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**Sustainability in Interior Design: A Comparative Analysis of Economic Feasibility, Durability, and Environmental Impact in Traditional and Sustainable Designs.**

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**Declaration**

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hereby declare that this thesis, titled "Sustainability in Interior Design: A Comparative Analysis of Economic Feasibility, Durability, and Environmental Impact in Traditional and Sustainable Designs.", is the result of my own independent research, conducted under the guidance of Prof. Dr. Markus Caspers. All sources used and referenced in this thesis have been properly cited and acknowledged.

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**Abstract**

This thesis investigates the economic, environmental, and durability aspects of sustainable interior design compared to traditional approaches. It explores whether sustainable materials and practices offer long-term value despite higher initial costs. Through qualitative research methods, including expert interviews, case study applications, the study evaluates material performance, life cycle cost, environmental impact. Findings indicate that sustainable interior design can reduce operational costs, extend material lifespan, and minimize ecological footprints. Companies exemplify circular economy principles by developing durable, recyclable materials for interior design and finishing purposes. The study concludes that sustainable interior design is a viable and future-oriented alternative that balances aesthetics, functionality, and sustainability goals.

**Keywords:**

Sustainable Interior Design, Traditional Interior Design, Economic Feasibility, Durability, Environmental Impact, Life Cycle Cost Analysis, Circular Economy, Green Building Certifications

**Kurzfassung**

Diese Masterarbeit untersucht die ökonomischen, ökologischen und haltbarkeitsbezogenen Aspekte nachhaltiger Innenraumgestaltung im Vergleich zu traditionellen Ansätzen. Sie geht der Frage nach, ob nachhaltige Materialien und Praktiken trotz höherer Anfangskosten einen langfristigen Mehrwert bieten. Anhand qualitativer Forschungsmethoden einschließlich Experteninterviews und Fallstudien bewertet die Studie die Materialleistung, die Lebenszykluskosten sowie die Umweltauswirkungen. Die Ergebnisse zeigen, dass nachhaltige Innenraumgestaltung Betriebskosten senken, die Lebensdauer von Materialien verlängern und ökologische Fußabdrücke minimieren kann. Unternehmen veranschaulichen Prinzipien der Kreislaufwirtschaft durch die Entwicklung langlebiger, recycelbarer Materialien für den Einsatz in der Innenraumgestaltung und im Ausbau. Die Studie kommt zu dem Schluss, dass nachhaltige Innenraumgestaltung eine zukunftsorientierte und tragfähige Alternative darstellt, die Ästhetik, Funktionalität und Nachhaltigkeitsziele in Einklang bringt.

**Schlagwört :**

Nachhaltige Innenarchitektur, Traditionelle Innenarchitektur, Wirtschaftliche Machbarkeit, Haltbarkeit, Umweltauswirkungen, Lebenszykluskostenanalyse, Kreislaufwirtschaft, Umweltzertifizierungen im Bauwe

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**List of abbreviations**

LEED	Leadership in Energy and Environmental Design
BREEAM	Building Research Establishment Environmental Assessment Method
BEPAC	Building Environmental Performance Assessment Criteria
RoHS	Restriction of Hazardous Substances
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
EPDs	Environmental Product Declarations
ISO 14001	International Organization for Standardization 14001
EMS	Environmental Management System
WEEE	Waste of electrical and electronic equipment
DGNB	Deutsche Gesellschaft für Nachhaltiges Bauen
FSC	Forest Stewardship Council
C2C	Cradle to Cradle
VOCs	Volatile Organic Compounds
PEFC	Programme for the Endorsement of Forest Certification
WELL	Wellness
HVAC	Heating, Ventilation, and Air Conditioning
PVC	Polyvinyl Chloride
LCCA	Life Cycle Cost Analysis
LCC	Life Cycle Costing
LCA	Life Cycle Assessments
IAQ	Indoor Air Quality

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TCO	Total Cost of Ownership
PET	Polyethylene Terephthalate
rPET	recycled Polyethylene Terephthalate
PLA	Polylactic Acid
SHGC	Solar Heat Gain Coefficient
CFLs	Compact Fluorescent Lamps
LEDs	Light Emitting Diodes
IEA	International Energy Agency,
EPBD	Energy Performance of Buildings Directive
CHP	Combined Heat and Power
SuDS	Sustainable Drainage Systems
UV	Ultraviolet
WASP	World's Advanced Saving Project
AI	Artificial Intelligence
B2B	Business to Business
SBTi	Science Based Targets initiative
RSL	Reference Service Life
SVHC	Substances of Very High Concern

### 1 Introduction

The term sustainability has become popular in this century, although the definition of sustainability is wide-ranging. According to the United Nations, sustainability has emerged as a global priority:

“Meeting the needs of the present without compromising the ability of future generations to meet their own needs.” (WCED, 1987).

This principle underscores the importance of Sustainability in the face of changes occurring in the world, such as climate change, resource depletion, etc. It also reinforces the importance of practices that promote environmental protection, social responsibility, economic development, and a more sustainable future.

Sustainability includes other principles such as the harmonious coexistence between human development and nature and working to live in balance between humanity and the environment. Integrating sustainability into industrial and human development and enhancing environmental management is very necessary to contribute to significantly reducing global environmental crises (Fischer, 2023) (Said, 2024).

Over recent decades, the acceleration of environmental degradation due to human activity has led to alarming consequences: rising CO<sub>2</sub> levels, melting glaciers, and the projected sea level rise of 2 to 6 feet by 2100. Unchecked, climate change may cause a 18% decline in global economic value by 2050 (Sarvapriya Singh, 2024) . This is a reality that requires immediate global collaboration, innovation and embedding of sustainable solutions across businesses.

In response to the challenges, it requires the immediate collaboration at international level that innovative actions are implemented to limit the natural catastrophes, the sustainability is encouraged, and alternative energies are invested in to reduce carbon dioxide emissions at the global level. These are solutions that will do more than protect our planet; they will create new economic opportunities around the world (Hugo Lucas, n.d.) (Desai, 2021).

One important sector is interior design, which contributes not only to creating functional and aesthetically pleasing living spaces but also plays a significant role in ecological impact through material choices, energy use, and lifecycle decisions. The sustainable approach focuses on using environmentally friendly and recycled materials, energy-efficient systems,

and circular economy principles without compromising the visual appeal or functional quality of the space (Moxon, 2012) (Omera, 2024).

### **1.1 Background & Context:**

The importance of sustainability in modern design has increased significantly and influenced many fields, interior design in particular. And while climate change, depletion of resources and pollution soar, architects and interior designers must also figure out how to use sustainable methods without sacrificing beauty, functionality, or longevity in building design.

Traditional interior design has also been characterized by prioritizing short term price and efficiency over long term environmental and economic expense, also often at the expense of the occupant's health. In contrast, Sustainable interior design focuses on environmentally responsible materials, energy-efficient processes. This system aims to reduce negative environmental impact, maintain efficient operation and minimize resource use including energy, water and materials, and raw materials, while also ensuring responsible waste management. With increasing public profile, sustainability is now not a niche issue, but central to contemporary design. Businesses and consumers are increasingly navigating territory, trying to balance that concern for the environment with practical considerations including cost, maintenance and long-term performance.

There is a lot of conversation about how to make the transition to sustainable interiors, among which the practical and the financial cost stands out. Relevant to traditional one, cheap start price and large source have been what consumers always prefer in traditional way. In contrast, alternative solutions are commonly described as resources that can save person or business money in the long run as well as reduce environmental damages. The present study investigates if sustainable interior design is the right answer to a problem regarding economic feasibility, durability, environmental impact, as well performance within interior spaces.

### **1.2 Problem Statement:**

Although sustainable interior design has gained more attention in recent years, many designers and firms continue to rely on traditional design practices. This is usually due to the perception of the high expense of eco-friendly materials, skepticism of their long-term longevity, and ambiguity regarding their real environmental advantage over traditional

alternatives. In many cases, decisions are made based on short-term costs rather than long-term savings and sustainability.

There is also a lack of clear and detailed comparisons between traditional and sustainable interior design in terms of economic feasibility, durability, and environmental impact. In the absence of detailed evaluations, it is difficult for designers, practitioners, and even landlords to assess whether sustainable design is a practical and reliable choice. This thesis aims to fill this gap and systematically compare the two models, to ascertain if sustainable interior design can offer practical, economically and environmentally sensitive solutions.

### **1.3 Research Questions**

This study will explore the dimensions of sustainable interior with emphasis on economic viability, durable materials and environmental performance. The critical comparative sustainability study between traditional and sustainable approach on interior design is guided by the following research questions:

- What are the long-term economic implications of using sustainable materials in interior design, and how do they compare to traditional alternatives in terms of initial investment, maintenance costs, and lifecycle efficiency?
- How do new product developments from companies working with sustainable materials influence designers' selection of materials from a design, aesthetic and functional perspective?
- What are the main differences in environmental impact between traditional and sustainable interior design practices, considering how they use resources, produce waste, and emit pollutants throughout the lifecycle of materials and systems?

### **1.4 Objectives**

The objective of this research is to demonstrate a transparent comparison between sustainable and traditional interior design methods, and whether sustainable designs can contribute practical benefits to the realistic changes without sacrificing aesthetics and functioning efficiency. The study will particularly explore the economic implications of sustainable materials systems constructed and reveal its initial costs compared to the future opportunities for savings on energy, maintenance and operation. Through investigating

## Introduction

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upfront investment and total lifecycle costs, this will explore whether sustainable alternatives are financially viable against alternatives.

Another important part of the study is evaluating the durability and performance of materials. Through selected case studies and interview specialists in the industry, the project will look to mold a series of selected case histories that could demonstrate how newer sustainable products recycled flooring, low-VOC finishes and natural fabrics make uplay over time traditional materials. Performance factors including wear resistance, maintenance requirements and replacement frequency will determine if sustainable materials can equal or exceed the durability performance of traditional interior components.

The study will ultimately consider the environmental impact of design choices. It will evaluate the impact of sustainable practices on energy, waste, and resources. The research will also explore a strategy from circular economy, reuse and recycle materials, for environmentally friendly, which consists of reduction of environmental impact. Integration of these economic, longevity, and environmental factors, the study aims to provide useful, evidence-based examples for designers, developers, and decision makers in application of sustainable interior design, practical cost effective and good performance.

## 2 Foundation of Sustainable Interior Design

### 2.1 Evolution of Sustainable Design

Long before modern sustainability movements took shape, ancient civilizations were already embracing principles of sustainable design, driven by practical wisdom and environmental necessity. From Middle Eastern desert homes to Southeast Asian stilted houses exemplified millennia of climate adapted design, and resource efficient insights. These early examples of vernacular architecture utilized passive design strategies such as natural ventilation, thermal mass, and building orientation to maximize daylight and regulate temperature.

Formal acknowledgement of sustainability within the built environment developed in the context of the environmental movements of the 1960s and early 1970s, a period when natural resource limitations and the ecological implications of industrial and urban development became widely recognized (Elkady, 2022). During this era, architects and designers were starting to argue for a more responsible approach to construction. The sway of influential literature such as " Silent Spring" (Rachel Carson 1962), and inception of organizations such as the U.S. Green building council in the 1990s contributed to the ideological legitimization of sustainable principles within architecture and interior design (Hartini, 2020).

The concept of sustainable and environmentally friendly interior design has become increasingly popular in recent years. A wide range of terms has been used to describe the incorporation of sustainability into interior design. Among the most widely used and popular terms that have been adopted are " environmentally sustainable interior design" (Hayles, 2015); "sustainable interior design" (Kang, 2009) ;" green interior design" (Ning, 2016); sustainable interior architecture (Celadyn, 2020).

Although, these terms overlap and are often used interchangeably, they do not fully define the borders of sustainability or encompass the full territory of environmentally responsible interior design patterns. Given this ambiguity, many scholars have chosen the appropriate term "environmentally sustainable interior design" and defined this approach as "focusing on the intended application of materials, aesthetic qualities, environmental and health impacts, availability, ease of installation and maintenance, and initial and life cycle costs" (Hayles, 2015).

Researchers have long been working to incorporate sustainability into the field of sustainable interior design through energy efficient lighting, resource conservation, and the use of local and recycled materials. However, the concept of sustainability in sustainable interior design is much broader and encompasses not only the environmental impact of design principles but also focuses on the psychological and physical impact on occupants. It considers functional and aesthetic needs, as opposed to traditional interior design which often prioritizes visual and functional aspects without considering long-term environmental or health consequences (Ashour, 2021).

Historically, sustainable design principles were established in design history by a few design movements. This was followed in the 20th century by the Bauhaus movement in Germany, founded by Walter Gropius in 1919, while not explicitly focused on sustainability, it embraced the idea of simplicity and efficiency of material use in manufacturing and design which laid the foundations for the later sustainable design practices (Bergdoll, 2009).

During the 1930s, the modernist approach of Le Corbusier emerged, which aimed to utilize and control natural light and ventilation in design and improve the indoor environment (Kim, 2012). At the same time, architects became also more interested in environmental topics, such as Frank Lloyd Wright who developed the concept of organic architecture by incorporating natural resources into his designs. He played a leading role in the early promotion of the use of alternative energy in building, notably in the wake of the 1973 oil crisis (Hartini, 2020) (Papanek, 1995).

During the 1970s and 1980s, rising environmental concerns amplified by the 1973 oil crisis -led architects to search for other forms of building that could lessen the human impact on the environment. Such early attempts for sustainable design focused on passive solar principles, natural ventilation, thermal insulation, and renewable or local materials. Experimental works in this period such as the “solar house” (Figure 1) in the American southwest with angled glass facades and the timber clad “eco-house” from the 1980s, with the intention of natural lighting and natural ventilation, were manifestations of environmental concepts put into action. These models established a significant basis for the sustainability frameworks that developed in the subsequent decade (Denzer, 2014).



Figure 1: Solar house (1970s) with angled glass for passive heating (Denzer, 2014)

By the 1990s, the green building movement emerged, focusing on the importance of building designs that reduce the impact on the environment and emphasize sustainable practices (Edwards, 2006). This movement worked to develop environmental evaluation principles such as BREEAM, BEPAC, and LEED that would promote sustainable building practices (Crawley, 1999).

These movements, with their various activities and movements, played a decisive role in the interior design of buildings and sustainable architecture and laid down the basic principles for practices that conserve all resources and energy and raise environmental awareness.

## 2.2 Principles of Sustainability in Interior Spaces

In contemporary interior design practice, the quest for sustainability no longer stands as some handy accoutrement you can opt into or out of, but a principle that underpins the selection of materials, the construction of spatial logic, and operational strategies. Energy efficiency rears its head as a primary goal here; specifying high-performance glazing, LED lighting systems with daylight-responsive controls, and not just timers, and HVAC equipment sized to actual occupancy levels rather than theoretical maxima, designers can slash a project's operational carbon footprint.

For instance, the Edge office building in Amsterdam, often cited as one of the world's most sustainable workplaces, is fitted with a network of smart sensors that adjust lighting and temperature in real time, resulting in energy consumption that's 70 percent lower than in comparable buildings. Such advances demonstrate that proactive design decisions – over insulating the building envelope beyond code, smart zoning of mechanical systems, passive solar – are directly equivalent to environmental benefit and gobs of cash over the lifetime of the project.

Resource conservation and the tenets of the circular economy introduce a change in basic assumptions away from the traditional “take-make-waste” model to a system of regeneration and recycling. Instead of throwing away furniture when it is no longer required, forward-thinking businesses work with manufacturers that have a take-back programme and remanufacturing process (Celadyn, 2018). Swedish floor brand Bolon has long had a commitment to, and ethos of, circularity by using waste materials -industrial, leftover vinyl- in their woven flooring.

Through new ways of working in production, aesthetic development, and material selection, Bolon demonstrates that high-end flooring can be both sustainable and beautiful, lessening dependency on virgin materials without compromising on design aesthetic (Bolon., n.d.). Similarly, the exhibition “Reset Materials – Towards Sustainable Architecture” at Copenhagen Contemporary showed that with creative use of locally available biogenic and recycled materials- mycelium, hempcrete, recycled plastics, and silicon by products, it is ingenuity rather than cost that drives truly resource-efficient design (dezeen, 2023).



Figure 2: Reset Materials – Towards Sustainable Architecture (dezeen, 2023)

To illustrate the criteria and strategies that drive sustainability in interior components, a conceptual approach for sustainable interior components is shown in (Figure 3). The latter highlights four fundamental evaluation criteria: aesthetic character, functional performance, formal integrity, and environmental contextualization. These contribute to integrated design strategies and modify sustainable evaluation standards. The figure then explores how elements will be evaluated in terms of waste generation, chemicals releases and how they serve as passive design actors to improve the performance of the building and waste management in general. This figurative model helps to reinforce the earlier argument of

how strategic planning and design decisions, including the integration of passive design, combination of waste-conscious component specification, contribute towards environmentally responsible interiors (Celadyn, 2019).

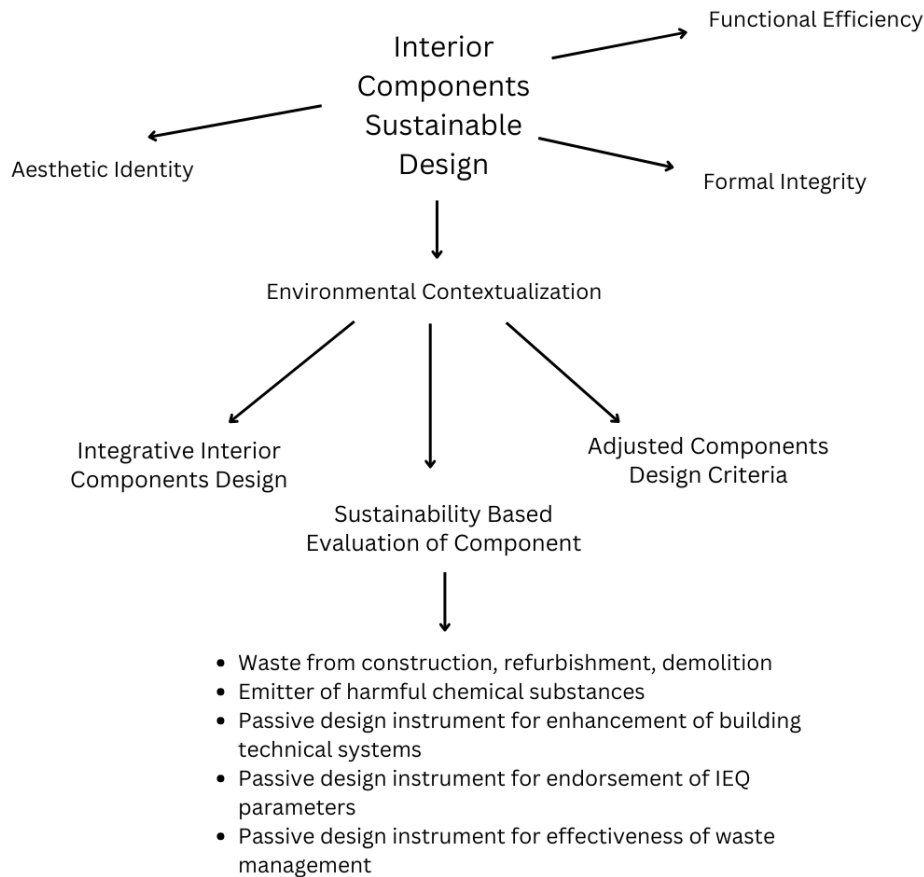


Figure 3: Assessment of interior components through environmental contextualization.

Sustainable design concepts include waste management and recycling, it designs solutions based on effective waste management and the minimization of construction and demolition waste, which is why it is preferred as an efficient and sustainable approach in construction. This approach aims to reduce dependence on landfills by reducing waste and working to reuse it and developing the idea of recycling and saving energy conservation. The European Union proposed, 40 years ago, the waste hierarchy model, with the aim of reducing the impacts of activities on the environment, as it develops these strategies for effective resource management (Williams, 2015) (Nilsen, 2019). The model illustrates a hierarchy of waste stages: prevention, preparation for reuse, recycling, other recovery methods, and finally, landfill disposal (Wilts, 2018). The following figure shows an illustrative model of the hierarchy.

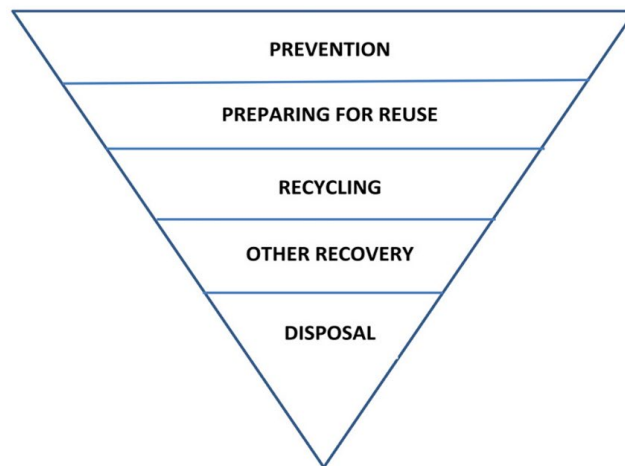


Figure 4: Waste Hierarchy model according to the European Union (Nelles, 2016)

In an effort to solve the problem of waste management, designers have developed new recycling methods and means of reusing materials in interior design. These steps consider the environmental effect as well as the product's durability and aesthetic, both of which are inextricably linked with the overall visual quality of the interior. (Gambhire, 2024). Methods of material reclamation and adaptive reuse divert this considerable waste from landfills and contributes to the environmental and sustainable aspects of interior design (Celadyn, 2018). Moreover, the moral obligation of the designers in the conceptualisation, planning and project's analysis in the interior design process also plays a role in waste minimisation. This line of thinking emphasizes the necessity of environment-friendliness and conservation of natural resources (Celadyn, 2018).

Elaborating these strategies, the three main sustainable design strategies, Reduce, Reuse and Recycle (Figure 5) are underscored as the centre of gravity of sustainable design to manage resources in effective manner. Each of these strategies corresponds each to certain techniques: for instance, dematerialization and multifunctionality under reduction; direct and adaptive reuse under reuse; and recycled-content materials under recycling. The figure highlights reuse within the setting and between settings, showing how adaptive interventions provide support for long-term sustainability aims. These are placed within the discourse to emphasize the theoretical and practical aspects of sustainable interior design, thus anchoring the abstract in the material and ordered (Celadyn, 2019).

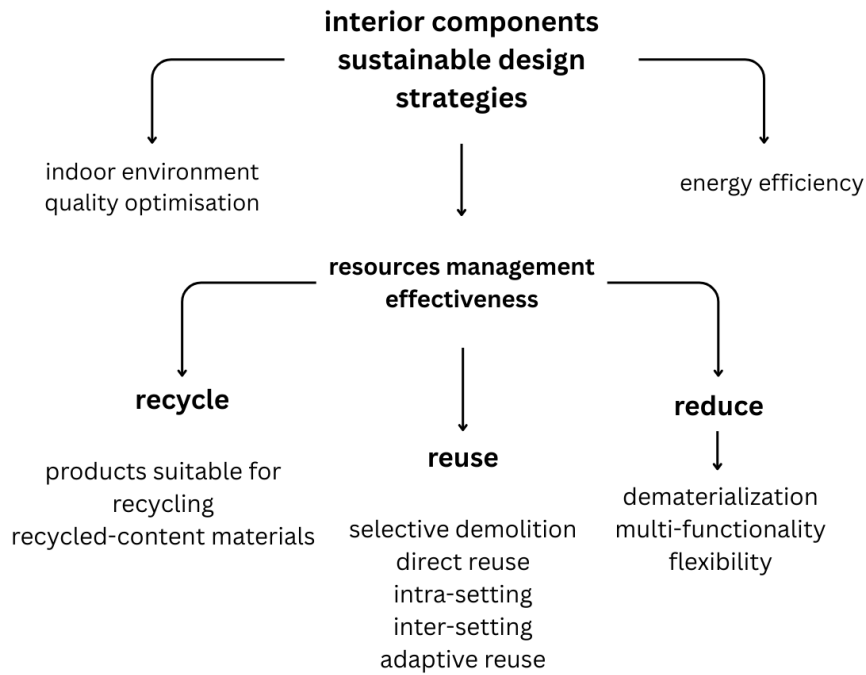


Figure 5: Inter setting adaptive reuse for efficient resource management in interior design.

