Research 7

# Enhancing Hotel Sustainability Through Ecological and Technological Integration

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Faculty of Engineering
Assiut University
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# Research 7

Enhancing Hotel Sustainability Through Ecological and Technological Integration

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## Research

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مدرس بقسم الهندسة المعمارية – كليه الهندسة – جامعة ٦ اكتوبر

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**تعزيز استدامة الفنادق من خلال التكامل البيئي والتكنولوجي**

**Enhancing Hotel Sustainability through Ecological and Technological Integration**

فانه يسعد هيئة تحرير المجلة ان تحيط سيادتكم علما بانه قد تم قبول البحث للنشر بالمجلة في تاريخ ٢٢ يناير ٢٠٢٤م وتم نشر البحث في المجلد ٥٢ – العدد ١– يناير ٢٠٢٤م.

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### Abstract

Abstract

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### References


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2. Ali K., (2006) "Smart Architecture - A Contemporary Formulation of Loca Faculty of Engineering, Department of Architectural Engineering, Assiut Univ
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# Abstract

The research explores the convergence of two pivotal trends in architecture: environmental and technological trends. The eco-trend focuses on the environmental impact of architectural practices, while the tech-trend emphasizes leveraging technology to enhance a building's performance. The thesis posits that integrating these trends holds the potential to create more sustainable structures, characterized by reduced environmental impacts and enhanced resource efficiency.

The study reviews environmental systems that achieve sustainability and focuses on one system that is applied to hotel buildings. The study also analyzes different forms of intelligence within environmentally friendly architecture, including smart materials, response to environmental changes, smart systems for automated building management, and smart interfaces that facilitate interaction. User intuitive.

The study proposes a range of key applications for environmental technology within hotel buildings, including energy-efficient lighting and heating systems, water-conserving fixtures, and innovative waste management systems.

The results obtained from the study reveal that the fusion of environmental and technological considerations significantly increases the development of sustainable hotel facilities. These facilities not only enhance environmental responsibility, but also enhance operational efficiency, which contributes to increasing diversified sources of national income.

## Key word

Eco-Friendly Building Design, Ecological Design, Technological, Sustainable Hotel Management, Smart Materials, Smart Systems, Hotel Facilities

## ملخص البحث

يستكشف البحث التقارب بين اتجاهين محوريين في الهندسة المعمارية: الاتجاهات البيئية والتكنولوجية. يركز الاتجاه البيئي على التأثير البيئي للممارسات المعمارية، في حين يؤكد الاتجاه التكنولوجي على الاستفادة من التكنولوجيا لتعزيز أداء المبنى. وتفترض الأطروحة أن دمج هذه الاتجاهات يحمل القدرة على إنشاء هياكل أكثر استدامة، تتميز بانخفاض التأثيرات البيئية وتعزيز كفاءة الموارد.

وتستعرض الدراسة الأنظمة البيئية التي تحقق الاستدامة وتركز على نظام واحد يتم تطبيقه على المباني الفندقية. كما تقوم الدراسة بتحليل أشكال مختلفة من الذكاء ضمن الهندسة المعمارية الصديقة للبيئة، بما في ذلك المواد الذكية، والاستجابة للتغيرات البيئية، والأنظمة الذكية لإدارة المباني الآلية، والواجهات الذكية التي تسهل التفاعل. المستخدم بديهية.

وتقترح الدراسة مجموعة من التطبيقات الرئيسية للتكنولوجيا البيئية داخل المباني الفندقية، بما في ذلك أنظمة الإضاءة والتدفئة الموفرة للطاقة، والتركيبات التي تحافظ على المياه، والأنظمة المبتكرة لإدارة النفايات.

تكشف النتائج التي تم الحصول عليها من الدراسة أن دمج الاعتبارات البيئية والتكنولوجية يزيد بشكل كبير من تطوير المرافق الفندقية المستدامة. ولا تعمل هذه المرافق على تعزيز المسؤولية البيئية فحسب، بل تعزز أيضا الكفاءة التشغيلية، مما يساهم في زيادة تنوع مصادر الدخل القومي.

الكلمة الرئيسية

تصميم المباني الصديقة للبيئة، التصميم البيئي، التكنولوجي، إدارة الفنادق المستدامة، المواد الذكية، الأنظمة الذكية، مرافق الفندق

# Enhancing Hotel Sustainability Through Ecological and Technological Integration

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## Abstract

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## 1 Introduction

Architecture is considered the cornerstone of human civilization, standing at a crossroads. While our modern built environment provides shelter and facilitates countless activities, its construction and operation often come at a heavy environmental cost. Rapid technological progress, despite its undeniable benefits, has simultaneously amplified energy consumption and pollution, exacerbating the environmental imbalance.

Environmental advocates have vocalized concerns, emphasizing the pivotal role of architecture in influencing the trajectory of our planet's future. Imperatively, there is an exigent requirement for strategic interventions aimed at diminishing the environmental impact of buildings, concurrently addressing the adverse repercussions stemming from unregulated energy consumption and waste generation.

This study delves into the burgeoning “ecotech” trend in architecture, an innovative approach that harnesses the power of technology to transform our built environment into a beacon of sustainability. We aim to dissect how embracing technological advances, from smart materials to intelligent systems, can revolutionize the way we design, build and operate buildings, promoting a harmonious relationship between architecture and nature.

This study will not only highlight the theoretical foundations of eco-technological architecture, but will also translate these principles into practical applications. We will explore cutting-edge technologies and showcase their real-world potential to reduce energy consumption, reduce waste, and optimize resource use within building complexes. By bridging the gap between theory and practice.

this study aspires to provide architects, engineers and policy makers with the knowledge and tools needed to usher in a new era of sustainable hotel building design.

## 1.1 Research Problem

The use of new technologies to reduce energy consumption without harming the environment is not being fully exploited. This can be done by using the latest scientific and technological advances in the field of artificial intelligence, including smart materials, smart systems, and smart interfaces. And integrating them with environmental considerations especially in hotel buildings.

## 1.2 Research Aim

Explaining the impact of integrating technology with environmental considerations and the emergence of a modern trend, which is ecotechnology, and the importance of applying it in buildings to raise their efficiency. And familiarity with all concepts of intelligence and technological development for smart architecture, while reviewing the different forms of intelligence in terms of (smart materials - smart systems - smart interfaces) that can be used In hotel buildings

## 1.3 Research Methodology

The research methodology employed in this study encompasses three distinct axes. The first axis, characterized as the descriptive approach, is dedicated to elucidating the eco-technological trend in architecture. This involves a comprehensive clarification of its main components, specifically the ecological and technological trends, along with an exploration of the associated concepts and dimensions of sustainability inherent in these trends. Furthermore, a detailed examination of concepts and definitions pertaining to intelligence, coupled with an analysis of the technological advancements in smart architecture, is conducted. This analytical process extends to the various manifestations of intelligence, encompassing smart materials, smart systems, and smart interfaces. The second axis, identified as the analytical approach, is a two-stage process. In the first stage, an exhaustive analysis is conducted on an evaluation system applied to hotel establishments, both on an international and local scale. The objective is to derive environmental standards and essential elements requisite for sustainability in hotels. The second stage involves the scrutiny of a hotel facility possessing environmental certifications from international and local evaluation systems. This analysis aims to identify the specific applications employed within the facility to attain the prescribed evaluation standards. The third axis, the exploratory approach, is centered on generating results and proposing a strategic framework based on the application of ecotechnology to hotel establishments. Positioned as a contemporary environmental architectural trend, this approach seeks to enhance the performance of hotel establishments across environmental, technological, and economic dimensions, addressing anticipated challenges affecting such establishments in the future.

