

## The Role of Interior Design in Promoting Sustainability and Combating Climate Change through Smart Applications

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### Abstract

The world is facing increasing environmental challenges due to climate change and urban expansion, necessitating the adoption of sustainable solutions in various fields, including interior design. This research explores interior design's role in promoting sustainability and combating climate change through innovative technology applications. It examines how Artificial Intelligence (AI) and the Internet of Things (IoT) can enhance energy efficiency and resource management within interior spaces, reducing carbon emissions and improving indoor environmental quality.

The study highlights key principles of sustainable interior design, such as using eco-friendly materials, optimizing natural lighting and ventilation, and integrating smart energy management systems. It also discusses the numerous benefits of smart interior design applications, including improved indoor air quality, reduced energy waste, and enhanced thermal comfort for occupants. Despite these advantages, implementing smart applications in interior design faces several challenges, such as high costs, a lack of awareness about the importance of smart technology in sustainability, and the need for supporting infrastructure. To address these challenges, the research proposes several recommendations, including strengthening sustainability regulations, providing financial incentives for adopting smart solutions, and increasing awareness and training for designers and engineers.

The research concludes that integrating smart applications into interior design is an effective solution for achieving sustainability. It helps reduce environmental impact, improves quality of life, and strengthens the role of interior design in addressing climate change and building a sustainable future.

### Keywords

Sustainable Design, Smart Applications, Indoor air quality, Climate Changes in Interior Design

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### Introduction:

In recent years, the world has witnessed an information revolution and rapid technological advancements, leading to significant developments across all fields of research, including the construction industry. This tremendous progress has also contributed to the enhancement of integrated control systems and smart solutions, opening new horizons for smart building technologies, which are considered a fundamental step toward creating smart cities. Building management systems and the Internet of Things (IoT) form the core of smart design, enabling efficient management of interior systems such as lighting, temperature, safety, and security. (Ibtisam Abdulelah Mohammed Al Khafaji and Raz Kamaran, 2019). In this context, sustainable interior

design has become one of the most important modern approaches aimed at reducing environmental impact and enhancing resource efficiency within interior spaces. Given the increasing challenges posed by climate change, adopting responsible design practices that help reduce carbon emissions, improve energy efficiency, and use eco-friendly materials has become essential. Sustainable interior design is based on key principles such as recycling, waste reduction, the use of natural and renewable materials, and the integration of smart technologies to optimize energy consumption and improve indoor air quality. By applying these strategies, interior design can play a crucial role in mitigating the effects of climate change while promoting the well-being and comfort of occupants. This research

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aims to explore the relationship between sustainability principles in interior design and their role in addressing climate change while highlighting best practices and sustainable solutions that can be adapted to create environmentally responsible interior spaces

### **Research problems:**

- 1- Relying on traditional design principles: principles instead of sustainable ones leads to negative impacts on the climate and environment.
- 2- High Implementation Costs: Integrating smart applications and sustainable interior design solutions often requires a significant investment, hindering widespread adoption, especially in low-budget projects.
- 3- A Lack of awareness and expertise: Many interior designers and stakeholders may lack sufficient knowledge about sustainable and smart design principles, leading to slow adoption and inefficient implementation of these technologies.
- 4- Technological and Infrastructure Limitations: Some regions may lack the necessary infrastructure to support smart applications, such as reliable internet connectivity, smart grids, and energy-efficient systems, limiting the effectiveness of sustainable interior design solutions.

### **Research importance:**

- 1- **Enhancing Sustainability and Combating Climate Change:** The research contributes to reducing natural resource consumption and carbon emissions through smart applications that support energy efficiency and environmental sustainability.
- 2- **Improving Quality of Life and Environmental Comfort:** Sustainable interior design helps enhance air quality and natural lighting, promoting both physical and mental well-being.
- 3- **Encouraging the Use of Smart Technologies in Interior Design:** The research highlights the role of smart applications in optimizing energy use, increasing efficiency, and creating environmentally friendly interior spaces.

### **Research objectives:**

#### **1- Reducing Implementation Costs:**

- Explore cost-effective solutions and technologies to support sustainability in smart interior design.
- Propose financial incentives and encourage investment in sustainable smart applications.

#### **2- Analyzing the integration of smart technologies and sustainable design principles in interior design:**

- Improve resource efficiency, reduce environmental impact, and enhance interior spaces' quality and well-being.

#### **3- Increasing Awareness and Enhancing Knowledge:**

- Develop training programs and educational materials for designers and engineers on sustainable interior design.
- Promote the integration of smart and sustainable design principles into educational curricula.

### **Research Methodology:**

#### **1- Research Approach**

- This study adopts a qualitative and analytical approach to explore the integration of sustainability principles in interior design and their role in mitigating climate change.

#### **2- Data Collection Methods**

- Literature Review: A comprehensive review of previous studies, books, and articles related to sustainable interior design and climate change.
- Case Studies: Examination of real-life projects that have successfully implemented sustainable interior design strategies through smart applications.

### **Research Hypotheses:**

- 1- It is assumed that the use of smart applications in interior design contributes to enhancing sustainability standards and reducing energy consumption.
- 2- Integrating smart technologies in interior design may lead to a reduction in buildings' carbon footprint, helping to combat climate change.
- 3- Sustainable interior design based on smart applications is expected to improve the quality of life and environmental comfort for users.
- 4- The integration of artificial intelligence and the Internet of Things in interior design is assumed to enhance resource efficiency and contribute to sustainable development.

### **Thematic or Chronological Organization:**

#### **1- Sustainability and Climate Change**

1-1 Definition of sustainability and its importance in interior design.

1-2 The impact of climate change on the built environment and the role of interior design in addressing it.

#### **2- Sustainability Concepts in Interior Design**

2-1 Fundamental principles of sustainable interior design.

2-2 The role of eco-friendly materials in reducing

carbon footprints.

2-3 Strategies for reducing energy consumption in interior spaces.

### 3- Smart Applications in Interior Design

3-1 Definition of smart applications and their role in enhancing energy efficiency.

3-2 The use of the Internet of Things (IoT) and Artificial Intelligence (AI) in interior design.

3-3 Smart lighting and HVAC systems and their impact on sustainability.

3-4 The positive effects of smart technology on air quality and environmental comfort.

### 4- Challenges and Solutions in Smart and Sustainable Interior Design

4-1 Obstacles to integrating smart applications in interior design.

4-2 Strategies to overcome technical and financial challenges.

### 5- Case Studies and Practical Applications

5-1 Examples of sustainable interior design projects using smart applications.

#### 1) Sustainability and Climate Change

##### 1-1 Definition of sustainability and its importance in interior design :

Sustainability refers to a collection of approaches designed to limit the use of natural resources and decrease environmental pollution, while also improving overall quality of life. Sustainability refers to meeting the needs of the present without compromising the ability of future generations to meet their own needs (United Nations, 1987). Thus, It is based on achieving a balance between environmental, economic, and social aspects to ensure the long-term preservation of natural resources and the environment for future generations. So, sustainability serves as a comprehensive framework that seeks to promote development while safeguarding environmental and resource integrity for both current and future societies. In the context of interior design, sustainability involves the thoughtful selection of materials, energy-efficient solutions, and design strategies that minimize environmental impact while creating healthy and functional spaces. The importance of sustainability in interior design lies in its ability to reduce resource consumption, improve indoor environmental quality, and contribute to the overall well-being of occupants. By integrating sustainable principles, interior designers can play a vital role in addressing global environmental challenges such as climate change, pollution, and resource depletion (Abdullah et al., 2020).



