friendly interface that allows building occupants to easily locate and activate emergency buttons.
Compatibility [2]	The system must be compatible with different types of emergency buttons and support multiple communication protocols, such as cellular or Wi-Fi, to accommodate different building configurations.
Maintenance [2]	The system must have maintenance features in place, such as testing and inspection schedules, to ensure that the system is functioning properly and up to code.

Hardware	Software
○ Emergency button ○ Intercom system ○ Access control system ○ Panic alarms	○ Building Automation System (BAS) ○ Emergency response management software ○ Incident management software ○ Mass notification software

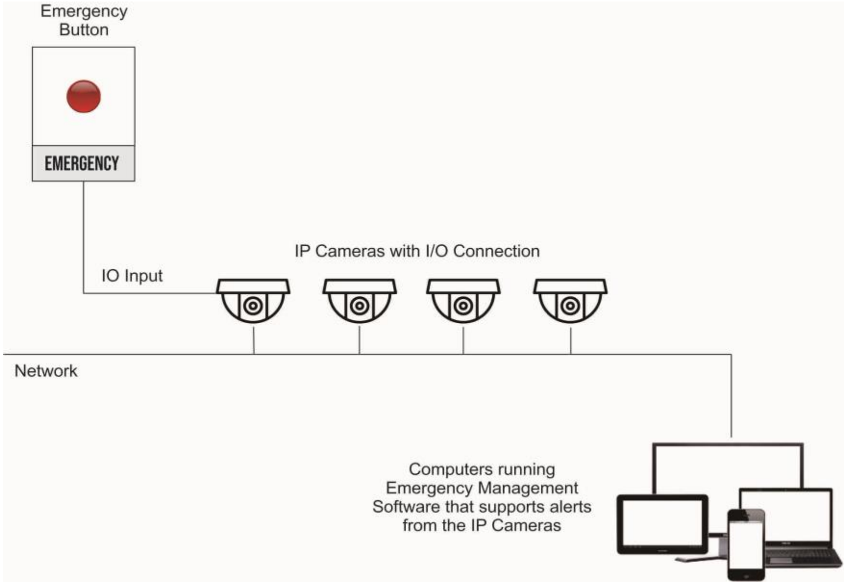


Figure 15. Emergency Button System

Reference Standard	
ISO 8201:2017	Alarm systems
ISO 30061:2007	Emergency lighting
ISO 16484	Building automation and control systems
ISO 20414:2020	Fire safety engineering — Verification and validation protocol for building fire evacuation models
ISO 16738:2009	Fire-safety engineering — Technical information on methods for evaluating behaviour and movement of people
SNI ISO 22320-2012	Public safety - Emergency management - Requirements for incident handling (ISO 22320:2011, IDT)
Others	and other applicable regulations or standards

5.5.4 Fire Safety Device Maintenance

Fire Safety Device Maintenance is a technology used to ensure proper maintenance of fire equipment through scheduling inspections and detecting damage or loss of equipment.

Functional Requirements		
Real-time monitoring [3]	The system must provide real-time monitoring of fire safety devices, such as smoke detectors or fire extinguishers to ensure they are working.	
Predictive maintenance [3]	The system must use predictive analytics to detect potential equipment failures before they occur, enabling preventative maintenance.	
Documentation [3]	The system must maintain documentation of all maintenance activities, including inspection results, repairs, and replacement records.	
User-friendly interface [3]	The system must have a user-friendly interface that allows building management or maintenance staff to easily access maintenance records and schedules.	
Hardware		**Software**
○ PIR/Weight sensor ○ Camera		○ Fire Alarm Maintenance Software ○ Inspection Software ○ Preventive Maintenance Software

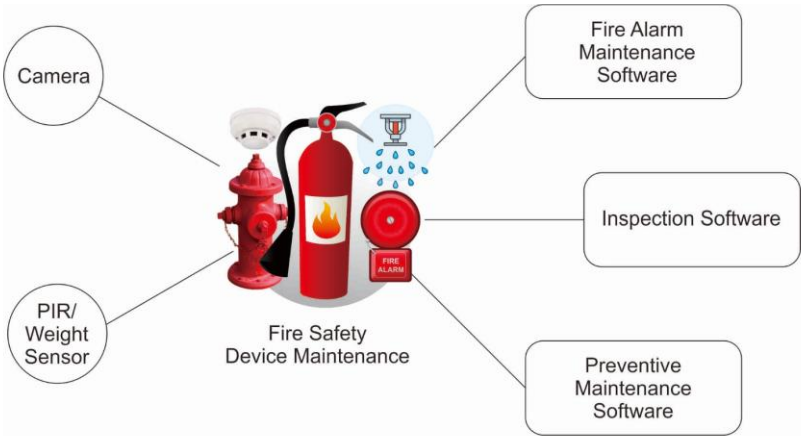


Figure 16. Fire Safety Device Maintenance

Reference Standard	
ISO 16484	Building automation and control systems
ISO/IEC 27037:2012	Information technology — Security techniques — Guidelines for identification, collection, acquisition and preservation of digital evidence
SNI 6570-2023	Fixed pump installation for fire protection
SNI 03-6571-2001	Fire smoke control system in buildings
SNI 03-6462-2000	Fire damper installation procedure
SNI 03-1746-2000	Procedures for planning and installing means of egress for rescue against fire hazards in buildings
SNI 03-3987-1995	Procedures for planning, installation of light fire extinguishers for fire prevention in houses and buildings.
Others	and other applicable regulations or standards

5.5.5 Animal Hazard Protection

Animal Hazard Protection is a technology that is able to detect the presence of animals in the vicinity of buildings and provide measures to safely remove these animals and alert building occupants automatically.

<table>
<tr><th colspan="2">Functional Requirements</th></tr>
<tr><td>Monitoring system [3]</td><td>Smart building technology must include surveillance systems such as sensors and cameras to detect the presence of insects and animals in and around buildings.</td></tr>
<tr><td>Real-time alerts [3]</td><td>The monitoring systems must be able to provide real-time alerts to building managers and occupants when insects or animals are detected.</td></tr>
<tr><td>Automated pest control [3]</td><td>The system must include automated pest control mechanisms such as insecticide sprays or traps to control insect populations and prevent infestations.</td></tr>
<tr><td>Automated deterrent systems [3]</td><td>Smart building technology can be used to install automated deterrent systems that use lights, sound, or other means to scare animals away from the building.</td></tr>
<tr><td>Air curtains [3]</td><td>Smart building technology can be used to install air curtains that can create a barrier between indoor and outdoor environments, preventing insects from entering the building.</td></tr>
<tr><td>Data analytics [3]</td><td>Smart building technology can be used to analyze data on insect populations and environmental factors to identify patterns and develop strategies to prevent future insect infestations.</td></tr>
<tr><th>Hardware</th><th>Software</th></tr>
<tr><td>○ Sensors
○ Cameras
○ Pest control mechanisms
○ Animal repellent</td><td>○ Wild animal monitoring
○ Safe zone integration
○ Smart pesticides monitoring
○ Automated pest control
○ Automated deterrent systems
○ Real-time alert system</td></tr>
</table>

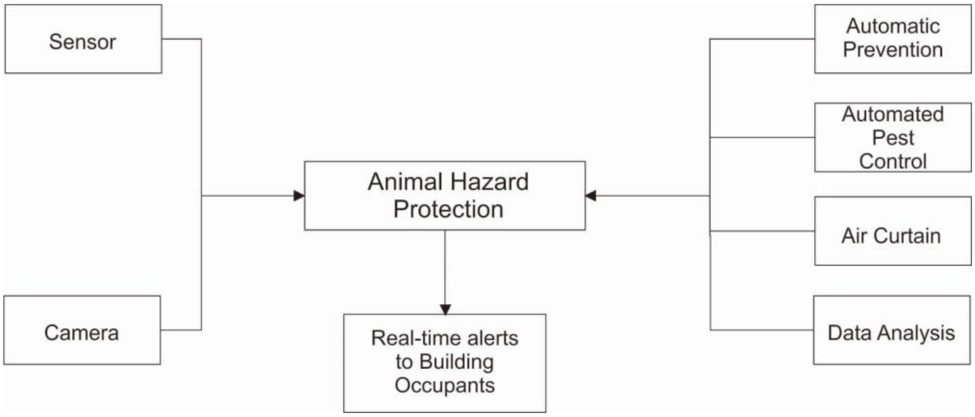


Figure 17. Animal Hazards Protection

Reference Standard	
Minister of Health Regulation No. 2 of 2023	Implementation regulation of government regulation number 66 of 2014 concerning Environmental Health
ISO 16484	Building automation and control systems
ISO/IEC 18025:2014	Information technology — Environmental Data Coding Specification (EDCS)
ISO/IEC 27037:2012	Information technology — Security techniques — Guidelines for identification, collection, acquisition and preservation of digital evidence
Others	and other applicable regulations or standards

5.6 Heating, Ventilation, and Air Conditioning (HVAC) System

5.6.1 Indoor and Outdoor Air Quality Monitoring

Indoor and outdoor air quality monitoring is a system to measure and monitor air quality both inside buildings and outdoors. Indoor air quality monitoring identifies and reduces indoor pollution, as well as maintaining a healthy environment for occupants. Meanwhile, outdoor air quality monitoring involves measuring pollutants in the outdoor air of buildings and surrounding environments to understand the level of outdoor air pollution and identify efforts that can be made to minimize its impact on occupant health

Functional Requirements	
Sensor-based monitoring [1]	The system must utilize sensors to measure and monitor air quality parameters according to the building and room functions.
Real-time monitoring [1]	The system must provide real-time monitoring of indoor air quality, alerts, and reporting of potential deviations from desired indoor air quality levels.
Historical data analysis [1]	The system must collect and analyze historical data on air quality, providing insights and recommendations to improve building ventilation, air filtration, or other actions to enhance indoor air quality.
Integration [1]	The air quality monitoring system must be integrated with other smart building technologies, such as demand-driven ventilation systems or building automation systems, to optimize the building's energy use and indoor air quality.
Maintenance [1]	The system must provide alerts and notifications for maintenance and repair needs, such as sensor calibration or replacement.