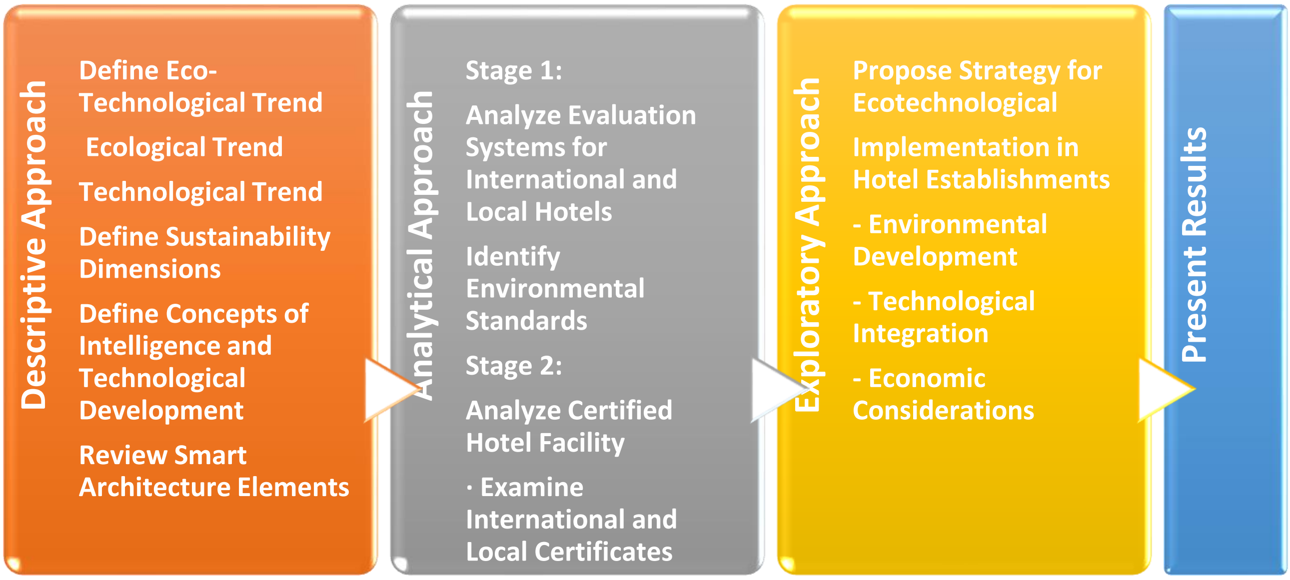


**Figure 1 Research Methodology process**

## 2 Synthesis of Eco-Technological Trends in Architecture

The eco-technological trend in architecture, denoted as Eco-Tech, represents a fusion of environmental sciences (Ecology) and technology. Coined by Mohamed (2011), Eco-Tech architecture encapsulates the integration of environmental considerations and modern technologies in architectural practices. The overarching objective is to harmonize smart technologies in a manner that is environmentally conscious, concurrently optimizing resource utilization and leveraging renewable energies with minimal ecological impact. In alignment with sustainability principles, Eco-Tech architecture operates within a smart technical framework, facilitating the creation of intelligent structures capable of interactive and responsive engagement with their ecological surroundings (Nadya, 2021). This approach constitutes a holistic eco-tech system, incorporating environmental design, technological design, and economic efficiency elements. Refer to Figure 2 for an illustration of the eco-tech system.

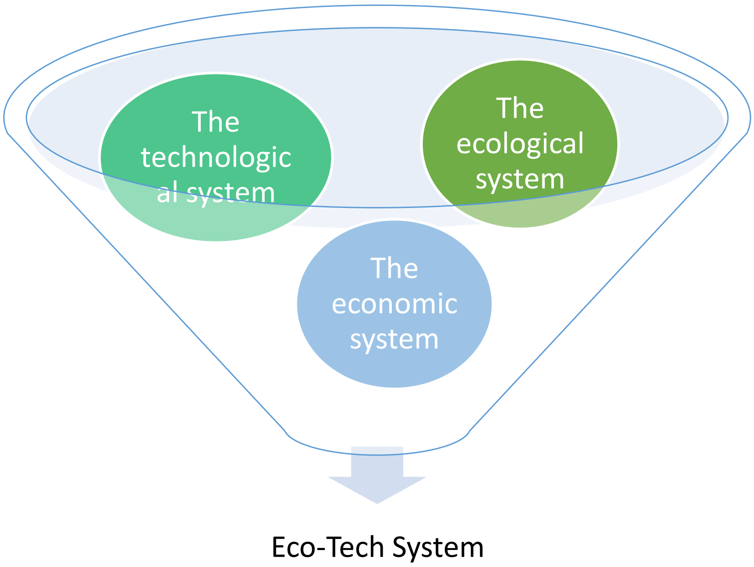


**Figure 2. The Eco-Tech System**

## 2.1 The Ecological Trend (Environmental Trend)

The ecological trend within the domain of architecture, as underscored by Diaa (2017), is characterized by a comprehensive consideration of sustainability concepts, performance efficiency, and the environmental ramifications of building structures. This entails a meticulous evaluation of the building's compatibility with its immediate surroundings, encompassing the biosphere and climate control aspects. Factors such as the design of the building mass, its orientation, and other environmental considerations are integral components of this ecological trend. Diaa emphasizes that the ecological system serves as the fundamental cornerstone in Eco-Tech design, incorporating renewable energy sources and leveraging insights from the natural environment, including sun, wind, earth, water, and organic materials.

These elements have emerged as pivotal determinants shaping architectural decisions, including building orientation, form, and experimentation with architectural treatments and construction methodologies. The overarching objective is to transform buildings into sustainable living entities. This transformation involves strategic design interventions informed by environmental data, encompassing passive solar design strategies, negative ventilation, optimal orientation of glass walls for natural lighting, thermal mass control, shading strategies, roof design considerations, and thermal storage management. Importantly, this transformative process is advocated for without incurring significant cost escalation, with due diligence to safeguard the interests of future generations and judicious use of renewable energy sources, as posited by Hindi (2021).

Furthermore, the discourse integrates the paradigm of intelligence within the context of ongoing technological advancements across various sectors of architecture. This pertains to advancements in structural systems, materials, and external facade finishes, with a primary aim to enhance performance and temporal efficiency. Diaa (2017) accentuates the significance of cost-effectiveness in the eco-tech system, highlighting the imperative to balance the ecological and technological dimensions within this architectural framework.

The concept of intelligence in buildings is not new. Since the beginning of history, humans have sought to build shelter to protect themselves from danger, using the technologies and building materials available to them at that time to provide comfort and safety (Khalid, 2006).

The term "smart building" first appeared in the United States in the 1980s. At that time, it referred to buildings that used remote control systems and building management systems. The development of smart buildings at that time was associated with information technology (IT) (Harrison, A. (1998)).

A smart building is a building that is equipped with technology that gives it the ability to think and change the internal environment according to the needs of the user and adapt to the external environment. This results in a smart building of all types, leading to a smart city or smart architecture (Kolterman, 2000).

## 2.2 The Eco-Technological Trend

The of the eco-technological trend within the realm of architecture is to safeguard environmental elements and energy resources. This is achieved through leveraging buildings as platforms for harnessing renewable energy sources using advanced technological methodologies, all while ensuring economic viability and minimizing the environmental footprint of the structures on their surroundings (Diaa, 2017). Within the context of addressing the global energy crisis, a focus on rationalizing energy consumption becomes imperative. Therefore, an exploration into the conceptualization of energy, its sources, and the global energy landscape is deemed essential (Saeed et al., 2018).

Energy constitutes a fundamental pillar of society, indispensable across various economic sectors and integral to daily life. Its pivotal role in development underscores its direct impact on economic, social, and environmental facets (Hani, 2012). A nuanced comprehension of the intelligence concept is requisite for delineating the characteristics of smart buildings. Intelligence is characterized as a sensory adaptive adaptation that sustains life within a given system (Sinan, 2019). Further division distinguishes between human intelligence and artificial intelligence, the latter being a computational emulation of human intelligence for problem-solving within computer systems.

According to the Arabic Language Academy, intelligence encompasses the abilities to analyze, synthesize, distinguish, choose, and adapt to diverse situations (Concise Dictionary, 2011). While the term "intelligence" conventionally pertains to distinctive human mental abilities (Kholoud, 2013), including perception, learning and memory, communication, and planning, understanding how to extrapolate these intelligence concepts to non-human entities like machines, cities, and buildings necessitates an exploration of artificial intelligence.

The pursuit of artificial intelligence involves comprehending human intelligence's nature by constructing computer programs capable of emulating intelligent behavior and problem-solving. Rooted in simulating human intelligence within computers, artificial intelligence seeks to imbue machines with intelligent responses through specialized software applications across various domains (Razzab, 2009).