Figure 1. The components of sustainable development

#### 2-1 The impact of climate change on the built environment and the role of interior design in addressing it.

Climate change directly affects the design, construction, and operation of buildings, in addition to affecting the internal spaces in which humans live and work. The most prominent impacts are:

##### Impact of Climate Change on the Built Environment:

###### 1- Increased Energy Demand:

Higher temperatures lead to greater reliance on mechanical cooling systems, increasing energy consumption and carbon emissions. Buildings, especially in urban areas, contribute significantly to global greenhouse gas (GHG) emissions, making energy efficiency crucial.

**Source:** Intergovernmental Panel on Climate Change (IPCC), 2022. "Climate Change 2022: Mitigation of Climate Change." Sixth Assessment Report. Cambridge University Press.

###### 2- Material Degradation and Maintenance:

Changes in humidity, rainfall patterns, and temperature extremes can accelerate building material deterioration, affecting structural integrity and increasing maintenance costs.

**Source:** United Nations Environment Programme (UNEP), 2021. "2021 Global Status Report for Buildings and Construction." UNEP.

###### 3- Urban Heat Island Effect:

Densely built environments exacerbate temperature rise, making indoor environments hotter and less comfortable, demanding more innovative interior solutions to maintain livability.

**Source:** Santamouris, M. (2015). "Analyzing the heat island magnitude and characteristics in one hundred Asian and Australian cities and regions." *Science of the Total Environment*, 512-513, 582-598.

## Role of Interior Design in Addressing Climate Change:

### 1- Sustainable Material Selection:

Interior designers can reduce a building's carbon footprint by specifying eco-friendly, low-emission, and recycled materials, and sourcing locally produced materials to minimize transportation emissions.

**Source:** Hegger, M., Fuchs, M., Stark, T., & Zeumer, M. (2008). "Energy Manual: Sustainable Architecture." Birkhäuser.

### 2- Energy Efficiency through Design:

Implementing passive design strategies, such as natural ventilation, daylighting, and thermal insulation, reduces reliance on artificial heating, cooling, and lighting, promoting energy efficiency.

**Source:** Kwok, A. G., & Grondzik, W. T. (2018). "The Green Studio Handbook: Environmental Strategies for Schematic Design." 3rd ed. Routledge.

### 3- Indoor Environmental Quality (IEQ):

Interior designers can improve occupant well-being by incorporating biophilic design, improved air quality, and adaptive comfort strategies, helping spaces remain functional and healthy despite climatic changes.

**Source:** Kellert, S. R., Heerwagen, J. H., & Mador, M. L. (2008). "Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life." Wiley.

## 4- Flexible and Adaptive Spaces:

Designing multi-functional and adaptable interiors allows spaces to be reconfigured for different needs, making them resilient to shifting environmental conditions or occupant demands.

So Interior design plays a critical role in mitigating the impacts of climate change on the built environment. By focusing on sustainability, energy efficiency, occupant health, and resilience, interior designers contribute significantly to reducing emissions and adapting spaces to emerging environmental challenges. This interdisciplinary approach aligns with global sustainability goals, including the United Nations Sustainable Development Goals (SDGs).

### 2- Sustainability Concepts in Interior Design:

#### Basic Energy Principles:

When designing, we must take basic energy principles, such as heating into account.

Heat is a form of energy that is particularly relevant to building designers. Heating, cooling, and lighting involve the addition or subtraction of heat. That is why the basic measurement of how heat is transferred and stored is required. Without a temperature difference, there can not be a transfer of energy. The three primary devices of heat are conduction, convection, and radiation. Conduction requires direct physical contact. Convection requires the movement of a fluid such as air or water. Radiation occurs between surfaces.

## Your Home Loses and Gains Heat in 3 Ways

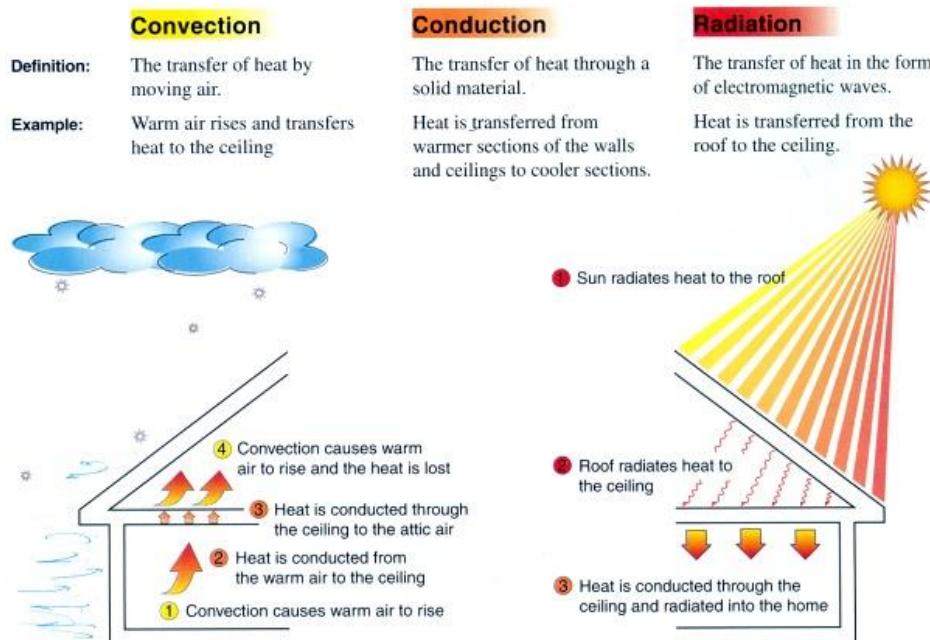


Figure 2. Basic Energy Principles

## 2.1 Fundamental principles of sustainable interior design.

Sustainable interior design aims to reduce negative environmental impacts while enhancing the health

and comfort of occupants. It focuses on responsible resource use, minimizing waste, and creating healthy interior environments.



Below are the key principles that guide sustainable interior design:

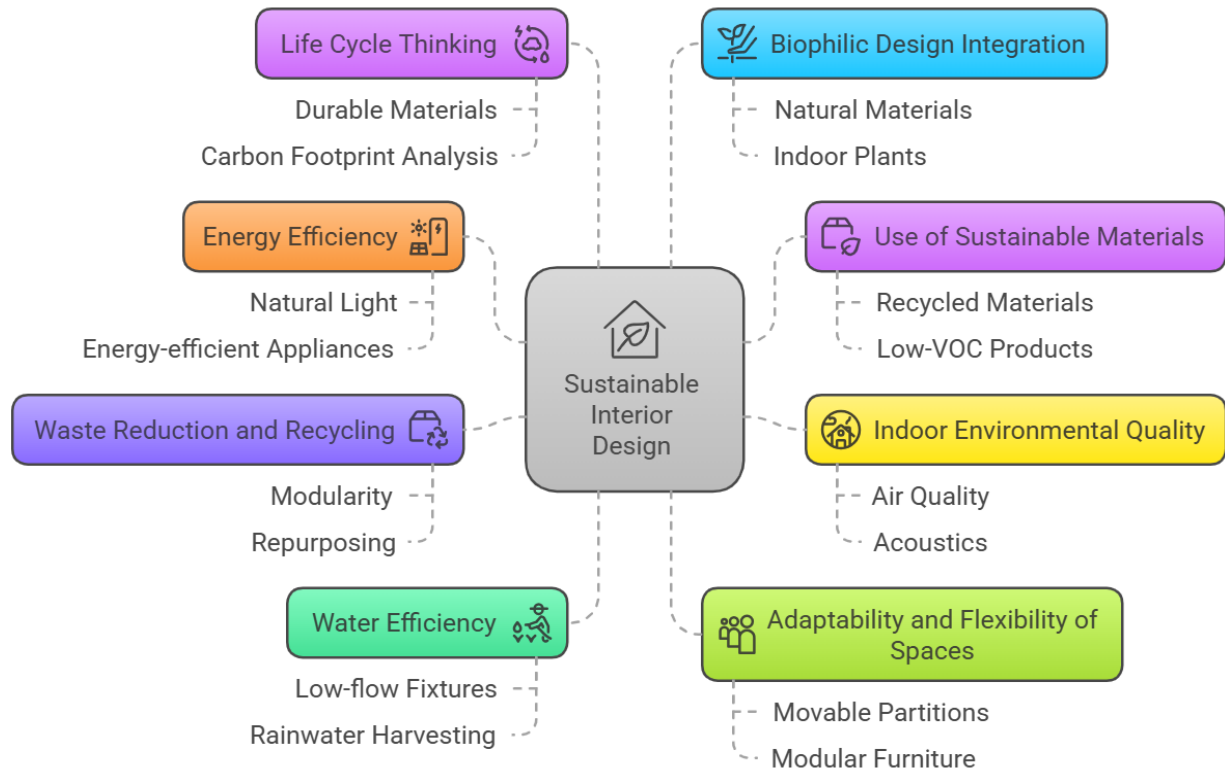


Figure 3. Key Principles of Sustainable Interior Design

## 2.2) Eco-friendly materials and their role in reducing the carbon footprint.

Eco-friendly materials minimize harm to the environment throughout their life cycle from production to disposal. In interior and architectural design, these materials are crucial in reducing carbon emissions, improving indoor air quality, and promoting sustainable living.

### Eco-friendly materials are characterized by:

- Recyclability and biodegradability.
- Renewable sources and sustainable extraction methods.
- Low or zero volatile organic compounds (VOC).
- Low embodied energy (less energy used during production and transportation).

Materials	Environmental Properties	Applications
Recycled Wood	Reduces deforestation, reuses old materials	Flooring, furniture, wall cladding
Green Concrete	Made from recycled content, lower emissions	Foundations, walls
Natural Clay Bricks	Non-toxic, thermally insulating	Walls, facades
Recycled Glass	Lowers energy demand compared to new glass	Windows, decorative elements
Natural Fibers (Hemp, Flax)	Renewable, biodegradable, insulating	Thermal and acoustic insulation
Recycled Aluminum	Uses 95% less energy than virgin aluminum	Windows, doors, roofing

Table 1. Types of Eco-Friendly Materials

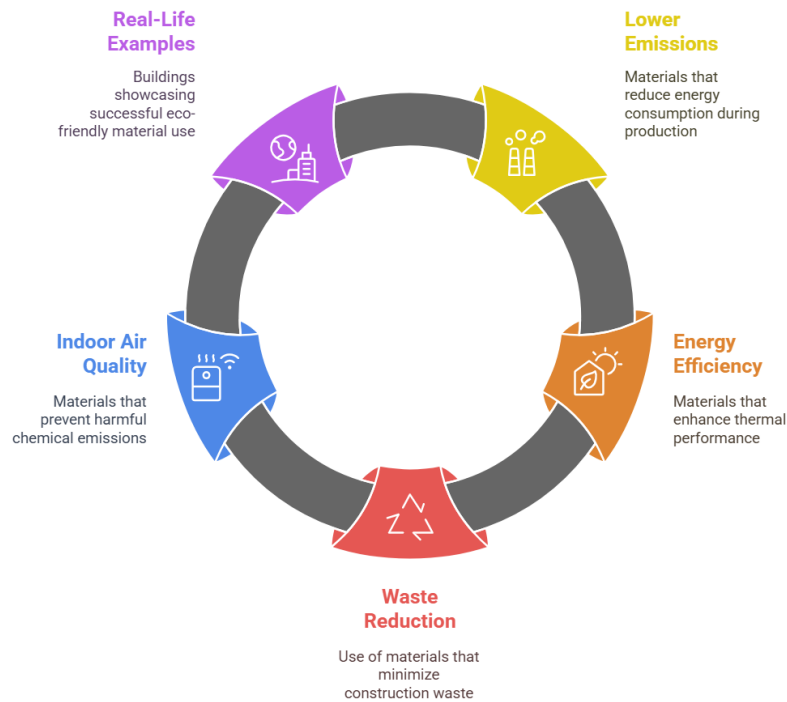


Figure 4. Role of Eco-Friendly Materials in Reducing Carbon Footprint

Application	Eco-Friendly Material	Environmental Impact
Flooring	Recycled wood, bamboo, cork	Reduces deforestation, lowers emissions
Walls and Ceilings	Low/Zero VOC paints, natural clay	Improves air quality, and reduces chemical use.
Insulation	Hemp fibers, sheep wool	Cuts heating/cooling energy, biodegradable
Furniture	Recycled or natural materials	Less resource depletion, lower carbon footprint

Table 2. Practical Applications in Interior Design

So Eco-friendly materials are vital for sustainable interior design, contributing to significant reductions in carbon emissions, energy consumption, and waste production. Their use also aligns with global sustainable development goals

(SDGs), particularly Goal 11 (Sustainable Cities) and Goal 12 (Responsible Consumption and Production).  
Comparison table between Sustainable Design and Traditional Design:

Aspect	Sustainable Design	Traditional Design
Materials Used	Eco-friendly, recycled, renewable, and low-impact materials.	Conventional materials are often non-recyclable and harmful to the environment.
Energy Consumption	Reduced energy use through energy-efficient solutions (natural lighting, insulation).	High reliance on artificial lighting, HVAC systems, and non-efficient energy use.
Indoor Environmental Quality	High quality with non-toxic materials, better air, and light quality.	It may include materials that emit harmful chemicals (e.g., formaldehyde).
Long-Term Cost	Higher initial cost but lower operational and maintenance costs over time.	Lower upfront cost but higher ongoing energy and maintenance expenses.
Waste Management	Focus on reducing, reusing, and recycling waste.	High waste generation without plans for recycling or reduction.
Environmental Impact	Low carbon footprint, conservation of natural resources.	High resource consumption and carbon emissions.
User Comfort and Health	Prioritizes user well-being, health, and comfort (healthy air, lighting).	Often overlooks environmental and health factors for users.
Use of Natural Resources	Maximizes the use of natural light and ventilation to reduce energy needs.	It relies heavily on mechanical systems, neglecting natural solutions.

Table 3. Difference between Sustainable Design and Traditional Design

## Real-life case study of using Eco-Friendly Material:

- **Bullitt Center** (Seattle, USA): Built with recycled and non-toxic materials, net-zero energy.

In the realm of sustainable architecture, each building tells a unique story of innovation and

environmental stewardship. One remarkable example is the Bullitt Center in Seattle, often hailed as the greenest commercial building in the world. By examining this building, we gain valuable insights into sustainable construction practices, design principles, and operational strategies that set new standards for eco-friendly architecture.