Meanwhile, the circular economy has challenged traditional creative floor plans and ideas. This process is a testament to the benefits of careful design, and the benefits of material-use from the offset for minimising the waste of welfare and our environment. Circular economy also fosters reuse and recycling of materials and design for disassembly and reuse. (Celadyn, 2018). The circular economy is defined as a sustainable approach that aims to reduce waste and make significant use of resources by addressing the production and consumption of products, however, its main goal is to find a new approach to recycling, where natural resources are best utilized from the start, before resorting to recycling or disposal. (Potting, 2018) (Whiting, 2023). Another important term connected to the circular economy is the concept of the “circularity ladder”, which shows the transition to a circular economy instead of a linear economy based on “take, make, dispose” (Esposito, 2018) (Kolesnik, 2021) .

The circular economy focuses on the “use” phases, as the focus in categorizing these strategies is on extending the life cycle of products according to sustainability criteria. It starts with the most sustainable options, Refuse, Rethink, and Reduce, which are based on reducing resource consumption. This is followed by the intermediate strategies of Reuse, Repair, Refurbish, Remanufacture, and Repurpose, which are based on extending the life

of products and reducing the need for new manufacturing. At the bottom of this ladder, the recycling and energy recovery options are still present, but they are considered less sustainable. The final option, avoided whenever possible, is landfill (Esposito, 2018) (Kolesnik, 2021).

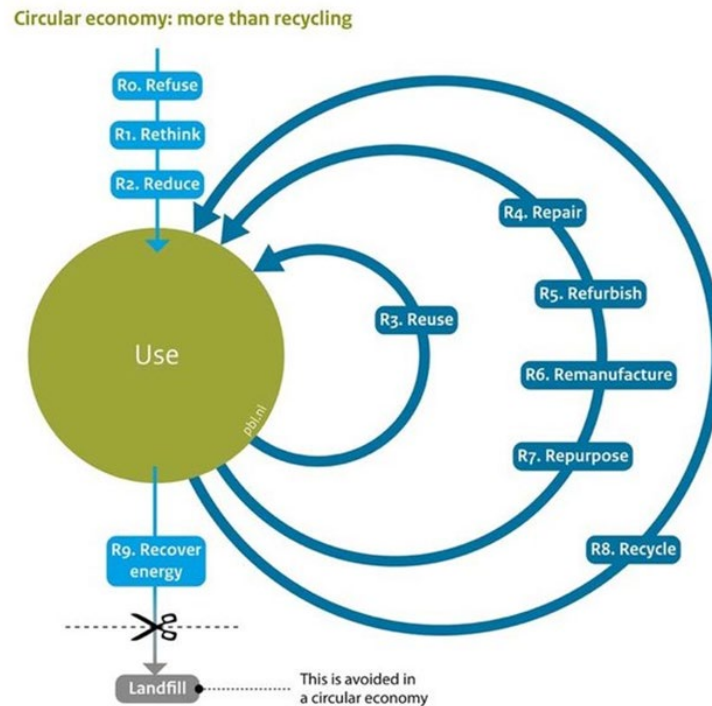


Figure 6: The concept of the Circularity Ladder (Rugi, 2024).

sustainability principles in interior design are no longer a secondary option, but a core consideration that drives choices regarding materials, build practices, and operation. With an emphasis on energy efficiency, resource recycling and circular economy, they help minimize environmental impact and produce beautiful products. What that means, however, is that sustainable interior design is no longer a trend, but a requirement triggered by the current environmental crisis and the chance to reconsider the way we relate to resources and spaces within which we work and live. Adopting methodologies such as recycling, extending product life, and considering the life cycle of materials from the planning stage enhances the designer's responsibility towards the environment and society.

### **2.3 Regulations and Certifications in Sustainable Design**

Modern and contemporary design significantly contributed to the development of sustainable design principles. This approach aims to minimize the environmental impact of building and materials on the environment, instead fostering creative and necessary designs that respect and maintain the environment and its resources. To attend to the life cycle of products for interior design and its use, including sustainable materials use, recycling, disposal, and waste management, the system of laws, legislation, and environmental controls has made any designer or company adhere to the "new green philosophy" and adopt responsible practices.

Internationally, numerous regulations and legislation frameworks have been established to define standards for sustainable design. One of the most prominent standards is ISO 14001 is part of the ISO family of standards, which outlines the requirements for an effective Environmental Management System EMS. This certification assists companies in reducing their environmental impact, complying with legal and other requirements, and continually improving their environmental performance. Certification to ISO 14001 is shown on products or company literature commencing an organization's commitment to environmental protection and integrity of the process of manufacturing, testing and certification, and the company's commitment for sustainable development initiatives (Kitazawa, 2000).

Another important initiative is the EU Taxonomy, developed by the European Union to environmentally sustainable economic activities and guide investors and companies to investments towards low-carbon technologies (Schütze, 2024). Additionally, the Waste of Electrical and Electronic Equipment WEEE Directive was adopted in 2003 to restrict the use of hazardous and toxic substances in products, a law that remains influential worldwide (Kumar, 2008).

Since the world has now awakened to the importance of conservation of natural resources, many European organizations have come out to develop and propagate sustainable building and interior design standards, attempting to minimize the environmental and health effects of toxic materials. Prominent among these is the introduction of REACH (Registration, Evaluation, Authorization, and restriction of Chemicals) in the European Union, which ensures manufacturers and importers assess the risks associated with the chemicals they produce and place on the market.

Concurrently, Environmental Product Declarations EPDs have emerged as tools for transparent information of the life-cycle environmental performance of construction and interior products, supporting informed choices in sustainable design (REACH, n.d.) (EPD, n.d.). Specifically in Germany, in which governmental policies like Germany Resource Efficiency Program (ProgRess) and the Energy Saving Ordinance (EnEV). have enormously promoted sustainable building and interior design by mandatory enregistering energy saving and resource efficiency measures. These initiatives reflect a strong national commitment to sustainability (Essig, 2021).

Among the most influential is the The German Sustainable Building Council “Deutsche Gesellschaft für Nachhaltiges Bauen” DGNB, founded in 2007. The DGNB intended among others to create seminal requirements on construction and interior design projects in terms of environmental quality, economic feasibility, social aspects, and culture development. beside this function. Additionally, it also emphasizes planning quality, technical efficiency, and the practicality of processes (DGNB, 2023).

DGNB’s standards are considered among the most significant European and international benchmarks for measuring and sustainable interior design. This system serves as a critical benchmark for sustainable design practices. It provides comprehensive criteria for selecting environmentally beneficial interior materials such as floor coverings, furniture, wall coverings, and finishing products (Council, 2023).

To support the promotion of sustainable material selection and encourage best practices, several environmental certifications have been established. These systems provide clear definitions of which products are environmentally friendly, safe and good quality. Considering good environmental practices such as low energy flooring, low VOC compounds paints, recyclable materials, and natural daylight layouts goes a long way in making your interiors greener and healthier.

Several internationally accepted product certifications exist, the well-known ones are used globally Notably the Forest Stewardship Council FSC and Program for the Endorsement of Forest Certification PEFC, provide rigorous criteria for the responsible sourcing of timber and ecosystem conservation, which help ensure that no trees are overcut to protect forests, they also evaluate products made from wood and paper, such as furniture, flooring, textiles, etc.. (Michal, 2019).

Concurrently, green building frameworks, such as LEED and BREEAM which focuses on reducing carbon emissions, improving light and air quality and is applied to interior design to create more sustainable spaces. They establish quantitative benchmarks for building, operating energy implementation, resource utilization and occupant comfort. (Cole, 2005) (Council, 2019).

Another type of certifications is Cradle to Cradle C2C, which directly engage more directly of the circular economy by evaluating products based to be fully recycled without producing harmful waste, evaluated based on the closed life cycle of the product (Certified®, 2024).

Meanwhile, WELL Building Standard places certification approaches a different aspect of interior design, it gives an effective system that focuses on the psychological well-being, and health of users in indoor spaces. It promotes the design of interiors that optimize air quality, natural and artificial lighting, and overall human comfort (Ildiri, 2022). Concurrently, GREENGUARD Indoor Air Quality Certification analyses chemical emissions to help reduce impacts on occupant health and protect the environment (GREENGUARD, 2024).



Figure 7: Logos of Key Sustainable Design Certifications

Despite growing awareness and adoption of these certification systems, multiple challenges persist in the application of sustainability standards. For small and medium-sized companies particularly, the high costs of certifications like LEED, WELL or DGNB are also an obstacle. Many businesses also lack access to technical skills and resources required to conduct rigorous evaluations. Additionally, inconsistencies between national regulations limit global standardization and can complicate international operations.

Public awareness of certification benefits remains limited, often weakening consumer demand for certified materials and interiors. Meanwhile, in the context of accelerating materials and technological development, new standards pose challenges for regulatory agencies to keep pace with. Looking ahead, new sustainability codes can be expected to embed digital assets, data sensors analysis, and smart tools like artificial intelligence and real-time monitoring. Policymakers are likely to prioritize adaptive, lifecycle-relevant rules which facilitate carbon neutrality, material recycling and circular economy principles. Sustainability is increasingly shaping the world of design, and it's important that governments, educators, designers and consumers work together to ensure that regulation is coherent and forward looking.

### **2.4 Sustainable Construction and Interior Design Techniques**

The Interior Design sector is no less important than other sectors. In this study, the importance of sustainability in this particular sector is assessed through the use of energy-efficient designs, minimizing the amount of waste, exploring suitable designs that adapt to nature and minimizing the negative impact on the environment associated with the use of traditional materials.

Traditional interior design relies heavily on artificial lighting and ventilation, as well as the use of plastics, wood and fabrics that are non-recyclable and harmful to the environment, thus the use of these materials increases energy consumption, produces harmful emissions and increases the carbon footprint. Adopting traditional interior design for the sake of aesthetics without considering resource waste will increase the negative impact on the environment.

As opposed to traditional interior design, sustainable interior design promotes the use of natural light indoors and utilizes daylight. The design of skylights or so-called glass ceilings in interiors can help bring light into spaces that cannot be provided with natural light through traditional windows. Other techniques that utilize daylight include atrium, outdoor reflectors, roof mirrors, light channels, skylights, overhead windows, and reflective curtains, as shown in (Figure 8) below (Design, 2024) (Parise, 2011).

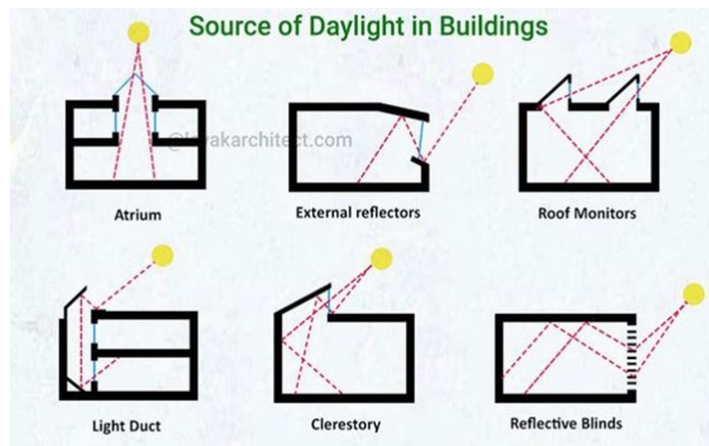


Figure 8: Sources of Daylight in Buildings (Design, 2024)

Furthermore, the use of light colors in design and light reflecting surfaces in walls, floors and mirrors contributes to better light distribution and help lower electricity consumption by 20 - 45% of the daily consumption, thus reducing excessive electricity consumption (Othman, 2024).

Interior design is not just about aesthetics, but it also plays an important role in maintaining good air quality in buildings. One of the key principles is to control the flow of fresh air while at the same time reducing the need for mechanical ventilation. This is achieved through cross ventilation by placing windows and openings on opposite walls to allow air to flow naturally. A good example is the “breathing window”, which cools the room air in summer and warms it in winter. This layout promotes even airflow and improves air quality by reducing indoor air pollutants (Attia, 2015). This approach can be illustrated in the following figure.

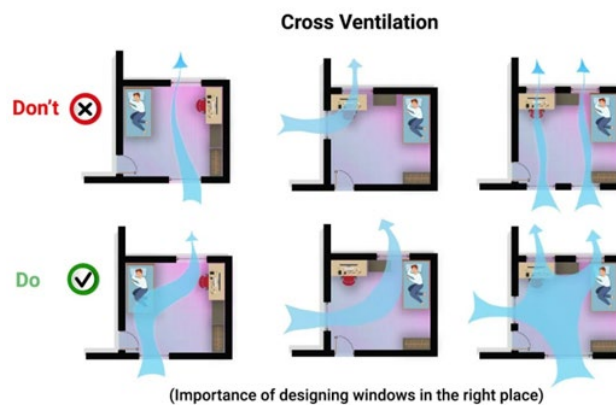


Figure 9: Cross ventilation in rooms (Attia, 2015)

Another effective technique is the “stack effect”, which uses temperature differences to improve ventilation. Warm air rises naturally and escapes through the upper chimney openings, while cooler air is pulled in through the lower openings. This approach not only improves airflow, but also maintains the aesthetic appearance of the design, reduces energy consumption for both heating and cooling, and lowers material and maintenance costs (El-Sayed, 2021). This concept is best illustrated in the following figure.

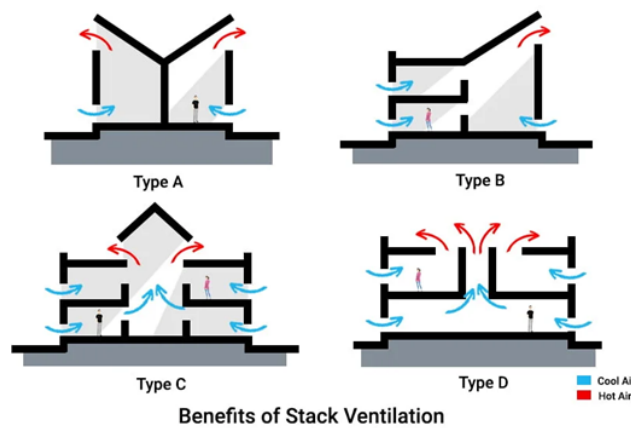


Figure 10: The stack effect (El-Sayed, 2021)

Meanwhile, traditional interior design is still the most widely used approach, mainly relying on heating, ventilation and air conditioning (HVAC) systems to control the temperature. Despite providing a comfortable environment, they require significant amounts of energy, thereby increasing the carbon footprint, negative environmental impact and high operating and maintenance costs. This shows how important it is to switch to an interior design that values the conservation of environment. Thus, we can integrate aesthetic and functional values while ensuring a green future (Ali, 2023).

Interior design embraces passive design, which utilizes natural elements such as sunlight, wind, and ambient temperatures to enhance interior spaces without relying on mechanical systems such as air conditioning, heating, or artificial lighting. This approach not only optimizes

energy efficiency but also reduces the environmental impact by making better use of more sustainable alternatives. It has been demonstrated that this approach also reduces the environmental impact by making better use of more sustainable alternatives. Studies have shown that passive planning strategies can conserve energy by controlling the design temperatures for heating and cooling. Thus, improving indoor living quality and reducing

maintenance and operating costs. These bright strategies promote sustainability and help us tackle climate change and the environmental challenges facing the world today. (Gil-Ozoudeh, 2022) (Elaouzy, 2022).

Economic aspects and durability in interior design are also key factors, as the cost of sustainable materials and their effectiveness, the durability of eco-friendly designs, and the energy-saving strategies provide a financial return that can be used in other fields, thus making sustainability a practical and excellent choice for a more sustainable future. This aspect will be further explored in the next section.

### **3 Economic and Durability Aspects in Interior Design**

#### **3.1 Economic Feasibility of Sustainable Materials**

An important aspect of interior design is the application of sustainable materials, which combine economic and environmental advantages, resulting in a balance between operating costs and prolonging the life of the materials used. As global awareness of environmental degradation intensifies, designers, architects, and developers are compelled to reconsider traditional practices toward more sustainable alternatives. However, the transition from conventional materials to sustainable options raises essential financial questions that must be addressed to justify broader adoption. The initial procurement costs of materials, maintenance costs, and the consumption of highly efficient resources are all factors that influence the cost-effectiveness of sustainable materials. As a result, long term financial benefits are achieved through energy and water conservation and the reduction of environmental emissions.

Interior design is one of the economic, social, and environmental strategies that many businesses and organizations rely on in their operations. Investing in sustainability has proven to have positive effects on businesses, real estate, and employee productivity (Keane, 2009). In order to promote sustainability in design, financial institutions have introduced financial and tax incentives that make it easier and more attractive to adopt sustainable practices. This development is encouraging more designers to embracing sustainability, further increasing its economic viability and popularity.

Conventional interior design is prevalent in our society due to the low initial cost of materials such as plastic, wood, paint, and synthetic materials. Even though these materials are less expensive, they have a short lifespan and require regular maintenance, which is costly in the years (Alfuraty, 2020). In contrast, sustainable interior design emphasizes the use of materials such as natural clay, bamboo, and recycled wood, which are more expensive to acquire but are characterized by durability, efficiency, and longevity. Over time, the operating costs associated with sustainable materials are significantly lower due to reduced needs for maintenance and renovation.

For instance, the economic efficiency of interior design is low-emission glass, which improves thermal insulation, which in turn reduces heating and cooling costs, thus cutting energy consumption by up to 30% in the long term . (Keane, 2009). Similarly, recycling and reducing the use of new materials contributes to minimizing environmental waste while lowering overall project costs (Fathy, 2016).

Empirical several studies have shown that there are significant economic benefits to adopting sustainable practices. For example, the use of natural lighting, natural ventilation, and other sustainable design principles has not only improved productivity and well-being in public spaces and workplaces but has also led to a 15% reduction in employee leave requests, which has led to improved economic performance (Sultan, 2022) (Yan, 2022). Sustainable design has attracted investors and tenants, which has increased the market value of real estate by 7-15%, due to its high energy efficiency, low cost, indoor thermal comfort, high air quality, and healthy environment, making it an ideal choice (Yan, 2022).

A life-cycle cost analysis LCCA is vital for accurately assessing the economic viability of sustainable materials. In addition to first costs, life cycle cost analysis considers operation, energy use, and end of life costs. For instance, reclaimed wood, although costs 20 - 30% more than conventional wood, less maintenance cost and longer service life bring about a net saving of 10 -15% in a 25 years' time span (Fathy, 2016) . Similarly, cork floor covering has been shown to have lower life cycle cost after initial investment because it is both durable and energy efficient.

With the goal of stimulating sustainable practices in interior design, governments and businesses have both started to provide incentives promoting sustainable energy and green design. Programs, including green mortgages and accelerated depreciation schedules, encourage the use of sustainable interior materials by offsetting as much as 30% of the incremental investment. Such strategies increase financial feasibility and cash flow for green interior design projects (Alfuraty, 2020).

A balance between sustainable design and construction not only protects the environment but also has clear economic benefits, such as lower operating costs, higher productivity, and financial returns. While sustainable materials offer clear long-term advantages, several challenges still impede their full integration into interior design. Foremost of these are the still relatively high costs of these technologies, as well as the absence of widely agreed cost numbers for newer and developmental materials, which tend to create financial uncertainty, mainly in small-scale applications. However, ongoing development of integrated databases and LCA tools is increasing cost transparency and the reliability of financial projections. As a result, though the first investment is higher for sustainability, it always comes out the way we want it to when you look at LCC consistently affirm their economic superiority over traditional options. With the growing availability of financial incentives and a clearer understanding of market dynamics, the use of sustainable materials in interiors, positioning sustainability as a key enabler of innovation, resilience and long-term value in space.

### 3.2 Durability and Performance Considerations

Sustainability in interior design materials and finishes plays an important role in balancing long-term performance and minimizing environmental impacts. The durability of materials used for interior design can thus be seen as a trade-off between a long lifetime and low environmental impact. The resistance of these materials is relatively high, depending on their physical and chemical properties that determine their behavior to different environmental influences and climates. Material Durability is Key In sustainable interior design, materials play a huge role, especially as maintenance and renovations can be an economical burden.

Designers can determine to what extent functional and visual principles remain effective over time, fully considering the structural strength and aesthetic lifespan of sustainable materials. This whole system approach not only elevates the performance and worth of interior spaces but promotes larger, environmental and economic objectives, lessening the necessity for continual replacements and expenditure of resources.

Thoughtful material specification is an important part of sustainable interior design by choosing materials wisely, you can help increase the lifespan of a space, minimize environmental harm and guarantee quality over time. And materials such as FSC-certified wood, recycled or reclaimed timber from old buildings, or recycled vinyl flooring products created by companies like Bolon and Interface, these speak volumes of interior design sustainability. These materials greatly resist wear, moisture and mechanical stresses, thus increasing their service life while also reducing embodied energy and emissions due to less frequent replacement (Falk, 2009) (Chaouch, 2024).

Furthermore, sustainable coatings and finishes have become an essential ingredient to improve material longevity and to minimize indoor pollution. Eco-friendly paints are offered by companies like Graphenstone and Benjamin Moore Eco Spec, which use low VOC technology and natural ingredients, making interior spaces healthier and longer lasting. These points demonstrate low fade resistance and low surface degradation as a function of time, allowing longer maintenance cycles and reducing the environmental impact (Graphenstone, 2023).

Textiles are another important area of sustainable interior design, with companies including Kvadrat and Camira using wool, organic cotton, bamboo fiber and post-consumer recycled plastic to produce high-performance fabrics for furniture and walls. These sustainable materials are not only visually flexible, but also engineered for longevity and minimal

maintenance, which facilitate a lower lifecycle environmental impact of indoor environments (Fabrics, 2022) (Kvadrat, n.d.).

A comparative analysis of some typical sustainable interior materials about their first cost, maintenance requirements, and estimated life span is listed in (Table 1). This analysis demonstrates the influence of material choice in the economic and environmental performance of sustainable interior design projects.

Table 1: Performance and cost analysis of sustainable interior materials

<b>Material</b>	<b>Initial Cost</b>	<b>Maintenance Needs</b>	<b>Environmental Impact</b>
<b>Recycled Vinyl Flooring (e.g., Bolon, Interface)</b>	Medium - High	Low (moisture and wear resistant)	Low (recycled content, minimal VOCs)
<b>Eco-Friendly Paints (e.g., Graphenstone, Benjamin Moore Eco Spec)</b>	Medium	Low (minimal fading, no toxic emissions)	Very Low (natural ingredients, zero VOC)
<b>Sustainable Textiles (e.g., Kvadrat, Camira)</b>	Medium - High	Low to Medium (routine cleaning required)	Low (organic and recycled sources)
<b>FSC-Certified Reclaimed Wood</b>	Medium	Low (periodic sealing may be required)	Very Low (salvaged material, no new deforestation)

As demonstrated in this analysis, use of long-lasting, low-maintenance building materials can significantly decrease lifecycle costs and environmental impact and thus contributes to achieving sustain-able development objectives. The thoughtful selection and incorporation of these materials in our environments, can positively impact building performance and human wellness. Sustainable interior design, therefore, is not just a matter of prettying-up the place, but is a key aspect of responsible interior design, which support environmental stewardship, economic efficiency, and social responsibility over the long term.

### 3.3 Business and Consumer Perceptions

Companies working in interior design and materials have given great importance to sustainable practices, Despite the challenges they face when implementing sustainable design, such as the high initial costs of materials, environmental technologies, and lack of in depth knowledge of sustainability standards in interior design, the lack of standardized

criteria to evaluate the efficiency, quality, and sustainability of projects has led to great variability in interior design. The lack of standardized criteria for evaluating the efficiency, quality, and sustainability of projects has led to significant variation in interior designs. (Rashdan, 2024).

In the past, sustainable design was seen as an unimportant additional cost, so companies hesitated to invest because of the high initial costs, but then companies began to realize that investing in sustainable interior design provides significant economic returns eventually. Consequently, sustainability measures have traditionally been an integral part of the effort of big players to balance profitability, economic viability and environmental responsibility in sustainable interior design (Tam, 2018).

Consequently, there are significant potential savings in operational costs in several fields, particularly in maintenance, and energy and water consumption as has been demonstrated from studies. Energy consumption is the major cost of water and electricity in the long term and savings of 30 - 50% in it are reported (Rashdan, 2024). Consequently, firms have begun embracing the principles of sustainable interior in particular, and in return to the continuing proliferation, in addition to making money, they have a race for producing sustainability associated products such as interior design and setting exigencies for branding so that the wave of environmentally conscious consumers surge toward them.

Consumers are increasingly undergoing an awareness of environmental concern and sustainability importance, so companies are encouraged to add sustainable principles to their interior design. In reaction, several firms are now vying to provide housing projects and interiors that are focused on sustainability and health. This transition is not just ethically driven, but it is also economically advantageous. Companies that have experimented with sustainable design strategies have received positive financial and economic rewards, while providing a better experience for the user. As such, it comes as no surprise that Customer satisfaction and loyalty has significantly improved Invalidating the sustainability as a central part of today's business operations. (Kim, 2021).