Hardware	**Software**
○ Air quality monitoring sensor ○ Connectivity	○ Building automation system ○ Monitoring software

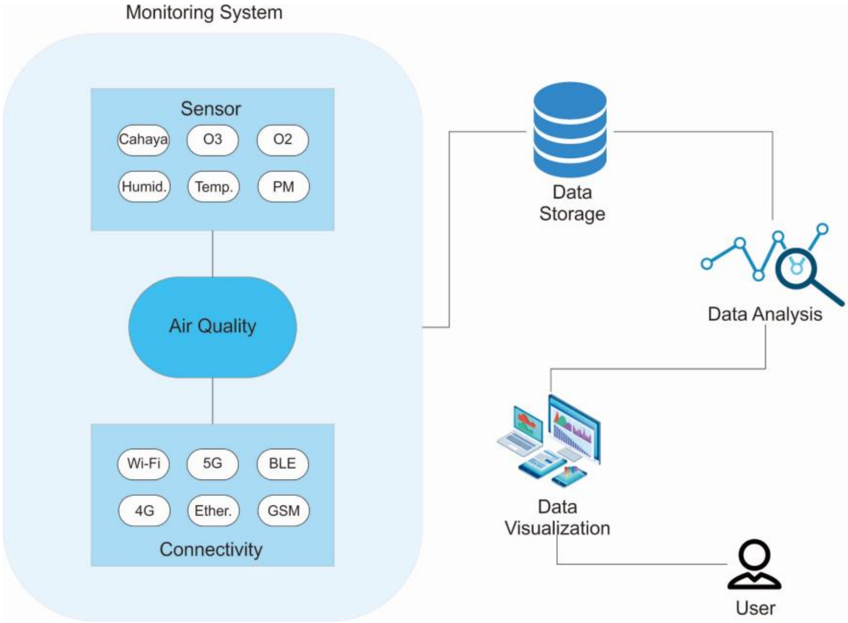


Figure 18. Indoor and Outdoor Air Quality Monitoring

Reference Standard	
Minister of Public Works and Housing Regulation Number 21 of 2021	Green Building Performance Assessment
Minister of Health Regulation No. 2 of 2023	Implementation regulation of government regulation number 66 of 2014 concerning Environmental Health
ISO 16484	Building automation and control systems
ISO 16813:2006	Building environment design — Indoor environment — General principles
ISO 16814:2008	Building environment design — Indoor air quality — Methods of expressing the quality of indoor air for human occupancy
ISO 1777-1:2017	Energy performance of buildings — Overall energy performance assessment procedures
Others	and other applicable regulations or standards

5.6.2 Air Conditioning System

Air Conditioning System is a technological system that regulates and controls the air temperature inside a building with the aim of creating a comfortable environment for its occupants, by lowering the air temperature inside the building when the outside conditions are too hot or increasing the temperature when the outside conditions are too cold, thus creating interior climate conditions optimally according to the preferences of the occupants.

Functional Requirements	
Temperature control [1]	The system must be able to maintain a comfortable temperature in the building, adjusting automatically according to the preferences of the occupants.
Energy efficiency [1]	The system must be energy-efficient, reducing energy consumption and costs by optimizing cooling and heating based on occupancy, ambient temperature, and other factors.
Remote access [2]	The system must allow building management or occupants to remotely access and control the air conditioning system, using a mobile app or web portal.
Integration [1]	The smart air conditioning system must be able to integrate with other smart building technologies, such as building automation systems, occupancy sensors, or weather forecasting systems, to optimize building energy use and comfort.
Zoning [2]	The system must support zoning, allowing different parts of the building to be cooled or heated independently, based on occupancy or other criteria.
Maintenance [1]	The system must provide alerts and notifications for maintenance and repair needs, such as filter replacement, refrigerant leaks, or system failures.
Data analytics [1]	The system must collect and analyze data on energy use, temperature settings, and occupancy patterns, providing insights and recommendations for optimizing building energy efficiency and comfort.
Automation [1]	The system will manage the condition of indoor air automatically from recommendations given by data analytics, but it can be interrupted by humans.
User-friendly interface [2]	The system must have a user-friendly interface that allows building occupants or management to easily adjust temperature settings, view energy consumption data, and access other system features.

Hardware	Software
○ Heavy-duty pressure ○ Thermal sensor ○ Gas quality sensor ○ Humidity sensor	○ Building automation system ○ Monitoring software

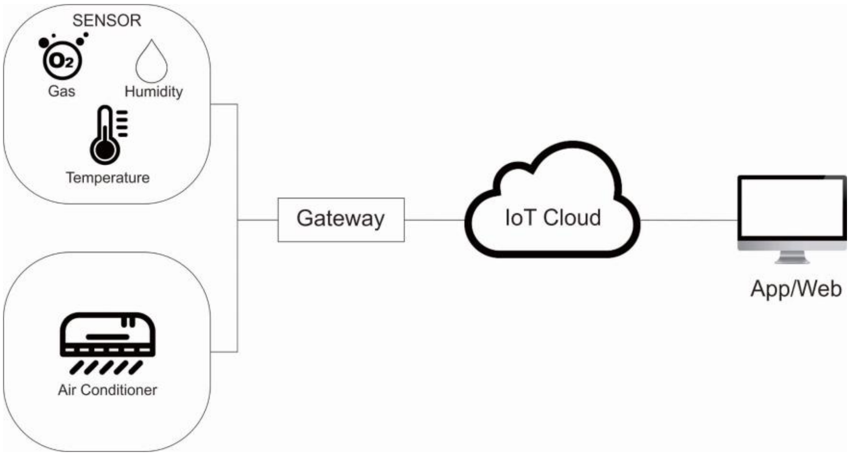


Figure 19. Air Conditioning System

Reference Standard	
SNI 6390:2020	Energy conservation of air conditioning systems in buildings
SNI 03-6572-2001	Procedures for designing ventilation and air conditioning systems in buildings
Minister of Public Works and Housing Regulation Number 21 of 2021	Green Building Performance Assessment
Minister of Health Regulation No. 2 of 2023	Implementation regulation of government regulation number 66 of 2014 concerning Environmental Health
ISO 16484	Building automation and control systems
ISO 16813:2016	Building environment design — Indoor environment — General principles
IEEE 3004.8-2016	Recommended Practice for the Application of Low Voltage (600 V and below) Air Conditioning and Heat Pump Equipment
ISO 17772-2:2017	Energy performance of buildings - Ventilation for buildings - Part 2: Ventilation requirements for non-residential buildings
Others	and other applicable regulations or standards

5.6.3 Air Purification and Filter Monitoring

Air Purification and Filter Monitoring is a technology system that can clean and monitor air quality inside buildings with the goal of creating a healthy and comfortable environment for occupants by removing dust particles, dirt, pollutants, and allergens from the air, as well as regulating humidity and temperature levels to create an optimal indoor environment.

Functional Requirements	
Sensor-based monitoring [1]	The system must use sensors to measure and monitor indoor air quality parameters such as particulate matter, volatile organic compounds (VOCs), or other relevant factors with high sensitivity and low error from the sensor.
Air purification [1]	The system must be equipped with air purification capabilities, such as HEPA filters or activated carbon, chlorine, nitrogen, etc filters, to remove gas pollutants from the air.
Real-time monitoring [1]	The system must provide real-time monitoring of indoor air quality, with alerts and notifications for any deviation from the desired indoor air quality levels.
Filter monitoring [2]	The system must monitor the status of air filters, alerting users when it's time for replacement, and track the history of filter replacements devices and sensors.
Integration [1]	The air purification and filter monitoring system must be able to integrate with other smart building technologies, such as building automation systems or air quality monitoring systems, to optimize building energy use and indoor air quality.
User-friendly interface [2]	The system must have a user-friendly interface that allows building occupants or management to easily access and view indoor air quality data, receive alerts, and access other system features, including filter replacement.
Maintenance [1]	The system must provide alerts and notifications for maintenance and repair needs, such as filter replacement or system cleaning.
Data analytics [1]	The system must collect and analyze data on indoor air quality parameters, providing insights and recommendations for optimizing air purification and filter replacement.

Hardware	Software
○ Gas Quality sensor ○ Airflow sensor ○ Humidity sensor ○ Particle sensor ○ Basic switch ○ Thermal sensor	○ Simulation software ○ Monitoring HVAC ○ Controlling HVAC

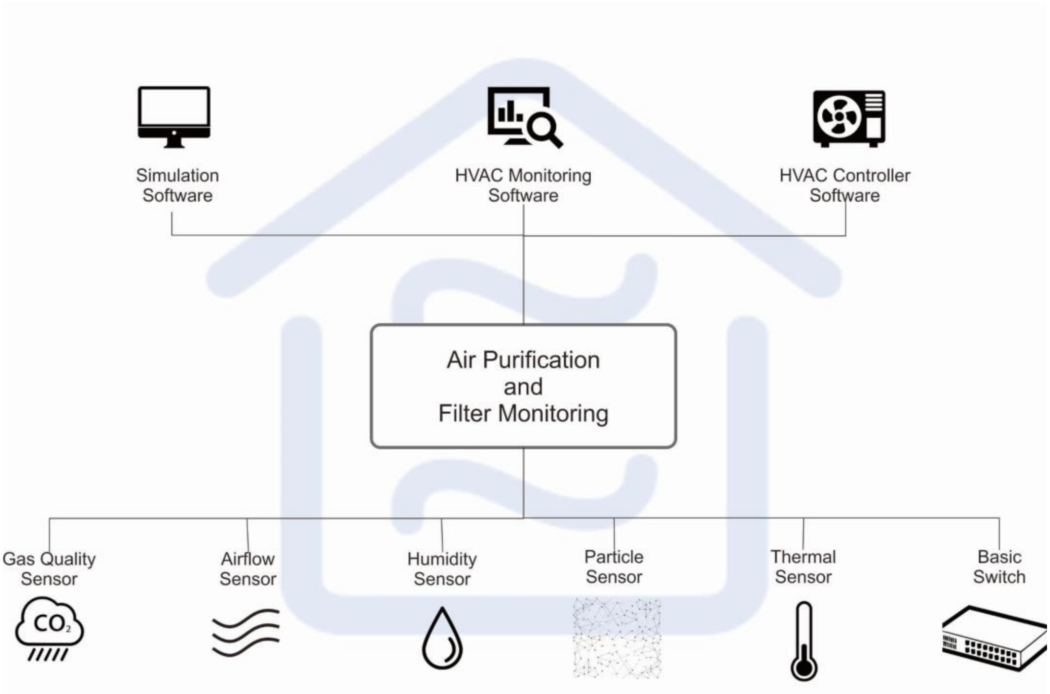


Figure 20. Air Purification and Filter Monitoring

Reference Standard	
Minister of Public Works and Housing Regulation Number 21 of 2021	Green Building Performance Assessment
Minister of Health Regulation No. 2 of 2023	Implementation regulation of government regulation number 66 of 2014 concerning Environmental Health
ISO 16813:2006	Building environment design — Indoor environment — General principles
ISO 16484	Building automation and control systems
ISO 16814:2008	Building environment design — Indoor air quality — Methods of expressing the quality of indoor air for human occupancy
ISO 1777-1:2017	Energy performance of buildings — Overall energy performance assessment procedures
Others	and other applicable regulations or standards

5.6.4 Demand Controlled Ventilation (DCV)

DCV is a ventilation system that automatically adjusts the amount of fresh air brought into the building based on real-time occupancy and air quality data that optimizes indoor air quality while minimizing energy consumption by providing ventilation in response to actual demand.

Functional Requirements	
Sensor-based ventilation [1]	The system must use sensors to detect occupancy and air quality parameters according to the building and room functions to adjust the level of ventilation and appropriate airflow.
Energy efficiency [1]	The system must be energy-efficient, reducing energy consumption and costs by optimizing ventilation based on occupancy, air quality, and other factors..
Integration [1]	The Demand-based ventilation systems should be integrable with other smart building technologies, such as building automation systems or air quality monitoring systems, to optimize building energy usage and indoor air quality.
Zoning [2]	The system must support zoning, allowing various parts of the building to ventilate independently based on occupancy or other criteria.
User preerences [1]	The system must allow building occupants to adjust ventilation levels based on their preferences or health conditions.
Maintenance [1]	The system must provide alerts and notifications for maintenance and repair needs, such as filter replacement or sensor calibration.
Data analytics [1]	The system must collect and analyze data on occupancy, air quality, and energy usage, providing insights and recommendations to optimize building energy efficiency and indoor air quality.
Automation [1]	The system will manage ventilation automatically based on data analytics recommendations but can be intervened by humans.