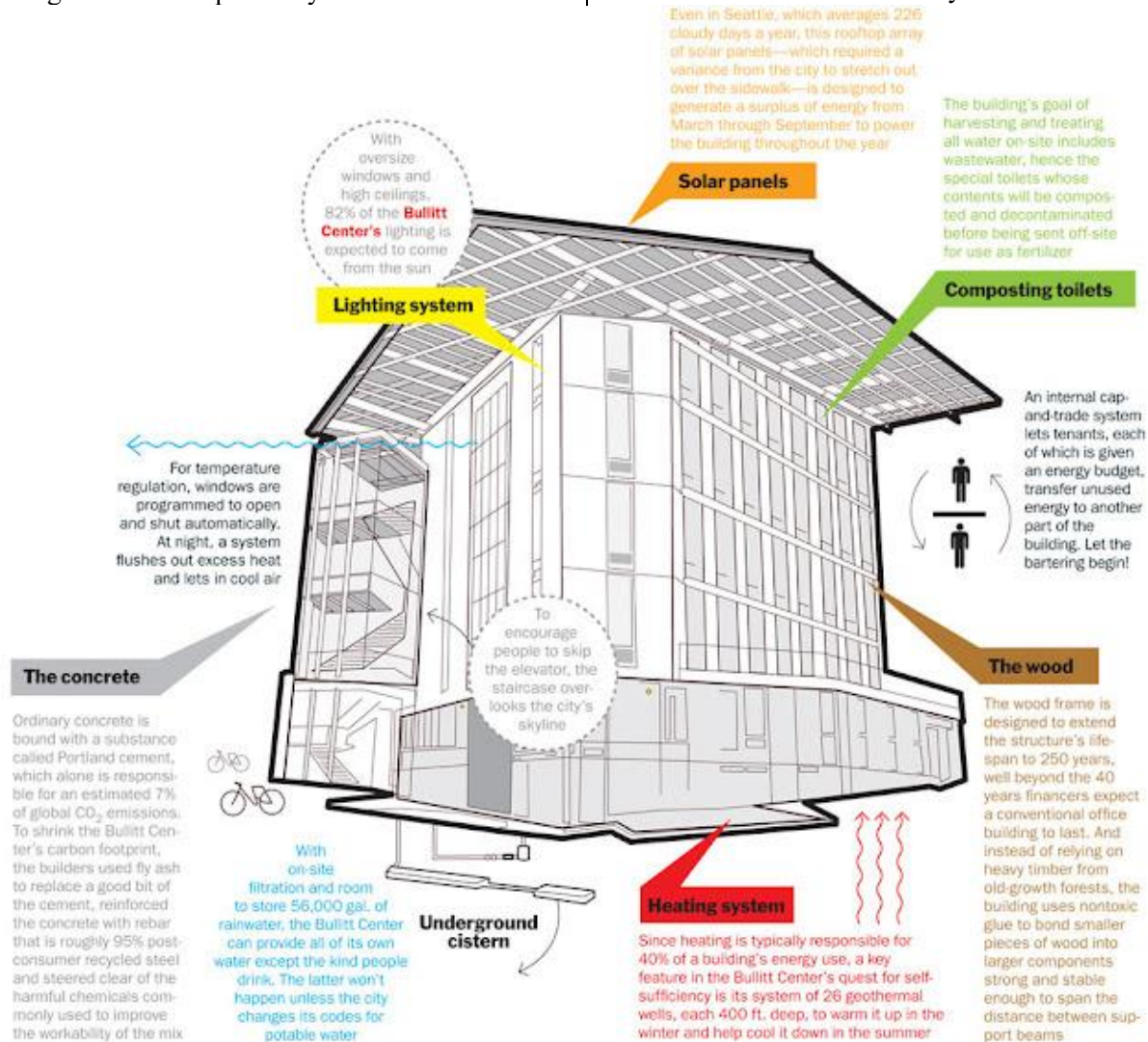


Figure 5. Sustainable Building Architecture

## Design Principles of Bullitt Center Architecture

The Bullitt Center was designed to achieve the Living Building Challenge (LBC), one of the world's most stringent sustainability certifications. The LBC establishes high standards for

sustainability, demanding that buildings operate as cleanly, beautifully, and efficiently as a flower. This entails generating all their energy, capturing and treating all water on-site, and utilizing only non-toxic, locally sourced materials.



### Site

The Bullitt Center is built on what is used to house a one-story restaurant with a surface parking lot. Many existing structures are simply demolished to minimize the impact on the overall project schedule

and associated costs. Builders also took into consideration saving the salvaged material from the destroyed structure and incorporating it into the new design.



The Bullitt Center utilizes portable water, wastewater, and grey water. It collects rainwater from the roof to meet all its needs and is regulated by the Washington State Department of Health's Group for safe drinking water. Wastewater is sent

to King County's Carnation facility for natural filtration and restoration of a native wetland. Grey water from sinks and showers is filtered, stored, and treated in a constructed wetland on the second-story roof.



Figure 7. Bullitt Center takes top prize at NIBS Awards  
Construction Specifier

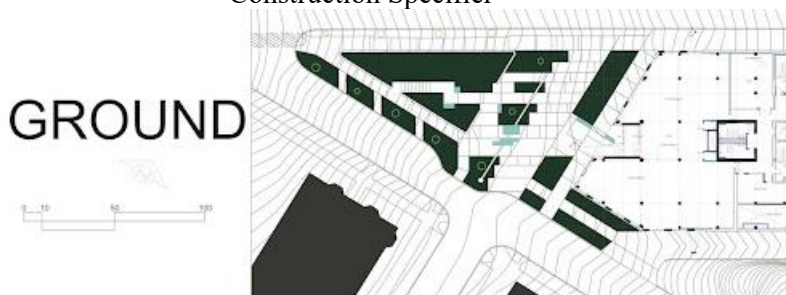
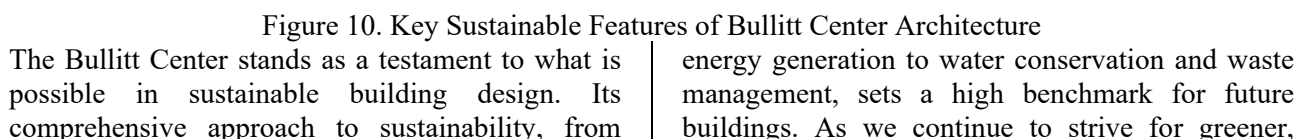


Figure 9. The ground-floor plan drawing includes the adjacent McGilvra Place park.





more sustainable construction practices, the lessons learned from the Bullitt Center will undoubtedly guide us toward a more environmentally responsible future.

### 2.3) Strategies for reducing energy consumption in interior spaces:

Reducing energy consumption in interior spaces is a critical component of sustainable design. Effective strategies not only reduce operational costs but also minimize environmental impact by lowering greenhouse gas emissions and carbon footprint.