Consumers are becoming interested in sustainable products and services, also eco-friendly interior design. This is motivated by emergent social awareness about environmental issues, health advantages, and the higher economical returns of the environmentally friendly methods. That is the reason there are major uplifts in sustainable trend in the markets now. Marketing strategies have been utilized to guide consumer practices by promoting the health and environmental benefits, and the energy efficiency of sustainable designs, resulting in consumers being coaxed to buy eco-friendly products (Ottman, 2017) .

Research has suggested that this awareness has been successful in raising one's willingness to pay for sustainable design. Women are particularly adept and likely to be receptive at this. (Mills, 1993). Yet the reality is that price is still the most important factor in purchasing an item for most people, and while most are willing to pay an up to 5% premium for sustainable products and interiors (Teotónio, 2020). But, a new generation like Millennials and Gen Z according to another study are willing to pay up to 10 - 20% more for interior products and designs for an enhanced air quality and lighting, as well as well-being using well designed sustainability elements, which is compatible with the ideals of sustainability (Obeidat, 2022).

Ultimately, investing in sustainable interior design is becoming more profitable, realizing economic returns, strengthening companies and investing in the long term despite the challenges. The growing awareness of consumers shows a greater willingness to invest in sustainable interior environments, in exchange for a better quality of life based on a sustainable future vision.

### **3.4 Life Cycle Cost Analysis LCCA in Interior Design**

Life cycle cost analysis LCCA is a critical methodology applied to assess both the financial and environmental impacts of materials and space selected during the course of an interior design project. LCCA goes beyond initial investment costs to include operation, maintenance, disposal and end of life recycling. And in this way, it provides an overall frame of understanding for the Total Cost of Ownership TCO interior materials, helps designers and stakeholders make sustainable decisions that are both environmentally sound AND economic.

The total cost of ownership TCO covers all costs related to the material production, supply, delivery and installation as well as operation, maintenance and ultimate disposal (Moussatche, 2002). This whole system's approach allows designers to specify materials that not only perform in terms of durability and beauty but also reap long-term cost and environmental benefits. For instance, when considering flooring materials, assessing the purchase price as well as maintenance effort, cleaning effort, and recyclability, can significantly affect the choice of material. It has been reported that the LCA methodology using LCCA helps designers to select sustainable materials that reduce LCC in the long term by achieving an extended service life and decreasing maintenance requirements (Norris, 2001).

Building upon this, Research has shown that LCA in combination with LCCA provides reliable tools for selection and recommendation of the most sustainable material alternatives, material options that will provide greater financial value for the owner over time (Norris, 2001). The products chosen due to such evaluations help ensure durability and maintenance cost efficiency beyond the most common alternatives in the market. When we see the operational phase, it has been found to compromise 80 - 95% of total environmental and financial impacts related to indoor materials as opposed to the 4 - 12% for production and installation phases, and approximately less than 1% for disposal and recycling (Dara, 2019). Consequently, the need for cost-effective and material-efficient during-use is crucial for sustainable interior design.

While the focus is placed on the operational phase, it is also important to realise that although they are more expensive up front, sustainable materials lend to reducing the environmental implications made with deforestation. Bamboo and FSC-certified wood are examples of materials used in sustainable interior design and environmentally certified timber. These types of wood are characterized by high durability, so they reduce the need for periodic maintenance and replacement, thus reducing costs eventually. Research has shown that adopting sustainable wood can reduce life-cycle costs by up to 15% compared to conventional wood (Xue, 2019).

Materials such as organic cotton, hemp, natural wool, linen, and recycled fabrics, polyester and plastic are preferred in sustainable interior design because of their biodegradability, low volatile organic compound VOC emissions and favorable impact on indoor air flow as well as healthier indoor environments. In addition, many companies are incorporated into recycled fabrics, which reduce waste and use fewer natural resources to the earth. While natural and recycled materials are typically at least 10 - 20% more expensive in their first costs than their conventional synthetic counter-parts, the use of such materials adds added durability and performance, and therefore, there are 8 - 12% savings in terms of total renovation costs over the cycle (Wang, 2016). Installation with recycled textiles is additionally flexible and aesthetically pleasing, thus serving as an economical sustainable alternative for interior design applications.

In addition to sustainable textiles, flooring is another area that needs to be addressed the sustainable and cost-effective use of floor coverings are pivotal to long-term sustainability and economy. There is an increasing interest in the use of sustainable flooring products, such as recycled ceramic tiles, cork, and reclaimed wood, which further emphasizes the importance of LCCA in the selection of materials. Although the initial investment in these

materials is hefty, sustainable flooring means could decrease the maintenance expenses by 30% over 20 years (Dara, 2019). For instance, cork floors last longer than other materials because it's naturally resistant, durable, and renewable, reducing the number of replacements and repairs compared with other flooring options over the years.

LCA also supports decision-making for sustainable design within depth analysis of the sustainability of materials, efficiency and total cost. When LCA is included in the design phase it enables a more detailed understanding of how decisions influence financial costs and environmental performance. Rugged, simple and sustainable materials like low-VOC paints are being sought after to minimize maintenance requirements. Despite cost 5 - 10% higher than traditional paint, low-VOC paints decrease potentially hazardous emissions by 90%, enhance IAQ, and extend the life cycle of coatings, and as a result, the frequency of re-coating and grain ventilation (Xue, 2019).

Besides the choice of material, design structures including modular and flexible interiors provide a cost effective and environmentally conscious option where spaces can easily be modified without the need for demolition, reducing long term operational cost (Yuan, 2021). These assessments have contributed to the movement towards sustainable design strategies that balance environmental efficiency and financial expenditure, thereby contributing to the creation of sustainable indoor environments that are prepared to meet the demands of the future.

In addition, sustainable interior design encompasses distinct modelling paradigms that support efficient resource and waste management, for which modular interior design is a key approach. It offers the ability to easily remodel and transform diverse and sustainable interior spaces without the need for complete remodeling, while reducing the carbon footprint and lowering long-term operational costs (Borsos, 2019). Additive reuse of materials and the reutilization of repurposed building materials and components for interior design promotes effective resource management and waste reduction. This approach results in the construction as well as restoration of buildings, particularly in connection with the structural elements and interior units.

Consequently, it is in line with circular economic approaches and fulfills the requirements of sustainable design to preserve natural resources and consider environmental sustainability (Celadyn, 2019). Modular design also allows us to connect the natural and built environment by considering adaptive use as an effective form and looking for ways to improve resource management and extend the life of building materials.

A prominent example to illustrate the benefits of modular construction approach is the application for removable, reusable walls. Although their initial cost is 10% higher than that of conventional walls, they reduce construction waste and environmental impact. Interiors can be remodeled at no additional cost, reducing maintenance and replacement costs by up to 50% over 20 years (Dara, 2019). Convertible furniture and multipurpose furniture are also a good and economical solution for small spaces. Despite the 15 - 25 % higher price, this type of furniture reduces the need for new purchases by 40 % compared to conventional furniture (Bierer, 2015).

In addition, intelligent lighting, which uses sensors to control lighting as required, can reduce energy consumption by 30 - 50% per year. Despite the high initial cost of 10 - 15% for this type of lighting, electricity costs and carbon emissions are reduced compared to conventional lighting, which has a positive impact on the sustainability of sustainable interior design (Bierer, 2015). Consequently, this emphasizes the importance of relying on modular interior design systems to improve economic efficiency, achieve environmental sustainability, and reduce resource waste.

### **3.5 Challenges and Opportunities in Sustainable Economic Strategies**

The greatest difficulty for sustainable interior design is cost, the prices of environmental and sustainable materials are generally very expensive compared to traditional ones. Therefore, sustainable economic strategies are the solution of coping with environmental, social and economic issues, and stimulate economic growth in the interior design domain, since identifying future prospects provides insights into latent innovations finding cost and durable sustainable solutions towards achieving sustainable development. Recent advances, however, demonstrate that sustainable, economical interior design is attainable (Alfuraty, 2020) (Celadyn, 2018)

The widespread perception of high costs in sustainable interior design can be attributed to elevated production and transportation expenses, and limited mass production of ecofriendly materials. Eco-friendly products are typically more costly, and sustainable development strategies are crucial in overcoming environmental and social challenges while promoting industries growth of the interior design sector (Alfuraty, 2020) (Celadyn, 2018).

One of the biggest challenges is the highly fragmented and immature eco-friendly material supply chain. Fragmented supply Each actor in the chain struggles to have a clear vision of the market in terms of sizing or types of materials, which means that he is not able either to

benefit from market trends and keep a sharp and positive brand image. These challenges are also exacerbated by limited domestic suppliers, and the pressure to source the bulk of materials from countries outside the Middle East, increasing procurement costs as well as supply chain risks and vulnerabilities (Celadyn, 2019) (Alfuraty, 2020) .

This challenges, comprehensive approaches like green purchasing, which treats suppliers with a high commitment to environmental standards preferentially, must be taken. Furthermore, creating strong partnership with designers, manufacturers and suppliers is a necessity to increase transparency, maintain material flows and attract investments in the sustainable materials market (Tafazzoli, 2017) (Okogwu, 2023). Through the creation of robust and hyper local supply chains, the design industry can significantly wean itself from a reliance on expensive imports and facilitate adoption of sustainable processes on a larger scale.

As innovative technologies evolve, innovation is one of the main contributors to reducing the cost of sustainable interior design and generating lower costs, considering that these methods also help improve the production process, reduce dependence on expensive materials. Some of these technologies are 3D printing, which provides a low-cost alternative for sustainable building material manufacturing projects at affordable prices, ensuring that interior designers can develop more stable and environmentally friendly building options at affordable prices. Alongside advances in artificial intelligence and data analysis, it is now possible to plan spaces in terms of interior design and choose more sustainable materials to reduce waste and achieve sustainability. (Rashdan, 2024) .

Economic considerations, notably the fluctuating prices, and integration of supply chain operations, are powerful drivers to the implementation of sustainable measures in interior design. Designers need to have a thorough insight of client requirements and also need to ensure they have rigorous and meaningful sustainability assessment systems . This two-way system helps to protect against the risk of volatility of sustainable materials where it contributes to volatile production and profit margins for both the corporations and consumers (Okogwu, 2023) .

The Tecla house in Italy, a collaboration between Mario Cucinella Architects and WASP, is one such example. As the planet's first 3D-printed abode that has been entirely constructed from local raw earth mixed with water, rice husks, and natural fibers, Tecla signifies a milestone for sustainable architecture. The structure stands as a proof of concept of a build that is intended to be zero-waste, low-energy and fully recyclable and was printed over the course of 200 or so hours using Crane WASP printer. The Tecla is just one house among

several that shows how natural, ancient materials can be creatively combined with cutting edge 3D printing to produce sustainable, future-focused housing (TECLA, 2024).



Figure 11: Tecla 3D-printed earth house by WASP (TECLA, 2024)

The recent influx of artificial intelligence (AI) in interior design has greatly optimized the creation of sustainable and energy efficient spaces. Designers have access to AI tools that help them determine precise layout for hotels, restaurants and other interiors, choose eco-friendly materials, and reduce energy usage. AI-enabled analysis allows designers to better understand the environmental and economic consequences of the various design choices.

Through the analysis of data around performance and eco footprint, AI aids in the balancing act of being environmentally responsible, and economical. Autodesk, for example, has Space maker, which can model numerous configurations to optimize natural daylight and airflow, while Tally offers LCA to help designers select low-carbon materials and thus deliver more sustainable results. These systems illustrate how AI gives us the opportunity to shape interiors that are the best of both worlds visually stunning and environmentally responsible with the bonus of being future-proof (Maksoud, 2022).

Advancements in materials and furniture design have greatly contributed to the affordability and sustainability of interior projects. The much higher consumption of sustainable and recyclable materials, including heat-reflective paints, energy-efficient glass and recycled waste finishes, has helped ensure the price has fallen over the past few years. These developments have led to the minimization of energy and resource usage, while facilitating a more economical sustainable interior design project (Alfuraty, 2020).

In addition to material developments, furniture design materials other modular, disassembling and reconfigurable models is also a new trend. Such flexible designs reduce the amount of overall production necessary while fulfilling both the roles of eco-friendliness and economy friendliness and demonstrate the increasing influence of circular economy thoughts in the design industry (Jain, 2023) .

Contemporary technological trends have contributed to enhancing global environmental sustainability, reducing dependence on traditional resources and lowering costs through the use of biodegradable materials such as sustainably treated wood and low-carbon environmental alternatives (Solange, 2024).

Integrating smart technologies into sustainable interior design that enable precise energy management and make interior spaces more efficient, such as smart lighting, energy management, and regulation, contributes to lower operating costs and reduced resource consumption, making sustainable interior design an attractive, efficient, and economical option in the long term (Sokienah, 2024). As consumers are becoming more aware of the importance of environmental sustainability, the demand for sustainable products is increasing, which encourages competition between companies to offer and develop sustainable solutions at lower costs to make them more available.

This results in making sustainable products more accessible to a wider range of users, supporting a wider spread of the concept of sustainable interior design. Accordingly, the next chapter will provide a comprehensive comparison between sustainable interior design and traditional interior design, and the opportunities that sustainable interior design offers towards a more sustainable future and a balance between the economy and the environment

## 4 Comparative Analysis: Traditional vs. Sustainable Interior Design

### 4.1 Material Selection and Environmental Impact

Quality of the indoor environment in homes has a significant impact, and decisions about interior design affect the quality of life in homes. Therefore, traditional interior design frequently focuses on the aesthetic and functional aspects of the materials employed without considering their environmental impact. In contrast, sustainable interior design considers the importance of materials and their environmental impact by selecting environmentally friendly, renewable, and recyclable materials while maintaining aesthetic and functional aspects.

Interior design encompasses all elements of a home's interior, ensuring occupant comfort. This encompasses flooring, walls, furniture, doors, windows, textiles, and numerous other components. The materials employed in interior design are diverse, including glass, wood, metals, fabrics, paints, stone, marble, insulating materials, and plastics. Traditional materials utilized in interior design frequently depend on non-renewable resources due to their relatively low cost and wide availability in the market. To better understand the distinction between material types, the following table provides a side-by-side comparison of commonly used traditional vs. sustainable materials in various aspects of interior design:

Table 2: Traditional vs. Sustainable Materials in Interior Design

Category / Use	Traditional Materials	Sustainable Materials
<b>Wood</b>	Oak, beech, pine, walnut	Bamboo, FSC-certified wood, reclaimed wood
<b>Stone</b>	Marble, granite, limestone	Recycled or reclaimed stone
<b>Flooring</b>	Ceramic, porcelain, natural wood	Cork, bamboo, recycled-content flooring
<b>Walls</b>	Acrylic/oil-based paints, traditional wallpaper	Natural plant-based paints, recycled-material wallpapers
<b>Insulation</b>	Fiberglass, polystyrene	Cork, cellulose, natural wool
<b>Fabrics &amp; Upholstery</b>	Synthetic fabrics, genuine leather	Organic cotton, linen, plant-based leather alternatives
<b>Decor</b>	Conventional plastics, metals, regular glass	Recycled plastics, recycled glass

The materials utilized in conventional wall paints are constituted of chemical compounds and contain elevated levels of volatile organic compounds VOCs. These paints emit toxic gases into the indoor air following application. However, protracted exposure to these emissions in indoor air engenders a health risk to users (Jana, 2005). VOCs are associated with health complications such as headaches and respiratory irritation, which particularly affect individuals with asthma (Rumchev, 2007) . Moreover, the chemical manufacturing process of paints contains environmental pollutants such as dust and water. Despite their aesthetically pleasing, vivid hues and ease of application, these paints bear a substantial environmental and health cost throughout their life cycle.

fundamental component of conventional interior design is the selection of resilient and visually appealing materials. Natural woods like parquet, natural stone like a marble, ceramics, and porcelain are used for flooring and walls. These materials have a distinct, classic appearance, but the development and refinement of raw materials for use and installation in interior spaces consumes significant natural resources. Consequently, they require extraction, manufacturing, and transportation processes, which negatively impact the environment (Rashdan, 2017).

Synthetic plastic is also a prevalent material in traditional interior design, commonly found in furniture like chairs and tables, lighting fixtures such as lampshades and diffusers, and decorative accessories including curtains and synthetic fibre carpets. For example, polypropylene is frequently used in chair shells because of its durability and moldability, whereas acrylic is favoured for lighting diffusers due to its transparency and shatter resistance (Antonenko, 2021).

Critically, plastic, manufactured from petroleum and natural gas via polymerisation, is non-biodegradable, persisting in the environment and often fragmenting into microplastics. Consequently, landfills and incinerators are frequently the final destination for these products, contributing to environmental pollution and resource depletion. This results in a significant carbon footprint due to the energy-intensive extraction, refining, and manufacturing processes involved in plastic production. Furthermore, the incineration of plastic waste releases harmful greenhouse gases and pollutants into the atmosphere, exacerbating climate change and posing risks to human health (Kajaste, 2021). Although bioplastics, derived from renewable resources, offer a potential alternative, their widespread use is hindered by cost, performance limitations, and scalability challenges.

Natural woods and stone, parquet flooring, and marble are widely appreciated in interior design for their elegance and durability; however, the processes involved in their extraction, manufacturing, and transportation consume significant amounts of energy and natural resources. For example, the creation of parquet flooring often necessitates the felling of mature trees, impacting forest ecosystems, while the extraction of marble from quarries can involve blasting and heavy machinery, consuming vast amounts of fossil fuels. Traditional materials like these, though visually appealing, often result in negative environmental impacts because their harvesting and processing contribute to resource depletion and ecological degradation. The extraction of wood may lead to deforestation and the loss of biodiversity, while quarrying stone like marble requires substantial energy and can result in habitat destruction and pollution, including water contamination from quarry runoff (Hill, 2016).

Furthermore, the transportation of these heavy materials over long distances increases their carbon footprint, compounding their environmental cost. Suppose a type of marble is imported from its country of origin to another country; shipping alone contributes significantly to greenhouse gas emissions. Despite the aesthetic appeal of natural wood and stone, their use in interior design and construction faces challenges due to their laborious and costly production, processing, and sourcing processes. These challenges require careful evaluation of materials selection, highlighting the importance for designers and consumers of considering more sustainable alternatives, such as reclaimed wood, bamboo flooring, and recycled glass tiles, which offer similar aesthetic properties with a lower environmental impact.

As the environmental issues such as climate change, resource exhaustion and environmental pollution become more serious, both the design and manufacturing industries are starting to grow green. They use some new alternatives those are supposed to reduce waste, cut down on emissions. At the same time these solutions support a circular economy, one in which products are made in such a way that what you put out there can be used again. Some particularly good bets right now are renewable materials, materials that have been recycled and biodegradable materials.

The renewable materials that come from resources which can be naturally renewed make another critical contribution to sustainable design. Examples here include timber from properly managed forests (where logging is done in such a way as to preserve the environment), bamboo and agricultural crops such as hemp or flax. For instance, with timber

certification programmes such as the Forest Stewardship Council FSC, we can ensure timber is harvested in a sustainable manner: it therefore provides ecological, social, and economic benefits. Rapid growth has made bamboo a popular material in various industries today, replacing such traditional materials as wood and plastic with an application scope ranging from construction to consumer goods (Borowski, 2021).

While recycled materials are basically waste products that are processed anew to get new and other materials. It lowers the need for brand new resources and prevents waste from going into landfills. However, recycled materials can be used in more specific applications since most companies are still using rPET into their PET packaging of many drinks and foods. Recyclable plastic rPET, metal (aluminium, steel, and other metals), paper, etc. Using recycled aluminium, for instance, requires 95% less energy than producing new aluminium from bauxite ore, significantly reducing greenhouse gas emissions (Olivieri, 2006).

Biodegradable materials are attracting growing interest for sustainable interior design applications owing to their intrinsic capacity to safely break down under certain environmental conditions, such as managed composting or burial underground. Upon disintegration, they yield innocuous substances like H<sub>2</sub>O, carbon dioxide, and organic biomass, posing minimal long-term ecological impact. Polylactic acid PLA, a bio-based plastic derived from renewable resources like corn starch or sugarcane, offers a notable example (Hartini, 2020). As the accompanying image depicts, PLA production begins with plant feedstocks like corn.

Starch is extracted and converted to glucose through enzymatic hydrolysis, which is then fermented to yield lactic acid. Through an exclusive process, lactic acid is transformed into lactide and subsequently polymerized into polylactide PLA pellets. From there, the pellets are melded into plastic sheets and end products. After use, they can be composted in dedicated facilities, ultimately returning nutrients to the natural world, closing the loop of a sustainable lifecycle (Din, 2020).



Figure 12: The Lifecycle of Poly(lactic acid) (PLA) (Din, 2020)

Within interior design, these biodegradable materials are valued not merely for their environmental benefits but also for their visual versatility and practical applications. Designers are experimenting with PLA and mushroom-derived composites to craft eco-friendly wall panels, lighting fixtures, acoustic elements, and pieces of furniture. These materials offer natural surface textures and organic forms that enhance the sensory experience of interior spaces. However, to fully realize their sustainable potential, appropriate disposal systems and supporting infrastructure must be established, as many biodegradable materials require precise conditions to efficiently decompose. Therefore, incorporating biodegradable materials into interior design demands a holistic approach that considers the entire product lifecycle, from sourcing to final usage.

This approach is partially a step in the right direction, as it is not only important to prevent further environmental impact, but also to ensure more functional and aesthetically pleasing spaces. The incorporation of biodegradable plastics, renewable resources, and recycled material will allow for interior design that address the challenges associated with the depletion of resources and ecological hazards created by traditional building materials. But for these materials to deliver their full potential, we need proper disposal and recycling channels. This brings us to the next step, which is to explore energy and resource efficiency in conjunction with performance-based strategies focused on sustainability in the context of energy consumption and resource use in contemporary modern interiors.

## 4.2 Energy and Resource Efficiency in Interior Design

Everyday life relies heavily on energy to operate everything from the homes, to lighting, and to the ability to create comfortable living conditions. The growing dependency on conventional fuels like coal and natural gas has highlighted the pressing demand for sustainable options that conserve resources and decrease carbon footprint. Other recent

studies show sustainable interiors provide a solution, delivering demonstrably lower energy consumption than traditional designs. Those savings come from improved insulation, energy efficient lighting and sophisticated heating and cooling systems. Sustainable house design, for instance, can mean energy bill savings of between 30% and 50%, because of the superior building materials used and the cutting-edge technologies employed (Sanytsky, 2012). This amounts to both monetary savings and a reduced carbon footprint.

Low-emissivity glass is one of the most important strategies for sustainable design. Low-E coatings minimize heat transfer and help keep your home at a more constant temperature throughout the year. LED lighting, on the other hand, also uses 75% less energy than its incandescent counterparts and has a longer lifespan, which lowers energy bills and the need to replace bulbs (Subhasish Das, 2021) . Advanced HVAC systems -like geothermal heat pumps-leverage the earth’s natural temperature to provide a highly efficient climate control solution. Likewise, insulation made from recycled or environmentally friendly materials helps maintain indoor temperatures with minimal energy use. Passive solar design, which considers building orientation to maximize winter sunlight and minimize summer exposure, further decreases energy demands.

Table 3: Comparison Between traditional and Sustainable Components




Component	traditional	Sustainable	Energy Savings
<b>Glass</b>	Regular glass	Low-emissivity glass (Low-E)	Up to 30% reduction in heat loss
<b>Lighting</b>	Incandescent bulbs	LED lighting	Up to 75% less energy usage
<b>Heating and Cooling</b>	Traditional systems	Geothermal heat pumps	Up to 50% less energy usage
<b>Insulation</b>	Traditional materials	Recycled materials (e.g., denim)	Up to 20% less energy waste
<b>Passive Solar Design</b>	No solar optimization	Solar-oriented building design	Up to 25% less heating/cooling demand

Desirable indoor comfort and lower energy bills are direct benefits of increased insulation, improved windows, and passive solar gains. Being well-insulated significantly reduces the need for heating and cooling. Insulation functions as a heat barrier, keeping indoor spaces warmer during winter and cooler in summer. Research shows that enhancing window

insulation in poorly insulated houses can lower annual heating and cooling energy demand by approximately 7.9 -16 .7% (Ahn, 2015).

The relationship between window insulation (U-value) and energy savings is especially strong in poorly insulated homes, regardless of window size. In contrast, houses with better insulation and larger window areas benefit more substantially from reducing the solar heat gain coefficient (SHGC), achieving energy usage reductions ranging between 18.4 - 29.7% (Ahn, 2015). High-performance windows such as double or triple pane, low-E types are essential in reducing glare, maintaining comfortable indoor environments, and boosting energy efficiency when SHGC values are optimized.