Hardware	Software
○ Humidity sensor ○ Gas quality sensor ○ Particle sensor ○ Thermal sensor ○ Occupancy sensor ○ Airflow sensor	○ Building Automation System (BAS) ○ Monitoring dashboard

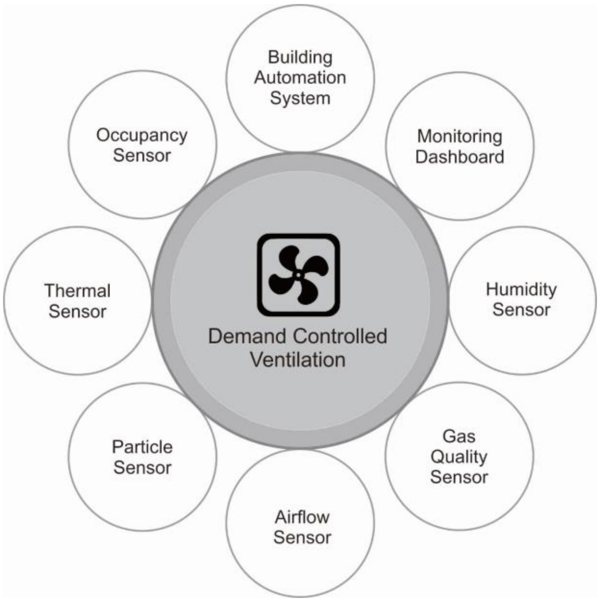


Figure 21. Demand Controlled Ventilation

Reference Standard	
SNI 6390:2020	Energy conservation of air conditioning systems in buildings
SNI 03-6572-2001	Procedures for designing ventilation and air conditioning systems in buildings
Minister of Public Works and Housing Regulation Number 21 of 2021	Green Building Performance Assessment
ISO 16484	Building automation and control systems
ISO 16813:2006	Building environment design — Indoor environment — General principles
ISO 1777-1:2017	Energy performance of buildings
ISO 16798-3:2019	Energy performance of buildings - Part 3: Ventilation for buildings - Performance requirements for ventilation and room-conditioning systems
Others	and other applicable regulations or standards

5.6.5 Climate Detection System

A system that monitors and controls various climate parameters inside buildings to create optimal and comfortable environmental conditions for occupants while optimizing energy use.

Functional Requirements	
Sensor-based monitoring [1]	The system must use sensors to measure and monitor indoor climate parameters such as temperature, humidity, and air pressure.
Real-time monitoring [1]	The system must provide real-time monitoring of indoor climate conditions, with alerts and notifications for any deviation from the desired indoor climate levels.
Historical data analysis [1]	The system must collect and analyze historical data on indoor climate conditions, providing insights and recommendations for improving building energy efficiency, comfort, and indoor air quality.
Integration [1]	The climate detection system must be able to integrate with other smart building technologies, such as HVAC systems or building automation systems, to optimize building energy use and indoor climate control.
User-friendly interface [2]	The system must have a user-friendly interface that allows building occupants or management to easily access and view indoor climate data, receive alerts, and access other system features.
Maintenance [1]	The system must provide alerts and notifications for maintenance and repair needs, such as sensor calibration or replacement.
Security [1]	The system must prioritize security by implementing appropriate data protection measures and secure access controls to prevent unauthorized access or tampering of system data.
Compliance [1]	The system must comply with relevant indoor climate standards and guidelines, such as the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards or local building codes.
Mobile access [2]	The system must provide mobile access to indoor climate data and alerts, allowing building occupants to monitor indoor climate remotely and take necessary actions to improve comfort and indoor air quality.

Hardware	Software
○ Humidity sensor ○ Air quality sensor ○ Thermal sensor ○ IoT device	○ Data processing application ○ Air quality monitoring algorithms, notifications and automatic actions ○ Control dashboard

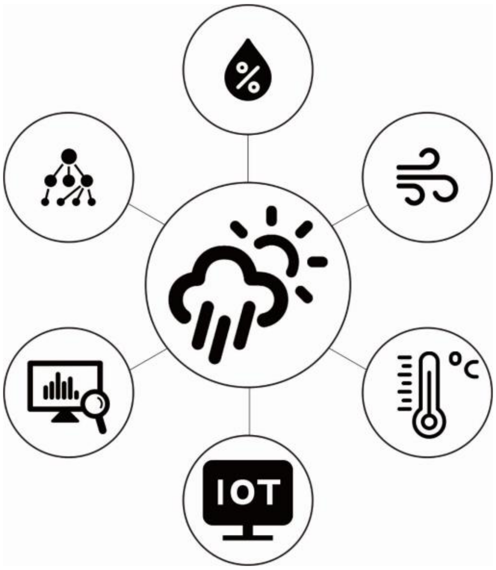


Figure 22. Climate Detection System

Reference Standard	
Minister of Health Regulation No. 2 of 2023	Implementation regulation of government regulation number 66 of 2014 concerning Environmental Health
ISO 16484	Building automation and control systems
SNI 6390:2020	Energy conservation of air conditioning systems in buildings
SNI 03-6572-2001	Procedures for designing ventilation and air conditioning systems in building
Minister of Public Works and Housing Regulation Number 21 of 2021	Green Building Performance Assessment
ISO 16813:2006	Building environment design — Indoor environment — General principles
Others	and other applicable regulations or standards

5.7 Lighting System

5.7.1 Sistem Pencahayaan Cerdas

A lighting system equipped with intelligent technology capable of detecting the environment and set automatically or through smart control. Intelligent lighting systems are able to adjust lighting levels so as to minimize energy use and maintain occupant comfort.

Functional Requirements	
Automated controls [1]	The system must be able to automatically turn lights on or off based on occupancy, time of day, or other specified conditions.
Sensor-based controls [1]	The system must use sensors to detect occupancy or daylight levels, allowing for more precise and energy-efficient lighting control.
Customizable settings [1]	The system must allow for customization of lighting settings, such as dimming levels, color temperature, or lighting scenes, to meet the needs of different spaces or tasks.
Integration [1]	The lighting system must be able to integrate with other smart building technologies, such as building automation systems or occupancy sensors, to optimize building energy use and lighting control.
User-friendly interface [2]	The system must have a user-friendly interface that allows building occupants or management to easily adjust lighting settings, schedule lighting scenes, or access other system features.
Maintenance [1]	The system must provide alerts and notifications for maintenance and repair needs, such as bulb replacement or sensor cleaning.
Energy monitoring [1]	The system must be able to monitor energy use and provide insights and recommendations for optimizing lighting control and energy efficiency.
Security [1]	The system must prioritize security by implementing appropriate data protection measures and secure access controls to prevent unauthorized access or tampering of system data.
Compliance [1]	The system must comply with relevant lighting standards and guidelines, such as the Illuminating Engineering Society (IES) standards or local building codes.
Mobile access [2]	The system must provide mobile access to lighting control and settings, allowing building occupants to adjust lighting remotely and increase energy savings.

Hardware	Software
○ Motion (PIR) sensor ○ Illumination sensor	○ Intelligent algorithm ○ Lighting analysis software ○ Lighting design software

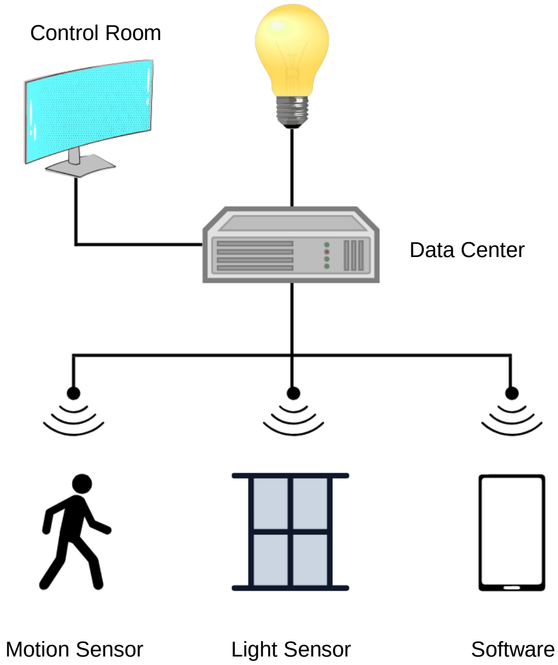


Figure 23. Lighting System

Reference Standard	
SNI 6197:2020	Energy Conservation in Lighting System
Minister of Public Works and Housing Regulation Number 21 of 2021	Green Building Performance Assessment
Minister of Health Regulation No. 2 of 2023	Implementation regulation of government regulation number 66 of 2014 concerning Environmental Health
ISO/CIE 20086:2019	Light and lighting — Energy performance of lighting in buildings
Others	and other applicable regulations or standards

5.8 Mobility System

5.8.1 Smart Escalator and Autowalk

Escalator and/or autowalk systems are systems that can improve safety and energy efficiency by detecting the presence of users, dangerous behavior, and integration with other building systems. The system is able to adjust the operating speed according to the user's presence and automatically stop in case of an emergency.

Functional Requirements	
Safety [2]	The smart escalator and autowalk system must prioritize safety, by implementing appropriate safety features such as anti-skid surfaces, emergency stop buttons, and handrail speed monitoring.
Efficiency [2]	The smart escalator and autowalk system must prioritize efficiency and reduce waiting times, by using algorithms to calculate the most optimal escalator and autowalk routing and speed control.
Integration [2]	The smart escalator and autowalk system must integrate with other smart building technologies, such as building automation systems or occupancy sensors, to optimize building operations and escalator/autowalk usage.
User-friendly interface [3]	The system must have a user-friendly interface that allows building occupants to easily access and use the escalator or autowalk, view system status, and receive alerts or notifications.
Emergency management [2]	The smart escalator and autowalk system must have an emergency management system, such as fire service mode, earthquake mode, and blackout mode, to ensure the safe evacuation of occupants in emergency situations.
Maintenance [2]	The system must provide alerts and notifications for maintenance and repair needs, such as mechanical failures or wear and tear, allowing for proactive maintenance and minimizing downtime.
Energy efficiency [2]	The smart escalator and autowalk system must prioritize energy efficiency, by using features such as regenerative braking, low-energy LED lighting, and sleep mode to reduce energy consumption.
Security [2]	The smart escalator and autowalk system must prioritize security by implementing appropriate access controls, data protection measures, and secure communication protocols to prevent unauthorized access or tampering of system data.
Real-time monitoring [2]	The smart escalator and autowalk system must provide real-time monitoring of escalator and autowalk usage, traffic patterns, and other relevant data, allowing for continuous improvement and optimization.
Automation [2]	The system will change slowly or fast automatically from recommendations given by data analytics, but it can be interrupted by humans.