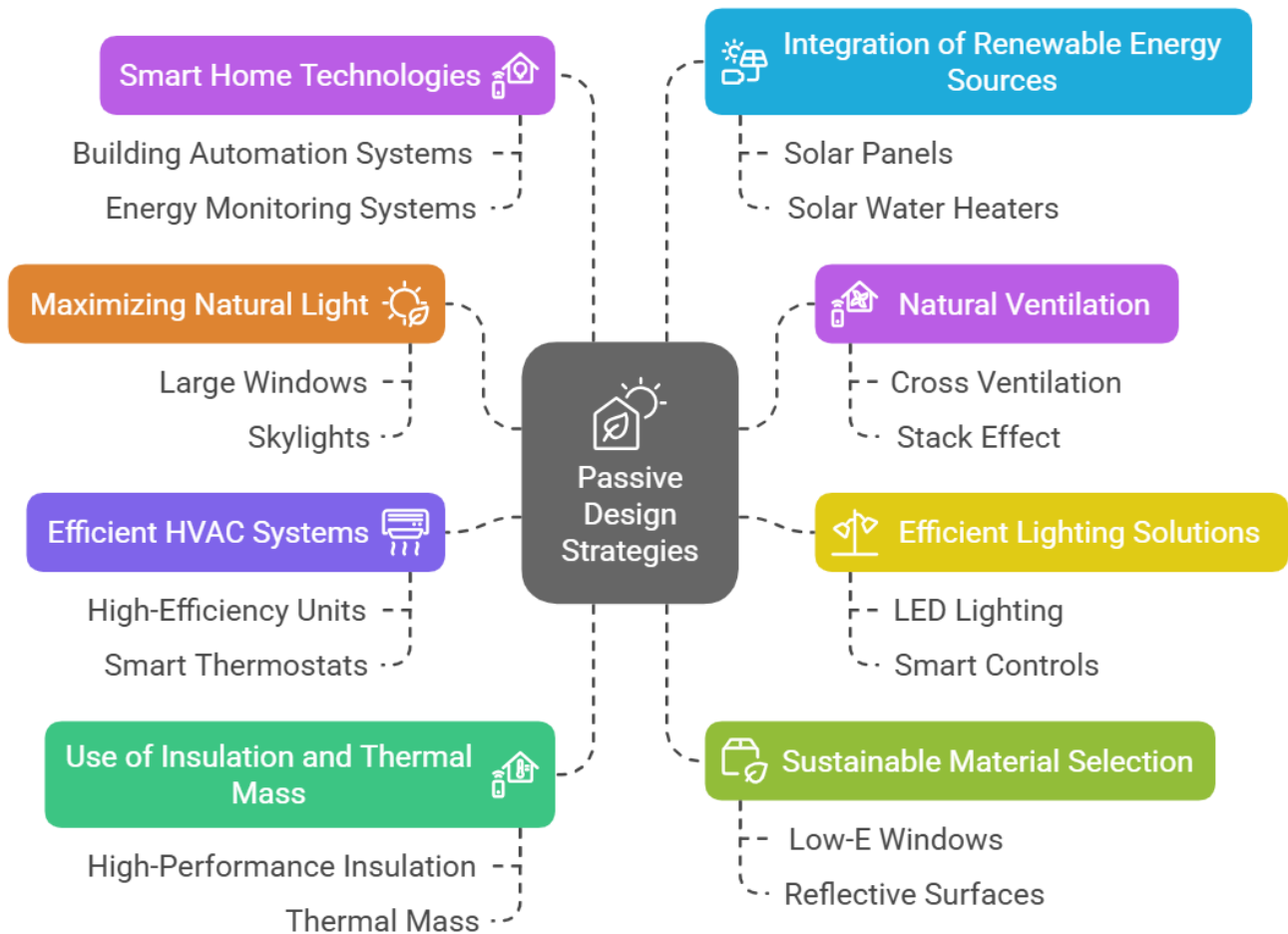


Figure 11. Passive and Efficient Design Strategies

### 3- Smart Applications in Interior Design:

#### 3-1 Definition of smart applications and their role in enhancing energy efficiency.

Smart applications refer to technological tools and systems that use advanced sensors, automation, artificial intelligence (AI), and the Internet of Things (IoT) to monitor, control, and optimize various functions within buildings and interior spaces. These applications enable real-time data collection and responsive adjustments to improve the performance and comfort of environments.

In the context of energy efficiency, smart applications play a crucial role by automating lighting, heating, cooling, and ventilation systems to operate only when needed, thus minimizing unnecessary energy consumption. For example, smart thermostats adjust indoor temperatures based

on occupancy patterns, and automated lighting systems turn lights on or off depending on natural daylight availability or room usage. Additionally, smart meters and energy management systems track energy use, allowing users to analyze and adjust behaviors for better energy conservation. By integrating smart technologies, interior spaces can achieve significant reductions in energy use, contribute to lower carbon emissions, and improve overall sustainability and user comfort.

#### Principles of smart design:

One of the principal challenges in smart architecture is how to construct systems that would provide enough variety to keep users engaged, four basic principles explain the natural relation between users and spaces.

Principles of smart design	Description	References
<b>Diversity</b>	Designers and planners over the past century were enamored with clinical zoning, under such zoning, uses were highly separated and segregated. In recent years, designers have called for a re-consideration of distinct zoning as a *mosaic of activities*	Branko 2015
<b>-Agility</b>	In buildings that have fixed and static structures, not easily modified or adjusted even though needs and uses may and do change over time. The result of this approach is that such buildings often cannot readily adapt to changing demands. Buildings cannot easily be reconfigured, expanded, or contracted as activities shift. Agility calls for thinking (designing and planning) and acting (constructing) that is far more open, responsive to needs, responsible to society, and system-oriented. Agile architecture encourages great mutability and adjustability across all realms of the building.	
<b>Reactive architecture</b>	Reactive or Responsive architecture means subtle technology as a networked structure that senses action within a field of attention and responds dynamically with programmed and designed logic.	
<b>Interactive Architecture</b>	The primary goal of responsive, adaptive architecture is to imbue buildings with the capacity to interact with the environment and their users engagingly. The user should affect the system's behavior or its outcome and how that behavior or outcome is computed.	

Table 4 . Principles of smart design

### 3-2 The use of the Internet of Things (IoT) and Artificial Intelligence (AI) in interior design.

The integration of the Internet of Things (IoT) and Artificial Intelligence (AI) in interior design has revolutionized how spaces are managed, optimized, and personalized. These technologies enhance efficiency, comfort, and sustainability by

automating various interior elements, adapting to user preferences, and reducing energy consumption.

#### 1. IoT in Interior Design

The Internet of Things (IoT) connects smart devices and sensors within interior spaces, allowing seamless communication and automation. IoT applications in interior design include:

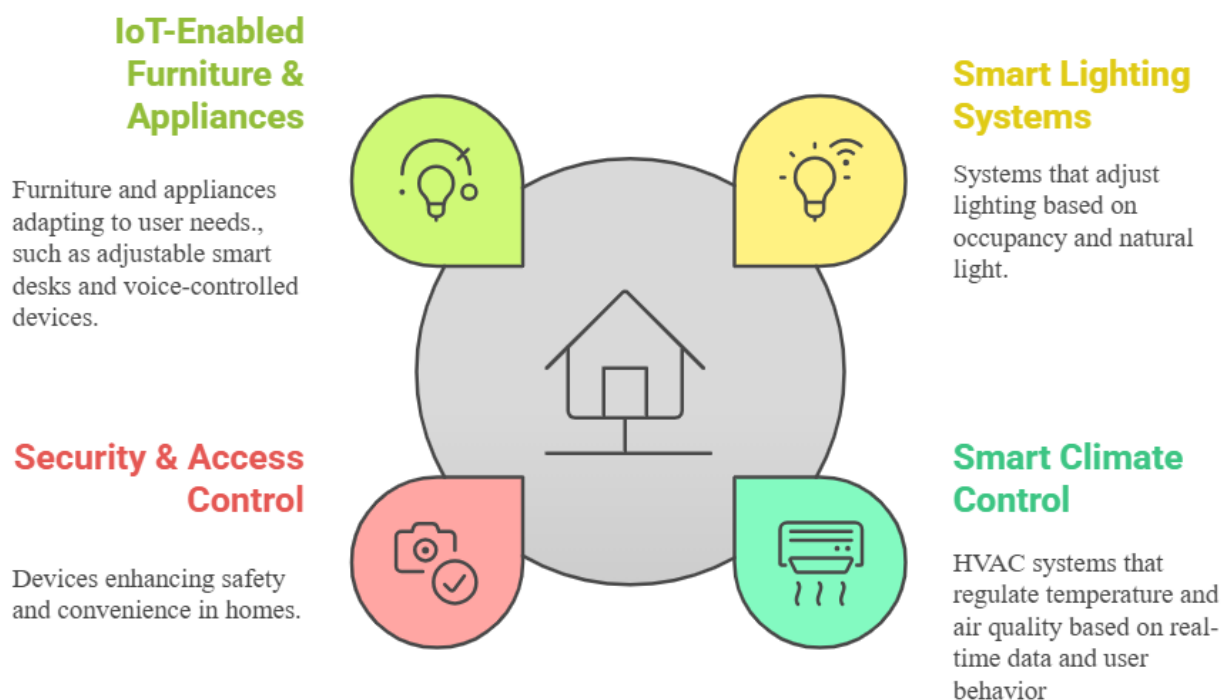


Figure 12. components of IoT Applications in smart home technology

## 2. AI in Interior Design:

Artificial Intelligence (AI) plays a crucial role in optimizing design solutions and enhancing user experience. Key applications include:

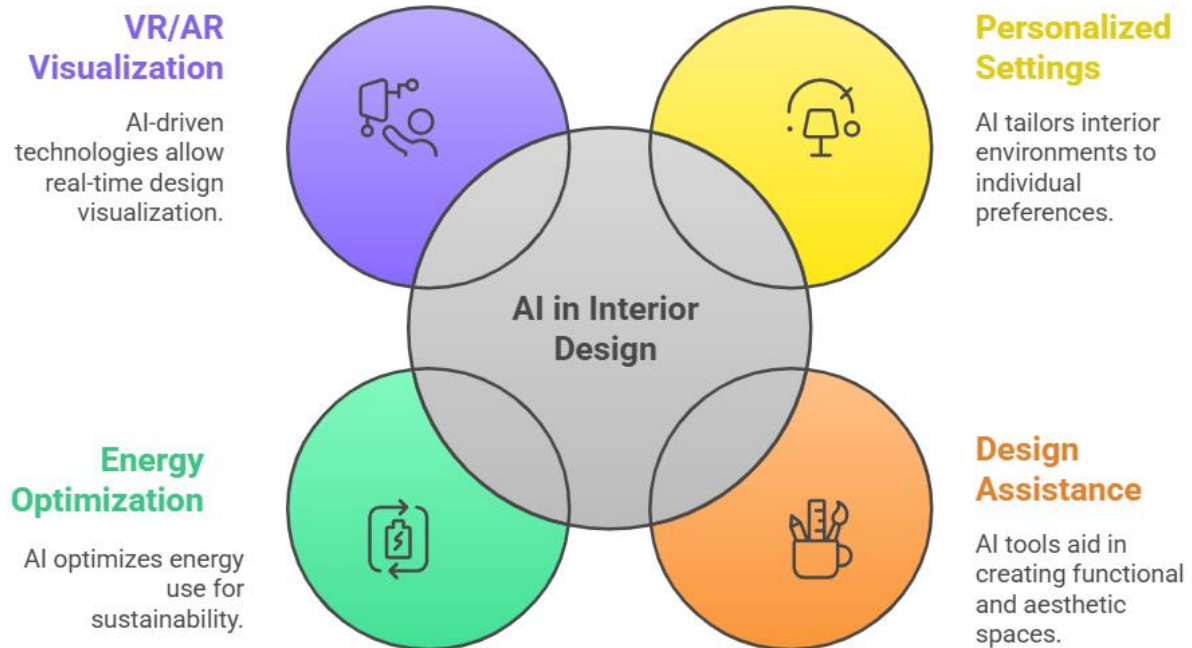


Figure 13. Transforming Interior Design with AI-Driven Innovations

### Sidewalk Labs– Toronto, Canada (Integrated Smart Residential District):

Sidewalk Toronto is a collaboration between Waterfront Toronto and Alphabet's Sidewalk Labs to develop a mixed-use, people-centered community on Toronto's Eastern Waterfront. This project merges innovative urban design with advanced physical and digital technologies to create a highly sustainable, affordable, and mobility-focused neighborhood while fostering economic opportunities. The 12-acre Quayside development marks the first phase of the Innovative Design and Economic Acceleration (IDEA) District, designed as a scalable model for urban innovation that can be replicated across Canada and globally. The planning framework integrates physical, digital, and policy elements to encourage third-party innovation in solving urban challenges and improving long-

term quality of life. Quayside incorporates several groundbreaking features, including pedestrian-friendly adaptive streets that support shared autonomous vehicles, heated bike lanes, modular dynamic pavement, and outdoor comfort systems to enhance public spaces. Additionally, flexible "stoa" ground-floor spaces accommodate diverse uses beyond traditional retail, while a thermal grid district energy system and underground package delivery and pneumatic waste networks improve sustainability and efficiency. Notably, Quayside will be the first neighborhood built entirely with mass timber construction, a more sustainable alternative to concrete and steel, helping to drive a new industry in Ontario. Through these integrated innovations, Quayside and the IDEA District aim to set a new benchmark for future urban.



Figure 14. BBB is collaborating with Sidewalk Labs on the master plan



## Key Objectives

- **Sustainability:** Implement climate-positive strategies to achieve negative carbon emissions.
- **Mobility:** Promote mixed mobility environments combining motor traffic with cycling and walking.
- **Public Realm:** Enhance public spaces to stimulate community engagement.
- **Buildings:** Develop adaptable and flexible building modules. Sidewalk Labs LLC (February 2, 2018).
- **Community & City Services:** Utilize digital technologies to connect and empower residents.
- **Digital Platform:** Integrate a digital layer with the physical environment from the outset.
- **Privacy & Data Governance:** Prioritize robust data governance and privacy considerations.
- **Housing Affordability:** Provide adequate affordable housing units to create a mixed-income community.
- **Economic Development:** Establish an urban innovation institute to foster job creation and economic growth. Sidewalk Labs LLC



Figure 15. Philips Hue wall switch module

### 3.3.2 Smart HVAC Systems:

- **Google Nest Thermostat:** Uses machine learning to adapt to users' schedules, automatically adjusting temperatures to optimize energy efficiency. It can reduce heating and cooling costs by up to 15%.
- **EcoBee Smart Thermostat:** Equipped with room sensors that detect occupancy and adjust heating/cooling only where needed, leading to more efficient energy use.
- **Trane Tracer SC+:** A commercial HVAC

(February 2, 2018).

- **Development & Planning:** Foster integrated planning throughout the development process. Sidewalk Labs LLC (February 2, 2018).