# 3 Materials

Smart materials exhibit distinctive properties that contribute to their versatile applications in various fields. The key characteristics of smart materials are outlined as follows:

- Responsiveness: Smart materials demonstrate the ability to alter their shape or properties in response to external stimuli, such as light, heat, or an electric field. This responsiveness enables adaptability to changing environmental conditions.
- Energy and Mass Transport: An essential feature of smart materials is their capacity to enhance the flow of energy and matter. Many smart materials have the capability to store and release energy, either through direct or indirect interactions with the surrounding environment (Schade, 2005).
- Compatibility with Electronic Systems: Smart materials find application in electronic systems, showcasing compatibility and integration possibilities within these systems.
- Remote Control: The controllability of smart materials from a remote location adds to their utility, allowing for dynamic adjustments and interventions as needed.
- Lightweight and Durable: Smart materials possess the advantage of being lightweight and durable. Their structural characteristics contribute to ease of replacement or repair, enhancing overall longevity.
- Self-Healing: A noteworthy property of smart materials is their ability to self-evaluate and initiate repair processes in areas damaged due to environmental conditions (Thomas, K., 2006). This self-healing capability contributes to prolonged functionality and resilience.

These properties collectively underscore the significance of smart materials in technological and engineering applications, where adaptability, efficiency, and sustainability are paramount considerations. There are many smart materials that can be classified into Figure 3:

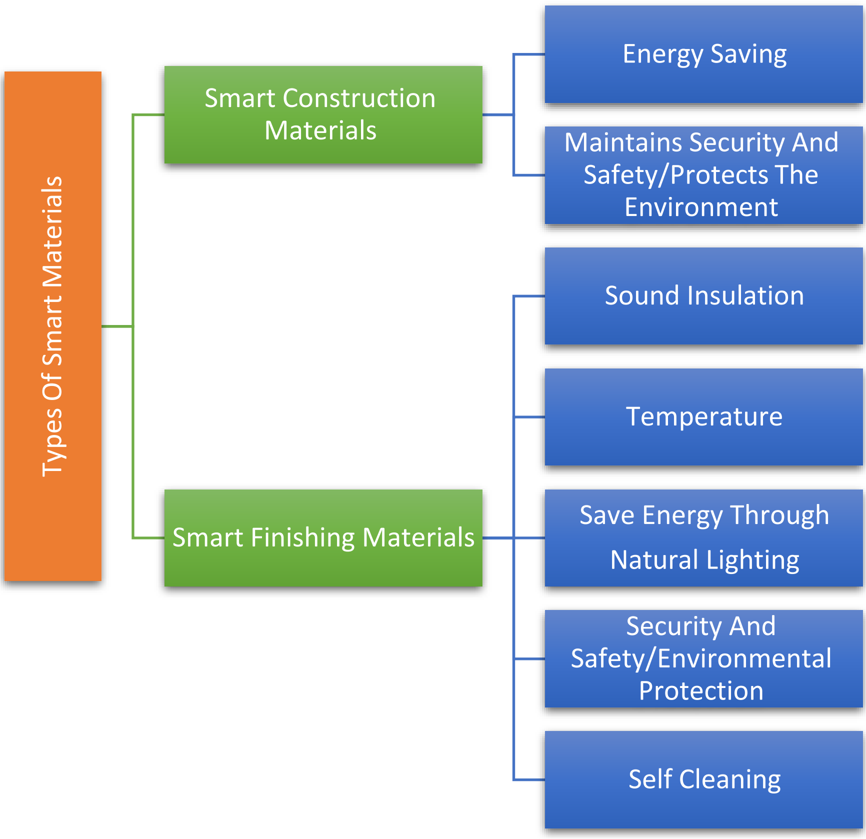


**Figure 3.Types of smart materials**

## 3.1 Smart construction materials

The contemporary discourse on sustainable architecture has witnessed a paradigm shift with the advent of smart construction materials and intelligent systems, propelling the field towards unprecedented levels of energy efficiency, environmental sustainability, and occupant safety. In this section, we delve into the multifaceted realm of smart construction materials, delineating their classifications based on energy conservation, security, safety, environmental protection, and finishing applications. Additionally, we explore the revolutionary impact of intelligent systems and technologies in buildings, encompassing dynamic facades, emerging sensor technologies, and advanced heating, ventilation, and air conditioning (HVAC) systems. This comprehensive exploration not only illuminates the diverse facets of these innovations but also underscores their transformative potential in fostering sustainable practices within the architectural domain. which can be divided into:

### a. Energy saving

There are a number of smart construction materials that can be used to conserve energy in buildings.

- transparent concrete.

Transparent concrete is a type of concrete that allows light to pass through it, making the building more like a large window Figure 4.This can reduce the need for artificial lighting, which can save energy and money.(Asmaa,2011)


**Figure 4. Transparent concrete**

- Self-luminescent cement

Self-luminescent cement is a type of cement that is made from industrial polymers, to which glass beads coated with phosphor are added Figure 5. This gives the material a glow that appears in the dark. Colored tiles are made from this mixture for floors and walls. It is very hard, especially when used with lighting that enhances the feeling of these materials (Asaad, 2009).

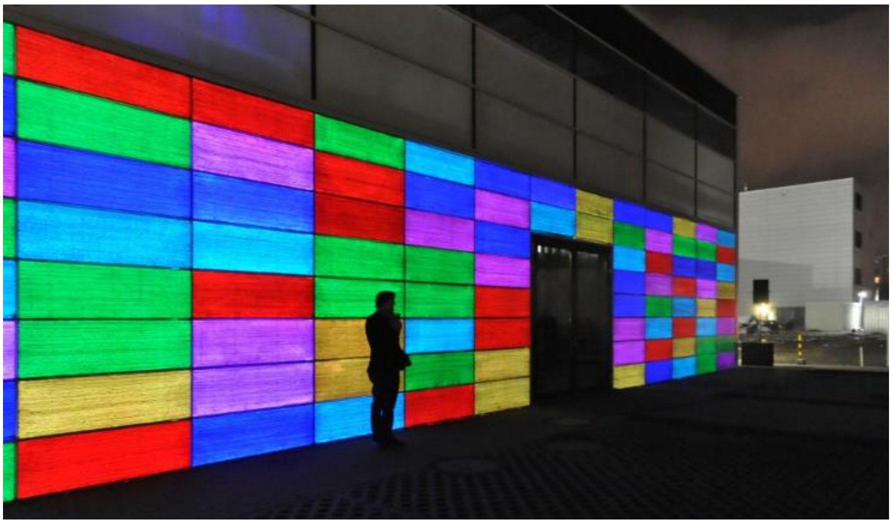

**Figure 5. As in the RWTH Aachen University building, self-luminescent cement was used https://www.archdiwanya.com**

**b. Security and safety / environmental protection in buildings**

There are a number of smart construction materials that can be used to. Security and safety / environmental protection in buildings

- Low-pollution cement

**Figure 6. Shows the use of pollution-reducing cement in the Palazzo-Italia building with a bio-green, air-purifying atmosphere**

It is a type of developed cement that is manufactured using magnesium carbonate instead of calcium carbonate in ordinary Portland cement. This cement works to absorb carbon dioxide gas, where one ton of concrete made using this cement has the ability to absorb 0.4 tons of carbon dioxide during its hardening period.as shown in Figure 6.

- Self-healing materials

These materials have the ability to repair damage caused by continuous mechanical use over time.

- Biological concrete

The green facades provide air purification from carbon dioxide CO2, and exploit rainwater to irrigate these microfungi without excessive consumption of energy or water, as shown in Figure 7.

**Figure 7. Biological concrete to create green facades for the Aviation Cultural Center41**

- Air purification: Water conservation

## 3.1. Smart Finishing Materials

which can be divided into

**A. Sound insulation**

- Aerogel glazing

In this type of glass, aerogel material is used to fill the void between the two layers of glass. This helps to provide good sound insulation and the ability to diffuse light and glare, which can create a comfortable and pleasant atmosphere in office spaces while giving a feeling of coolness in the summer

**Figure 8. Demonstrates Glass Electrochromic Material (Telhan,2010)**

**B. Energy saving through (natural lighting)**

- Electrochromic materials

These materials are characterized by their ability to change color as a result of the use of electricity. They can control natural lighting, as shown in Figure (7).

- Plastic glass: Plastic glass is a type of glass that is made from polymers. It is lighter and more durable than traditional glass, and it can be used to reduce the amount of energy required for heating and cooling.

**C. Energy saving through (temperature)**

- Aerogel:

A transparent gel-like material that resembles glass, with air accounting for 99.8% of its volume with a density of approximately 3 mg/cm, reduces temperature, and is used as an alternative to glass in windows and can be used in transparent walls (Asmaa, 2011). as shown in Figure 9.