Hardware	Software
○ Sensor ○ Controller ○ Motors ○ Steps and handrails	○ Escalator management system ○ User interface ○ Predictive maintenance software ○ Energy management software

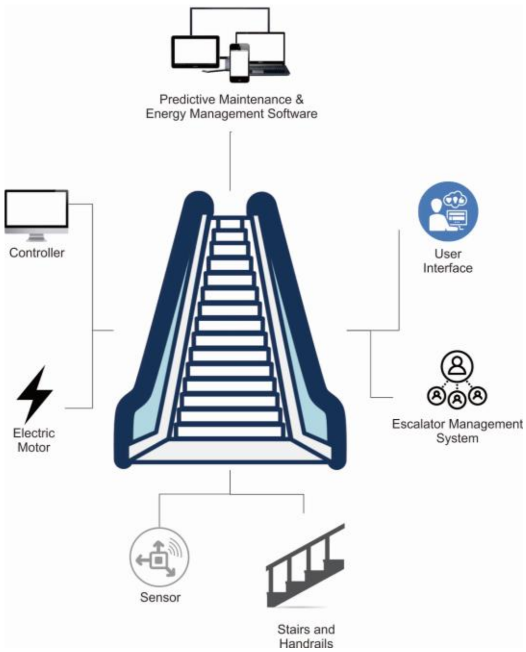


Figure 24. Smart Escalator System

Reference Standard	
Minister of Manpower Regulation Number 6 of 2017	Elevator Occupational Safety & Health
EN 115-1:2017	Safety of escalators and moving walks
EN 115-2:2010	Safety of escalators and moving walks
ISO 25745	Energy performance of lifts, escalators, and moving walks
ISO 27001:2022	Information security, cybersecurity, privacy protection
ISO 27010:2015	Information security controls for cloud services
IEC 62443-4-1	Secure product development lifecycle requirements
IEC 62443-4-2	Industrial Automation & Control - Technical security requirement
Others	and other applicable regulations or standards

5.8.2 Elevator Cerdas

Smart Elevator is elevator system that improves energy efficiency, user experience and safety by detecting user presence, determining effective routes, and integration with emergency systems.

Functional Requirements	
Efficiency [2]	The smart elevator system must prioritize efficiency and reduce waiting times, by using algorithms to calculate the most optimal elevator route and elevator group control.
Access Control [2]	The smart elevator system must have secure access control, allowing authorized individuals to access specific floors or areas based on their credentials.
Integration [2]	The smart elevator system must integrate with other smart building technologies, such as building automation systems or occupancy sensors, to optimize building operations and elevator usage.
User-friendly interface [3]	The system must have a user-friendly interface that allows building occupants to easily select their desired floor or destination, view elevator status, and receive alerts or notifications.
Emergency management [2]	The smart elevator system must have an emergency management system, such as fire service mode, earthquake mode, and blackout mode, to ensure the safe evacuation of occupants in emergency situations.
Maintenance [2]	The system must provide alerts and notifications for maintenance and repair needs, such as mechanical failures or wear and tear, allowing for proactive maintenance and minimizing downtime.
Energy efficiency [2]	The smart elevator system must prioritize energy efficiency, by using features such as regenerative braking, low-energy LED lighting, and sleep mode to reduce energy consumption.
Security [2]	The smart elevator system must prioritize security by implementing appropriate access controls, data protection measures, and secure communication protocols to prevent unauthorized access or tampering of system data.
Real-time monitoring [2]	The smart elevator system must provide real-time monitoring of elevator usage, traffic patterns, and other relevant data, allowing for continuous improvement and optimization.

Hardware	Software
○ Sensor (Weight, motion) ○ Controller ○ Motor ○ Elevator car	○ Elevator management system ○ User interface & IoT device ○ Predictive maintenance software ○ Energy management software

Figure 25. Smart Elevator System

Reference Standard	
Minister of Manpower Regulation Number 6 of 2017	Elevator Occupational Safety & Health
Minister of Public Works and Housing Regulation Number 21 of 2021	Green Building Performance Assessment
SNI 03-6573:2001	Design procedure for vertical transportation system
SNI 03-7017.1:2004	Handover inspection and testing
SNI 03-7017.2:2014	Periodic inspection and testing
SNI 05-7052:2004	General requirements for roomless elevator machine construction
EN 81-20:2014	Safety rules for the construction and installation of lifts
EN 81-50:2014	Design rules, calculations, examinations
ISO 25745	Energy performance of lifts, escalators, and moving walks
ISO 8100-34:2021	Measurement of lift ride quality
ISO 27001:2022	Information security, cybersecurity, privacy protection
ISO 27010:2015	Information security controls for cloud services
IEC 62443-4-1	Secure product development lifecycle requirements
IEC 62443-4-2	Industrial Automation & Control - Technical security requirement
Others	and other applicable regulations or standards

5.8.3 Smart Parking System

Smart Parking System is a technology system that uses various sensors and smart devices to optimize and manage the parking process in building parking areas to improve efficiency, safety and user experience.

Functional Requirements	
Real-time monitoring [3]	The system must provide real-time monitoring of parking occupancy and availability.
Accurate detection [3]	The system must be able to accurately detect the presence or absence of vehicles using sensors and/or cameras.
Easy navigation [3]	The system must provide clear and easy-to-follow navigation to available parking spaces.
Reservation system [3]	The system must allow users to reserve parking spots in advance, either through a mobile app or a web interface.
Payment system [3]	The system must provide a payment system that allows users to pay for parking with credit cards, mobile payments or other payment methods.
Integration with other systems [3]	The system must be integrated with other building systems, such as security systems, building automation systems, and transportation systems.
Maintenance [3]	The system must provide alerts and notifications for maintenance and repair needs, such as mechanical failures or wear and tear, allowing for proactive maintenance and minimizing downtime.
Security [3]	The system must prioritize security by implementing appropriate access controls, data protection measures, and secure communication protocols to prevent unauthorized access or tampering of system data.
Energy efficiency [3]	The system must prioritize energy efficiency, by using low-power sensors and sleep mode to reduce energy consumption.
Compliance [3]	The system must comply with relevant parking and transportation regulations, such as accessibility requirements and local parking codes.
Data analysis [3]	The system must analyze parking data over time, identifying patterns and trends, and provide data-driven insights to building management for decision making.
User experience [3]	The system must provide a positive user experience, with intuitive interfaces, clear instructions, and responsive customer service.

Hardware	Software
○ Sensors (Ultrasonic, magnetic, infrared) ○ Cameras ○ LED displays ○ Communication devices ○ Barrier gates ○ Parking systems ○ Central server or cloud	○ Parking management system ○ User application ○ Dashboard control and monitoring

Figure 26. Smart Parking System

Reference Standard	
Minister of Public Works and Housing Regulation Number 21 of 2021	Green Building Performance Assessment
ISO 16787:2017	Intelligent transport systems — Assisted parking system (APS)
Others	and other applicable regulations or standards

5.9 Security System

5.9.1 Intelligent Video Surveillance

Intelligent Video Surveillance is a security system that uses surveillance camera technology equipped with artificial intelligence to increase effectiveness and efficiency in surveillance and security monitoring through motion, face, object and action detection as well as integration with related parties.

Functional Requirements	
High-quality video resolution [2]	The video surveillance system must provide high-resolution video footage to capture clear and detailed images of all areas within the building.
Real-time monitoring [1]	The video surveillance system must provide real-time monitoring of all areas within the building, allowing security personnel to quickly respond to any security incidents.
Intelligent video analytics [1]	The video surveillance system must incorporate intelligent video analytics technology to detect and alert security personnel of any suspicious behavior or security threats. This includes facial recognition, object detection, and people counting.
Automated alerts [1]	The video surveillance system must be able to send automated alerts to security personnel when suspicious behavior or security threats are detected.
Integration with other security systems [1]	The video surveillance system must be able to integrate with other security systems such as access control systems, alarm systems, and intercom systems to provide a comprehensive security solution.
Storage and retrieval [1]	The video surveillance system must be able to store and retrieve video footage for a predetermined amount of time, allowing security personnel to review past footage for investigations.
Remote monitoring [1]	The video surveillance system must be accessible remotely, allowing authorized personnel to view live footage and access recordings from a remote location.
Compliance with data protection regulations [1]	The video surveillance system must comply with data protection regulations, including GDPR, by ensuring that the data captured is used and stored securely and only accessed by authorized personnel.

Hardware	Software
○ Biometric Readers ○ Camera ○ Barriers ○ Buzzer	○ Video Management Software ○ Access Control Software ○ Artificial Intelligence (AI) and Machine Learning (ML)

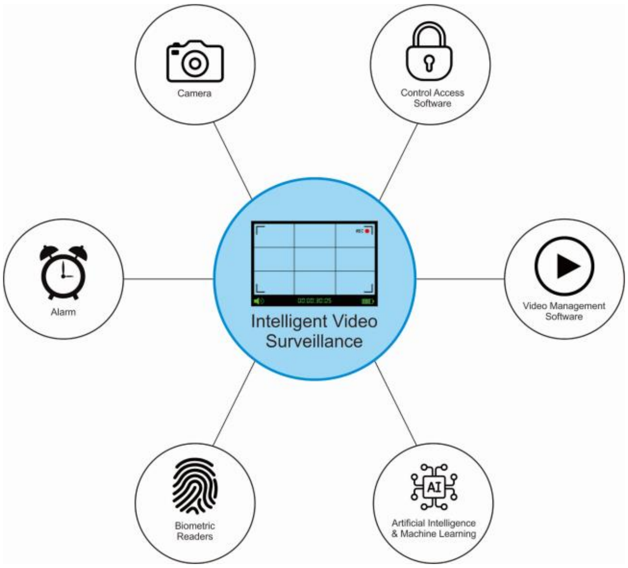


Figure 27. Intelligent Video Surveillance

Reference Standard	
ISO 30137	Information technology - Use of biometrics in video surveillance systems
ISO/IEC 27037:2012	Information technology — Security techniques — Guidelines for identification, collection, acquisition and preservation of digital evidence
ISO 27001:2022	Information security, cybersecurity, privacy protection
ISO 27010:2015	Information security controls for cloud services
IEC 62443-4-1	Secure product development lifecycle requirements
IEEE 2410-2020	Standard for Biometrics Open Protocol Extended Frameworks (OPEN)
Others	and other applicable regulations or standards

5.9.2 Smart Locking System

Smart Locking System is a technology that can increase the efficiency and security of access control and door locking by selecting various locking methods, integration with applications and related parties, real-time data collection and detection of restricted access.