## Technological Innovations:

- **Utility Infrastructure:** Proposed underground utility channels to house conduits for electricity, waste, and water, allowing maintenance without disrupting public spaces. Wikipedia
- **Transportation:** Envisioned adaptive roads and streetlights, with self-driving electric shuttles to enhance accessibility. Wikipedia
- **Public Spaces:** Planned to use asset monitoring systems to track usage patterns and dynamically adjust space designations.

## 3-2 Smart lighting and HVAC systems and their impact on sustainability.

### 3.3.1 Smart lighting:

**Philips Hue:** This smart lighting system allows users to control brightness and color temperature via mobile apps or voice assistants, reducing unnecessary energy consumption.



Figure 16. TANSYAN Colour Changing Light Bulbs with Remote Control

control system that integrates IoT and AI to optimize climate control based on real-time occupancy and weather data, significantly lowering energy waste.

## 3-4 The positive effects of smart technology on air quality and environmental comfort.

### Smart technologies inside smart home:

A brief description of the most influential smart technologies on the spatial design of houses is given in (table 5)

Smart technologies inside smart home	Description	references
Technical components	Sensors and Actuators: sensors and actuators are responsible for performing the five basic functions of building automation (switching, positioning, indications, counting, and measuring ).	Maad Bali 2018
	Automation Equipment: is responsible for processing functions (monitoring, controlling, regulating, and optimizing )	
	Management and Operating Equipment: it is responsible for the operating and management functions	
	Data Interface Units: In all situations where two or more networks based on different communication systems have to be connected.	
Spatial interconnected devices	A smart wall with hidden cameras and sensors integrates TV and computer functions, offering interactive surfaces, changeable scenery, and support for tele-education, tele-care, e-meetings, and remote teamwork.	
	Smart furniture features a unique user interface and interaction style, characterized by flexibility, mobility, and intelligence. It adapts to users' needs, such as smart mirrors providing personalized information or smart beds adjusting environmental conditions. It is also responsive, like dimming lights when unoccupied or brightening for tasks. Additionally, it includes interactive touch surfaces and multifunctional designs.	
	Smart boundaries with adjustable transparency are switchable glass partitions that let users control light, glare, and visibility. They create adaptable spaces by regulating light, temperature, view, and sound as needed.	

Table 5. Smart technologies inside smart home

#### 4- Challenges and Solutions in Smart and Sustainable Interior Design

##### 4-1 Obstacles to integrating smart applications in interior design:

###### 1. High Initial Costs:

- Implementing smart applications, such as IoT-based lighting, HVAC, and security systems, requires a significant financial investment, making it less accessible for budget-conscious projects.

###### 2. Technical Complexity and Compatibility Issues

- Integrating various smart devices from different manufacturers often leads to compatibility challenges, requiring additional efforts in system integration and maintenance.

###### 3. User Resistance and Learning Curve:

- Some users may be hesitant to adopt smart technologies due to a lack of technical knowledge or concerns about system reliability, leading to resistance to implementation.

###### 4. Dependence on Internet and Power Supply:

- Most smart applications rely on a stable internet connection and electricity; disruptions in either can impact the functionality of automated systems.

###### 5. Rapid Technological Advancements:

- The fast-paced evolution of smart technology

can lead to obsolescence, requiring continuous updates and upgrades to stay relevant.

##### 1-2 Strategies to overcome technical and financial challenges.

###### 1. Reducing Complexity for Users:

- Design user-friendly interfaces with simplified controls through mobile apps or voice commands.
- Provide user training and support to ease the transition to smart technology.

###### 2. Ensuring System Reliability and Redundancy

- Use backup power sources (e.g., UPS or solar panels) to maintain operation during power outages.
- Implement edge computing to reduce reliance on internet connectivity.

###### 3. Keeping Up with Rapid Technological Advancements:

- Opt for scalable and modular systems that allow future upgrades without full replacement.
- Partner with technology providers that offer long-term support and software updates.

###### 4. Implementing Cost-Effective Smart Solutions:

- Start with basic automation systems (e.g., smart thermostats, lighting) and gradually expand.
- Use energy-efficient devices to achieve long-term cost savings.

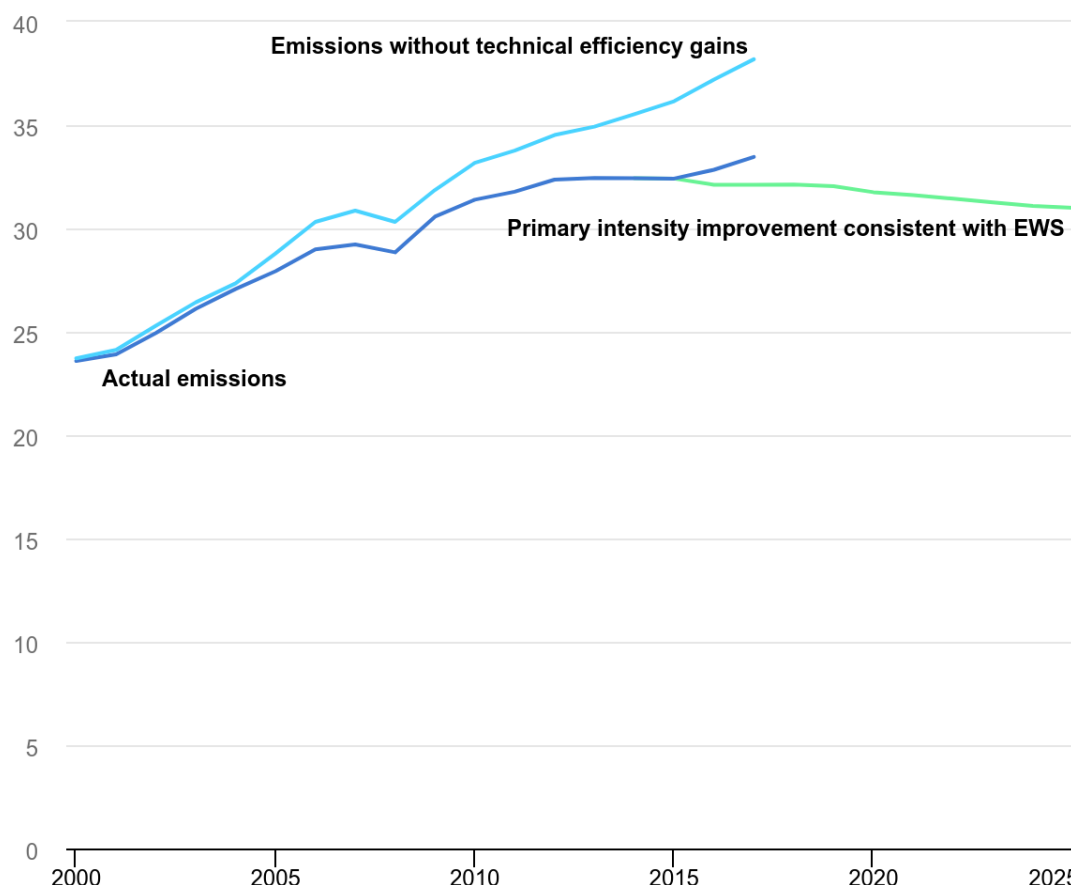


Figure 17. Energy-related greenhouse gas emissions, with and without technical efficiency gains, 2000-2025

- Emissions without technical efficiency gains
- Actual emissions
- Primary intensity improvement consistent with EWS.