Table 4: Comparison Between LED, CFL and Incandescent Light Bulbs

Feature	LED Bulbs	CFL Bulbs	Incandescent Bulbs
Format			
Energy Consumption	8-12 watts	13–18 watts	60 watts
Energy Savings	75% - 80%	~60% – 70%	0% (reference)
Lifespan	25,000 - 50,000 hours	8,000 – 10,000 hours	~1,000 hours
Energy Conversion to Light	80% - 95%	~60% – 70%	~5%
Energy Lost as Heat	5% - 20%	~30% – 40%	~95%
Upkeep & Replacement	Very Low	Moderate	Very High
Available Options	Wide range of colours and brightness levels	Fewer options than LEDs	Limited
Environmental Impact	Eco-friendly	Eco-friendly	Higher negative impact
Operating Cost	Low	Moderate	High

Additionally, energy-efficient lighting like LEDs allows savings between 15% and 80% (Moram, 2011). For instance, swapping a 60 - watt incandescent bulb with an 8 - 12-watt LED can result in energy savings exceeding 75% (Moram, 2011). These efficiencies lead directly to lower electricity costs and a reduced environmental footprint. When used under standard household conditions (3 - 4 hours per day), LED bulbs provide reliable illumination for many years without the need for maintenance. With lifespans ranging from 25,000 to 50,000 hours compared to the mere 1,000 hours for incandescent bulbs, LEDs greatly reduce the frequency and cost of replacements.

Compared to incandescent bulbs, LEDs use a much larger percentage of the electricity in their operation to illuminate and a small fraction elsewhere. Incandescent bulbs, on the other hand, waste a massive portion of their energy as heat, making them far less efficient. In fact, only about 5% of the energy consumed by an incandescent bulb is converted into light, with the remaining 95% being lost as heat (Moram, 2011). This difference in energy conversion is a key factor in the superior energy efficiency of LEDs. Moreover, LEDs are available in a wide range of colour temperatures and brightness levels, offering consumers greater control over the ambiance and lighting design of their homes.

Energy efficiency fundamental aspect of both sustainable and the traditional frameworks of interior design. Central to this efficiency are two main strategies, passive and active energy systems, which each effect performance over time in the interiors. Sustainable design can anticipate these systems and plan for their environmental impact while traditional design often follows tried and true aesthetics and functionality without recognizing energy consumption that will still be required post construction.

Passive energy solutions refer to architectural design strategies which improve performance without the use of mechanical systems. And these strategies include the use of orientation, thermal mass, natural ventilation, high performance insulation and windows and shading. For instance, with respect to colder climates, a south facing window can improve solar gain during the winter months, thus minimizing the need for artificial heating. High thermal mass materials like brick and concrete absorb heat during the day and slowly release it at night, moderating indoor conditions. Automated skylights and windows also permit natural airflow in summer, decreasing reliance on air conditioning (Chao He, 2021).

According to the European Energy Performance of Buildings Directive (EPBD, 2020), if Passive Solar Solutions are designed properly heating need for residential purposes

annually may be reduced by around 25% (Chao He, 2021). However, the effectiveness of these strategies is highly climate-dependent; designs suitable for southern European countries may not be effective in colder northern regions. Therefore, careful consideration of local climate conditions is crucial for implementing effective passive solar design and achieving optimal energy savings.

Active energy strategies, on the other hand, deploy mechanical and technology-driven systems to manage indoor climate and lighting. Examples of these devices are HVAC systems, energy-efficient lighting like LED, smart thermostats, energy monitoring systems, home automation. Although these need electrical power to run, they are designed to use a fraction of the power traditional systems do (Hariharan, 2021). One highlight of the European Commission's 2021 Lighting Factsheet is that LED lighting uses around 75% less energy than incandescent lighting and has a much longer (Zissis, 2021). Revolutionary smart thermostats adjust heating and cooling to the home based on occupancy patterns and user behaviour.

Integrated systems have been suggested to limit total energy use by 40% to 70%, depending on local climate and system quality (International Energy Agency, IEA, 2019) (Qamar, 2019). As a practical example, passive solar heating could be coupled with a high efficiency heat pump, both controlled via a smart thermostat to balance comfort, energy consumption, and sustainability.

This leads us to a wider topic sustainable vs traditional interior design. The principles of sustainable design combine both passive and active energy saving measures with attention to the use of environmentally sound materials, long product life cycles, low-VOC finishes, and efficient spatial planning. Its goal is to reduce resource depletion, waste, and energy use over the lifespan of a space.

Table 5: Comparison: Passive, Active, Sustainable, and Traditional Interior Design Strategies

<b>Feature</b>	<b>Passive Strategies</b>	<b>Active Strategies</b>	<b>Sustainable Interior Design</b>	<b>Traditional Interior Design</b>
<b>Energy Use</b>	Low, natural control mechanisms	Low, through smart technologies	Optimized through passive + active integration	Often less energy-efficient
<b>Approach</b>	Design-based (orientation, insulation, ventilation)	Technology-based (HVAC, LED, smart tools)	Eco-conscious, integrates both passive & active strategies	Aesthetic and functional, less focused on environmental impact
<b>Electricity Dependency</b>	Minimal or none	Requires power	Uses power efficiently, minimizes overall consumption	Varies; may use inefficient appliances or lighting
<b>Climate Sensitivity</b>	High	Works across various climates	Adaptive and responsive to climate	Not specifically climate-adaptive
<b>Focus</b>	Regulating natural indoor climate	Automating control and monitoring	Sustainability, health, and long-term resource efficiency	Tradition, comfort, and craftsmanship
<b>Environmental Impact</b>	Reduced	Controlled	Minimized across entire design lifecycle	Often higher due to less focus on material sourcing or energy use
<b>Material Use</b>	Emphasizes thermal mass and natural ventilation	Emphasizes tech components and efficient devices	Prioritizes recyclable, renewable, non-toxic materials	Durable materials, but not necessarily eco-friendly

This comparison highlights the fact that sustainable interior design not only combines passive design principles with advanced active technologies, but also focuses on green materials, which enables it to be more energy efficient, adaptable to climate, and to have less impact on the environment during the entire life of the material. In contrast, traditional interior design, while sometimes praised for its aesthetic and functional appeal, is almost invariably based on systems and materials that are not as efficient, and consequently burn more resources, making for a greater eco-footprint and operational expense.

### 4.3 Aesthetic and Functional Aspects of Sustainable Interior Design

In contemporary interior design, the notion of beauty has experienced a major shift especially as sustainability takes centre stage in both design practice and the public consciousness. What we once would have described as beautiful - characterized by elaborate ornamentation, sumptuous materials, and a visual abundance - is being redefined by both environmental stewardship and ethical consumption. More and more, aesthetic value is assigned not only to what things look like but also where they came from, what they are made of, and how long they last.

This shift in aesthetics of course demands a rethink on interior finishes and materials. Sustainable design tends to a minimalist aesthetic characterized by clean lines, muted colour palettes, and an embrace of a material's natural state including the knotted grain of reclaimed wood, the variegated textures of natural stone and clay, and the subtle irregularities found in organic textiles and recycled elements. Instead of concealing imperfections, this approach celebrates them cracks, weathering and colour variations become part of a piece's story, enhancing its visual richness and authenticity in keeping with the Japanese principle of wabi-sabi, which finds beauty in imperfection, transience and the natural aging of materials (Salman, 2023).

The importance of ethical material sourcing is on par with the visual. A piece of furniture made from reclaimed wood or one of its textile counterparts dyed with natural pigments goes beyond aesthetic fulfilment; it has a story of environmental stewardship, artisanal craftsmanship and resilience. These objects possess true beauty not only in their physical shape, but rather in the values they embody. This resonance enables an emotional relationship between the user and the piece, one that inspires a sense of coexistence with intentional and considered materials that denote inherent meaning and use.

In sustainable interior design, Colour is a critical link between the built environment and the natural one, making it an extremely principal factor in sustainable interior design. Colour palettes in such contexts tend to be extracted directly from nature, invoking the tones of different ecosystems, from forests to deserts to grasslands to oceans. The most used tones earthy browns, warm terracottas, olive and moss greens, muted blues, soft greys, and sandy beiges are employed, not just for their aesthetic value, but for their psychological and emotional evocation. They are natural shades that encourage serenity, balance, and warmth creating a relaxing environment that encourages mental health.

Natural colour palettes have been shown in empirical studies to reduce stress levels and enhance mood, so can be particularly appropriate in residential interiors where rest and relaxation is key. And these classic colours stand the test of time, supporting the sustainability tenet of design longevity (Sokolova, 2015). Through a harmonious balance of emotional gratification and ecological awareness, sustainable colour palettes allow interiors to connect not only viscerally but also ethically and environmentally.

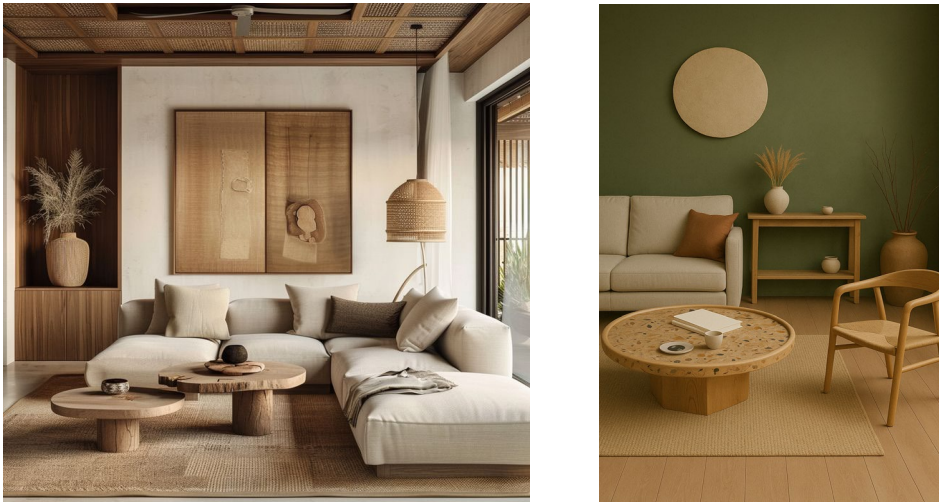


Figure 13: Sustainable living room with natural tones and materials (Pinterest, n.d)

traditional interior design tends to celebrate visual opulence and decorative proliferation at the expense of ecological accountability. It usually features high-gloss finishes, synthetic materials and complex ornamental elements that convey a sense of luxuriousness and sophistication (Fedorovskaya, 2021). Common materials: plastics; composite wood with chemical adhesives; synthetic fabrics; and petroleum-based paints. Although these decisions can lead to striking visual effects, they often come at a high environmental cost. Production of such materials tends to be energy-intensive and polluting, while short lifespans increase waste and require frequent replacement.



Figure 14: T Ornamentation-focused traditional living room (Pinterest, n.d)

Even worse, many of these finishes release toxic volatile organic compounds VOCs, which degrade indoor air quality and can be dangerous to your health. Sustainable design emphasizes durability and harmoniousness with the ecosystem, whereas traditional design is often based on transient fashions that promote overconsumption and disposability. Through this, traditional interiors may impact sustainable environments and users' well-being in the longer run.

In modern day design practices, the connection between sustainability and aesthetics in interior design has grown increasingly important. The role of visual allure as the only arbiter of design worthiness is in the rearview mirror, replaced by a renewed emphasis on environmental impact and the potential long-term consequences of material choices. By traditional, there has been the held belief that sustainable materials will lack the richness and refinement of more traditional options but with advances in technology has challenged that. Advances in manufacturing techniques allow the production of green materials with comparable visual aesthetics (Hartini, 2020). High-quality finishes on recycled wood, bio-based textiles with chic prints, and eco-conscious coatings have all added to the sleek graphic possibilities of sustainable interiors.

Achieving a balance between aesthetic requirements and sustainability requirements can be particularly challenging for designers. Many inherently sustainable materials are restricted in colour range, texture, or structure, limiting their use as a vehicle for creative expression. Yet those constraints have inspired innovation and experimentation. Designers are consciously integrating local and natural materials, combining reused or repurposed elements in whimsical ways. As a result, contemporary design trends are emerging that highlight the natural, "raw," and "unfinished" features of materials where imperfections have become features that add character and authenticity to the design rather than flaws. This method has become increasingly popular as it provides a different view for beauty that works in sustainable values.

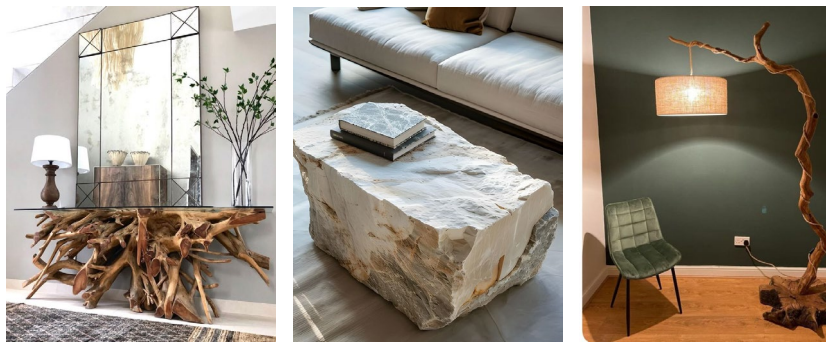


Figure 15: Raw Materials in Design: Embracing Natural Imperfections (Pinterest,

In addition to their aesthetic value, sustainable materials offer numerous functional advantages that enhance interior performance. Reclaimed wood, bamboo, and recycled metals are a few of the materials that offer superior strength, flexibility, and limited maintenance uses all traits that help lower the consumption of resources while lowering the need for repairs and maintenance as well. Sheep wool or cellulose for natural insulation is not only biodegradable and help to eliminate building disuse while offering high thermal and acoustic performance, guaranteeing indoor comfort and reducing the energy needs associated with environmental systems. These developments show how current sustainability practices combine performance and aesthetic one another.

However, sustainable materials are not devoid of challenges. Some of them might be more expensive at first, because of rarity or an artisanal production process. The rest may have unique installations or treatments to ensure the best results over time: For instance, you might need to seal the natural wood to prevent moisture from compromising its integrity. Furthermore, stringent environmental accreditations and ethical sourcing criteria may also extend project timelines. However, these issues are becoming more manageable with technological development and a broader adoption of the industry, bringing functional sustainability to the mainstream interior design (Susanto, 2017).

In this respect, the minimalist design becomes a style not only but also a sustainable means. A simple approach to design, such as minimalism, is essential for sustainable design, not as an aesthetic choice but as a means of avoiding excess materials and visual pollution which ties into emotional design (Lukito, 2018). The honesty of form and spatial clarity brings forward the natural qualities of materials to create a space of calm, order, and understated elegance.

Occupants of sustainably designed interiors often report greater satisfaction, having expressed a sense of comfort, ethical likeness and psychological well-being. While mainstream interiors may initially entice with visual opulence, their enduring appeal often wanes as fashions shift and materials wear out. This sets them apart from the fast fashion of interiors, which accrue short-lived meaning, purely aesthetic, before being replaced with the next superficially similar successor.

#### **4.4 The Future of Interior Design: Trends and Innovations**

The phenomenon of environmental transformation, scientific and technological development, and shifting cultural trends and lifestyle and consumption patterns is revolutionizing the world today. These transformations are echoed in several new

developments around interior design that have close associations with the agendas of sustainability, flexibility, and material innovation. With a growing necessity for healthier, more sustainable, and more aesthetically attractive indoor environments, interior design is now an integral part of contributing to living and working environments as much as a force for social transformation.

The future of interior design is ever more determined by advances in sustainable materials and the integration of "smart" and ecologically oriented technologies. Moreover, with industries worldwide having sustainability and environment as a priority, interior designers are attracted to trends in materials designed to endure the elements, have little environmental footprint, and open design opportunities. A key megatrend in this revolution is advanced development of innovative material concepts that are aesthetically pleasing as well as conform to circular design principles. These novel materials are not only a means of reducing waste, but also a means by which to reimagine how design will benefit people and the planet over the long term.

the sector grapples with some of the inevitability sustainability challenges, material innovation is instrumental in breaking the status quo of what is possible in interiors. A splendid example of this innovation is the Growth Collection by The Good Plastic Company. This is a project that demonstrates how recycled materials can be re-purposed and create a beautiful and sustainable design (Polygood®, 2024).

Polygood®'s Growth Collection processes 100% recycled and recyclable polystyrene into terrazzo like panels of an assortment of colours and patterns that are non-toxic and made with zero VOC. These panels are suitable for interior applications like furniture surfaces, walls cladding and kitchen finishes. The plastic is recycled from elements of electronics, appliances, and other industrial waste. By creating a product made with these materials, the collection reduces the demand for new "virgin" resources and keeps plastic waste out of landfills. This fits well with the design circle concept, which is a keystone of sustainability (Polygood, 2024).

The Growth Collection is also compliant with multiple international quality and environmental regulations. It is certified Cradle to Cradle® Bronze, with an Environmental Product Declaration EPD and a VOC exceptionally low emissions rating. Polygood® is also ISO quality ISO 9001, environmental management ISO 14001 and occupational health and safety ISO 45001 certified. These certifications underscore the company's dedication to environmentally- and socially conscious production methods (Polygood, 2024).

On top of that, Polygood operates a Take-Back scheme to collect panels that have reached the end of their service life from users. Then those panels are recycled and used to create new panels for upcoming projects. This closed loop system is resource efficient and contributes to the circular economy. Pairing environmental performance with contemporary design, the Growth Collection proves that sustainability and style can coexist (Polygood, 2024).

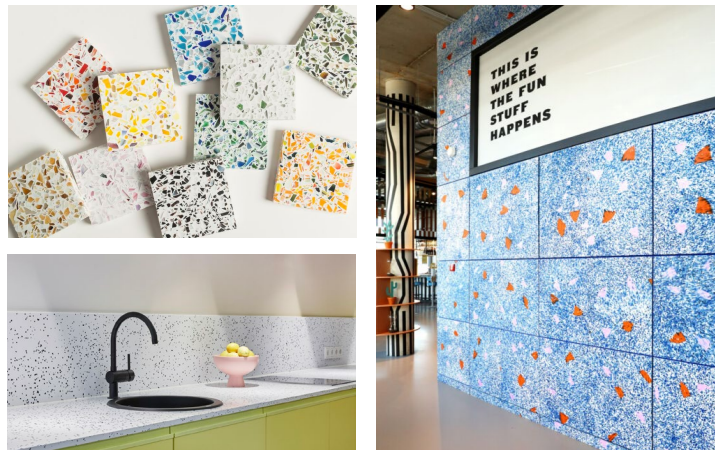


Figure 16: Applications of the Polygood recyclable polystyrene (Polygood, 2024)

Forward thinking companies like Mogu, an innovative Italian company, developing sound absorbing panels and pliable floor coverings from mycelium-based composites that are biodegradable, lightweight, sound buffering, fire retardant, eye catching and entirely natural. These bio-designed materials illustrate how nature can reconcile structure with aesthetics in contemporary interiors (Mogu, 2024).

Mogu has created a revolutionary line of bio-based flooring products in tile or flex flooring, tailored to the emotional and functional demands of modern interior spaces. These floors from low value agricultural and food industry waste such as seashells, coffee grounds, seaweed, and rice straw, combined with a patented bio resin formula. Mogu's floor solutions are durable, solvent free and UV resistant and provide not only aesthetic wealth but sustainable performance.

Mogu Floor Flex is a 67% biobased roll-type product for modular and customizable design compositions, while Mogu Floor Tiles contain a minimum of 87% biobased content and offer scratch resistance and durability similar to those of traditional flooring materials. These lines offer a low haptic, matte surface effect, desaturated nature-based range of colours and help to further sensitize resin-based applications to VOC reduction and circular economy objectives. Mogu's flooring collection is certified with the Blue Angel Eco-Label confirming

its environmentally friendly character and suitability for green building applications (Mogu, 2024) .



Figure 17: Mogu Panels & Flooring (Mogu, 2024)

Mogu is embracing the mandate of circular design, in which materials are designed to be made from waste and can safely return to the natural environment at the end of life. It is this that shows the company’s commitment to environmentally friendly manufacture and the process of using nature to build lasting, and practical, interior solutions.

Despite the momentum of sustainable interior design, it still confronts several hurdles in the battle for wide scale acceptance. One of the top issues is the fact that “green” materials and technologies are not cheap in the short term, and that is a huge barrier to any budget minded clients or developers. Moreover, a sizeable proportion of sustainable alternatives involves the development of new infrastructure, skilled labour, or certified processes, which translates into time consuming projects with difficult implementation. Still, there are some widespread knowledge gaps among both consumers and professionals when it comes to alternative sustainable options, limited exposure and misconceptions about performance or even designs tend to shape the market (Hartini, 2020).

In addition, incongruences in environmental standards and measures and the absence of common and linked rules for green construction which can be applied everywhere, prevent scaling in sustainability across various regions and markets. Addressing these barriers will involve greater incentives, firmer policy structures and cross industry and government collaboration in pushing sustainability as a need rather than an option.

Modular and adaptable environments are one of the dominant trends that will shape the interior of the future. These 'systems' are walls and furniture and light fixtures that can be reordered, replaced, or updated, to reflect how interior designs may change adjust considering changing needs and tastes (Yu, 2019). When new design can occur without starting over, less material goes to waste and products have longer lived, which supports closed loop sustainability. This approach speaks to responsible design in a new era, one that prioritises longevity over profit as well as a more open, sustainable path to achieving interiors that will be more visually and conceptually cost effective.

Developing hybrid offices and residential spaces has, in turn, accentuated the call for multi-functional spaces, where modularity is revealed both as a pragmatic means to design products and as an expression of sustainability which revolutionizes the way we design, use, and conceive interiors (Yu, 2019). Companies like IKEA have successfully subscribed to this thinking, with adaptable solutions such as the PLATSA storage series and VALLENTUNA modular sofas ensuring the home can change in relation to life and not the other way round (IKEA, n.d.).



Figure 18: IKEA's Modular Solutions: PLATSA & VALLENTUNA (IKEA, n.d.)

And in the same vein Swiss outfit USM Haller has forged a reputation for modular furniture that can be easily added to, reshaped, and maintained. Each item is built using standard parts, so the people who buy them they can use and change their pieces over time, based on their requirements. This benefits long term use and reduces the wastage of materials it also shows the brand's dedication to durability and circular considerations (USM, n.d.).



Figure 19: USM Haller modular system - durable & reconfigurable (USM, n.d.).

In place of the promotion of use overuse, current thought is to encourage preservation and sustained interaction with the interior environment. Moreover, modular furniture, in particular, permits, in a more apparent manner than traditional furniture, the substitution, rearrangement and addition of the various components. This flexibility reduces waste, lengthens the life of furniture, and supports a sustainable consumer way of living. From an aesthetic perspective, modular systems afford versatility as well with the ability to refresh spaces channeled through approaches that rely on responsible design and sustainability.

To address these issues, companies are increasingly investing in research and transparency. Swedish company Bolon, for one, which makes woven flooring, creates long-lasting and recyclable floors powered by renewable energy. Their creations are a balance of artistic invention and sustainable ethics artistic because of design, sustainable because of the materials. As are Camira Fabrics and Kvadrat who also use natural and recovered fibres whilst striving for eco-accreditations in textile manufacturing and encouragement to the rest of the industry.

Advancements in technology are major contributors to the potential to create flexible, adaptive, and modular interiors in response to the changing needs of the user. This increasing trend of flexibility and sustainable design solutions attempt to reduce renovation and replacement activities, which may be environmentally damaging. By modular design, we mean the capability to assemble, disassemble and reassemble; whilst by adaptive design we mean the reconfiguration of furniture and interior elements for new programs of use, for user preferences, and to fit to the available space. Combined, these methods are not only

dramatically increasing the life cycle of interior furnishings but are also encouraging for a more sustainable style of consumption.

Lighting is a key aspect of the sustainable interior design, not just for its functional and atmospheric potential, but also for its contribution to creating spaces that are energy efficient. The British lighting company Tala has emerged as a top player in sustainable light design, blending smart style with low-energy LED technology and responsibly sourced materials such as wood, brass, and glass. Their belief is that beautiful lighting is a step toward climate action. Sourcing is also the focus of Tala, with the group promoting ethical sourcing, energy efficiencies and the lifecycle of materials, with all its wrapping recyclable. Their key collections are "Loop" and "Voronoi" which suggest long-term usability, beauty, and the principle of repairability (Tala, n.d.).