Functional Requirements		
Access control [1]	The system must provide access control, allowing only authorized personnel to enter the building or specific areas within the building.	
Security [1]	The system must provide a high level of security to prevent unauthorized entry, such as using strong encryption, tamper-proof hardware, and intrusion detection.	
Ease of use [1]	The system must be easy to use for authorized personnel, requiring minimal training to operate and providing clear feedback on access status.	
Scalability [2]	The system must be scalable, allowing for easy expansion to accommodate growing building needs and changing access requirements.	
Remote management [1]	The system must provide remote management capabilities, allowing administrators to control access from a centralized location and monitor access logs.	
Integration [1]	The system must integrate with other building systems, such as security systems and building automation systems, to optimize building operations and security.	
Emergency access [1]	The system must provide emergency access to authorized personnel in case of emergency, such as using emergency override keys or providing access to first responders.	
Durability and reliability [1]	The system must be durable and reliable, able to withstand frequent use and exposure to harsh environmental conditions.	
Compliance [1]	The system must comply with relevant building codes and regulations, such as ADA requirements and fire safety codes.	
Cost-effectiveness [1]	The system must be cost-effective, providing value for money while meeting building security needs.	
Hardware		**Software**
○ Biometric Sensor ○ RFID Reader ○ Camera ○ Battery ○ IOT device ○ Door locking equipment		○ Door locking system ○ Monitoring dashboard ○ Access control software ○ Alarm management software

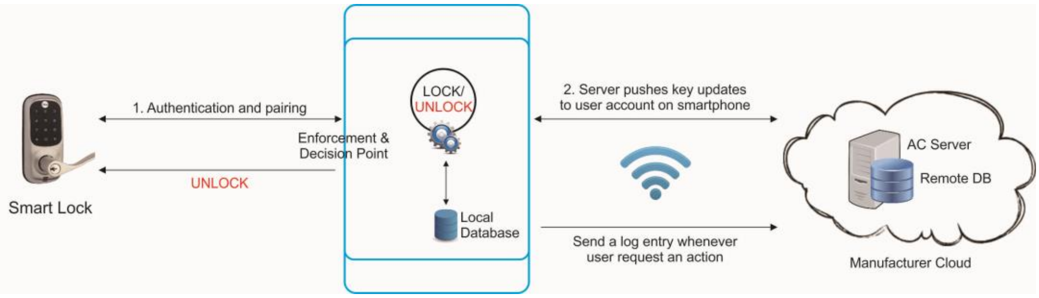


Figure 28. Smart Locking System

Reference Standard	
ISO 30137	Information technology - Use of biometrics in video surveillance systems
ISO/IEC 27037:2012	Information technology — Security techniques — Guidelines for identification, collection, acquisition and preservation of digital evidence
ISO 27001:2022	Information security, cybersecurity, privacy protection
ISO 27010:2015	Information security controls for cloud services
IEC 62443-4-1	Secure product development lifecycle requirements
IEEE 2410-2020	Standard for Biometrics Open Protocol Extended Frameworks (OPEN)
Others	and other applicable regulations or standards

5.9.3 Virtual Gates

Virtual Gate is a technology that can control access to an area without the need to use a physical door or a conventional gate, but with smart devices such as surveillance cameras and sensors. Integration with other building systems is needed so that building managers can manage occupant access and get warnings if violations occur.

Functional Requirements	
Access control [3]	The system must be able to verify the user's identity and grant access or deny access based on their permission level.
Integration with hardware [3]	When a virtual gateway is used to control physical access points, it must be integrated with hardware such as card readers or biometric scanners.
Real-time monitoring [3]	The system must be able to monitor the status of the port and provide real-time alerts about potential problems such as unauthorized access attempts.
Customization [3]	A virtual gateway must be customizable to meet the specific needs of the organization, such as setting access levels, managing user profiles, and defining access rules.
Reporting and analysis [3]	The system must provide detailed reporting and analysis to help organizations understand and optimize their access control practices.
Scalability [3]	The system must be designed to scale as the organization grows and accommodate future expansion.
User interface [3]	The virtual port must have an intuitive and user-friendly interface that makes it easy for users to interact with the system.
Access control [3]	The system must be able to verify the user's identity and grant access or deny access based on their permission level.

Hardware	Software
○ Depth camera ○ Network video recorders ○ Access control systems ○ Proximity Sensor	○ Video analytics software ○ Access control software ○ Alarm management software

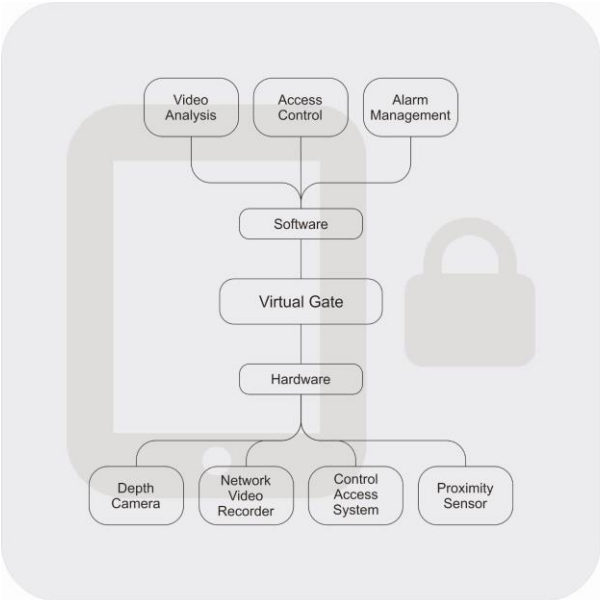


Figure 29. Virtual Gates

Reference Standard	
ISO 30137	Information technology - Use of biometrics in video surveillance systems
ISO/IEC 27037:2012	Information technology — Security techniques — Guidelines for identification, collection, acquisition and preservation of digital evidence
ISO 27001:2022	Information security, cybersecurity, privacy protection
ISO 27010:2015	Information security controls for cloud services
IEC 62443-4-1	Secure product development lifecycle requirements
IEEE 2410-2020	Standard for Biometrics Open Protocol Extended Frameworks (OPEN)
Others	and other applicable regulations or standards

5.9.4 Occupancy Monitoring

Occupancy Monitoring is a technology that is able to detect and observe the occupancy level of a building to improve security and safety through accurate occupancy tracking, real-time data collection, and integration with other building systems

Functional Requirements	
Accurate occupancy tracking [2]	The system must accurately track the number of people in a building or specific areas of the building using sensors, cameras, or other technology.
Real-time data [2]	The system must provide real-time data on occupancy levels, allowing building management to make informed decisions about building operations and resources.
Data analytics [2]	The system must provide data analytics on occupancy patterns and trends, enabling building management to identify opportunities for optimization and improvement.
Privacy protection [2]	The system must protect the privacy of occupants by using anonymous data collection and ensuring compliance with relevant privacy regulations.
Integration with other systems [2]	The system must integrate with other building systems, such as HVAC, lighting, and security, to optimize building operations and energy efficiency.
Customizable alerts and notifications [2]	The system must provide customizable alerts and notifications based on occupancy levels, enabling building management to respond to changing conditions.
Scalability [2]	The system must be scalable to accommodate buildings of different sizes and complexities, from small offices to large commercial or residential buildings.
Energy efficiency [2]	The system must prioritize energy efficiency by using low-power sensors and sleep mode to reduce energy consumption.
Remote monitoring and control [2]	The system must allow building management to remotely monitor and control occupancy levels through a centralized platform or mobile app.
Health and safety [2]	The system must prioritize health and safety by ensuring compliance with relevant regulations and codes related to occupancy levels and building capacity.
Cost-effectiveness [2]	The system must be cost-effective, providing value for money while meeting building occupancy monitoring needs.
Flexibility [2]	The system must be flexible enough to accommodate different occupancy tracking methods and technologies, depending on the needs of the building and occupants.

Hardware	Software
○ Motion sensor ○ RFID tag ○ Bluetooth low energy (BLE) beacon ○ Camera	○ Occupancy management software ○ Indoor positioning software ○ People counting software ○ Video analytics software

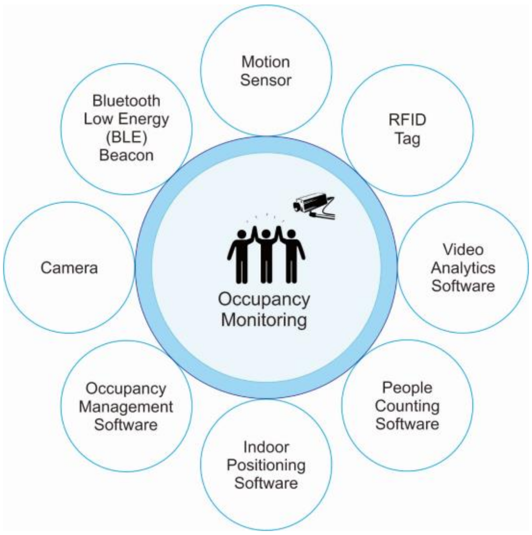


Figure 30. Occupancy Monitoring

Reference Standard	
ISO 30137	Information technology - Use of biometrics in video surveillance systems
ISO/IEC 27037:2012	Information technology — Security techniques — Guidelines for identification, collection, acquisition and preservation of digital evidence
ISO 27001:2022	Information security, cybersecurity, privacy protection
ISO 27010:2015	Information security controls for cloud services
IEC 62443-4-1	Secure product development lifecycle requirements
IEEE 2410-2020	Standard for Biometrics Open Protocol Extended Frameworks (OPEN)
Others	and other applicable regulations or standards

5.10 Resource System

5.10.1 Smart Water Management

Smart Water Management is a technology system used to optimize the management of water resources by collecting precise and real-time data regarding water infrastructure and usage. An intelligent water management system is designed to detect leaks and measure water quality automatically and alert building managers.

Functional Requirements	
Water quality monitoring [1]	The system must be able to continuously monitor water quality to ensure it fulfills health and safety standards.
Leak detection [1]	The system must be able to detect leaks and alert the building managers in real-time to minimize water damage and prevent waste.
Water usage tracking [1]	The system must track water use and provide analysis of usage patterns to enable facility managers to identify areas of waste and optimize water use.
Water conservation [1]	The system must be able to identify inefficient water fixtures and suggest upgrades or replacements that will reduce water usage.
Smart irrigation [1]	The system must include smart irrigation controls that adjust irrigation schedules based on weather conditions and soil moisture to reduce water waste and maintain healthy landscaping.
Remote monitoring and control [2]	The system must allow building managers to remotely monitor and control water usage through a centralized platform or mobile app.
Integration with other systems [2]	The system must be integrated with other building systems, such as lighting systems and HVAC, to optimize water usage and improve overall building performance.
Maintenance [1]	The system must alert and notify for maintenance and repair needs, such as leaks, clogs, or malfunctioning equipment, allowing for proactive maintenance and minimizing downtime.
Energy efficiency [1]	The system must prioritize energy efficiency by using low-power sensors and sleep mode to reduce energy consumption.
User experience [2]	The system must provide a positive user experience, with intuitive interfaces, clear instructions, and responsive customer service.