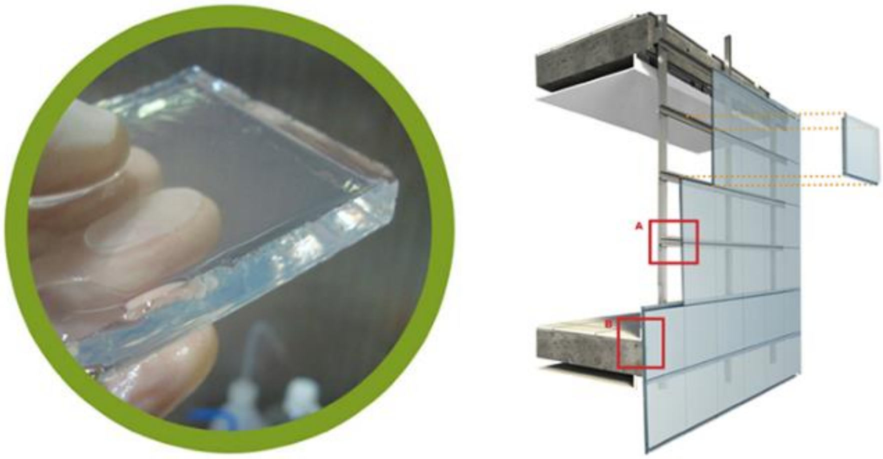

**Figure 9. Aerogel material https://www.eloficial.ec/aerogel-innovador-material-para-construir/**

- Temperature regulation glass

It is a glass treated with ANZ nanomaterial that acts as an insulating layer to reduce temperatures in the summer by 20 degrees and equalize temperatures in winter, (Ala, 2012).

**D. Self-cleaning**

- Active glass

It is a type of glass panel coated with a thin transparent layer of photocatalytic particles . These particles keep the glass surface clean permanently and prevent the deposition of any pollutants or pollutants on it, so they guarantee what is now known as the term self-cleaning.

**E. Security and safety/environmental protection**

- Solar protection glass

Solar protection glass is a type of glass that uses nano-technology to provide effective solar protection by controlling the amount of light that enters a building.

- Solar panels

Solar panels are devices that convert sunlight into electricity. When solar panels are installed on a building, they can help to reduce the building's reliance on fossil fuels. as shown in Figure 10.

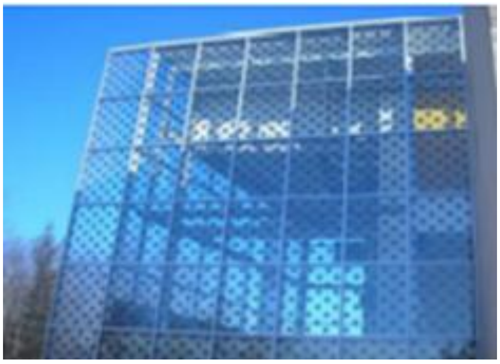

**Figure 10. Shows glass equipped with solar cells**

## 3.2 Intelligent systems and technologies in buildings

- Self-moving smart facade systems

these are dynamic and interactive facades that are able to flexibly adapt to the continuous changes in the surrounding environment, such as making automatic responses to changes in temperature, light, humidity, wind, etc., in order to improve and prepare the internal spaces in a way that meets the needs of the user and also taking into account his behavior and interaction with the internal space while practicing his activities (Nada et al., 2021).

- Emerging sensor technologies

This new generation of sensors adds the ability to know the conditions and needs of the building and change the behavior of the building's control systems (Emmitt, S. (2002)). Operating a large number of sensors inside the building will allow for responsive operation in addition to the use of pre-programmed control models (Bakeev, K. (2010)).

- Heating, ventilation, and air conditioning (HVAC) systems

It is the systems associated with building automation and management systems that help improve the indoor air quality of smart building spaces and help with the following:

- Monitoring temperatures and adjusting them according to the needs of users.
- Adjusting the indoor air quality based on the occupancy rate of the spaces.
- Adjusting the humidity, temperature, and airflow speed of the room.

(Binggeli, (2003).

- Recycling systems

Waste bins are divided according to the materials they contain to make it easier to collect them for recycling . Citizens are given a monetary or small incentive for their waste, depending on its weight or number, to encourage them to dispose of their waste in the appropriate place and protect the environment.

Control of opening and closing

- Dimming control

Ergo light is considered one of the best systems that has provided energy savings inside the building by 87% of the total energy consumption, in addition to the ease of installation and use Figure (14), (www.masstech.orgProject Deliverables GB).

- Induction stoves

are used in the kitchen to prepare food and drinks instead of the common gas stoves. Figure (15)

- Eco-Powr bikes

ECO fitness equipment (such as Eco-Powr bikes) generate power to the grid instead of drawing it. This is in addition to SportsArt's energy-generating treadmills and stationary bikes Figure 11.


**Figure 11. Fitness equipment Eco-Powr bikes.** **https://athleticshop.com.pl/cms/eco-powr**

- Pavegen path

Pavegen path is a type of paving tile that can generate electricity from the movement of people. The tiles are made of a flexible material that bends when someone steps on them. This bending motion generates electricity, which can then be used to power lights, sensors, or other devices. Figure 12.

**Figure 12. Pavegen path in Bird Street, London** **https://newatlas.com/bird-street-pavegen-clearair-airlite/50321**

- Double skin system

A double skin system is a type of building envelope that consists of two layers of glass or other transparent material. The space between the two layers can be used to control the flow of heat, light, and air into the building .shown inThe Singapore Arts Centre is a good example of a building that uses a double skin system with computer-controlled solar shading. The building has an outer layer of glass that is covered with a system of movable solar panels Figure 13.

**Figure 13. The Singapore Arts Centre** **source: https://www.atelierone.com**

## 3.3 Types of assessment systems:

To ensure the implementation of green architecture in buildings in general, and hotel facilities in particular, it was necessary to establish systems to set standards and requirements that are compatible with the environment to evaluate these buildings and encourage the increase in the environmental efficiency of these buildings.

Many different methodologies have emerged for environmental assessment systems, some of which include many types of buildings, and some are limited to hotel and tourism facilities only as shown in Figure 14.

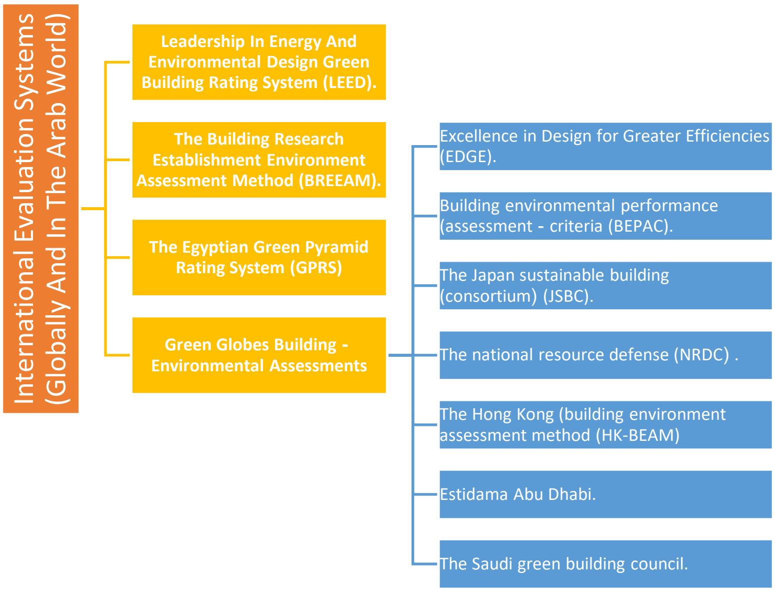


**Figure 14.Some international evaluation systems (globally and in the Arab world)**

### 3.3.1 The Egyptian Green Pyramid Rating System (GPRS)

As an immediate step to enhance the role of the Egyptian Green Building Council (EGBC), the decision was made to create a national green building rating system, known as the Green Pyramid Rating System (GPRS). The EGBC took the initiative to outline the structure of this rating system, and a national committee was established to thoroughly examine and eventually approve the Green Pyramid Rating System. This process was finalized in January 2009 (The Egyptian Green Building Council, 2010).

Acknowledging the distinctive ecological, industrial, and social circumstances of the region, this rating system aims to define the characteristics of "Egyptian Green Building." To achieve this objective, the rating system incorporates principles and techniques proven successful in established programs from various regions, including the United States, Europe, Asia, South America, and the Middle East. The Green Pyramid System (GPRS) comprises the following levels as Silver Pyramid, Gold Pyramid, and Green Pyramid. It's noteworthy that while most international systems employ the term "platinum" for the highest certification level, in the case of the GPRS, the highest rating is referred to as "Green."