Figure 20: Tala's "Loop" and "Voronoi" lights unites (Tala, n.d.) .

What makes Tala different is its holistic view of sustainability. The company doesn't just design a product, but it is actively offsetting the carbon footprint by planting a tree for every product they sell and using renewable resources in every step of the manufacturing process to save waste in the environment. Tala takes a circular design approach, creating lighting products that are purpose built to be repaired, disassembled and recycled. This demonstrates how sustainability can be seamlessly incorporated into even the smallest facets of interior other than light bulbs bringing about a transformative effect on the environment (Tala, n.d.).



Figure 21: Tala lights deconstructed, showing repairable, sustainable design (Tala, n.d.)

Ultimately, Interior Design's Future is Influenced by Sustainability, Flexibility or Technology. Businesses and designers are using sustainable production methods, creating more multiuse and reusable products, and a designing with a circular process. The change is indicative of a more serious pursuit of interiors that are functions and beautiful but also respectful of environmental and community values.

The interior design industry, by putting sustainability at the heart of design, is participating in the creation of spaces that cater to wellness and sustainable resource management. And so sustainable interior design is emerging as a potent future force in creating an ethical, resilient and future-thinking built environment.

#### **4.5 Psychological and Social Impact of Sustainable Interior Design**

Interior design no longer involves simply making attractive spaces; it has an impact on mental health, physical health, social engagement, and ethical responsibility. An increasing number of studies point out that environment incorporating sustainable design principles, such as biophilic design, ethical material sourcing, and indoor environmental quality, heightens emotional wellbeing, lower stress levels, and stronger social relations (Mohsen, 2023). Through the importance of using natural materials and designing for environmental conservation one is not only shaping the physical landscape, but one is also developing attachment and responsibility toward nature and society.

By including natural light as an element of sustainable interior design, it not only plays a surface role as an aesthetic tool but also serves as a primary stimulus that helps create a harmonization between the human system and certain basic environmental rhythms. This

coordination is essential not only for the sake of physical homeostasis but for the preservation of reliable emotional balance and flexible mental workload. Without natural light sleep rhythms are thrown out of whack which can lead to mood disorders, executive function disorders, or general cognitive burning out. Therefore, sustainable design strategies that increase penetration of the daylight recreates a primordial sensorial conversation between individuals and the natural environment and further enhances the psychological coherence and existential well-being at the neuropsychological level (Zumkhawala, 2021).

While it's stylish to use greenery, natural materials and organic shapes in interior design, not only are these natural elements not simply used as decor, but they are also a very useful tool to boost comfort and make us feel more at home. The hardwired attraction to nature that evolutionary psychologists call "Biophilic design" is a set of inherited preferences about what we like for the most part see and are calmed by living things. Plants and natural textures and natural scents are not just beautiful add-ons; they give the brain subliminal messages that are strangely life affirming (Widayat, 2021).

Though it is trendy to incorporate plants, natural materials and organic shapes into interior design, it's not just for decor, these natural elements are also an incredibly helpful tool to enhance comfort and increase our sense of belonging. Evolutionary psychologists have dubbed this innate attraction to nature "biophilic attachment" an inherited set of preferences that for the most part cause us to feel calmed by living things. Plants and natural textures and natural scents are not just beautiful add-ons; they give the brain subliminal messages that are strangely life affirming. Plants, natural textures and natural scents are not only aesthetically pleasing; they provide the brain with unconscious signals of safety and life. Gazing at or feeling a complex natural shape provides a rest for the brain after sustained concentration and a kind of (subtle) mental refreshment. That is why sustainably designed, natural rich interiors help not only to make a lovely space but also provide a sense of safety, energy, and mental equilibrium (Celadyn, 2020).

In contemporary working spaces, sustainability in interior design is crucial not just in its support of being environmentally aware, but in driving human productivity and the overall nature of a business. Research suggests that natural light, non-toxic, and sustainable materials, as well as biophilic elements such as plants and natural textures, also contribute to increased engagement and emotional well-being of employees (Stringer, 2010). Sunlight exposure has been positively correlated with increased "serotonin turnover," which enhances concentration and emotional wellbeing both critical elements in stressful working

environments. Likewise, building with low-emissive, environmentally friendly materials prevents a build-up of indoor pollutants that cause headaches, breathing problems.

Beyond health, Sustainable workspaces are necessary to create a deeper psychological connection between employees and the organisations they work for. Research has found that those who work in a green-certified business are more likely to believe an emphasis is placed on ethical values, caring for others, enjoying greater appreciation and being supported (Swartz, 2020). And sustainably designed building workers also tend to be more loyal as employees, take less sick leave and demonstrate a greater sense of connection with the values of their employers. This means that the internal operation of sustainable interior design shifts from an eco-friendly commitment to an act of investment in human capital to build environments in which people, and organizations live and work together in harmony and flourish.



Figure 22: Sustainable vs. traditional office design comparison (Pinterest, n.d).

Designers that use ethically sourced and fair-trade certified materials are not only saving the environment but saving the world. They demonstrate that they care about fairness, about respect, about human dignity. Opting for these materials meant that the workers had safe jobs, were paid fairly for their work and could provide for their communities without anyone being exploited or abused (Hayles, 2015). For those who live in these environments, the reassurance of making an ethical choice makes them proud and comfortable. It serves as a link between the place and core personal values such as justice, honesty and kindness, and as a way of reinforcing self-esteem and emotional connections between people (Littrell, 2012).

Time spent in well-designed spaces can make us feel more psychologically secure. Places that feel human, natural, and real are naturally trusted by them. It is in these spaces people

recover from a hard day's work, are able to think more clearly and connect with others quietly. but more effectively, they create positive underpinnings for social well-being, encouraging empathy, openness, and mutual respect. This positive vibe helps establish communities where folks feel like they belong, can get involved, and learn together.

Sustainable interior design cannot only reach into our individual spaces but also reaches out into societal values and attitudes. When places like parks, libraries, workplaces and community centres are conceived with sustainability, equity and community well-being in mind, they demonstrate a culture of care and stewardship in these spaces of controlled silence, they convey principles such as respect for humans and the environment, and encourage, for example, appreciation of fair-trade, the conservation of natural resources, and respect for local crafts (Hartini, 2020). In time, these minor design decisions can help create communities where environmental responsibility and social justice are everyday attitudes, resulting in happier, more cohesive and more resilient societies (Williams, 2007).

In contemporary society, the significance of sustainable interior design as the one of the most essential responses to various serious problems that our societies encounter today is recognized more today than ever before. It helps on a mental level, as it cuts out harmful products and promotes natural, calming spaces, which translates into better mental health and well-being. At the same time, it nourishes communities by promoting cultural identity, preserving traditional crafts, and generating fair, ethical trade. Environmentally, sustainable designs help people save the world by reducing the number of non-renewable resources that are used, limiting their impact to the environment, and encouraging responsible purchasing behaviours.

Ultimately, sustainable design is more than creating environments that are beautiful and functional but rather a commitment to contributing to spaces that benefit both the people who inhabit them and the larger environmental and social systems to which they belong. Every product chosen, every space planned, and every design decision taken is working towards a future that is healthier, fairer, and more connected (Banihashemi, 2022). To operationalize these applications in practice, the next chapter examines the methodology used, describing the method, methods of data collection, and analytical methods used to see how sustainability is manifested in interior design decisions.

## **5 Case Studies of Corporate Practices and Residential Applications**

In response to increasing environmental challenges and the urgent need for more responsible resource consumption, the interior design industry is progressively embracing sustainable practices. This chapter focuses on how pioneering companies have implemented sustainable principles in innovative ways, such as materials applications, low-impact production processes, and long-term strategic planning. Such companies not only fulfil environmental targets in terms of emissions reductions and waste recycling, but they are also characterized by a high level of quality design and long product life. For these reasons they are important model examples for successfully integrating sustainable aspects during the development, production and life cycle of interior materials and furnishings.

By carrying out detailed case studies, this chapter demonstrates the necessity for combining environmental responsibility with financial viability and design quality. The case studies illustrate the breadth of sustainable design applications from circular material procurement and closed-loop recycling programs to energy efficient manufacturing and clear environmental certifications. These real-world examples offer critical insights into the challenges and achievements of companies breaking new ground in sustainable innovation and offer valuable perspectives to designers, researchers, and policy makers engaged in the advancing of sustainability in the built environment.

### **5.1 Bolon's Sustainable Flooring Applications and Expert Interview**

This case study shares findings of a qualitative interview with Håkan Nordén, Sustainability Manager, Bolon, a company known for their sustainable use of recycled material in resin flooring and carpets. In the interview Mr. Nordén stressed Bolon's continued support for sustainable policy. The company was founded more than 75 years ago and has consistently included recycling and the operations and utilization of materials and waste in production, he said. This early adoption of circular principles is evidence of Bolon's long-term dedication to sustainability in interior design.

To understand Bolon's role in sustainable interior design, it is essential to examine the company's historical background and foundational values. Bolon is a Swedish family-owned design company, known for its flooring concepts with the woven vinyl and a global leader in sustainable flooring and unmatched design quality. The company's roots go back to 1949, when Nils-Erik Eklund, the grandfather of the current owners, opened Bolon in Stockholm.

At the very beginning, the company focused on the manufacture of woven rugs from textile waste, which was one example of the early efforts to recycle production and sustainability, that still characterizes the company identity (Bolon., n.d.).

The name “Bolon” is derived from the Swedish words for “cotton” (bomull) and “nylon,” reflecting the materials in early textile innovations. Over the years, the company has continued to grow, always under the leadership and ownership of the Eklund family, evolving steadily while maintaining its core values of quality and environmental responsibility (Bolon., n.d.).

In the 1960s Nils-Erik’s son Lars and his wife Monica assumed management. They diversified Bolon’s product line to include mats for caravans, providing actual use for their woven products and laying the foundation for Bolon’s future in flooring. A major turning point came. In 1993, Bolon began producing wall to wall woven vinyl ground covering still an innovative move on the international design scene (Bolon., n.d.).

The real transformation began in 2003, when the business was taken over by the third-generation sisters Annica and Marie Eklund. Under the guidance of their visionary leadership, Bolon transformed the company into a new brand, where design, innovation and sustainability got together in a new combination. They transformed the firm from a traditional flooring manufacturer into an internationally recognized design brand. Partnerships with international star architects and design houses (Jean Nouvel, Missoni, and Tom Dixon,) helped establish Bolon as a maker of high-end commercial and residential design (Bolon., n.d.).

Bolon’s is based on conscious raw material choices, a clear commitment to integrating recycled and renewable material streams into the manufacturing process. By the end of 2024 Bolon successfully raised its recycled content of flooring products to 68%, far higher than the 28% just a few years before. This was achieved with the help of the local suppliers, covering a region with the radius of 250 km from its Swedish factory which brought down the emissions due to transportation and benefitted the sustainable supply chain prospects (Bolon, 2025).

In an interview, Mr. Nordin explained that Bolon employs high-performance plastic polymers in its flooring, making it “much more resource efficient” than wood or ceramic. The products incorporate the manufacturer’s commitment: it comprises 44% consists of chalk sourced from industrial marble waste, offering minimal climate impact; 36% is made up of recycled and BIO-sourced PVC, the latter derived from the pulp and paper industry’s waste streams;

and 15% includes environmentally conscious plasticisers that ensure product flexibility and longevity. Reinforcement 3%, stabilisers 1.7% and pigments 0.3% are added in small amounts and they are quite essential for preserving the functional and aesthetic properties of the flooring. Bolon thus exemplifies how sustainable material sourcing can be seamlessly integrated into industrial production without compromising on performance or design (Bolon, 2025).

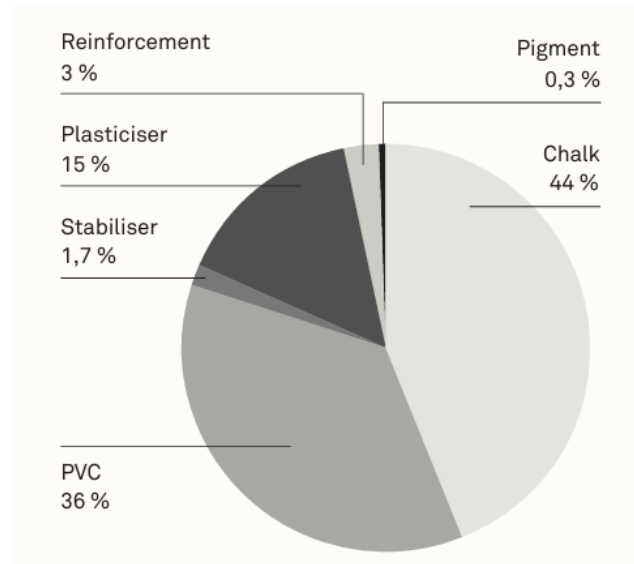


Figure 23: Distribution of Material Content in Bolon Products (Bolon, 2025)

In terms of performance, Mr Nordin emphasised that Bolon's flooring products are extremely durable and efficient, with a long-life cycle which can last as long as 25 years and an official warranty that spans from 10 - 15 years. Unlike traditional flooring solutions made from heavy materials like hardwood, ceramic, or stone, that require intensive maintenance, but the Bolon's woven vinyl flooring that the company provides only counts for about 3 kilograms per square meter. This not only simplifies installation and transportation but also enables a reduction of carbon emissions for the entire supply chain. Despite this reduced weight, they are also low maintenance, requiring no sanding, repainting, or polishing, which further minimizes environmental impact over their usage phase.

According to Mr Nordin, 2024 marked a milestone year for Bolon, as the company began offering climate neutral flooring, with an average climate impact of "0.2-kilogram CO<sub>2</sub>e" per square metre. This was achieved by the use of lower even negative climate footprint materials, including recycled PVC and production waste, which significantly lower the net emissions reduction throughout the product lifecycle.

Bolon's sustainability started with the realisation that raw materials have the largest environmental impact and are the source of around two-thirds of the overall climate footprint, as reported by life cycle assessments LCA conducted by the company. The remaining third, however, were generated during transport, installation, maintenance, and disposal. The chalk was found to have a near-zero climate impact and as such it formed a key ingredient towards climate neutrality from a materials perspective. The company also totally replaced a fossil-based PVC by a bio-sourced PVC and recycled PVC showing a negative carbon footprint under the "avoided emissions method." This method quantifies environmental benefits by substituting high-impact materials with more sustainable alternatives (Bolon, 2025).

Although plasticisers and reinforcement materials still contribute relatively high emissions per kilogram, considering (Figure 24), plasticisers have the highest particular emissions over "0.35 kg CO<sub>2</sub>e/m<sup>2</sup>" of a single material, with reinforcement at about "0.09 kg CO<sub>2</sub>e/m<sup>2</sup>". On the other hand, the use of recycled PVC as well as production scrap have a negative impact on the carbon balance, which are somewhat compensated for by the savings in more environmentally harmful components (Bolon, 2025).

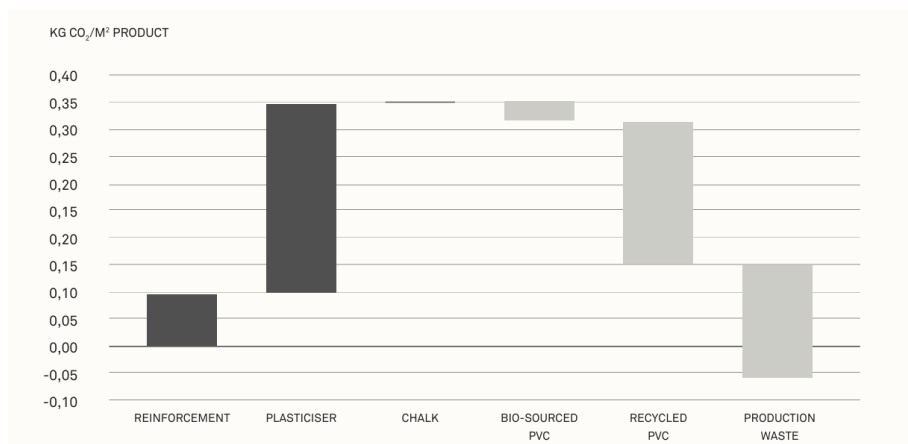


Figure 24: Climate Neutral Products (Bolon, 2025)

Bolon succeeded in reducing its overall climate footprint by 53% compared with 2018 by adopting these material strategies and innovations, exceeding global climate targets and establishing itself as the driving force in sustainable interior design. The company's range of products now represents a complete system of play offering performance, aesthetics and environmental responsibility (Bolon, 2025).

	Base year 2018	2022	2023	2024
Climate index	100	70	60	47
KG CO <sub>2</sub> per Swedish krona of turnover	0,030	0,022	0,020	0,014

Figure 25: Climate Overview (Bolon, 2025)

Bolon’s focus on sustainability is well documented with an impressive list of certifications, many of which are required due to the company’s global market presence. As stated by Mr. Nordin:

*"Yes, we have around 20 different certificates, because we sell to over 50 markets around the globe, and all countries or all regions have their own certificates."*

This global presence requires conformance to many regional and national health, safety, and environmental performance standards. Consequently, Bolon flooring is certified according to international standards, including ISO 14001, EPD, Green Tag, Floor Score, M1, CE, UKCA as well as on local markets such as Bggvarubedömningen “Sweden”, ECO product “Norway” and “Declare” (US).

CORPORATE RESPONSIBILITY		
ISO 14001	International	Internationally recognized standard for environmental management systems with systematic control and regular audits of our work to minimize our environmental impact.
EcoVadis	International	Evaluates how we manage environmental, social and governance risks and meet our sustainability goals. Also provides guidance to help improve our value chain and sustainability performance.
CE	EU	Label that verifies the product complies with current EU legislation regarding safety, health and the environment. It also sets requirements regarding the product's fire resistance.
UKCA	UK	Label that verifies the product meets UK health, safety and environmental requirements following the UK's withdrawal from the EU.
LIFE CYCLE PERSPECTIVE		
EPD	International	Environmental product declaration that describes the product's environmental impact throughout its life cycle. Verified by an independent third party. Created based on standards EN 15804 and ISO 14025. Published on <a href="http://www.environdec.com">www.environdec.com</a>
DGNB- Navigator	Germany/International	A platform that collects manufacturers' information on construction products. This information is required by planners and architects and is based on data from environmental product declarations.
GreenTag- Green Rate	Australia/ International	Assesses the product's overall health and environmental impact. Factors such as emissions and social responsibility are also evaluated to provide a comprehensive sustainability perspective.
INDOOR AIR		
M1	Finland/International	Classification with strict demands regarding low emissions to ensure good indoor air quality.
FloorScore	International	Certification with strict demands regarding low emissions to ensure good indoor air quality.
French VOC	France	French regulation that requires mandatory product labelling regarding emission classification.
NAAF	Norway	Cooperation agreement confirming that our products are recommended by the Norwegian Asthma and Allergy Association.

Figure 26: Summary of Bolon’s key certifications, their issuing bodies (Bolon, 2025)

## Case Studies of Corporate Practices and Residential Applications

PRODUCT AND RAW MATERIAL		
BASTA	Sweden	Registration with the aim of phasing out particularly hazardous substances in construction products. Our products and their contents are verified against specific criteria set by Basta.
Byggsvarubedömningen	Sweden	Our products are evaluated according to 'Byggsvarubedömningen', which examines chemical content, life cycle and sustainable supply chains. The aim of 'Byggsvarubedömningen' is to promote a non-toxic and sustainable environment.
ECOproduct	Norway	System that assesses products based on factors such as indoor air quality, substances hazardous to health and the environment, resource utilization and global warming potential.
eBVD- byggsvarudeklaration	Sweden	Construction product declaration that provides transparency throughout the construction phase. All our products have construction product declarations.
Kretsloppsmärkning i golvbranschen	Sweden	Information database that gives customers the opportunity to view the content of a product throughout its entire life cycle. Based on information from eBVD.
Best Practice PVC	Australia/ International	Environmental labelling of PVC raw materials. Manufacturers and raw materials are all assessed based on criteria such as manufacturing technology, energy use and presence of substances hazardous to health and the environment.
GreenTag-PHD	Australia/ International	Product Health Declaration proving that the manufacturer has provided a complete declaration of the product's toxicity. Raw materials are assessed from an environmental and occupational health and safety perspective during manufacturing as well as low emissions during use.
Declare	The United States	Platform where manufacturers declare product content. This facilitates the construction of houses that promote healthy conditions for people and the environment. Products are evaluated for compliance with Living Building Challenge, LEED and WELL.

Figure 27: Summary of Bolon's key certifications, their issuing bodies (Bolon, 2025).

In the interview, Mr. Nordin pointed out that around the world, the demand for environmentally friendly flooring has grown over the past five years. He stated that sustainability performance has become a key factor for customers when choosing flooring materials. While Bolon is in the Business to Business (B2B) space, the trend is universal, be it in Australia, Sweden, the US and Taiwan. Mr. Nordin also pointed out that the younger generations such as students and professionals are more and more aware of things like climate change and circularity and are actively seeking materials that align with these values. Such a transition of consumers supports Bolon's strategy of focusing on its low-carbon, circular products.

As a company on the circular economy principle when it comes to both products and design. This model is designed to minimize waste by prolonging the life of products, and recycling or reusing them rather than disposing of them. In this spirit, Bolon is purpose developing its durable flooring to be taken back, recycled, and fed back into the manufacturing flow, minimizing its dependence on virgin resources and minimising harm to the environment. In this framework, Bolon manufactures durable flooring solutions that are 100% recyclable and designed to be reprocessed and reintegrated into new production cycles (Bolon., n.d.).

Considering that the materials used are specifically engineered for longevity in recycling states Mr. Nordin, Director: "Our flooring and rugs are made with recycled material and can be recycled again, The PVC polymer in our products can be recycled seven times or more. The chalk can be recycled infinite times."

This closed-loop system reflects Bolon's on-going dedication to minimise waste and preserve resources. The recycling process does not rely on third-party systems, allowing the company to maintain full control over the material flow and ensure traceability and quality. Mr. Nordin talked about, *"At Bolon, we have our very own recycling plant, where we can recycle our own products if no permanent adhesives have been used, and the floors originate within the EU."*

In addition to this Bolon, has launched take-back initiatives so that clients can send back their used flooring to be recycled back into the production process. Although still at a limited scale, these programs illustrate Bolon's intent to transition from a linear to a circular production model. But as Mr. Nordin emphasized, the biggest problem is not technical capabilities, but logistical and bureaucratic in those operations:

*"It's a pilot in scaling. If people ask, we can offer it, because we have the machinery and we know how to do it, we have done it many times. But when it comes to take-back, it's not a technical issue. It's about logistics: moving flooring across borders, import - export regulations on waste, and how to dismantle, package, and transport the old floors. These are the real challenges, and they are shared by all manufacturers in the industry."*

This observation raises the more systemic challenges of companies such as Bolon that are working to develop circular production on an international market level. Even if the technical infrastructure is working, well designed regulatory frameworks and logistical operations across countries are necessary for these programs to succeed.



Figure 28 Flooring Designs by BOLON (Bolon., n.d.)

Ultimately, Mr. Nordin discussed the importance of government support in activating circular economy systems on a large scale. He also explains that companies like Bolon are technically capable of recycling their flooring, however, such a system cannot work as long it is not coordinated at an industry level, and that it is not easy to manage this system even for larger companies, as logistics and organization would be a big issue if they wanted to do this on their own. He urged more robust national and European regulatory frameworks to aid recycling systems and help to move materials between regions. Mr. Nordin thinks government legislation and institutional collaboration will be essential to accelerate the transition from a linear to a circular economy.

The case study of Bolon highlights the possibilities that exist with regards to integrating sustainable practices into the interior design sector, using new materials to create products on a circular basis and a commitment to environmental responsibility. With the company has achieved significant progress in reduction of its carbon footprint and driving recyclability, it still sees challenges in logistics, regulatory framework in certain countries and how scalable take-back systems are. Bolon's experience can provide a useful way forward for sustainability in design and act as a pragmatic exemplar for other collaborators to take circular and more eco-conscious strategies on board.

### **5.2 Kvadrat's Sustainable Design Practices and Environmental Impact**

Kvadrat was chosen as a case study, creator of sustainable practices in the interior design industry. The brand is known for being environmentally conscious, responsibility through the use of innovative, eco-friendly materials and circular production methods. Kvadrat integrates into every stage of its design and manufacturing processes, from material sourcing to product use, maintenance and recycling. This renders it a suitable research subject for the investigation of applications of sustainable design. In addition, Kvadrat's methodology is closely related to the purpose of this study, the evaluation of the environment and economic impacts of the sustainable interior design solutions. By analyzing Kvadrat's strategies, material choices, and sustainability initiatives, the research aims to provide useful information on how eco-design can be effectively applied in the field.