**Notes:** EWS = Efficient World Scenario

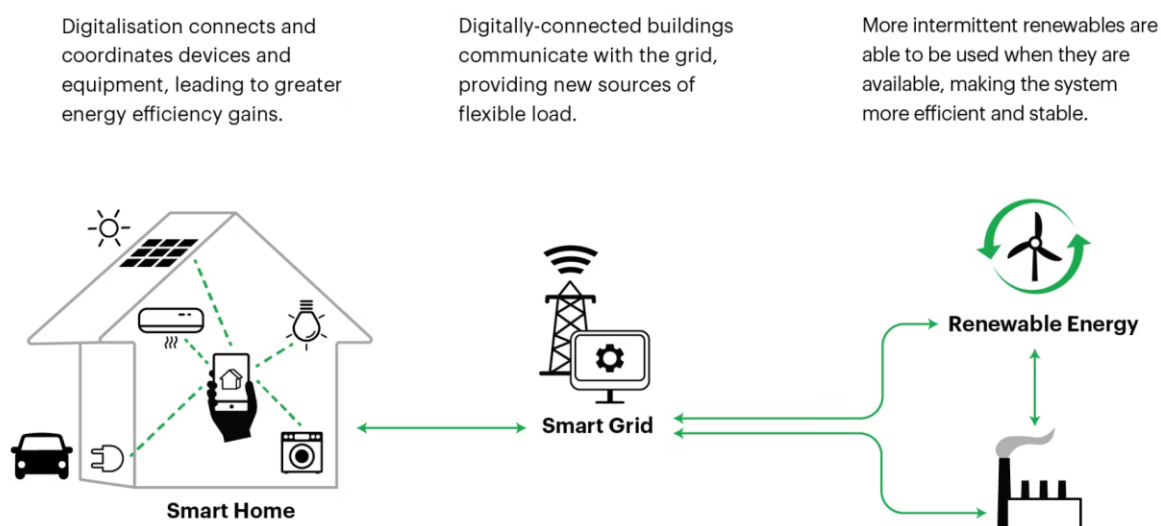


Figure 18. Energy Efficiency

## 5. Case Studies and Practical Applications

### 5.1 Examples of sustainable interior design projects using smart applications.

MEGHA SMART Automation: is a company that specializes in providing advanced automation

solutions for both residential and commercial spaces. Their offerings encompass a wide range of smart technologies designed to enhance convenience, security, and energy efficiency.





Home Automation in MEGHA SMART Automation

- HOME Automation becoming a part of daily LIVES around the world Or Today's technology has become an integrated part of people's lives.
- one-button control of everything hands-free
- With no touch at all, your home knows when you're arriving in the evening and sets your lights to lead the way.
- Turn on or off multiple rooms, or your entire

house, with one tap as you're headed off to work or turning in for the night. There's no longer a need to travel from room-to-room switching off individual lights and televisions.

- Smart home devices within the home automation system connect and communicate with each other over a local wired or wireless network.

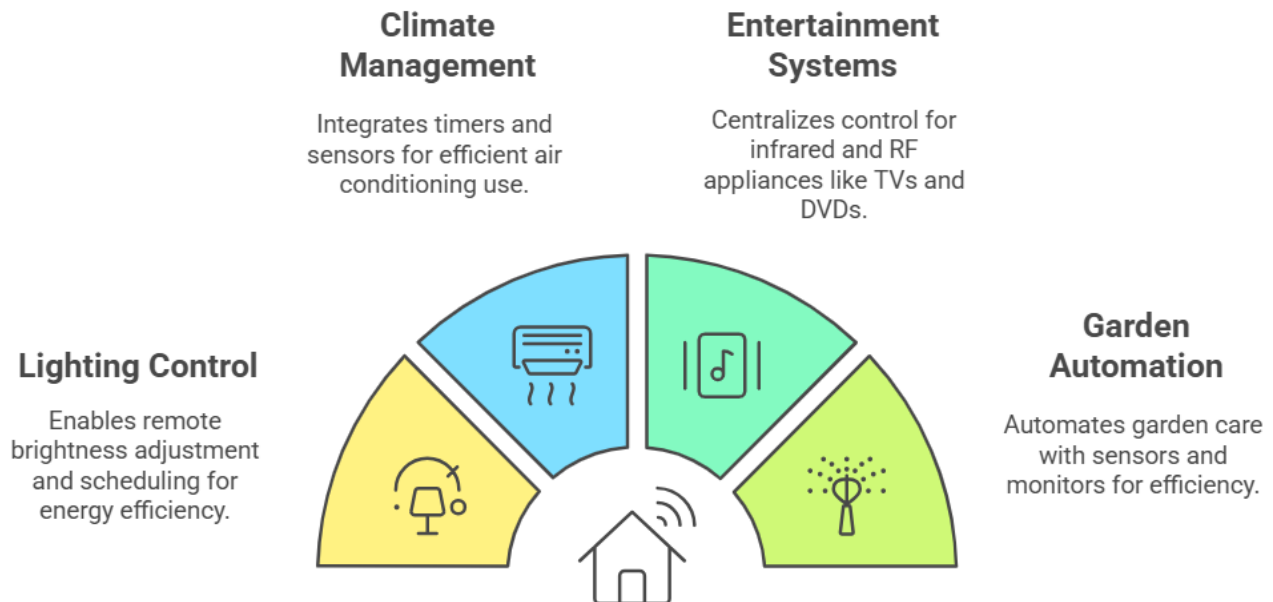


Figure 19. Enhancing Home Efficiency with Smart Automation Solutions

### Research conclusion:

- Sustainable interior design helps reduce the environmental impact of buildings by using eco-friendly materials and technologies that minimize energy and water consumption.
- Smart applications play a crucial role in improving energy efficiency, such as smart lighting and HVAC systems, which help lower the carbon footprint of buildings.
- The use of smart technology in interior design enhances the quality of life by improving ventilation, and natural lighting, and creating more comfortable and healthier indoor environments.
- Integrating the Internet of Things (IoT) and

Artificial Intelligence (AI) in interior design can drive a major transformation in sustainability by optimizing resource management and increasing building efficiency.

- Studies and real-world applications indicate that cities and buildings adopting smart and sustainable interior design solutions achieve significant reductions in energy and water consumption, directly contributing to climate change mitigation.

### Recommendations:

- Promote the use of smart technologies in interior design by encouraging the integration of smart lighting systems, energy consumption

controls, and smart ventilation systems to enhance resource efficiency.

- Develop policies and incentives to support sustainable interior design by offering financial benefits such as tax exemptions and encouraging investments in smart and sustainable solutions.
- Increase awareness among designers and engineers about the importance of sustainability and smart technologies through specialized training programs and workshops focusing on the latest practices and technologies in this field.
- Encourage the use of sustainable and eco-friendly materials in interior design, such as recyclable materials and non-toxic paints, to reduce the environmental impact of buildings.
- Improve infrastructure to support the transition towards smart and sustainable design by integrating Internet of Things (IoT) and Artificial Intelligence (AI) technologies into new urban projects.
- Conduct further research and studies on the impact of smart applications on sustainability to enhance and develop future solutions in the field of sustainable interior design.
- Strengthen legislation and regulations that mandate the use of sustainable solutions in interior design to ensure compliance with energy efficiency and environmental sustainability standards in new projects.
- Enhancing collaboration between interior designers and other engineering fields, such as architecture, environmental engineering, and smart systems engineering, to exchange expertise and knowledge in sustainability and smart technologies.

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