Hardware	Software
○ Smart water meters ○ IoT pump switch ○ Water level sensor ○ Flow sensor ○ Automated valves ○ Leak detection sensor ○ Water quality sensor ○ Water filtration and purification system ○ Soil moisture level sensor ○ Automated irrigation sprinkler	○ Smart Irrigation Controller ○ Smart Metering ○ Waste Management and Treatment Controller

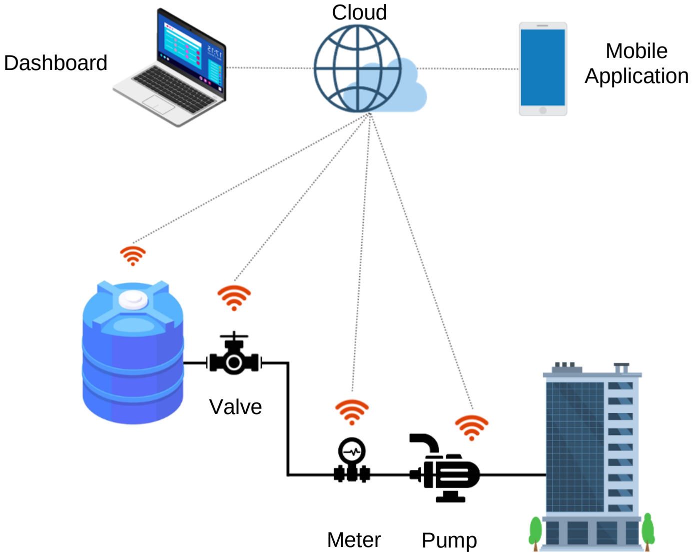


Figure 31. Smart Water Management

Reference Standard	
Minister of Public Works and Housing Regulation Number 21 of 2021	Green Building Performance Assessment
Minister of Health Regulation No. 2 of 2023	Implementation regulation of government regulation number 66 of 2014 concerning Environmental Health
ISO/IEC 18025:2014	Information technology — Environmental Data Coding Specification (EDCS)
ISO 24512:2007	Activities relating to drinking water and wastewater services — Guidelines for the management of drinking water utilities and for the assessment of drinking water services
Others	and other applicable regulations or standards

5.10.2 Smart Drinking Water Fountain

Smart Drinking Water Fountain is a smart facility designed to provide reliable drinking water to the public by ensuring water hygiene, providing a good user experience and minimizing water wastage.

Functional Requirements	
Dispensing water [3]	The fountain must be able to dispense water when activated by a user.
Controlling water temperature [3]	The fountain must be able to control the temperature of the water that is dispensed, allowing users to choose between cold, room temperature, and hot water.
Filtration system [3]	The fountain must have a filtration system that removes impurities from the water, ensuring that the water is safe and clean to drink.
Water level monitoring [3]	The fountain must be able to monitor the water level in its reservoir and alert maintenance staff when the water level is low.
Touchless operation [3]	The fountain must have a touchless operation mode, allowing users to activate the fountain without touching any buttons or handles.
Automatic shut-off [3]	The fountain must be equipped with an automatic shut-off feature that turns off the water flow after a certain amount of time to prevent water wastage.
Maintenance alerts [3]	The fountain must be able to send alerts to maintenance staff when filters need to be replaced or when other maintenance tasks need to be performed.
User interface [3]	The fountain must have an easy-to-use user interface that allows users to select the water temperature and activate the fountain.
Water usage monitoring [3]	The fountain must be able to monitor the amount of water dispensed over a certain period of time to help facility managers keep track of water usage and identify any leaks or other issues.
Connectivity [3]	The fountain must be able to connect to a network, allowing maintenance staff to remotely monitor and control the fountain, and to collect data for analytics purposes.

Hardware	Software
○ Dispenser mechanism ○ Water tank ○ Filtration system ○ Temperature control system ○ Sensors ○ User interface	○ Firmware ○ User interface software ○ Maintenance software ○ Analytics software

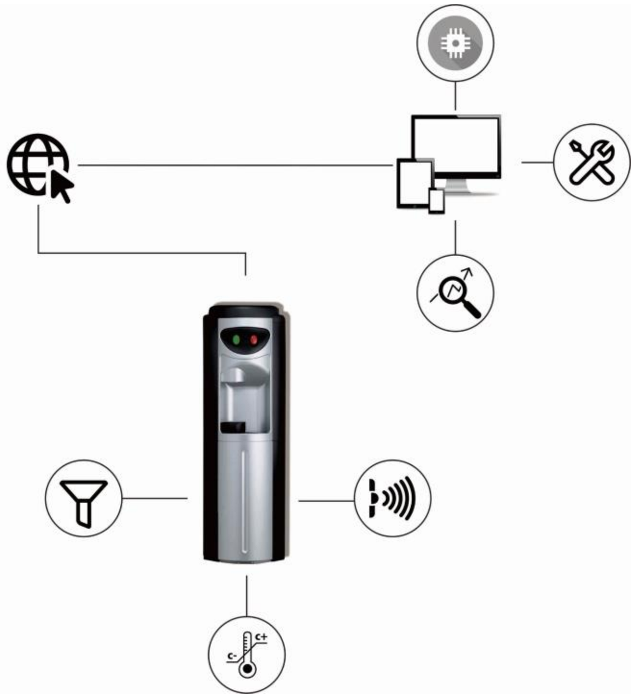


Figure 32. Smart Drinking Water Foundation

Reference Standard	
Minister of Health Regulation No. 2 of 2023	Implementation regulation of government regulation number 66 of 2014 concerning Environmental Health
SNI 2547-2019	Specification of potable water meter
SNI 7831-2012	Water supply system planning
ISO/IEC 18025:2014	Information technology — Environmental Data Coding Specification (EDCS)
ISO 24512:2007	Activities relating to drinking water and wastewater services — Guidelines for the management of drinking water utilities and for the assessment of drinking water services
Others	and other applicable regulations or standards

5.10.3 Smart Waste Chute

Smart Waste Chute is a technology system used to optimize waste management efficiently and integratedly by collecting precise and real-time data, optimizing waste collection routes, and integrating with authorities.

Functional Requirements	
Automated waste disposal [2]	The system must enable automated waste disposal by integrating with waste collection vehicles and providing real-time data on the fill levels of the waste chutes.
Waste sorting and recycling [3]	The system must enable waste sorting and recycling by including sensors and cameras to identify and sort different types of waste.
Data analytics [2]	The system must provide data analytics on waste generation patterns, enabling building management to identify opportunities for waste reduction and recycling.
Maintenance and repair [2]	The system must provide alerts and notifications for maintenance and repair needs, such as equipment malfunctions or blockages, allowing for proactive maintenance and minimizing downtime.
Energy efficiency [2]	The system must prioritize energy efficiency by using low-power sensors and sleep mode to reduce energy consumption.
User experience [3]	The system must provide a positive user experience, with intuitive interfaces, clear instructions, and responsive customer service.
Integration [2]	The system must integrate with waste management companies to ensure efficient collection and disposal of waste.
Remote monitoring and control [3]	The system must allow building management to monitor and control waste disposal and recycling remotely through a centralized platform or mobile app.
Health and safety [2]	The system must prioritize health and safety by ensuring proper waste disposal and minimizing risks associated with waste handling and storage.
Sustainability [2]	The system must prioritize sustainability by enabling waste reduction and recycling, and promoting environmentally responsible practices.

Hardware	Software
○ Smart trash chutes ○ Compactors ○ Waste sorting stations ○ CCTV cameras	○ Waste management software ○ Building automation systems ○ Cloud-based platforms

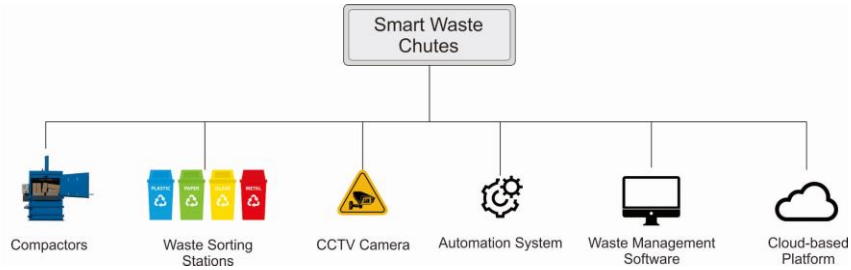


Figure 33. Smart Waste Chute System

Reference Standard	
Government Regulation Number 81 of 2012	Management of Household Waste and Waste Similar to Household Waste
Minister of Public Works and Housing Regulation Number 21 of 2021	Green Building Performance Assessment
SNI 8632-2018	The procedure for planning operational techniques for urban waste management
Others	and other applicable regulations or standards

5.10.4 Smart Bin

The Smart Waste Bin is a technology used to optimize waste management through the use of sensors and integration with relevant parties. This technology can determine the operation schedule of the system, detect the level of container fullness, and alert relevant parties about waste collection..

Functional Requirements	
Automated waste sorting [3]	The system must use sensors and/or cameras to sort waste into different categories automatically, such as recyclables, organic waste, and general waste.
Real-time data [3]	The system must provide real-time data on waste volume levels and categories, enabling building management to make informed decisions about waste management and collection.
Data analytics [3]	The system must provide data analytics on waste patterns and trends, enabling building management to identify opportunities for optimization and improvement.
Remote monitoring and control [3]	The system must allow building management to monitor and control waste levels and collection remotely through a centralized platform or mobile app.
Customizable alerts and notifications [3]	The system must provide customizable alerts and notifications based on waste levels and collection schedules, enabling building management to respond to changing conditions.
Health and safety [3]	The system must prioritize health and safety by ensuring compliance with relevant regulations and codes related to waste management and collection.
Durability and weather resistance [3]	The system must be durable and weatherproof to withstand outdoor conditions and daily use.
User-friendly interface [3]	The system must have a user-friendly interface that is easy for building occupants to use and understand.
Energy efficiency [3]	The system must prioritize energy efficiency by using low-power sensors and sleep mode to reduce energy consumption.
Flexibility [3]	The system must be flexible enough to meet different waste management needs and requirements, depending on the needs of the building and occupants.

Hardware	**Software**
○ Camera Module ○ Proximity Sensor ○ Load Sensor ○ GPS module	○ Garbage type recognition algorithm ○ Data processing applications, notifications and automated actions ○ Dashboard monitoring

Figure 34. Smart Bin System

Reference Standard	
Minister of Public Works and Housing Regulation Number 21 of 2021	Green Building Performance Assessment
Government Regulation Number 81 of 2012	Management of Household Waste and Waste Similar to Household Waste
SNI 8632-2018	The procedure for planning operational techniques for urban waste management
ISO 24533:2019	Smart community infrastructures - Smart waste management
Others	and other applicable regulations or standards

5.10.5 Smart Restroom

Toilet Cerdas adalah teknologi yang digunakan untuk meningkatkan efisiensi sumber daya dan pengalaman pengguna melalui penggunaan utilitas hemat sumber daya, sensor, dan integrasi dengan sistem bangunan lainnya.