Kvadrat is a Danish textile company established in 1968 in Ebeltoft, Denmark, by Poul Byriel and Erling Rasmussen. Established with principles of simplicity, quality and functionality at

its core, Kvadrat continues to be a consistently innovative and influential voice in the contemporary textile landscape for modern interiors. It had a breakthrough success with the introduction of Nanna Ditzel's hallmark Hallingdal 65 fabric, which was the very first fabric launched by Kvadrat when the company was founded. This textile became an enduring classic, widely used in public buildings, transportation, and homes across Europe (Kvadrat, n.d.).

Kvadrat is now one of the leading companies in contemporary textiles, collaborating with leading designers, artists and architects. The company has 49 showrooms and operates in 22 countries, with a wide client base across Europe, Asia and North America. Its portfolio of products for residential and commercial applications offers the finest in design and material quality, from traditional to modern, a variety of colours and finishes, and innovative performance. The company's main products are upholstery and curtain fabrics, acoustic panels, rugs, roller blinds and innovative recycled composite surfaces (Kvadrat, n.d.).

Kvadrat also develops innovative recycled material surfaces through its brand Kvadrat Really. In addition, Kvadrat also enhances its offering with exclusive sub brands Sahco, dedicated to superior soft furnishings, Kvadrat-Raf Simons for fashion influenced textiles, Febrik for 3D knitted fabrics and Magniberg, for modern bed linen and home accessories.

- Sahco: Known for opulent, timeless soft furnishings, as an expert in the fine field of interior textiles velvets, sheers and jacquards, products can be seen throughout high end residential and hospitality projects.
- Kvadrat-Raf: Kvadrat-Raf brings the world of fashion and interior together by playing with bold textures, colour combinations and choices, and material fusion to blur the lines between fashion and furniture design.
- Febrik: This sub brand for 3D-knitted textiles has stretch, tactility, and visual depth. For contemporary furniture. Febrik fabrics are ideal for modern furniture, bringing softness and innovation to seating design.
- Magniberg: A design lifestyle focused sub brand offering modern bed linen and home accessories. Magniberg is a fashion led concept inserting a fresh stylistic language into bedroom interiors.

Together, Kvadrat's product range and sub brands serve a wide array of environments, including homes design, public spaces, offices, hotels, and cultural institutions around the world consistently prioritizing sustainability, design innovation, and collaborative creativity.

Kvadrat initiated its sustainability journey early on, as sustainability has been a fundamental element of Kvadrat's design philosophy and corporate culture since its foundation. In 2013, primarily for residential and commercial applications, these products add a rich aesthetic to homes and business. Building on this commitment, Kvadrat began systematically exploring resource optimisation through recycling, reuse, and upcycling of yarns and textiles in 2017, laying the groundwork for its more structured circular economy efforts. This commitment marked a significant step towards integrating sustainability into its business model. Kvadrat is committed not only to researching cutting edge recycling practices but to constantly finding new methods to minimize environmental impact through considered design and responsible sourcing of natural and synthetic materials, making it one of the leaders in sustainable textile manufacturing (Kvadrat, 2024).

In the manufacture of Kvadrat textiles, the use of light, clean and environmentally responsible materials is of foremost importance, in considerations for quality, durability, and aesthetic values. According to Kvadrat's 2024 Sustainability Report, the composition of raw materials across its textile collections is as follows: 43% regenerative materials natural wool and plant-based fibres, 31% synthetic materials recycled polyester from PET bottles and textile waste, and 26% recycled materials, inclusive of recycled content sourced from both pre- and post-consumer waste. Wool remains an essential material due to its durability, natural resilience, resistance to wear, and biodegradability, making it ideal for high traffic interior environments (Kvadrat, 2024).

Kvadrat is becoming increasingly focused on post-industrial and post-consumer textile waste. Another key input is recycled polyester is made from PET bottles and textile waste, helps lower environmental pollution, by recycling its own production scraps, including wool and polyester, company reduces energy use decreased dependence on fossil-based virgin plastics. and the company is investing in traceability and transparency by publishing Environmental Product Declarations (EPDs) for over 100 of its textiles. These third party verified documents provide transparent environmental information about the life cycle impact of each product, including carbon footprint, energy use, and further recycling details. A prime case in point is Kvadrat Fabrik's partnership with suppliers to create a 100 % recycled yarn made of 60 % production waste and 40 % post-consumer polyester, a significant success in the sustainable textile solutions arena (Kvadrat, 2024).

Kvadrat is about making textiles that are strong and durable, which is why many of its products are rated to over 100,000 Martindale rubs a measure of abrasion resistance in the textile industry and how well a fabric will stand up to wear and tear from repeated use. This

makes them suitable for busy places such as offices and hotels while retaining touchable softness and stylized looks. Due to the extended durability of these fabrics, you don't need to replace them as often, so money is saved, and the environment is spared. Kvadrat also works according to a "design for disassembly" principle, so that the textiles can be easily removed from furniture and reused or recycled further serving its sustainability goals of waste reduction an approach that aligns with the company's broader vision for circularity and sustainable design (Kvadrat, n.d.).

By supporting sustainable material innovation, Kvadrat consolidates its position as a leading force of environmentally cognisant design. One of its standout projects is the collaboration with Ocean Bound Plastic Waste. In collaboration with Kvadrat, the company has developed new material with solid recycled fibre from plastic bottles collected from the ocean. A product of this process the Diade fabric is a high-quality upholstery fabric manufactured wholly from 100% recycled polyester. This initiative serves to underline Kvadrat's work on reducing global plastic waste and protect our marine environment. Through ongoing research and collaboration with designers and suppliers, Kvadrat is still a leading force in the sustainable textile solutions for the interior design field (Kvadrat, n.d.).



Figure 29: Kvadrat's circular process—plastic waste to yarn (Kvadrat, n.d.).

A subsidiary of Kvadrat, Kvadrat Really has its sights set on reshaping the way in which end-of-life textiles are regarded, transforming them into high-quality, circular materials for interiors. This is based on a deep commitment to sustainability, with a focus on reducing textile waste, extending the lifecycles of valuable resources, and responsible material innovation.

One of its flagship products, Textile Tabletop™, exemplifies this approach. Each panel is upcycled cotton and wool from the textile industry and combines about 70% recycled textile fibres, 20% binder made of industrial waste, and 10% bio-based binder that comes from a renewable source. The result is a hard-wearing, durable surface that can work as well at home and office, offering the same functionality as conventional materials but with a significantly reduced environmental footprint (Kvadrat.Really, n.d.).

The production of Kvadrat Really takes place in a fully circular system that aims to upcycle textile waste into sustainable materials with the least possible environmental impact. It starts with the collection of post-consumer and post-industrial textiles, from laundries, and fashion waste, etc. These are then separated into fibre types and colours for material consistency, cut into short fibres, and combined with an environmentally friendly binder. The fibre blend is made into sheets without the use of water, via a dry, chemical-free process known as “Airlaid”. The sheets are then pressed at specific temperature and pressure conditions to form finished products, including Textile Board and Textile Tabletop™ (Kvadrat.Really, n.d.).

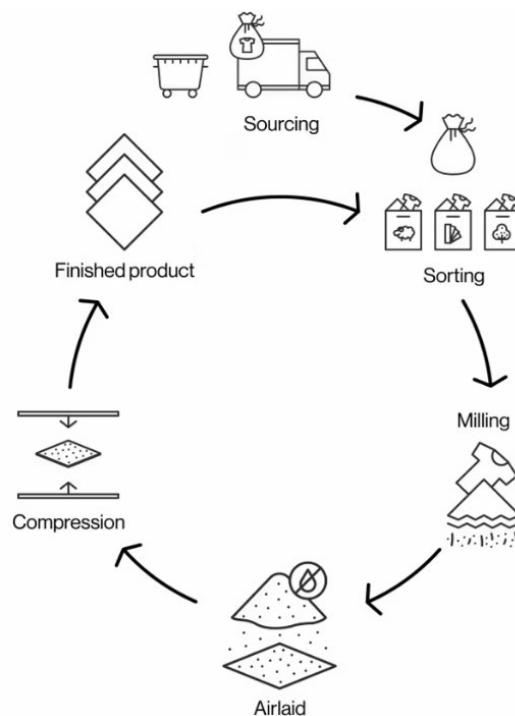


Figure 30 Kvadrat Really's Circular Manufacturing Process (Kvadrat, n.d.)

Textile Board is designed for all interior applications from architectural. It is widely used in furniture construction, such as cabinet fronts, shelving, and drawer panels, and wall covering, room dividers, and acoustic panels. Its distinctive texture and subtle colour variation, retained from the original textile fibres, contribute to a warm and natural aesthetic. In addition to its visual appeal, the material offers high structural integrity, making it well-

suited for demanding environments such as offices, such as offices, schools, shops, hospitality venues and private houses. As an eco-conscious, long life alternative to traditional sheet materials, Textile Board contributes to circular design practices as well as improved environmental performance for interior architecture.

The final products are all 100% recyclable and have been designed to re-enter the production cycle after their use, the company noted, confirming its adherence to circular economy principles. Every panel, which measures 800 x 1600 mm, requires as much as 70 discarded T-shirts, and the carbon footprint is up to 75% lower than competitors made through conventional methods. No chemicals, clean water, or colorants are used natural fibre colours are preserved during processing (Kvadrat.Really, n.d.).



Figure 31: Kvadrat Really circular process—waste to Textile Tabletop™ (Kvadrat.Really, n.d.)

Through this model, Kvadrat Really shows how its products are part of a low-impact, circular future, proving that it is possible to produce high quality materials and products that challenge the status quo of industry practises. (Kvadrat.Really, n.d.)

Kvadrat's sustainability strategy embraces more than product innovation and choice of materials, it includes holistic environmental and social performance that mirrors the company's values as a responsible business. As per the 2024 Sustainability Report, Kvadrat continues to demonstrate measurable progress in reducing its environmental footprint while advancing workplace equality and ethical governance.

Environmentally, Kvadrat manage to reduce its direct and indirect operational greenhouse gas emissions by 11% compared to the 2019 baseline, which is in line with the science based target of a 50% reduction by 2026. The company has also enhanced transparency by releasing Environmental Product Declarations EPDs of more than 148 products the equivalent of 55% of sales and is aiming to achieve 70% by 2025 (Kvadrat, 2024).

In addition, Kvadrat has a water intensity of 66 m<sup>3</sup> /ton for textile, 29% above that of 2013, which shows a room for improvement. Material usage wise, 67% of its packaging already uses recycled content, with an aim to reach 100% by 2030. 10% per ton of textile waste intensity is estimated and a challenge to reduce it to 7.5% by 2030 (Kvadrat, 2024).

Kvadrat is a market-leading manufacturer and supplier of design textiles for both contract and residential interiors, paying equal care and attention to environmental and social concerns. In 2024, the company reached full validation of its net zero target from the Science Based Targets initiative SBTi which certifies that its commitment is in line with the 1.5°C climate trajectory of the Paris Agreement. Additionally, Kvadrat increased the number of Environmental Product Declarations EPDs, to more than 148 products, which provide 55% in revenue and targeting to reach 70% in 2025 (Kvadrat, 2024).

Table 6 Key Environmental Performance Indicators of Kvadrat 2024

Indicator	2024 Result	Target / Notes
Greenhouse Gas Emissions (Scope 1 & 2)	11% reduction from 2019 baseline	50% reduction by 2026 (SBTi aligned)
Products with Environmental Product Declarations (EPDs)	148 products (covering 55% of revenue)	70% of revenue by 2025
Water Intensity	66 m <sup>3</sup> per ton of textile	Reduce to 30 m <sup>3</sup> per ton by 2030
Packaging from Recycled Materials	67%	Target 100% recycled content by 2030
Textile Waste Intensity	Estimated 10% per ton	Target 7.5% per ton by 2030
EU Ecolabel Certified Products	42 products	Recognition of environmental compliance
Net Zero Target Validation	Achieved (Science-Based Targets Initiative)	In line with 1.5°C climate trajectory (Paris Agreement)

Furthermore, Kvadrat promotes sustainable construction standards, and its products are compatible with major international environmentally friendly certification forms, including BREEAM, LEED, DGNB, and WELL. These systems assess the sustainability of buildings under several criteria, such as indoor environmental quality, emissions reduction and user well-being. Kvadrat textiles and acoustic solutions help achieve these certifications thanks

to third-party verified EPDs, low-emission materials, high acoustic performance and a verified lack of harmful substances (Kvadrat, n.d.).

In that regard, the Company's product innovation PFAS-free and recycled product line reflects the material health and life cycle assessment measures contained in these certifications. The strategic alignment with building certification schemes further complements Kvadrat's leadership in the field of sustainability, enabling architects and designers to raise the performance bar when it comes to environmental standards in contemporary interior environments.

### 5.3 Practical Implications of Sustainable Interior Design

#### 5.3.1 Experimental Haus R128, German

Developed by the German architect and engineer Werner Sobek and completed in 2000, the R128 House is a pioneering prototype of sustainable housing in Stuttgart, Germany. Positioned on a steep hillside, the home is a study in how new methods of building construction can bring about sustainability. It reflects a new perspective that defines the relationships between architecture, energy and living spaces. The building's all-glass exterior, minimalist interior, and modular systems all serve the broader goal of minimizing environmental impact without compromising on design quality and function.



Figure 32: Figure: Experimental haus R128, Stuttgart (Halbe, n.d.).

The construction is of a lightweight steel frame carried on 12 columns with a features four-storey and an approximate open plan living space gross floor area of 250 square meters. Prefabricated components were used throughout, facilitating rapid assembly and disassembly without permanent fixings. Whole envelope is constructed of 3-glazed glass, provides excellent insulation and extensive natural daylight (Ferreira Silva, 2020). The

exterior transparency does not infringe on privacy, courtesy of the building's height and the reflective nature of the glass that are sufficient in offering privacy for the users.

A central principle guiding the design is Sobek's "Triple Zero" concept-zero energy consumption, zero emissions, and zero waste. Zero energy on site photovoltaics power the entire building, producing 100% of electricity demand, approximately 10,000-12,000 kWh per year, enough for a family of four, zero emissions zero CO<sub>2</sub> emissions while in operation as no fossil sources are used entirely based on renewable energy, zero waste 100% of building materials are recyclable or reusable and there are no wet finishes or adhesives (Sobek., n.d.). The building is self-sufficient for energy production with rooftop-mounted photovoltaic arrays and requires no external source or power system. It also doesn't emit anything while in operation, all owing to its dependency on renewable power and passive environmental features. Crucially, all the materials used in the build are recyclable or have been chosen for future use, designed to render the house entirely demountable and environmentally circular (Sobek., n.d.)

Internally, the house breaks away from traditional compartmentalization. Everything inside is open, except for the bathrooms, where inhabitants can set and expand the space with modular, transportable furniture, rather than fixed partitions. This adaptability allows for shifting needs overtime whilst limiting material risorius renovation. The furniture and finishes are chosen for their simplicity, durability, sustainability of material and low environmental impact, in keeping with the idea of minimal resource consumption and functional transparency (Sobek., n.d.).

Also, environmental control is managed through innovative systems integrated into the ceilings and floors. Radiant heating and cooling are delivered via copper pipes embedded in aluminium ceiling panels, while ventilation is achieved largely through natural airflow enabled by operable window segments. Lighting is designed to be energy-efficient and is embedded into ceiling modules that also provide sound absorption. These systems are hidden, yet readily available, enabling maintenance and renewals without invasive impact (Sobek., n.d.).

The use of construction materials underscores durability and circularity. The steel structure has a lifespan exceeding 75 years, glass the structure for their recyclability and robustness. Timber has been employed on the floors as a renewable resource that can be reused or removed from the house with minimal intervention. and aluminium parts are rustproof and form part of the overall mechanical system. Everything is connected mechanically nothing

is glued or welded thus, allowing the entire structure to be dismantled and reassembled in another shape or different context (Sobek., n.d.).

Although the initial construction costs were relatively high, such advanced technology and custom designed systems have contributed to the economic sustainability of the R128 House with its low operating costs and low maintenance demands. The elimination of energy bills and the durable, flexible design contribute to significant savings over the building's lifecycle, making it an economically responsible model in the long term.

From the perspective of sustainable interior design, R128 is a significant reference project. It challenges traditional norms through its transparent envelope, fluid interior spaces, and integration of building systems. The house demonstrates how aspects as environmental performance, material sustainability and user adaptability can find a balance with modern housing. Unlike the common procedures of the interior, which are characterized by inflexible floor plans and high resource use, R128 presents a viable and inspiring alternative that aligns closely with sustainable design principles.

### **5.3.2 DH IV Apartment, Belgium**

With a few experimental models like the R128 House spread all over the world, a significant portion of contemporary residential buildings, still adhere to conventional design and construction methods. These traditional approaches often overlook long-term considerations regarding environmental impact, spatial adaptability, and material lifecycle.

An example of such is DH IV housing block in Kortrijk, Belgium constructed at the end of the 1960s. Before deep renovation, DH IV was a place with very poor thermal performance and energy efficiency. Apartments suffered from high heat loss due to uninsulated façades with U-values as poor as  $2.2 \text{ W/m}^2\cdot\text{K}$  and obsolete double-glazed windows reaching  $5.8 \text{ W/m}^2\cdot\text{K}$ . The building had a central gas-fired heating system with badly insulated piping throughout the building, resulting in excessive heat loss on the way to residents (Van de Putte, 2025).



Figure 33: Drie Hofsteden project (Van de Putte, 2025)

Additionally, traditional materials such as concrete, brick, and gypsum board require a large amount of energy to produce and pose significant recycling challenges. Common finishes like PVC flooring, synthetic paint, and composite cabinetry often contain harmful VOCs, contributing to indoor air pollution, and typically have short lifespans. In the case of DH IV, continuous redevelopment has generated substantial demolition waste, further harming the environment.

The environmental control systems of these buildings are usually relied on fossil fuel based centralized mechanical heating, ventilation and lighting. In DH IV mechanical ventilation scarcely existed with open window operation being the only way to let in fresh outside air, even during cold conditions giving poor thermal comfort. Such outdated systems result in high operational energy consumption and the IAQ to be compromised.

Energy consumption for space heating and domestic hot tap water in one flat in DH IV ranged between 12,000 and 14,000 kWh per annum values that in no way meet the current definition of low-energy building. In addition, above average indoor temperatures were higher amongst elderly residents who spent more than 95% of their time indoors thus creating an additional burden of energy inefficiency on user behaviour (Van de Putte, 2025).

Economically speaking, traditional apartment buildings are usually built to house at that time and at as little cost as possible. But this may result in long term costs tending to increase such as maintenance, energy requirements and regulations. Without substantial renovation, buildings like DH IV risk becoming both economically and environmentally obsolete, particularly because of growing urban sustainability policies.

By contrast, sustainable prototypes such as the R128 House prioritize integrative environmental strategies, including high-performance envelopes, renewable energy systems, modular construction, and reusing materials to reduce waste. These models represent a shift away from industrial-era, mass-produced housing toward user-centric,

adaptive, and environmentally responsible alternatives. Therefore, conventional apartment buildings represent a critical domain for reform technically, behaviourally, and legislatively if urban environments are to meet sustainability objectives.

### 5.3.3 Bahnstadt, Germany

Bahnstadt in Heidelberg, Germany, is the largest urban development ever built entirely to Passive House principles. Such strategies can be primarily translated into how energy can be effectively implemented, as is seen here in these 116 hectares site district (Bahnstadt, n.d.). Some of the main design features that contribute to this are optimal siting for solar gain, high performance insulation and the use of thermal mass material like concrete to retain cooler daytime temperatures.

All of these elements work beautifully together to reduce the usability of mechanical heating and cooling systems. Additionally, the energy needs of Bahnstadt are supplied by a wood powered combined heat and power CHP plant that provides 100% renewable energy (Bahnstadt, n.d.). Smart electricity meters installed in discovery on homes provide those who live there with real-time data about energy usage and encourage energy efficient behaviours. Sustainable urban drainage SuDS systems, green roofs and similar systems are also installed across the district, serving as both part of the biodiversity and the rainwater management.

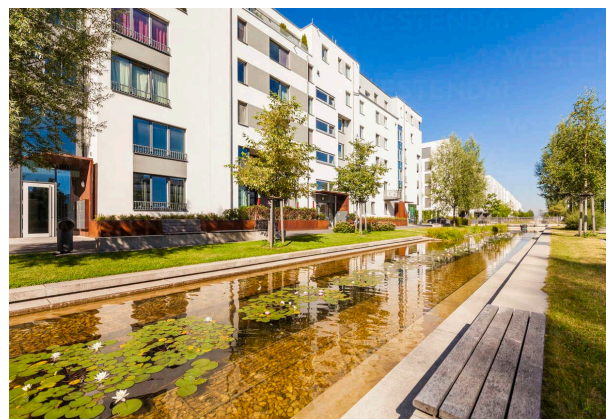
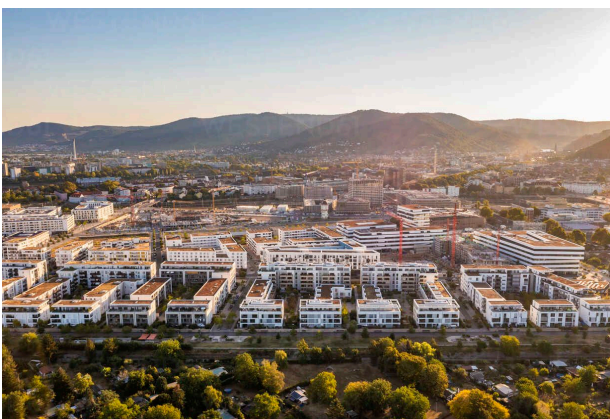


Figure 34: Bahnstadt, Heidelberg - Passive House applications (Bahnstadt, n.d.)

### 5.3.4 The Edge, Netherlands

The Edge in Amsterdam achieves a prominent level of sustainability and intelligence through a carefully considered set of active energy strategies complimented by a user-centric design philosophy from building architects, PLP Architecture. The interior design used in The Edge improves the environmental performance of the building substantially, as the materials were based on LCA. All finishes covering all interior components are low embodied energy and have all been designed to be able to be taken apart and recycled at the end of life. Spread over 40,000 square meters, the building houses an Ethernet powered LED lighting system with motion and daylight sensors that ensure the automatic adjustment of lighting, depending on the occupancy and the direction of the sunlight, using up to 90% less energy (Jalia, 2019). Its innovative HVAC system enables workers to adjust lights and temperature in their immediate surroundings through a smartphone app, providing personalized comforts that increase overall well-being.

The Edge workspace is designed to be flexible by utilizing adjustable furniture and dynamic spatial planning that can be rotated and tweaked for the user's ever-changing demands. A smartphone app enables employees to reserve workspaces and personalize lighting and temperature settings according to lighting and temperature to suit personal schedule. These functions are supported by a network of over 30,000 sensors that gather real-time data on occupancy, air quality, and lighting conditions, enabling predictive maintenance and energy efficiency without compromising user comfort (Jalia, 2019) (Architecture, n.d). The internal spaces are flexible, creating new work zones for focus, collaboration and serendipitous engagement and promoting not only productivity, but also the health of occupants, in a technology sensitive place.

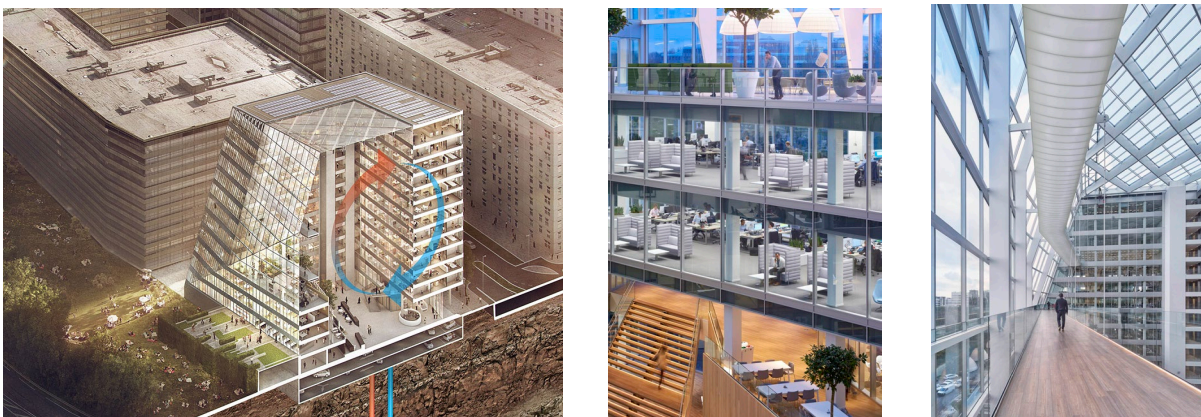


Figure 35: The Edge – Sustainable and Smart Building Design (Jalia, 2019)

The building's interior design also supports its health and sustainability on the inside as well, with high-performance accolades that include BREEAM-NL Outstanding rating of 98.36% and WELL Core & Shell Platinum. These awards highlight the project's achievement in balancing sustainable strategies and user comfort, making The Edge a leading case of smart environmental design and sustainability interior design (Architecture, n.d) (Jalia, 2019).