### 3.3.2 Green globe

Green Globes stands out as a prominent green building assessment system, particularly prevalent in Canada and the United States. Distinguished as a global leader in sustainable tourism certification, Green Globes has earned recognition from the World Travel and Tourism Council and holds an associate membership with the United Nations World Tourism Organization. With a legacy spanning over three decades, Green Globes has evolved into the preeminent certification standard for ensuring the sustainable operation and management of establishments within the travel and tourism sector. Widely embraced by hotels, resorts, convention centers, and attractions, Green Globes plays a pivotal role in enhancing the sustainability and appeal of tourism-related businesses on a global scale, as shown in Table Green Globes standard and its elements .

**Table 1. Green Globes standard**

| Main criteria | Elements | |
|---|---|---|
| Sustainable management | – Implementing a sustainability management system<br>– Legal compliance<br>– Employee training<br>– Customer satisfaction<br>– Accuracy of promotional materials<br>– Interpretation<br>– Communications strategy | – Local zoning, design and construction<br>– Design and construction - compliance with legal requirements<br>– Sustainable design and construction of buildings and infrastructure – new and existing buildings<br>– Health and safety |
| Social/economic | – Community development<br>– Local employment<br>– Fair trade<br>– Support local entrepreneurs | – Exploitation Respect<br>– local communities<br>– Fair recruitment<br>– Protection of employees<br>– Basic services |
| Cultural Heritage | – Code of conduct<br>– Historical artifacts | – Site protection<br>– Integrating culture |
| the environment | – Conserve resources | – Water consumption: Water consumption must be measured, |

| | | |
|---|---|---|
| | – Energy consumption: Energy consumption must be measured and measures taken to reduce total consumption while encouraging the use of renewable energy.<br>– Consumer Goods | sources identified, and measures taken to reduce total consumption<br>– Purchasing policy favors environmentally friendly products |
| | – reduce pollution<br>– Greenhouse gases<br>– Sewage<br>– Waste management plan | – Planning and minimization<br>– reuse<br>– Recycling<br>– Harmful substances<br>– Other pollutants |
| | – Preserving biodiversity, ecosystems and landscapes<br>– Wildlife species | – Landscaping<br>– Preserving biological diversity<br>– Wildlife in captivity<br>– Interactions with wildlife |

# 4. Case Study

The La Gree Des Landes - Eco-Hotel-Spa Yves Rocher Hotel was selected, and the hotel was analyzed according to the Green Globe standards because it is a certified hotel and is considered one of the environmentally designed hotels, and some smart systems for the building will be proposed Figure 15.

**Figure 15. La Gree Des Landes - Eco-Hotel-Spa Yves Rocher Hotel** https://www.lagreedeslandes.com/en/eco-hotel-france.html

Building Name: La Gree Des Landes - Eco-Hotel-Spa Yves Rocher is located in France and was built by architect Jacques Roche in 2009 and is a Platinum Green Globe.

The Yves Rocher Eco-Hotel & Spa was opened in April 2009, and it is environmentally friendly in all its aspects. It is the first hotel designed to be 100% environmentally friendly. It has won the Platinum Green Globe award and the European Ecolabel, and it is located between slate rocks, trees, and plants in Cournon, a village in Brittany, France.

The building will be analyzed according to Green Globe standards, and proposals for smart systems will also be added, in order to integrate the two systems (environmental and technological)

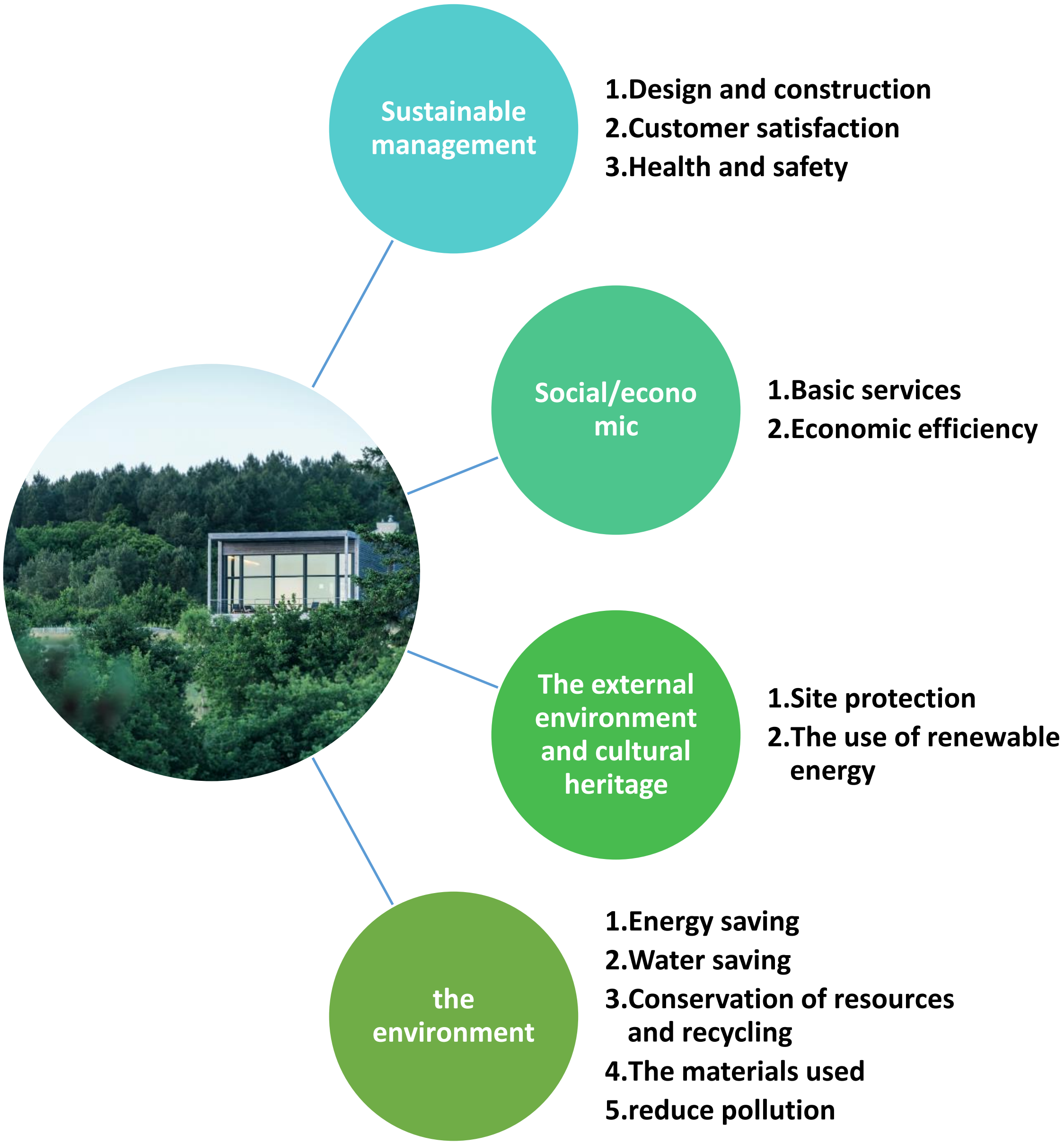


**Figure 16.Sustainable management**

## 4.1. Sustainable Management

Sustainable management is a holistic approach that transcends traditional business practices, emphasizing the integration of environmental, social, and economic considerations into organizational strategies. In the context of diverse sectors, sustainable management seeks to strike a harmonious balance between present needs and future generations' well-being. This comprehensive framework extends beyond immediate profit-making goals to encompass responsible practices in design, construction, customer satisfaction, health, and safety. It encompasses a commitment to basic services, economic efficiency, and the preservation of external environments, cultural heritage, and natural resources. In this introductory exploration, we delve into the core facets of sustainable management, examining its multifaceted dimensions and the pivotal role it plays in fostering enduring, positive impacts on society, the economy, and the environment as shown Figure 16.

### 4.1.1. Design and construction

#### A. Design and exploitation of project areas

The design of the resort is in harmony with the surrounding environment, as the resort is surrounded by green spaces from all four directions

Design of the facades: The facades are designed to be as open and airy as possible, with large windows and doors that allow natural light and ventilation to flow through. The facades are also covered with green spaces, which help to reduce the heat gain from the sun and improve the overall aesthetic of the resort.