Functional Requirements	
Automated cleaning and maintenance [3]	The system must have automated cleaning and maintenance features, such as self-cleaning toilets and floors, and automated refill of consumables like soap and paper towels.
Real-time occupancy monitoring [3]	The system must use sensors to monitor restroom occupancy in real-time, enabling building management to optimize cleaning schedules and avoid congestion.
Queue management [3]	The system must provide real-time information on restroom availability and queue times to help users plan their visits.
Environmental monitoring [3]	The system must have sensors to monitor air quality, temperature, and humidity in the restroom to ensure user's comfort and hygiene.
Remote monitoring and control [3]	The system must allow building management to monitor and control the restroom's status remotely, including occupancy, cleaning, and maintenance.
Accessibility [3]	The system must provide accessible features such as wheelchair-accessible stalls, grab bars, and audio cues for the visually impaired.
Hygiene and sanitation [3]	The system must prioritize hygiene and sanitation, using contactless technology and self-cleaning features to minimize the spread of germs and bacteria.
Sustainability [3]	The system must prioritize sustainability by using water-saving appliances, smart LED lighting, and other energy-efficient features to minimize environmental impact.
User feedback [3]	The system must provide a feedback system, such as a mobile app or touch screen display, to allow visitors to provide feedback on their restroom experience and suggest improvements.
Privacy and security [3]	The system must ensure privacy and security, using features such as private stalls, locks, and surveillance cameras to ensure visitor safety and deter vandalism.
Multilingual support [3]	The system must provide multilingual support, including signage and audio cues in different languages to accommodate visitors from diverse backgrounds.
Data analytics [3]	The system must provide data analytics on restroom usage, occupancy patterns, and maintenance needs, enabling building management to optimize operations and improve visitor experience.

Hardware	Software
○ Smart Mirror ○ Smart Toilet ○ Camera module ○ Voice detection ○ Proximity Sensor ○ Microphone & Speaker	○ Control and monitoring dashboard ○ Mobile Applications ○ Voice-enabled Assistants ○ Cleaning and Sanitizing Software

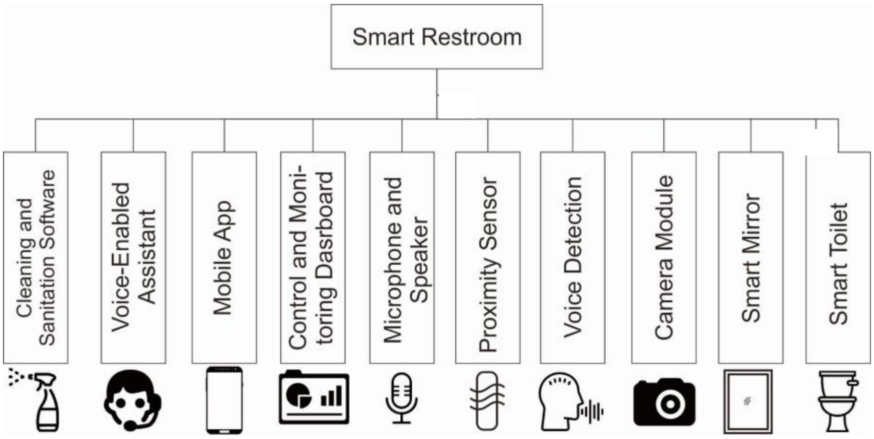


Figure 35. Smart Restroom

Reference Standard	
Minister of Public Works and Housing Regulation Number 21 of 2021	Green Building Performance Assessment
Minister of Health Regulation No. 2 of 2023	Implementation regulation of government regulation number 66 of 2014 concerning Environmental Health
ISO 30500	Non-sewered sanitation systems — Prefabricated integrated treatment units — General safety and performance requirements for design and testing
ISO/IEC 18025:2014	Information technology — Environmental Data Coding Specification (EDCS)
ISO 24512:2007	Activities relating to drinking water and wastewater services — Guidelines for the management of drinking water utilities and for the assessment of drinking water services
Others	and other applicable regulations or standards

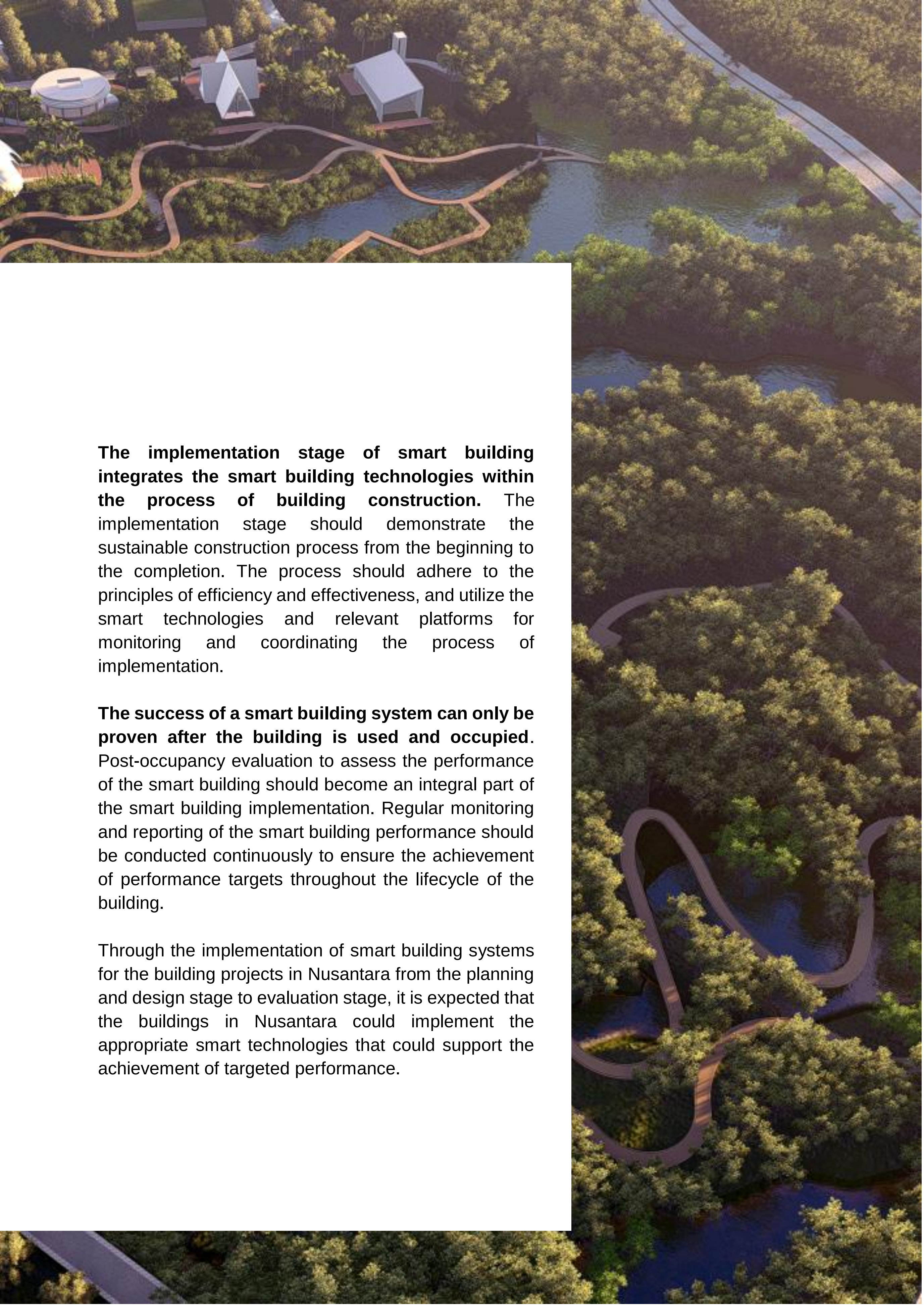
6. Implementation of Smart Building in Nusantara

6.1 Implementation Stages

The implementation of smart building is aimed to support the vision of Nusantara Capital City, namely 'World City for All' through sustainable development in the energy, water, waste, environment & biodiversity, economy, tourism, security, and technology sectors. The application of smart technologies should be integrated within the whole building design as an approach to achieve the targeted performance. To ensure the achievement of the smart building performance, the implementation of smart building in Nusantara consists of several stages, from planning and design, performance review, implementation, and performance evaluation.

The planning and design stage should be conducted based on the targeted performance of each building project, which should support the Nusantara targeted performance. Each building project should define the specific targeted priority in relation to the specific building uses. Depending on the building type, some building projects could have different priorities regarding the energy efficiency, increased productivity, and occupant comfort and safety. The site of each building project should also become a consideration in defining the targeted priority. Building project located on different sites might need to apply different smart technologies to respond to the specific environmental contexts and conditions. The planning and design stage should integrate various smart building systems as stated in this guideline in accordance to the targeted performance.

Based on the smart building design proposed for each building project, **performance review should be conducted on the proposed smart building system design to ensure that the proposed system could achieve the targeted performance**. This stage is necessary to ensure the use of appropriate smart technologies that are relevant to the targeted performance while at the same time fit to the building environmental context. Each aspect of smart building design should be reviewed in accordance with the relevant standard of performance. The performance review result will become the basis for finalizing the smart building design.



The implementation stage of smart building integrates the smart building technologies within the process of building construction. The implementation stage should demonstrate the sustainable construction process from the beginning to the completion. The process should adhere to the principles of efficiency and effectiveness, and utilize the smart technologies and relevant platforms for monitoring and coordinating the process of implementation.

The success of a smart building system can only be proven after the building is used and occupied. Post-occupancy evaluation to assess the performance of the smart building should become an integral part of the smart building implementation. Regular monitoring and reporting of the smart building performance should be conducted continuously to ensure the achievement of performance targets throughout the lifecycle of the building.

Through the implementation of smart building systems for the building projects in Nusantara from the planning and design stage to evaluation stage, it is expected that the buildings in Nusantara could implement the appropriate smart technologies that could support the achievement of targeted performance.

6.2 Benefits of Smart Building

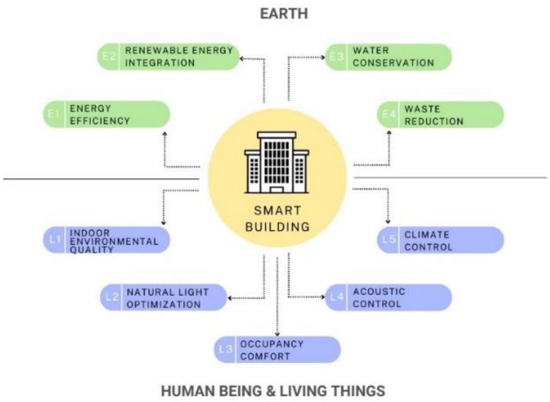


Figure 36. Smart Building Benefit

Smart buildings play a crucial role in creating a more sustainable and energy-efficient built environment, which benefits both living things and mother earth. By incorporating advanced technologies such as Internet of Things (IoT) sensors, artificial intelligence, and machine learning, smart buildings can, among other things, optimize energy consumption, reduce pollution, and enhance indoor air quality.

Table 1. Environmental Benefits of Smart Building

Code	Benefit	Description
E1	Energy efficiency	By automating and optimizing systems such as heating, ventilation, and lighting, smart building technologies can help reduce energy consumption and improve energy efficiency, leading to lower carbon emissions and a decreased carbon footprint. For example, the monitoring and controlling systems for the humidity levels, temperature, and air quality that enhance the indoor air quality in smart buildings can also help reduce the need for ventilation systems that are energy intensive. Moreover, smart buildings can determine when a room is vacant using occupancy sensors, allowing for the optimization of heating, ventilation, and lighting systems that further decreases energy consumption and contributes to a smaller carbon footprint.
E2	Renewable energy integration	Smart buildings can be designed to integrate renewable energy sources like solar, wind, and geothermal power. These systems produce clean energy and can aid in decreasing reliance on fossil fuels.
E3	Water conservation	To reduce water usage and conserve water resources, smart buildings incorporate water-saving technologies such as low-flow fixtures, rainwater harvesting, and intelligent irrigation systems.
E4	Waste reduction	Waste management technologies, such as recycling and decomposition systems, can be installed in smart buildings to reduce waste. Moreover, this technology also lowers greenhouse gas emissions and aids in conserving natural resources.