In addition, its intelligent systems, its interior design has been conceived to promote a healthy and enjoyable work environment. It incorporates natural elements indoor plants, wood textures, and a whole lot of daylight to create a more peaceful space. The massive central atrium links all the floors and draws natural light deep into the building. Offices rooms have open space, lounge areas, and green walls that encourage people to relax, interact, and be creative. The mix of natural and technological elements results in a harmonious, comfortable environment for everyone (Architecture, n.d). The Edge is a great example of sustainable interior design, this mix of natural and technological elements results in a harmonious, comfortable environment for everyone. also to create buildings that save energy, improve well-being, and support a better future.

Bahnstadt, The Edge, DH, and Haus R128 demonstrate that sustainable architecture and interior design are not merely extensions of traditional design principles focused solely on energy management. Instead, they represent a fundamental shift that integrates both passive and active energy efficiency strategies. These approaches not only reduce environmental impact but also enhance human comfort and well-being within residential and commercial spaces. The projects have shown that a ten-fold reduction in energy consumption is achievable without compromising occupant comfort or architectural design quality. By blending natural climate control, advanced technologies, and low-impact materials, these case studies position sustainable interior design as a powerful driver of positive environmental transformation.

## **6 Research methodology**

### **6.1 Methodology overview**

This research adopts a comparative qualitative methodology, drawing together extensive secondary research with primary data was collected through expert interviews, conducted as part of an in-depth investigation into selected applications and companies specializing in sustainable finishes. This methodological framework is developed in order to meet the in-depth research objectives to assess and evaluate the economic feasibility, the sustainability and the environmental impact, and durability of sustainable designs in interior space relative to non-sustainable technique. To investigate the industry's views and gain a detailed understanding of the practical application and issues of interior design for sustainability a qualitative approach is considered as most appropriate.

First, an extensive review of relevant literature, including scholarly articles, industry reports, and case studies, establishes the theoretical foundation, and informs a comprehensive understanding of current knowledge and practice in the areas of sustainable and conventional design of interior space. This literature review synthesizes existing academic insights, cost analyses, durability assessments, environmental impact, and industry trends have been synthesized in this literature review. It includes regulation aspects affecting adoption of sustainability in interior spaces, which provide the theoretical framework for the comparative analysis.

Second, a qualitative interview was conducted with a company specializing in sustainable interior design and the production of environmentally friendly materials. This purposeful selection is intended to offer practical insights into the sustainable concept with regard to the aspects of cost control, materiality, durability and environmental strategies. While the initial research design included the intention to interview companies following traditional design approaches, this was not feasible due to a lack of transparency and limited willingness to share information on their processes. However, the compiled information provides valuable insights into the application of traditional and sustainable design principles.

Detailed Description of Research Dimensions:

- **Economic feasibility:** This dimension involves a thorough comparative evaluation of the financial aspects related to sustainable and traditional interior design practices. It includes the assessment of initial procurement costs, long term maintenance

expenses, operational costs, lifecycle financial benefits, and potential economic barriers to adopting sustainable solutions. The literature review sets a theoretical bottom line combined with available cost analysis studies and industry data and the interviews compliments this analysis by bringing perspectives from practical experience to the field to the research on cost in sustainable design. The aim is to determine whether the long-term financial benefits of sustainable practices can outweigh the often-higher initial investment.

- **Durability:** The second dimension studies the durability, resistance and performance of sustainable and traditional inner materials. Important considerations are maintenance, ease of repair, and resistance to environmental conditions. Lifecycle assessments and performance data are matching this dimension with the literature review, while interview with industry experts provide real world validation and insights. This combination approach helps to ground theoretical expectations about durability, considering real world experience.
- **Environmental impact:** This dimension analyzes the environmental consequences and resource consumption patterns associated with each design approach. Factors are wood source, energy efficiency, carbon footprint through life cycle of product (production, usage and disposal), and adherence to environmental certification standards like LEED, BREEAM, and ISO. The literature is used to contextualize environmental benchmarks and regulation, while interviews and case studies provide insights into practical implementation and observed environmental benefits.

The study is exploratory, aiming to gather insights from existing literature and professionals within the interior design industry. By addressing these aspects, the research contributes valuable knowledge to the discourse on sustainable interior design. bridging the gap between theoretical benefits and practical implementation.

### **6.2 Qualitative Analysis – Content Analysis**

Considering the overall thematic coverage of sustainable interior design in this thesis, a qualitative content analysis is applied as the main methodological. This approach enabled a systematic identification of recurring themes, patterns, and narratives across a broad spectrum of sources including academic literature, industry reports, case studies, and interviews with companies actively engaged in sustainable practices in this area.

Analysis was structured through four fundamental analyses: environmental sustainability, economic sustainability, aesthetic functional sustainability, and psychosocial. Environmental sustainability combated carbon emissions, fostered circular economic habits and added recyclable renewable materials. The financial aspect included LCCA, long-term economic benefits, and the available financial bonuses. Aesthetic and functional sustainability questioned the way in which contemporary design concepts embrace eco-friendly materials, focusing on natural textures and imperfections and not forgetting about functional characteristics. The psychosocial impact factor encompassed the impact of elements like natural light, biophilic design details, and ethically sourced materials on user well-being, productivity, and lived cultural or societal values.

Pivotal findings from the analysis reveal a global shift, sustainable interior design has evolved from being a secondary consideration to a central design philosophy that influences material selection, spatial layout, and operational strategies. Terms such as “circular economy,” “waste reduction,” and “modular design” frequently emerged, demonstrating a pretty strong agreement on flexibility and resource efficiency.

Although high initial costs for sustainable materials emerged as the most common challenges, the content also revealed a strong movement for innovative solutions, including 3D-printed earth composites, smart lighting systems, and AI-powered design simulation tools, to counter economic limitations.

In contemporary sustainability driven age, interior design embraces minimalism, natural textures, and celebrates imperfections as expressions of character and authenticity. The qualitative content analysis highlights that sustainable interior design has moved from being an optional element to a multidimensional practice that is now essential. Ideas around circularity, cost and aesthetics and human well-being suggest a holistic design ethos that values environmental stewardship over time as much as practical and emotional response.

Recognizing these interrelated patterns allows designers and stakeholders to develop solutions that deliver beauty, performance, and sustainability, yielding interior spaces that are not just visually intriguing, but also sensitive to social needs and ecologically responsible.

### **6.3 Data Collection**

Information for this research was collected from two main sources to ensure both a broad and in-depth understanding of traditional and sustainable interior design practices. An extensive literature review took place to review existent literature on environmental, economic and social aspects of interior design. This was complemented by in-depth interview with Bolon company that produce sustainable interior design products and implement them in real-world projects.

This research was based on the literature review, where it provided the historical background, current trends, sustainable material and methods as well as existing framework and guideline for sustainable design. This was complemented by the interview and case study which delivered the industry point of view and realistic applications, contributing more practical knowledge, applications and future challenges.

The interview with sustainability manager by Bolon company and product, offering insights into how sustainability principles are integrated into material production and design processes. The company were selected based on their participation in sustainability certifications, usage of recycled and renewable materials and their adoption of circular economy principles. Interview questions were semi-structured, and the respondent were encouraged to expand on issues like sourcing, durability, environmental impact, and market demand.

Such interviews enhanced the qualitative data obtained with practical experiences, challenges and solutions, thus supporting the theoretical framework of literature. The combination of these sources allowed for a comparative analysis that addressed both macro-level theoretical insights and micro-level, company-specific realities. In addition, the interview findings helped identify future directions, innovation gaps, and opportunities in sustainable interior design, providing important information for evaluating the feasibility and applicability of sustainable alternatives.

#### **6.3.1 Literature Review**

The literature review provides a comprehensive foundation for understanding the theoretical and practical dimensions of sustainable versus traditional interior design. It investigates the scholarly and professional literature to inform the development of environmentally responsible design practices and evaluate their long-term feasibility and performance. This

review encompasses all kinds of sources like academic papers, theses, technical reports, or industry cases.

Key areas of the literature are:

The research on sustainable interior design explores themes such as psychological impact, circular economy, and energy efficiency (Hayles, 2015). emphasizes the importance of material selection, life cycle costs, and environmental and health impacts. (Celadyn 2018, 2019) explores evaluation criteria and circular design frameworks, while (Hartini, 2020) examines the historical development of sustainability within architectural contexts.

Case studies further illustrate the application of these principles in practice. Real world applications like The Edge in Amsterdam (Jalia, 2019) and Bahnstadt in Heidelberg (Bahnstadt, n.d.) demonstrate the integration of smart technologies, passive and active strategies, and resource efficient materials , serving as exemplary models of sustainable design.

Economic dimension are also major element towards design sustainability since it is the part of LCCA of interior design. High initial costs of sustainable materials are commonly regarded as the liberty they levy at the beginning of the building process Compared to non-sustainable materials, research confirms their long-term cost benefits, including reduced maintenance needs and lower energy consumption (Keane, 2009) (Fathy, 2016) .

The durability of material and environmental impact have also been well studied. Research shows that FSC wood, recycled vinyl flooring, low-VOC paint, and biodegradable composites have performance and health advantages. These materials show a reduction in environmental footprints, improved air quality, and longer service lives, far more efficient than several traditional materials.

Also, industry trends and legislation have played a vital role in encouraging sustainability in the built environment. International standards like LEED, BREEAM, ISO 14001, WELL Building Standard and the German DGNB system are now powerful standards in the evaluation of the sustainability of buildings and interior spaces. In addition, ideas like the circular economy, modularity and adaptive re-use are emerging, once again changing the definition of sustainability in interior design.

By synthesizing these diverse academic and practical perspectives, the literature review establishes a solid theoretical base that supports the study's objectives and future directions in sustainable interior design. It informs the development of the interview questions, and it provides the theoretical basis for the interview phase and shapes the interpretation of qualitative data throughout the research.

### **6.3.2 Case Studies & Interview**

A case study approach was employed to complement this study with real-life industry insights. Case studies and expert interview with challenging companies in interior design were carried out, which reflect diversity of the field. Some of these businesses have traditional design practices rooted in cost, aesthetics, or familiar materials, others are commercially focused and are lending their voice to sustainability in interior design and the use of recycled and renewable resources. This varied representation offers a more comprehensive and balanced picture of the current state of current practices, challenges, and opportunities in the interior design industry.

interview were based on a semi-structured style in order to maintain consistency. The discussions centered on several core themes, including the criteria for material selection, cost-related decision making, product lifespan, maintenance frequency, and the degree to which sustainability was embedded into their design processes. Participants were asked to reflect on the challenges they face when applying their strategies.

All participants were informed about the academic nature of the research and participated voluntarily. Ethical standards were upheld throughout the process. While the identities of most interview and companies were kept confidential to ensure privacy and encourage open communication, and consent was obtained from some participants to include their names in the study. This balance permitted transparency when necessary but also guarded against the risk of compromised integrity and genuineness of the gathered insights.

The case studies also showed that companies had different priorities. Firms that operated in established systems tended to emphasize the economic viability and client demand for visually interesting and cost-effective results. Commonly used materials included plastics, composite wood, and conventional finishes. These choices were frequently based on availability and cost as opposed to environmental sustainability. Companies that made sustainability their priority chose sustainable materials like recycled, renewable and low

emitting materials often under the umbrella of certification programs like FSC or C2C. The cost saving from life cycle benefits and potential brand promotion has justified initial higher cost of green alternatives.

For several companies described the need to educate clients about the long-term value of sustainable design, noting a gradual shift in consumer awareness and demand. and reported to face logistical and cost-related barriers, such as having a small number of suppliers or higher purchasing costs, which prevent a shift towards more sustainable production approaches. The challenges aside, these sustainable-oriented companies showed that interior design with respect for the environment is both possible and can work increasingly in line with industry trends and likely future regulations.

By analyzing these case studies and interview, the research obtains a wide range of perspective on how interior design companies balance tradition and innovation. The insights provided practical context for understanding how sustainability is interpreted and implemented in real projects, highlighting both the progress being made and the structural changes still needed to support a more sustainable future in interior design.

### **6.4 Data Analysis Procedures**

Qualitative themes were identified from secondary sources, case study of firms and interviews with firm representatives from sustainable interior design companies. The main aim was to bring out recurrent patterns and insights concerning the operationalization of sustainability principles in practice, regarding the choices and strategies made in material selection, design, and production processes, to provide a structured basis for comparing traditional and sustainable interior design. The evaluation is centered on three primary parameters: Economic feasibility, Durability and Environmental Impact. Each section is backed by practical case details and real product examples from the companies interviewed.

Economic feasibility played a significant role in determining design decisions, particularly for commercial and residential applications. The findings of the interviews supported the literature and highlighted the general pattern that, in addition to being more expensive in terms of first costs, sustainable materials can be financially beneficial against conventional materials in the long run. For example, LCCA models show that the initial high cost of reclaimed wood or bamboo flooring may result in lower costs for maintenance and replacement over a 15-year timeframe.

Interviewees from companies that produce sustainable interiors, like Bolon for example, also reduced energy consumption (for example insulation and energy efficient lighting) and good material choices. Government handouts and increasing consumer desire were also mentioned as catalysts in the quest for more economically sustainable materials. By contrast, interviewees from traditional practices noted lower cost and widespread availability but also reported frequent maintenance and shorter product life.

Interviewees from companies that produce sustainable interiors, like Bolon for example, also reduced energy consumption (for example insulation and energy efficient lighting) and the use of long-lasting materials contribute to a lower total cost of ownership TCO. They also pointed to Government handouts and increasing consumer desire were also mentioned as catalysts in the quest for more economical sustainable materials. Advocates of the traditional method are quick to point out that it is an inexpensive and readily available option, but they concede it is not without its drawbacks but also reported frequent maintenance and shorter product life.

In terms of the long-term financial effects of interior design, sustainability is definitely an economically sensible choice to make. Quantitative comparisons indicated that sustainable design could result in -15% to -30% energy and maintenance life cycle cost savings. It also implies that, taking a more holistic view, sustainable interior design is economically profitable in the end, even though it might be more expensive in the beginning.

Durability was considered in terms of material duration, wear resistance, and maintenance requirements. The Interviews and document review both identified a consistent trend that sustainable materials are largely engineered or selected specifically for their performance in high-use environments. Items like recycled vinyl floors, FSC certified reclaimed wood, and organic fabrics have been tested to be water-tight, abrasion resistant, and UV resistant.

Respondents by sustainable design companies explained that while durable materials improve performance, they also lower environmental and economic costs related to frequent replacements. In addition to adding advanced coatings “low-VOC finishes” the service life of surfaces is further increased, and interior air quality is improved.

On the other hand, traditional materials, even if they were initially cheaper, decomposed more rapidly mainly under environmental conditions. Many products, such as synthetic fabrics and cheap paints, necessitating regular regeneration Reduces long-term economic and environmental gains. The comparative results indicate that durability advantage of

sustainable interior design, which are directly associated with the general practicability as well as long-term efficacy in terms of resources.

Environmental impact constituted the third axis and arguably most foundational of the analysis. Analysis was based on a few factors such as material sourcing, production emissions, recyclability and indoor air quality IAQ. Sustainable materials received much better scores for reducing carbon footprint and circularity. For example, Bolon's reuse of production waste and Kvadrat's utilization of post-consumer recycled fibres demonstrate methods of minimizing environmental harm.

Interviewees emphasized the importance of eco-certifications C2C, FSC, EPDs as not only marketing tools, but as necessary to aid the transparency of the environmental performance. Materials like recycled PET material and low emission glass were most cited as leading examples of environmentally preferable alternatives.

However, these traditional materials such as vinyl, conventional paint, and non-certified wood products were determined to be large generators of indoor air pollution, deforestation, and waste. In comparison, the non-degradability and non-recyclability properties of these materials make them pose much heavier ecological burden.

Overall, the data suggest that sustainable interior design reduces environmental impact considerably vs. traditional models. Energy efficiency, lower VOC emissions and the incorporation of renewable or recycled materials are some of the ways sustainable behaviour leads to a healthier indoor space and lower resource usage. The comparison helps in understanding whether sustainable interior design is practically and financially viable for large-scale implementation.

The interview and case representative product examples provide evidence that sustainable interior design is not only possible, but it is also beneficial in more than one way. Even though cost is perceived to be a challenge, businesses that design by material and apply circular strategies are demonstrating that value of sustainability, environmental responsibility can also equate to economic performance. These results provide further insights into how the principles of sustainability are enacted in the context of actual product designs and material usage.

## 6.5 Limitations of the Study

To enrich the empirical dimension of this thesis, a multi-pronged case study approach was adopted, supplemented with an expert interview. This qualitative inquiry aimed to reflect the diversity and complexity of sustainable and traditional interior design practices. The research involved interviews and analyses of companies with contrasting approaches at identifying key contrasts between sustainable and traditional interior design types. The purpose is to uncover not only conceptual distinctions but also practical implications in real world applications.

The study involved four primary case studies: Bolon, Kvadrat, the generation10 Bungalow R128 in Stuttgart, Germany, and the apartment block DHIV in Kortrijk, Belgium. These cases were selected because of their topicality and the differences in view with regard to sustainable and traditional interior design. Every example was a lesson on something to do with materials, about economic feasibility, about product durability, about environmental sustainability.

One of the primary contributions came from the expert interview with Mr. Norden, a senior representative at Bolon, a Swedish company recognized for its sustainable flooring solutions. Conducted the interview offered deep insights into Bolon's circular design philosophy. Mr Norden explained how Bolon incorporates recycled materials into high-end woven flooring, supports take-back programmes and is aligned with international sustainability standards, including FSC and C2C. Further discussion addressed hurdles like supply chain limitations and the necessity of educating customers on long-term sustainability advantages.

Danish textile company Kvadrat was also explored for its leadership in sustainable innovation. It utilizes natural and recycled fibres, follows take-back systems, and integrates life cycle thinking into its product development. Kvadrat's strategies reflect a growing emphasis on durability, transparency and circularity, especially in textile production an industry that frequently attracts criticism for its significant environmental impact.

The residential case studies added a user-centered dimension to the analysis. Haus R128 exemplifies a high-performance, fully sustainable home design. The building uses a glass frontage, modular internal components and low-emission materials. It also utilizes passive design strategies like natural ventilation and solar orientation. In contrast, the DH IV Building was constructed as multi-unit housing amidst the more typical block of apartment buildings. This included traditional heating, ventilation, and air conditioning systems that

were not energy efficient, without consideration for environmental performance in practical application.

Throughout these case studies and interviews, several common themes emerged. Many with legacy systems are still entrenched in conventional business ethos that place cost and aesthetics as the primary consideration, selecting materials based on availability rather than sustainability. Companies focused on sustainability, however, are more apt to invest in certified, renewable and recycled materials, even if they are more expensive at the outset. These businesses justify their decisions through long-term cost savings, branding advantages, and alignment with evolving regulations.

A common challenge identified by all was the limited availability of sustainable material suppliers, particularly at the local level. Furthermore, high initial investment costs and a continued issue to inform clients about the benefits of long-term sustainable decisions were mentioned as key challenges. Nevertheless, the findings indicate a gradual increase in consumer awareness and a growing market readiness to embrace sustainable interior design solutions.

In summary, the case studies and expert insights provided a rich, practical context for understanding how sustainable is considered and implemented in practical interior design. They highlight both the promising progress made by pioneers like Bolon and Kvadrat and the structural changes still needed to make sustainable interior design the norm rather than the exception

### 7 Results and discussion

This chapter summarises the most significant findings of the study and reflects on these findings in relation to the literature, the case studies and the interviews. The comparative framework explores the economic feasibility, material durability, and environmental impact of sustainable versus traditional interior design approaches. The data, primarily qualitative, is analyzed in the context of industry insights from Bolon, Kvadrat, and real-world case comparisons of sustainable and conventional buildings.

#### 7.1 Economic Viability

From the in-depth examination of the case studies, expert interviews, and literature in this study, several key findings emerged revealed concerning the economic viability of sustainable interior design compared to the conventional approach. The analysis revealed a clear economic between traditional and sustainable interior design approaches. immediate cost-effectiveness and wide availability. While traditional materials offer immediate affordability and widespread availability, they often result in elevated long-term expenses due to their shorter lifespan, recurring maintenance requirements, and frequent replacements. In contrast, although sustainable materials require a higher initial investment, these materials demonstrate substantial long-term financial advantages, primarily due to their durability, reduced maintenance needs, and lower operational costs.

In contrast, environmentally conscious companies and sustainable design practitioners increasingly adopt materials. Although these materials are associated with higher initial investment costs which are higher than for conventional materials but offer substantial long-term financial advantages. These benefits are due to greater longevity, reduced maintenance and enhanced energy efficiency. LCCA is one of the strongest instruments in proving the economic benefits of sustainable design. This approach considers not only the purchase price of materials but also operational costs, maintenance frequency, and end-of-life disposal or recyclability (Kolesnik, 2021).

Bolon, a renowned Swedish flooring manufacturer, exemplifies this principle through its integration of recycled industrial waste into high-performance woven vinyl flooring. The data from Bolon suggests that despite an upfront cost premium of 15 - 30%, the material's extended lifespan and minimal maintenance result in cost neutrality within a decade indicating strong lifecycle cost performance compared to traditional alternatives. their lifespan between 20 and 30 years, significantly outpacing standard alternatives. According

to the interview conducted with Bolon, their low maintenance nature, due to high strength, water-resistance and resistance to mechanical stress enable users to recover the initial cost difference within 8 - 10 years. Consequently, most clients experience a total lifecycle cost reduction of up to 20%, particularly in hospitality and office environments where durability and hygiene are crucial (Flooring, n.d.).

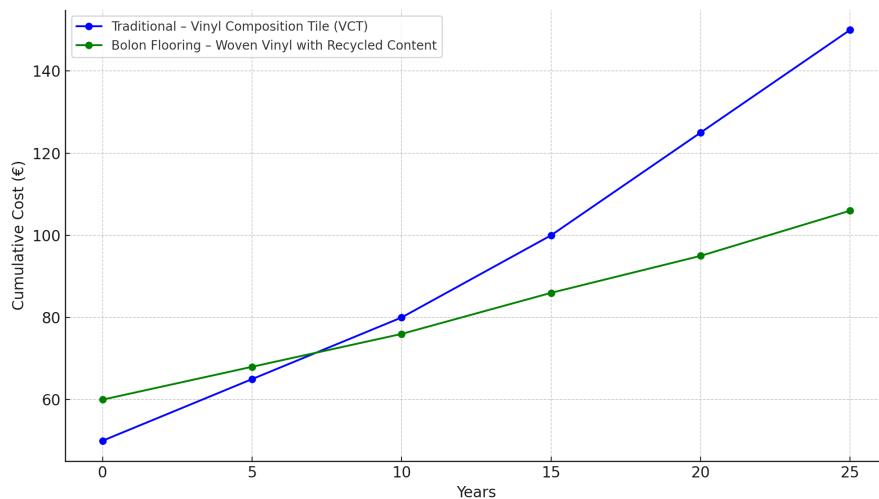


Figure 36 :Cumulative Cost Comparison – Traditional vs. Bolon Flooring Over 25 Years

This line chart compares the cumulative cost of two flooring systems Traditional Vinyl Composition Tile VCT and Bolon Woven Vinyl with Recycled Content over a 25-year period. Although, the Traditional flooring has a significantly lower initial cost “~€39/m<sup>2</sup>”, it requires replacement every 10 years, leading to steep increases in total cost due to repeated material, labour, and downtime expenses (Coleman, 2022). In contrast, the Bolon flooring, although more expensive initially “~€170/m<sup>2</sup>”, can last over a longer period of time 25 years requiring no replacement in the middle of this period. Therefore, Bolon exhibits a more stable and cost-efficient trajectory in cumulative cost (Flooring, n.d.). This analysis highlights those sustainable materials, despite higher upfront investment, often lead to lower long-term costs and reduced environmental impact due to extended product lifespans and fewer resource inputs. In LCCA, Bolon exceeds VCT as a cost-saving and environmentally responsible option for sustainable interior design.