#### a. Functional spaces

**Figure 17.Swimming pool** https://www.lagreedeslandes.com/en/eco-hotel-france.html

- The building consists of 29 rooms, all on one floor with a private balcony. There is also a spa, gym, swimming pool, and some green spaces.
- There is an indoor swimming pool Figure 17

### b. Reservation

Room reservations can be made using various online hotel reservation sites.

### 4.1.2. Customer satisfaction

#### a. Food and drinks

- Most of the food served at the resort is sourced locally.
- The restaurant was selected by the 2023 Michelin Guide France for its outstanding cuisine and awarded a Michelin Green Star for sustainable cooking.
- The resort takes measures to reduce food waste
- Most of the food served is organic

#### b. The provision of services

- Free parking with disabled access: This is a great amenity for guests who have disabilities. It ensures that they have a safe and convenient place to park their cars.

- Electric vehicle charging station.
- Free internet access in hotel rooms

### 4.1.3. Health and safety

- The combination of a one-story building and multiple exits is a good safety measure to help people evacuate the building in case of an emergency Figure 18.

**Figure 18. Multiple exits**

## 4.2. Social/economic

### 4.2.1. Basic services

**A. Natural lighting and ventilation**

Using balconies overlooking green spaces to rely on natural ventilation

Relying on natural light in different spaces Figure 19

**Figure 19. Relying on natural lighting** https://www.lagreedeslandes.com/en/eco-hotel-france.html

### B. Artificial lighting

The use of artificial lighting to highlight the facade, external spaces, and internal spaces and surrounding corridors. The use of lighting along the internal corridors to make it easy to access rooms and different spaces

### C. Furniture and interior design

The breakfast hall was designed with consideration of the distances between tables and the buffet for easy movement within the space while providing natural light. Figure 20

**Figure 20. The use of furniture that is compatible with the surrounding environment**

### D. Caring for the surrounding landscape

- The abundance of green spaces and water bodies allows guests to enjoy the natural beauty from all directions.
- Seating areas have been provided in the green spaces as part of the site's layout. Figure 21.

**Figure 21. Seating areas** https://www.lagreedeslandes.com/en/eco-hotel-france.html

### 4.2.2. Economic efficiency

Using different methods to save energy and water consumption and recycling waste leads to lower operating costs.

Paying attention to the quality of the indoor environment and customer satisfaction leads to increased

## 4.3. The external environment and cultural heritage

### 4.3.1. Site Protection

This site, which is monitored by the LPO, is home to 48 species of birds, including six new nesting species: woodlark Figure 22, spotted flycatcher, common sparrow, house sparrow, firecrest, and European nightingale.

**Figure 22. The Protection of Birds https://www.lagreedeslandes.com/en/eco-hotel-france.html**

### 4.3.2. The use of renewable energy

The hotel relied on solar energy, as solar panels were placed to rely on renewable energy Figure (29).

**Figure 23. Solar panels were placed https://www.lagreedeslandes.com/en/eco-hotel-france.html**

## 4.4. The Environment

### 4.4.1. Energy saving

**A. Traditional methods**

- Rely on natural ventilation to save energy.
- Use glass to increase reliance on natural daylight to reduce reliance on electric lighting during the day to save energy Figure 24
- Rely on natural lighting to save energy
- Direct the windows to the southwest, where it enjoys the sun all day and the green roofs regulate the indoor temperature naturally.

**Figure 24. Use glass** [https://www.lagreedeslandes.com/en/eco-hotel-france.html](https://www.lagreedeslandes.com/en/eco-hotel-france.html)

**B. Smart methods**

Wood-fired boilers provide heating from renewable wood produced in locally managed sustainable forests.

- Energy-efficient lighting is used throughout the resort.
- Most of the lighting throughout the resort uses energy-efficient LED lights.
- The windows are made of double-glazed glass.
- There is an electric vehicle charging station available.
- Guest electricity service is operated via motion sensing or card.

## 4.4.2. Water saving

**A. Traditional methods**

- Rainwater is collected. .
- Guests have the option of not having their rooms cleaned daily.
- Guests have the option of reusing towels. .

**B. Smart methods**

- Recycling water from the relaxation pool and then using it in the bathrooms.

Using water from the Wellness Space swimming pool Figure 25, in addition to rainwater, to irrigate plants and flowers.

**Figure 25. Swimming poolhttps://www.lagreedeslandes.com/en/eco-hotel-france.html**

- Recycling wastewater in the hotel garden through a filtering basin surrounded by reeds to ensure ventilation and bacterial growth) then to a pond with filtration stations to remove all impurities before flowing into the soil.
- in the bathrooms that help to reduce water consumption by half Figure 26

**Figure 26. Using shower head https://www.lagreedeslandes.com/en/eco-hotel-france.htmls**

- Using water-saving toilets.

### 4.4.3. Conservation of resources and recycling

- No single-use plastic bottles of shower gel, shampoo, and conditioner are used.
- No single-use plastic drinking cups are used. .
- No single-use plastic cups are used.
- Recycling bins are available for guests, and waste is recycled.

### 4.4.4. The materials used

**A. Traditional methods**

- Most of the materials used are local and environmentally friendly so as not to have negative effects on the environment.
- Local wood from the surrounding environment. Figure 27.

**Figure 27. Using local material lhttps://www.lagreedeslandes.com/en/eco-hotel-france.html**

**B. Smart methods**

- Thermal and sound insulation for walls is provided by cellular concrete and hemp fiber

### 4.4.5. reduce pollution.

- The design is working to create a healthy environment by using a lot of green spaces.
- Using green spaces can help to improve air quality by absorbing pollutants and releasing oxygen.
- It balances part of its carbon footprint.
- Maintaining the environmental footprint at the absolute minimum.

## 5. Results

The findings of this study reveal a comprehensive exploration of innovative smart systems and materials designed for sustainable management within the context of project areas as shown in Figure 28. Notably, the incorporation of dynamic facades, altering the building's form and guest walkway perspectives over time, coupled with computer-controlled solar breakers, exemplifies a technologically advanced approach to sun angle processing. Within functional spaces, the integration of interactive floors capable of harnessing power from guest movement, along with the utilization of Eco-Powr bikes and SportsArt exercise equipment generating electricity, underscores a multifaceted strategy aimed at enhancing energy efficiency. In the domain of reservation management, the transition to electronic signatures during check-in, complemented by facial recognition technology for guest recognition, manifests as an expedited and technologically sophisticated process with legal equivalency to traditional paper-based signatures.

Moreover, advancements in the realm of food and beverage services are evidenced by the implementation of an automated bar service, ensuring efficiency and concurrently mitigating labor costs. The provision of services demonstrates a commitment to sustainable energy practices through the utilization of solar panel-covered carports for power generation. In matters of health and safety, comprehensive measures encompassing fire protection systems, evacuation instructions, water safety devices, and air purification systems across all rooms collectively contribute to a heightened level of guest safety and well-being. The incorporation of robotic functionalities, notably in automated luggage storage and retrieval, within the resort further exemplifies a forward-looking approach to service provision. These results collectively underscore the profound impact of integrating cutting-edge technologies and sustainable practices across various facets of hotel management, showcasing not only operational efficiency but also a commitment to environmental and guest well-being.