From the human perspective, smart buildings can provide greater comfort and convenience for occupants through automated lighting, temperature control, and security systems. In addition, they can boost productivity and well-being by optimizing illumination and air quality to create a healthier and more comfortable indoor environment.

Table 2. Occupant Benefits of Smart Building

Code	Benefit	Description
L1	Improved indoor environmental quality	Smart building technologies can monitor and control temperature, humidity, air quality, and ventilation, improving indoor air quality and reducing the risk of respiratory illnesses. This can benefit both humans and animals
L2	Natural light optimization	Smart building technologies can control lighting systems to optimize natural light exposure, which has been shown to improve mental health, productivity, and the overall well-being of occupants.
L3	Occupancy comfort	Smart building technologies can monitor occupancy levels and adjust heating, cooling, and lighting systems to ensure optimal comfort levels for occupants. Occupant safety is also supported by smart building technology, creating a sense of comfort for occupants. This can enhance productivity and reduce stress levels.
L4	Sound Management/Acoustic Control	Smart buildings can use noise reduction technologies like acoustic panels to improve sound quality and reduce noise pollution. This can lead to a more peaceful environment for both humans and animals.
L5	Climate control	Smart building technologies can optimize heating and cooling systems to create a comfortable environment for living things. This is especially important for plants and animals that require specific temperature and humidity conditions.

Table 3. Benefits of Each Smart Building Features

Features	Benefits
Touchless Access Control	L3
Visitor Management	L3
Intercom system	L3
AV & Digital Signage	L3
Smart Meter Readers	E1, E2, E3
Automatic Sub-Meter Readers	E1, E2, E3
Electricity Load Balancing	E1, E2
Public Electric Vehicle Charging Station	E1, E2
Active Disaster Response System	L3
Smart Fire Suppression System	L3
Emergency Button	L3
Fire Safety Device Maintenance	L3
Animal Hazard Protection	L3
Indoor and Outdoor Air Quality Monitoring	L1, L3, L5, E1
Air Conditioning System	L1, L3, L5, E1
Air Purification and Filter Monitoring	L1, L3, L5, E1
Demand Controlled Ventilation (DCV)	L1, L3, L5, E1
Climate detection system	L1, L3, L5, E1
Smart Lighting System	L1, L2, L3, E1
Smart Escalator and/or Autowalk	E1
Smart Elevator	E1
Smart Parking System	L3
Intelligent Video Surveillance	L3
Smart Locking System	L3
Virtual Gates using CCTV Cameras	L3
Occupancy Monitoring	L3
Smart Drinking Water Fountain	E1, E3
Smart Water Management	E1, E3
Smart Waste Chutes	E4
Smart Bin	E4
Smart Restroom	L1, L2, L3, L4, L5, E1, E3

The effectiveness of smart buildings ultimately depends on how they are designed, implemented, and used. Smart buildings must prioritize both environmental sustainability and human well-being instead of focusing merely on one or the other. Additionally, it is essential to ensure that smart building technology is accessible and affordable.

Smart building feature implementation guidelines are determined for state building based on the state building classification as shown in Table 4 and the implementation matrix in Table 5.

Table 4. Building Class Classification (State Building)

Classification	Definition
Simple	Buildings with simple technology and specifications include: 1. Office buildings and other state buildings with the number of floors up to 2 (two) floors; 2. Office buildings and other state buildings with an area of up to 500 square meters (m2); and 3. State houses include country houses type C, type D, and type E.
Not Simple	Buildings with technology and specifications are not simple include: 1. Office buildings and other state buildings with more than 2 (two) floors; 2. Office buildings and other state buildings with an area of more than 500 m2; and 3. State houses include type A and type B country houses
Special	Be: 1. State building that has special standards, as well as in its planning and implementation requires special completion or technology; 2. State building which has a high level of confidentiality in the national interest; 3. State building whose implementation can endanger the surrounding community; and 4. State building that has a high risk of harm Include 1. State palace; 2. House of office of former presidents and/or former Vice Presidents; 3. House of ministerial posts; 4. State guesthouse; 5. Nuclear installation building; 6. Radioactive buildings; 7. Defense installation building; 8. Police of the Republic of Indonesia building with special uses and standards; 9. Air, sea and land terminal buildings; 10. Railway station; 11. Stadiums or sports halls; 12. High-security detention centers; 13. Data centers; 14. Dangerous goods warehouse 15. Buildings are monumental; 16. Heritage building; and 17. State representative building of the Republic of Indonesia

Table 5. Smart Building Feature Matrix Based on State Building Classification

Features	State building Classification		
	Simple	Not Simple	Special
Integrated Building Management System	✓	✓	✓
Control Room and Data Center		✓	✓
Fiber-to-the Room (FTTR)	✓	✓	✓
Digital Twin		✓	✓
Touchless Access Control	+	✓	✓
Visitor Management		+	✓
Intercom system	+	✓	✓
AV & Digital Signage		+	✓
Smart Meter Readers	✓	✓	✓
Automatic Sub-Meter Readers	+	+	+
Electricity Load Balancing	✓	✓	✓
Public Electric Vehicle Charging Station		✓	✓
Active Disaster Response System	+	✓	✓
Smart Fire Suppression System	✓	✓	✓
Emergency Button	+	✓	✓
Fire Safety Device Maintenance		+	+
Animal Hazard Protection	+	+	+
Indoor and Outdoor Air Quality Monitoring	✓	✓	✓
Air Conditioning System	✓	✓	✓
Air Purification and Filter Monitoring	✓	✓	✓
Demand Controlled Ventilation (DCV)	✓	✓	✓
Climate detection system	✓	✓	✓
Smart Lighting System	✓	✓	✓
Smart Escalator and/or Autowalk		✓	+
Smart Elevator		✓	✓
Smart Parking System		+	+
Intelligent Video Surveillance	✓	✓	✓
Smart Locking System	✓	✓	✓
Virtual Gates using CCTV Cameras		+	+
Occupancy Monitoring	+	✓	✓
Smart Water Management	✓	✓	✓
Smart Drinking Water Fountain		+	+
Smart Waste Chutes		✓	✓
Smart Bin	+	+	✓
Smart Restroom	+	+	+

✓ = Mandatory implementation **+ = Recommended to implement**

Guidelines for the implementation of smart features in smart buildings are also specified for non-state buildings, with building class classifications as listed in Table 6 and Table 7.

Table 6. Building Class Classification (Non-State Building)

Building Class	Definition	Example
Class 1a	One single house, one or more articulated houses separated by fireproof walls	Simple houses, row houses, villas, garden houses
Class 1b	Dormitories, hostels or the like with a maximum area of 300 m2 and not occupied by more than 12 people	Boarding houses, inns, hostels that cover an area of no more than 300 m2 and are inhabited by no more than 12 people
Class 2	Residential buildings consisting of 2 or more residential units, each of which is a separate residence	Complex houses
Class 3	Residential buildings outside classes 1 and 2, which are commonly used as old or temporary residences by a number of unrelated people	Dormitories, guest houses, inns, and the like
Class 4	Residential buildings that are located within a building of class 5, 6, 7, 8, or 9 and is a residence within the building	Mixed-use apartments
Class 5	Buildings used for professional business purposes, administrative management, or commercial enterprises, outside of class 6, 7, 8, or 9 buildings	Office buildings, government buildings, and its kind
Class 6	Shop buildings or other buildings used for retail sales of goods or direct needs services to the community	Shops, restaurants, markets, car showrooms, and its kind
Class 7	Building used as storage	Public buildings and parking lots
Class 8	Laboratory buildings and buildings used for processing a production, assembly, change, repair, packing, finishing, or cleaning of production goods in the context of trading or selling	Laboratories, auto repair shops, factories and its kind
Class 9a	Public building for health care services	Hospital
Class 9b	Public meeting building that does not include any part of a building that constitutes another class	Schools, places of worship, places of culture, workshops, and its kind
Class 10a	Non-residential buildings in the form of facilities or infrastructure built separately	Private garages, public garages and its kind
Class 10b	Structure in the form of facilities or infrastructure built separately	Fences, antennas (masts), swimming pool, and its kind

Tabel 7. Smart Building Feature Matrix Based on Non-State Building Classification

Features	Non-State Building Classification											
	1	2	3	4	5	6	7	8	9a	9b	10a	10b
Integrated Building Management System	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	+	
Control Room and Data Center				✓	✓			+	✓	+		
Fiber-to-the Room (FTTR)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	+	
Digital Twin				✓	✓			+	✓	+		
Touchless Access Control	+	+	+	✓	✓			✓	✓	✓	+	+
Visitor Management			+	+	+			+	✓	✓	+	+
Intercom system	+	+	+	✓	✓			+	✓	✓	+	+
AV & Digital Signage				+	+	+		+	✓	+		
Smart Meter Readers	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Automatic Sub-Meter Readers	+	+	+	+	+	+		+	✓	+		
Electricity Load Balancing	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Public Electric Vehicle Charging Station				✓	✓		+		✓	+	+	
Active Disaster Response System	+	+	+	✓	✓	+	+	✓	✓	✓	+	+
Smart Fire Suppression System	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Emergency Button	+	+	+	✓	✓	✓	+	✓	✓	✓	+	+
Fire Safety Device Maintenance				+	+			+	+	+		
Animal Hazard Protection	+	+	+	+	+	+			+	+		
Indoor and Outdoor Air Quality Monitoring	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Air Conditioning System	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Air Purification and Filter Monitoring	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Demand Controlled Ventilation (DCV)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Climate detection system	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Smart Lighting System	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Smart Escalator and/or Autowalk				✓	✓				✓	+		
Smart Elevator				✓	✓				✓	✓		
Smart Parking System				+	+		+		+	+	+	
Intelligent Video Surveillance	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	+
Smart Locking System	✓	✓	✓	✓	✓	✓		✓	✓	✓	+	+
Virtual Gates using CCTV Cameras				+	+				✓	+		
Occupancy Monitoring	+	+	+	✓	✓	+	+	+	✓	✓	+	+
Smart Water Management	✓	✓	✓	✓	✓	✓	+	✓	✓	✓	+	+
Smart Drinking Water Fountain				+	+				+	+		
Smart Waste Chutes				✓	✓				✓	✓		
Smart Bin	+	+	+	+	+	+		+	✓	✓		
Smart Restroom	+	+	+	+	+	+		+	✓	✓		

✓ = Mandatory implementation **+ = Recommended to implement**

Determination of feature implementation obligations in table 5 and table 7 is determined as follows.

1. A feature becomes mandatory when it becomes a requirement for another feature.
2. A feature becomes mandatory when it is critical in saving a building's energy.
3. A feature becomes mandatory when its main function is to maintain the safety and security of the occupants.
4. A feature becomes mandatory if it can only be installed during the construction stage and cannot be installed as an add-on during the operational stage.

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