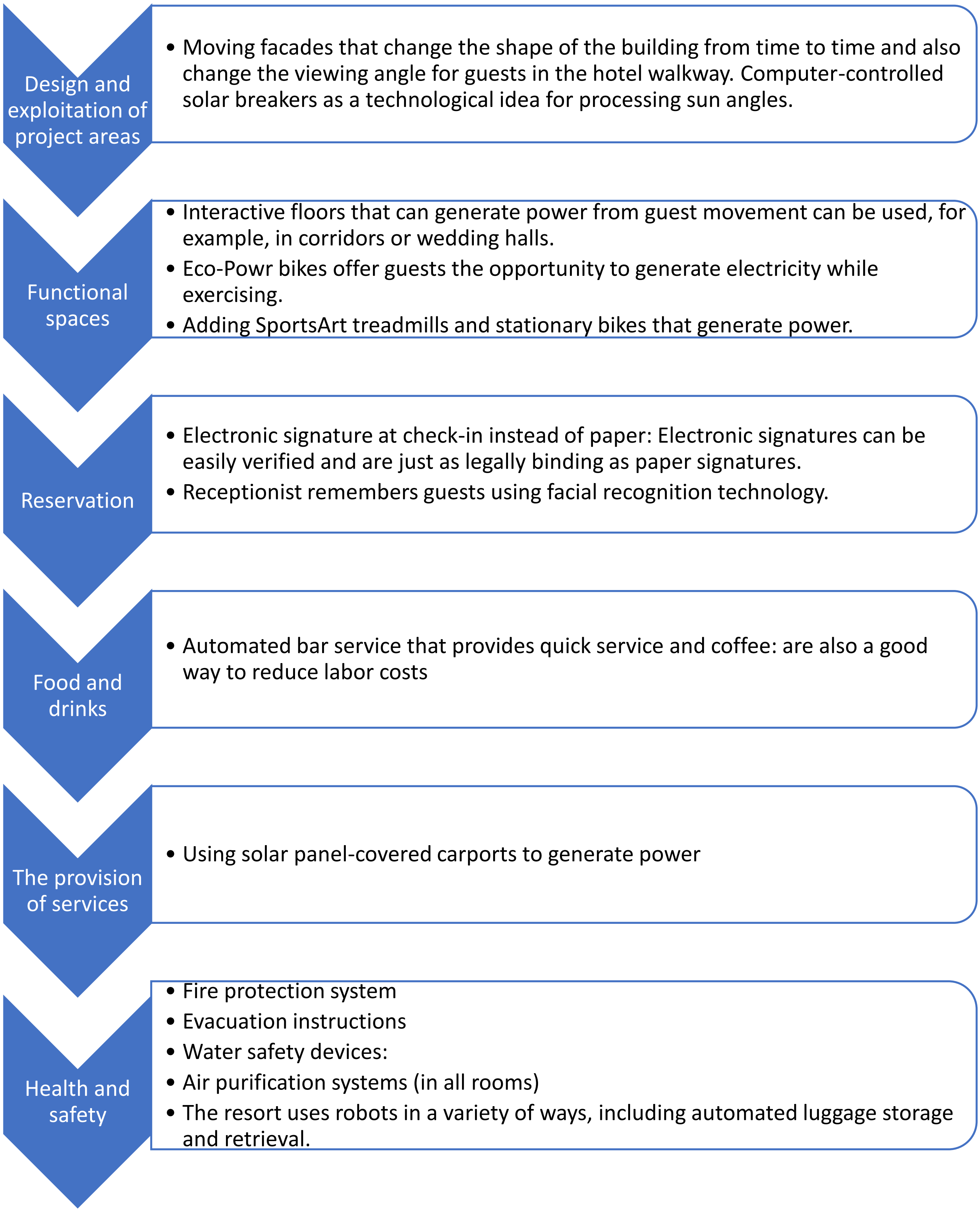


**Figure 28.The proposed smart systems and materials for Sustainable management**

The investigation into smart systems and materials for socio-economic implications within the realm of sustainable architecture yielded noteworthy outcomes as shown in Figure 29. Natural lighting and ventilation strategies were implemented through the incorporation of double-glazed glass windows, characterized by two panes with an intervening layer of air or gas, effectively enhancing building insulation and mitigating heat loss. Additionally, the infusion of aerogel into glass surfaces emerged as a promising avenue for temperature reduction.

Artificial lighting interventions were focused on energy-efficient LED lights throughout the accommodation, complemented by strategically implemented timers in office and select public areas. The provision of variable color lighting was explored to enable facile transitions between robust and subdued illumination, fostering energy conservation. Furthermore, the integration of motion-sensing mechanisms facilitated the effortless control and cessation of lighting, contributing to resource efficiency.

Furniture and interior design modifications included the substitution of traditional reception counters with self-service stations and the adoption of temperature-regulating glass. Sensor systems were strategically employed to automatically deactivate air conditioning units when balconies were opened, thus optimizing energy utilization and extending equipment lifespan. Guest electricity services were ingeniously managed through motion-sensing or card-operated systems. Public areas benefited from motion-sensing lights, and environmental sensors in rooms dynamically adjusted temperatures during periods of vacancy.

In terms of economic efficiency, a significant outcome was observed in the reliance on newly developed technology for the solar-based production of hot water. This not only showcased a commitment to sustainable practices but also contributed to long-term economic viability through the harnessing of solar energy resources. Collectively, these results underscore the tangible impact of integrating smart systems and materials in sustainable architectural practices, particularly with regard to energy conservation, resource optimization, and economic sustainability within the context of hotel infrastructure.

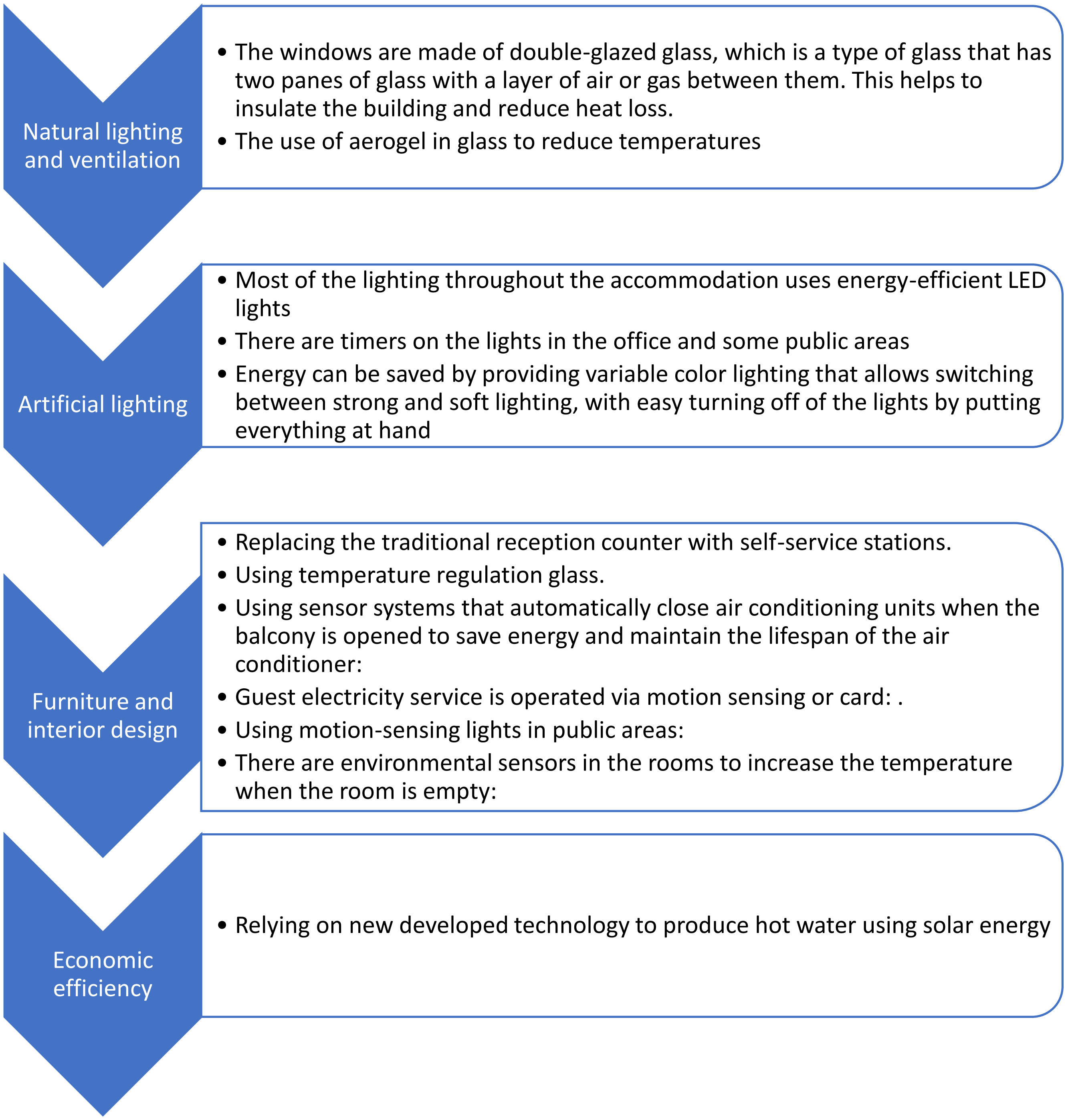


**Figure 29.The proposed smart systems and materials for Social/economic**

The implemented smart systems and materials for environmental management within the studied context yielded noteworthy outcomes as shown in Figure 30. In the domain of energy conservation, the incorporation of energy-efficient VRF cooling technology, specifically programmable variable refrigerant flow systems, manifested a discernible reduction in air conditioning costs. Furthermore, the adoption of VRV air conditioning systems, characterized by Variable Refrigerant Volume, demonstrated substantial energy savings of up to 50%, with the added advantage of operability on solar energy. The integration of smart home technology, featuring a 24/7 service through the utilization of a smart speaker system (Tmall Genie) in guest rooms, represented a novel approach in enhancing energy efficiency.

In the realm of water conservation, traditional methods were juxtaposed with innovative approaches. The utilization of inclined surfaces for rainwater collection was supplemented by contemporary practices such as the collection and storage of rainwater and domestic wastewater in dedicated tanks. This reclaimed water was subsequently repurposed for irrigating green spaces and flushing toilets, offering a comprehensive and sustainable solution. The introduction of timed operation for sprinklers, calibrated in response to rainfall levels, further optimized water consumption in landscaping.

The commitment to resource conservation and recycling was evident in several aspects of the hotel's operational framework. The adoption of environmentally friendly and biodegradable cleaning products underscored a conscientious approach to minimizing ecological impact. Automated check-in and check-out procedures not only streamlined operational processes but also significantly reduced the demand for printed invoices, aligning with sustainable practices. The conscious choice of sustainable wood and the exclusion of small single-use bottles in favor of large pump bottles in guest rooms represented tangible steps towards waste reduction and a more sustainable hospitality model.

Traditional methodologies pertaining to materials used in construction were juxtaposed with innovative strategies, such as the application of reflective paint for exterior walls and the incorporation of MIG insulating paints and coatings. These measures collectively aimed at mitigating energy consumption and optimizing temperature control, resulting in tangible kilowatt-hour savings.

An impactful initiative aimed at pollution reduction involved enveloping all four facades of the building with green spaces, featuring diverse plants and shrubs. This strategic landscaping not only contributed to the creation of a aesthetically pleasing environment but also facilitated the absorption of carbon dioxide by plants during photosynthesis, consequently generating vital oxygen essential for life. In summary, the amalgamation of traditional and smart methodologies in resource management and environmental conservation within the hotel infrastructure has yielded substantive results, underscoring its significance in fostering sustainability and mitigating ecological impact.

**Traditional Methods In Energy Saving**

- Used energy-saving VRF cooling technology (programmable variable refrigerant flow system), which reduced air conditioning costs.
- Used energy-saving VRV air conditioning (Variable Refrigerant Volume), which can save up to 50% of electricity and can operate on solar energy.
- Uses smart home technology, where a smart speaker system is used in the rooms for 24/7 service (tmall Genie).

**Smart Methods In Energy Saving**

- Induction stoves are used in the kitchen to prepare food and drinks instead of the common gas stoves.

**Traditional Methods In Water Saving**

- Using inclined surfaces to collect rainwater.

**Smart Methods In Water Saving**

- Collecting rainwater and domestic wastewater, storing it in a tank and reusing it in irrigating green spaces and flushing toilets. .
- Sprinklers operate on timers that are adjusted according to the amount of rainfall.

**Conservation Of Resources And Recycling**

- Using environmentally friendly and biodegradable cleaning products.
- Using automated check-in and check-out procedures, which reduces the need for printed invoices.
- Using sustainable wood.
- Recycling bins are available for guests, and waste is recycled.
- No small single-use bottles of shampoo, conditioner, shower gel, and body lotion are used in any guest rooms. Instead, large pump bottles are used.

**Traditional Methods In The Materials Used**

- Using reflective paint for exterior walls and insulation of surfaces and exterior walls to reduce energy consumption.
- Applying the new MIG insulating paints and coatings that control temperature and save kilowatt-hours.

**Reduce Pollution**

- Covering the four facades of the building with green spaces, different plants, and shrubs, which helps to create a clean environment where plants and shrubs absorb carbon dioxide and produce oxygen needed for life in the process of photosynthesis.

**Figure 30. The proposed smart systems and materials for the environment**

# 6. Discussion

The amalgamation of ecological and technological trends within the realm of sustainable architecture represents a pivotal strategy aimed at conserving energy, reducing costs, and prolonging the lifecycle of buildings, thereby fostering enhanced air quality and contributing positively to the urban environment. The incorporation of technological advancements in sustainable architecture not only facilitates the integration of smart implementation technologies but also augments the overall efficiency of buildings.

The synergistic utilization of technological and environmental trends in architectural practices endeavors to strike an optimal balance between delivering high-quality structures and ensuring exceptional environmental performance. It is imperative to select advanced technological means judiciously, ensuring that their deployment remains ecologically benign while concurrently enhancing human comfort across diverse levels.

The strategic integration of local materials in conjunction with smart technologies underscores a commitment to technological prowess, demonstrating an awareness of sustainable material properties and their conscientious application. Furthermore, the incorporation of artificial intelligence in sustainable architecture stands out as a significant contributor to time and resource conservation.

Smart technologies, particularly within the building envelope, play a pivotal role in bolstering the sustainability of structures. The incorporation of dynamic facades introduces an innovative dimension, altering perspectives and fostering inclusivity, making the building more receptive to its surrounding environment.

The judicious utilization of green spaces emerges as an economically viable and efficacious approach to both health improvement and climate change mitigation, concurrently contributing to the enhancement of the urban environment. Similarly, the adoption of double-glazed windows emerges as a prudent choice, not only curbing energy costs through improved thermal insulation but also enhancing sound insulation, thus creating a formidable barrier between the building and its external milieu. These considerations collectively underscore the multifaceted dimensions of integrating ecological and technological trends in sustainable architecture, particularly in the context of hotel infrastructure, promising augmented performance and enduring environmental impact.

# 7. Conclusions

This comprehensive investigation delves into the intricate interplay of innovative smart systems and materials within sustainable architecture, focusing on the context of a contemporary eco-hotel. The amalgamation of ecological and technological trends emerges as a pivotal strategy, contributing to energy conservation, cost reduction, and prolonged building lifecycle. The incorporation of dynamic facades, artificial intelligence, and sustainable materials epitomizes technological prowess and environmental consciousness, resulting in heightened operational efficiency and a positive impact on guest experience.

Emphasizing the judicious selection of advanced technological means aligned with ecological principles, this study underscores the importance of enhancing human comfort. The strategic integration of local materials, coupled with smart technologies, signifies an informed approach to sustainable material properties. Artificial intelligence's role in streamlining processes is highlighted, contributing to time and resource conservation.

Furthermore, the judicious utilization of green spaces is recognized as an economically viable approach for health improvement and climate change mitigation. Measures such as adopting double-glazed windows and other environmentally conscious practices not only curb energy costs but also contribute to sound insulation, creating a formidable barrier between the building and its external environment. These considerations collectively underscore the multifaceted integration of ecological and technological trends in sustainable architecture.

**Drawing from the study's findings, several recommendations are proposed for further research and practical implementation:**

- Continuous Technological Integration: Encourage ongoing exploration and integration of emerging technologies within sustainable architecture, aligning advancements with ecological considerations for long-term efficiency.
- Localized Sustainable Practices: Advocate for future projects to adopt and adapt locally relevant sustainable practices, utilizing materials and technologies aligned with specific environmental contexts.
- User-Centric Design: Prioritize the enhancement of user experience through seamless integration of smart technologies, elevating the sustainability profile of architectural projects.
- Holistic Environmental Impact Assessment: Promote the incorporation of comprehensive environmental impact assessments in projects, considering factors beyond energy efficiency, including biodiversity conservation, cultural heritage preservation, and community well-being.
- Knowledge Transfer and Education: Facilitate awareness and knowledge transfer regarding sustainable architecture, emphasizing initiatives that educate architects, builders, and the general public on the benefits and practical aspects of sustainable design.
- Policy Advocacy: Encourage and advocate for policies incentivizing and enforcing sustainable architectural practices to contribute significantly to the broader adoption of eco-friendly designs.

In essence, the synthesis of cutting-edge technologies and sustainable practices in architecture represents a fundamental paradigm shift toward creating resilient, efficient, and environmentally conscious built environments. The provided recommendations aim to guide future endeavors in aligning technological advancements with ecological responsibility for a more sustainable and harmonious architectural landscape.

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