And Danish sustainable textile leader Kvadrat takes a circular economy approach with its recycled-rPET fibres and biodegradable materials as well as its product take-back programs. Economically speaking, sustainable textiles at Kvadrat also offer clear added value for the user in application within the interior over a longer period of time. Despite an initial cost premium of 10 - 20%, users benefit from the Total Cost of Ownership TCO that is 8 - 12% lower over a 15-year period. This is because the materials have increased

longevity, lower maintenance requirements, and lower environmental impact costs tied to low-VOC exposure (Kvadrat, n.d.).

In addition, Kvadrat's modular take-back system not only supports circular design but directly translates into economic value by reducing renovation labor and material waste key cost drivers in conventional interiors. translating into additional savings in refurbishment and labor costs. For users, investing in Kvadrat's products not only supports sustainability goals but also ensures measurable financial returns over time.

presents the results and discussion of selected case studies that highlight the impact of sustainable interior design on energy savings. Through examination of four residential and commercial projects (Bahnstadt, The Edge, R128 Experimental House, DH IV Apartment), the beneficial effects of building insulation, passive design and renewable energy can be observed, which result in notable decrease in energy consumption and better economic performance over the life span of the buildings.

In the Heidelberg Bahnstadt district, where built to the Passive design level, indoor environment space-heating demands were indeed restrained to less "15 kWh/m<sup>2</sup>" ·a in the Heidelberg Bahnstadt district, which is only 10% of the average demand in that of German dwelling buildings. This outstanding performance is due to super-insulated envelopes, sun-optimized orientation, and heat recovery ventilation systems, which result in added warmth and great air quality indoors. This demonstrates that sustainable interior design provides positive experiences in terms of comfort and environmental quality in their homes (Cities, 2020).

Post-occupancy evaluations over the course of two years further substantiated that real energy consumption was consistent with design estimates and demonstrated the success of sustainable solutions for interior spaces. Although the cost of Passive House construction is 5 -15% above traditional construction, LCA demonstrate that the energy savings and reduced maintenance costs pay for this over 11-12 years, making sustainable interior design economically feasible considering the 30 year life of a building This supports the conclusion that investments in passive strategies for interior spaces can yield reliable financial returns, especially in energy-sensitive climates (Galvin, 2014).

In The Edge, Amsterdam, sustainable interior design is driven by the integration of smart technologies such as 30,000 IoT sensors and 6,500 high-efficiency LED fixtures and the use of smart glass for natural light control. These elements allow dynamic control of lighting,

temperature, and occupancy settings, reducing electricity consumption to just 30% compared to traditional design office interiors that rely on static systems and less efficient lighting resulting in annual saving around USD 100,000 annually in energy costs (Jalia, 2019).

In the detailed monitoring when other factors were taken into account the site energy demand was “0.3 kWh/m<sup>2</sup>” per year, versus “+ 40.7 kWh/m<sup>2</sup>” per year in typical office scenarios. The building’s interior strategy prioritizes energy efficiency and occupant comfort, contributing to its exceptional BREEAM score of 98.36% and setting a benchmark for sustainable interior design performance in modern workspaces (OpenCourseWare, 2023).

The R128 house in Stuttgart, created by Werner Sobek, demonstrates how ecological interior design can have economic advantages in the long term. Although construction costs about 25 - 30% more than in a standard building, its all-glass triple pane facade, modular setup and built-in solar systems make heating largely unnecessary and significantly reduce energy consumption (Ferreira Silva, 2020). Over two decades, the house enjoys 35 - 40% energy savings and almost 50% less in maintenance and renovation costs, due to long-lasting, low-maintenance materials and passive energy strategies. This result demonstrates that even in experimental housing, sustainability-driven interior design can produce measurable economic benefits through lower operating and upkeep costs. This makes R128 a very real case study in how intelligent sustainability led interiors can contribute to the bottom line over time (Ferreira Silva, 2020).

In the DH IV social-housing block in Kortrijk, Belgium, deep energy retrofitting between 2015 and 2019 significantly enhanced the economic performance of the building's interior spaces (Van de Putte, 2025). The energy-efficient interior features including upgraded thermal insulation, triple-glazed windows, and a central hydronic heating system reduced space heating demand to less than “15 kWh/m<sup>2</sup>·a”, an almost 90% saving compared to pre-retrofit levels. While such improvements usually command up to a 20 - 30% cost premium over a traditional interior remodel, Measured energy reductions of up to 90% in DH IV translate into quantifiable savings that offset retrofit premiums within 10 - 15 years, validating sustainable design as an economically rational intervention (Van de Putte, 2025). Additionally, the sustainability interior design improvements such as better thermal comfort and healthier air quality into long-term economic benefits by lowering occupant complaints, maintenance needs, and health-related costs.

## Results and discussion

The next table gives a comparison of these four projects including their principles of sustainability, energy consumption, and monetary constraints to illustrate the tangible benefits of sustainable interior design versus traditional practices:

Table 7: Economic Comparison of Sustainable Interior Design Cases

Case Study	The Edge	Heidelberg Bahnstadt	House R128 (Experimental)	DH IV Apartment
Location	Amsterdam, The Netherlands	Heidelberg, Germany	Stuttgart, Germany	Kortrijk, Belgium
Primary Measures	IoT sensors, LED lighting, aquifer	Passive House, super insulation, heat recovery, solar orientation	Triple-glazing, modular design, solar panels, recyclable materials	External insulation, triple glazing, hydronic heating system
Energy Savings	~70 %–100 % (net neg.)	~90 % reduction	≈ 0 kWh/m <sup>2</sup> ·a (no heating)	~90 % reduction
Heating Demand	~ 0.3 kWh/m <sup>2</sup> ·a (net negative)	≤15 kWh/m <sup>2</sup> ·a	~90%	≤ 15 kWh/m <sup>2</sup> ·a
Payback Period	7–8 years*	11–12 years	– (long-term savings)	10–15 years
References	(OpenCourseWare, 2023) (Jalia, 2019)	(Galvin, 2014) (Cities, 2020)	(Ferreira Silva, 2020)	(Van de Putte, 2025)

Collectively, the case studies and manufacturer insights analyzed in this research highlight a consistent pattern: sustainable interior design leads to significant long-term cost efficiency across both residential and commercial settings. The Edge’s integration of smart systems and low-maintenance materials demonstrates that operational savings can outweigh initial investments in under a decade. Similarly, R128 and DH IV show how high-performance envelopes and modular, recyclable interiors drastically reduce energy costs, refurbishment needs, and user complaints. Kvadrat and Bolon further reinforce these trends by proving that materials with higher upfront costs yield measurable lifecycle savings through reduced maintenance, increased longevity, and circular reuse. These converging outcomes underscore a key result economic viability in interior design is not defined by initial price alone, but by total performance across time.

In conclusion, it can be concluded that adopting 'Sustainable Interior Design', based on modern insulating materials, smart building technologies, on-site renewable energy, and full retrofits will lead to drastic reductions in energy demand and CO<sub>2</sub> output in comparison with conventional design options. Though initial costs can be in the higher end the payback period of approximately 7 -15 years indicates a clear economic viability over the lifespan of a building. Beyond cost savings, these strategies enhance thermal comfort, indoor air quality, and occupant well-being, underscoring that sustainable design is not just an environmental imperative but a superior choice over traditional interiors in every respect.

### 7.2 Durability

Durability is a pivotal element in sustainable interior design, as it determines how long materials last under typical wear and environmental conditions, and how often they require maintenance or replacement. Durable materials not only reduce resource consumption, but they also reduce the need for renovation. By examining corporate case studies from Bolon and Kvadrat alongside residential examples such as Experimental Haus R128 and the DH IV apartment block. This research demonstrates that, in contrast to traditional interior design which often relies on short-lived materials and energy-intensive systems sustainable interior design leverages durable materials, circular supply chains, and renewable energy integration to achieve significantly lower energy demand and reduced carbon emissions. This finding suggests that durability is not only a technical characteristic, but a strategic design driver that shapes long-term performance and environmental outcomes.

The analysis revealed a found trend across the categories of materials utilized in these designs, while traditional materials could initially provide the basic functionality and aesthetic appeal expected of these finished surfaces, they would generally have lower life cycle durability, thus they were more likely to require maintenance at potentially more frequent intervals and are replaced sooner. In contrast, sustainable materials like FSC-certified wood, recycled textiles, and low-VOC coatings and finishes, consistently showed superior durability. This contrast highlights a paradigm shift in material strategy, where longevity becomes a form of embedded environmental value, reducing the frequency of material turnover and associated emissions.

interviewed with industry professionals confirmed that the longevity of sustainable materials significantly reduces the need for repairs or refurbishments, thereby saving repair costs and reducing waste, contributing to both environmental conservation and significantly decreasing lifecycle cost reduction. This enhanced durability positions sustainable interior

design as a resilient and future ready solution, particularly in high-traffic or long-term residential and commercial settings.

Material selection is fundamental in interior design, influencing both functionality and aesthetics. This comprises flooring, wall surface finishes, curtains and furniture fabric. In addition to aesthetics, these choices affect durability and environmental impact. Using sustainable options like such as Bolon's flooring and Kvadrat's, creates a longer lasting as well environmentally design.

Bolon's woven vinyl flooring exemplifies outstanding durability, establishing it as a premier solution for both residential interiors and high-traffic commercial environments. Created with a multilayer structure that includes a moisture barrier and sound-dampening pad, vinyl planks Recycled remain stable so they will not deteriorate, cup or warp even if you install them over an existing floor. Bolon products are certified under ISO 10874 and EN 13501, and perform well under heavy usage, lasting between 20 and 30 years (AB, 2021). The technical specifications of Bolon indicate that design decisions rooted in circularity and material engineering can meet high-performance standards while drastically reducing lifecycle interventions.

Unlike printed alternatives, the woven construction resists surface degradation, while the colour fastness rating ">7, EN ISO 105-B02" and slip resistance "EN 13893,  $\mu > 0.3$ " contribute to sustained performance over time. Its water-resistant and easy-to-clean surface further reduces long-term maintenance requirements, making it a cost-effective and reliable choice. Together, these features embody a fundamental tenet, sustainable interior design to maximizing material longevity while minimizing resource consumption and environmental impact over the product's lifecycle (AB, 2021).

In assessing the durability of sustainable interior solutions, Kvadrat and its subsidiary present a range of products that combine robust material engineering with circular-economy principles to deliver exceptional durability in both residential and heavy-use commercial settings. Kvadrat's woven textiles are crafted from wool and nylon blends and are suited for heavy duty applications, like upholstery and curtains, routinely exceed "100,000 Martindale" rubs for abrasion resistance, while also meeting stringent standards for pilling, colourfastness, and flame retardancy (A/S, 2023). Special backings and coatings further offer dimensional stability and protect against UV light and humidity while providing durability and aesthetic maintenance over the life of a textile,

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This performance positions Kvadrat’s materials as a benchmark for combining textile aesthetics with industrial durability, aligning material innovation with environmental responsibility. Although no fixed technical Reference Service Life RSL is officially declared due to varying use conditions, but they have a general warranty of 10 years, They are commonly used in building elements and transportation interiors due to their mechanical properties, the wear resistance of the fabrics (A/S, 2023).

Meanwhile, Kvadrat Really’s textile boards and tabletops made from upcycled textiles are specifically engineered for furniture and interior applications. These boards demonstrate strong physical resilience, including resistance to abrasion, heat, and liquids, without the need for additional surface treatments. According to the manufacturer, features a declared RSL of 15 years, reinforcing its durability in daily use (Really, 2023) (A/S, 2024). The durable performance of Kvadrat products is not only evidence of their capacity for endurance, but also of a material's ability to meet long-term functional needs while advancing sustainable interior design goals.

The following table consolidates key durability indicators to compare how sustainable materials outperform conventional ones across multiple performance dimensions.

Table 8: Durability Comparison Table: Bolon vs Kvadrat vs Traditional Materials

Criterion	Bolon	Kvadrat	Traditional Materials
<b>Product Type</b>	Recycled woven vinyl flooring	Upcycled textile surfaces and furnishings	Conventional materials and finishes
<b>Abrasion Resistance</b>	Very high	>100,000 Martindale – abrasion, heat & liquid resistant	Low to moderate – more prone to wear and tear
<b>Reference Service Life (RSL)</b>	20–30 years (declared)	10 years warranty (textiles) / 15 years RSL	Often less than 10 years – depends on material type
<b>Moisture Resistance</b>	High – highly stable and durable	Improved moisture resistance	Low – prone to swelling, warping, or degradation
<b>Maintenance Needs</b>	Low	Relatively low	High – frequent upkeep needed
<b>Sustainability</b>	Made from 100% recycled content	Circular design using end-of-life textiles and low-VOC finishes	Typically uses virgin or industrially processed raw materials

The comparative analysis of the DH buildings before and after renovation reveals clear differences in durability between traditional and sustainable interior design approaches. The DH buildings were originally comprised of old materials and finishes from the 1970's era construction. The conventional elements were of low cost initially; however, these traditional elements had a poor resistance to moisture, heat, stresses, and wear over time resulting in frequent maintenance and premature material failure (Van de Putte2025 ). This renovation demonstrates how even legacy buildings can benefit from durability-focused upgrades, significantly extending functional lifespan and reducing maintenance burdens in a cost-effective manner.

Internally, the DH renovation prioritized sustainable design solutions such as moisture-proof flooring, VOC-free paints, and high-durability fixtures. These choices significantly reduced the need for frequent repainting, repairs, and surface maintenance. In contrast to traditional interiors where materials like plastic laminates or composite wood often degrade within 10 to 15 years the sustainable materials used in the DH buildings are projected to retain their performance and visual quality for 25 to 30 years after renovation (Van de Putte2025 ).

Durability is a foundational aspect of The Edge's interior design concept in Amsterdam. The materials were carefully selected based on Life Cycle Assessment (LCA) criteria to ensure both long-term flexibility and low environmental impact. The Edge in Amsterdam offers a compelling example of how interior durability can support environmental goals. Unlike conventional approaches where durability is often considered after construction, The Edge integrates it from the outset as a strategic priority, reinforcing both the environmental performance and economic efficiency of the building. This foresight contributes to lower material degradation, extended lifecycle of interior components, and greater resilience against functional obsolescence. positioning The Edge as a reference point in sustainable and durable design for high-performance commercial buildings.

The building employs smart LED lighting systems developed in collaboration with Philips, designed to last longer and consume less energy. These fixtures are embedded with motion and temperature sensors and are connected via Ethernet cables, reducing the need for frequent replacements and enabling predictive maintenance. This strategy not only improves performance but also extends the usable life of interior systems, reducing environmental degradation associated with premature disposal (Jalia, 2019).

Additionally, the building's predictive maintenance system, powered occupancy sensors, ensures that interior systems are maintained only when needed, based on real-time data.

The use of data in this way minimizes over-maintenance and avoids unnecessary wear. Rather than being based on fixed service intervals, the system takes into account the real actual state of the lighting, the HVAC and the workstations extends the life of this equipment. This intelligent infrastructure minimizes intervention frequency, prolongs system reliability, and exemplifies how technology can support material durability in a dynamic environment.

Durability also intersects with user behavior. The Edge promotes a non-assigned seating policy and uses an app that allows employees to reserve workspaces tailored to their daily tasks. While this reduces personalization of desks, it surprisingly increases collective responsibility and respect for shared spaces. This behavioral shift reduces (Life-Cycle, n.d). This behavioural integration marks a critical advancement in sustainable design where social practices are engineered to reinforce physical durability, minimizing user-induced wear and prolonging interior integrity.

when combined with smart technologies and adaptable layouts as in The Edge, both flexibility and sustainability in interior design are potent weapons in the to make less of a negative impact on the environment. It moves beyond the use of long-lasting materials to include intelligent maintenance, modularity, and behavioral design. By extending the life cycle of interior components, reducing resource consumption, and minimizing waste, durability serves as a cornerstone for sustainable interior environments. When evaluated collectively, these cases reveal that durability in sustainable interior design is not an isolated attribute, but a systemic outcome resulting from integrated material, technological, and behavioural strategies.

R128 House shows that interior durability may be possible by combining the high-performance structural systems, environmental strategies, and modular adaptability. It features steel encapsulated triple glazing mounted in bolted steel frames to reduce thermal stress and condensation, protecting adjacent surfaces from moisture damage and wear (Ferreira Silva, 2020). Lightweight partitioning and demountable partitions and engineered wood-composite panels allow frequent reconfiguration without compromising structural integrity, reducing renovation-related waste and extending component lifespans. Passive solar orientation, seasonal thermal storage, and sensor-based ventilation maintain stable internal conditions, preventing deformation, mold growth, and material deterioration over time. By designing all internal elements for disassembly and recycling, the R128 integrates

circular economy principles into its durability strategy, ensuring that every component can be refurbished or reused at the end of its life rather than being discarded (Sobek., n.d.).

Durability plays a crucial role in sustainable interior design, influencing both the environmental and economic performance of a space over time. Unlike traditional designs that often prioritize initial aesthetics or cost at the expense of longevity, sustainable interiors aim to extend the lifecycle of materials and systems. This section explores how durability is applied across different scales from material innovations by companies like Bolon and Kvadrat to holistic building strategies seen in The Edge, R128, and the DH IV project highlighting how thoughtful design choices can reduce maintenance, minimize waste, and improve long-term resilience.

### 7.3 Environmental Trade-Offs

The environmental impact of interior design practices significantly differs depending on whether traditional or sustainable methods are employed. In traditional interior design, aesthetics and cost-efficiency often reign supreme, which commonly means the utilization of non-renewable, energy intensive materials. These materials are not only responsible for resources depletion, but also lead to indoor air pollution and long-term environmental degradation (Graphenstone, 2023) . Moreover, the extraction and processing of marble, tropical hardwoods, and synthetic fabrics require intensive energy inputs and often result in a large carbon footprint due to long-distance transportation (Rashdan, 2024). This finding confirms that conventional material choices contribute disproportionately to environmental harm, both in terms of embodied carbon and operational inefficiency.

In contrast, sustainable interior design takes a lifecycle approach to materials selection focusing on environmental certifications, recyclability and biodegradability. Such materials as bamboo, recycled wood and cork are used more and more, because they are environmentally- friendly and reusable (Rashdan, 2017). These results highlight a deliberate shift towards materials that ensure resource conservation and reduced carbon emissions, as reinforced by their alignment with FSC, PEFC, and C2C certifications (Certified®, 2024) (Cole, 2005) (Council, 2019). Sustainable design also tends to emphasize passive energy approaches like daylighting, natural ventilation, and thermal mass that significantly minimize mechanical systems dependency and decrease energy use (Design, 2024). This demonstrates that environmental efficiency in interior design is not solely about material selection but also about integrating passive energy strategies to reduce operational impacts.

The circular economy concept is also central to sustainable interior design, promoting reuse, recycling, and material recovery at the end of a product's life. For instance, companies like Bolon incorporate industrial waste into their flooring products, while Kvadrat repurposes post-consumer plastics into high-performance textiles (Bolon, 2025) (Kvadrat, 2024). The data shows that such practices directly reduce reliance on virgin resources and landfill usage, in alignment with the EU waste hierarchy (Wilts, 2018).

However, while the ecological advantages of sustainable design are clear, challenges such as higher upfront costs, limited supply chains, and lack of public awareness still hinder widespread adoption. Nevertheless, as this research suggests, the long-term environmental and health benefits significantly outweigh these initial barriers, making sustainability an essential rather than optional direction for future interior design.

As shown previously, the environmental superiority of sustainable interior design lies not only in material selection and energy efficiency but also in the credibility provided by internationally recognized certifications and assessment systems. These certifications are essential in guiding designers, and toward more environmentally responsible choices by providing verified standards that evaluate the environmental impact of materials and construction practices. Evidence from the case studies confirms that certification systems like LEED, BREEAM, and DGNB play a pivotal role in ensuring transparency, environmental accountability, and market competitiveness (Cole, 2005) (Council, 2019).

These systems promote environmental quality by assessing factors such as energy efficiency, IAQ, resource conservation, and LCA. For instance, the DGNB certification not only emphasizes environmental and economic sustainability but also includes social and cultural criteria, making it one of the most holistic assessment tools in Europe. (DGNB, 2023). In addition, product-based certifications such as the FSC and PEFC help ensure that timber and wood-based products used in interiors are sourced responsibly, without contributing to deforestation or biodiversity loss. These certifications serve as proof of sustainable sourcing, enabling designers to select materials with confidence that their environmental footprint is minimized. (Michal, 2019).

Highlighted in the research is the C2C certification, which evaluates a product's ability to be fully recycled or safely composted at the end of its life (Certified®, 2024). This supports the circular economy by encouraging manufacturers to design products with end of life recovery in mind. Products with C2C certification typically undergo rigorous assessments for material health, reuse potential, renewable energy usage, water stewardship, and social fairness.

supports the result that end-of-life material management is essential to achieving circularity in interiors.

Furthermore, certifications such as GREENGUARD and the WELL Building Standard are essential in addressing health-related environmental concerns within interior spaces. GREENGUARD-certified products, are tested for emit minimal chemicals, thereby improving indoor air quality and reducing air pollution within enclosed spaces and protect occupant health an aspect increasingly emphasized in modern sustainable design (GREENGUARD, 2024) (Ildiri, 2022) .And the WELL certification integrates environmental and human centred design, evaluating how building features like air, water, light, and comfort directly impact human well-being (GREENGUARD, 2024) .These appear to be certificates that health-focused are integral to sustainable interiors, ensuring that environmental performance does not come at the expense of occupant health.

These certificates are important. in making certain sustainable interior design contrive is credible, shippable, and value effective with environmental initiatives that arcades are. They contribute to promoting transparency and accountability in the design process by helping set explicit criteria for assessing the ecological impact of materials and methods as well. By trusting these certifications, designers and stakeholders are empowered to make decisions that reinforce responsible environmental behaviour, improve indoor health, and conserve resources. Furthermore, they act as strong instruments to enhance consumers' confidence, promote competitiveness in the market and in long run, sustain in the interior design industry.

Projects that integrate sustainable materials like Bolon's woven vinyl flooring show quantifiable environmental benefits. For instance, the use of this flooring in high-traffic commercial spaces contributes to lower global warming potential due to its low CO<sub>2</sub> emissions per square meter over time and minimal maintenance requirements (AB, 2021). Such materials also support indoor air quality by avoiding substances classified under SVHC, making them safer for occupants over the lifespan of the project.

In comparison, traditionally designed interiors using standard PVC, untreated wood, or synthetic carpets often lack environmental certifications and produce more waste at the end of their useful life. Moreover, they typically require more intensive cleaning and earlier replacement, increasing resource consumption over the building's lifecycle. Bolon floors, like last 20 - 30 years and are partially recovered through energy generation after use, whereas traditional materials frequently end in landfills without reuse or recovery strategies

(AB, 2021) (AB, 2021). By implementing sustainable interior solutions in actual projects, designers and stakeholders not only minimize carbon emissions and water usage but also enhance long-term building performance and compliance with green building standards like LEED or BREEAM. A comparative analysis of Bolon versus traditional PVC flooring shows up to 40% lower emissions over a 30-year life span, validating the effectiveness of circular product design. This proves that sustainable design is not only environmentally responsible but also practical and impactful in real architectural applications. This further reinforces the finding that sustainable materials reduce both environmental degradation and long-term operational costs.

Integrating Kvadrat products into real interior design projects yields measurable environmental benefits compared to traditional materials. When Kvadrat's wool-rich woven textiles composed of 90 - 92% wool and 8 - 10% nylon are specified in commercial or residential schemes, the reliance on 100% hydropower at the Vestland production site significantly lowers upstream emissions (A/S, 2023). This example clearly illustrates how upstream clean energy sourcing significantly lowers the carbon footprint of interior textiles.

In practical terms, specifying these textiles for upholstery or drapery in interior design fitouts reduces the global warming potential attributable to fabric procurement, since the cradle to gate is confined largely to renewable powered processing rather than fossil-fuel-intensive manufacturing. Moreover, the absence of products enhances indoor air quality in occupied spaces, minimizing post-installation ventilation requirements and associated energy use (AB, 2021).

Projects that use Kvadrat Really's recycled materials like Textile Felt and Textile Tabletop show how sustainable products can reduce environmental impact in real interior spaces. When Textile Felt panels are used as acoustic ceiling elements, their high recycled content 72.9% helps reduce the need for new raw materials. These panels have a low environmental footprint, with a cradle to gate global warming potential of about "0.49 kg CO<sub>2</sub> eq" per square meter (Really, 2023). At the end of their use, they are often incinerated with energy recovery, which helps reduce overall emissions something that traditional options like fiberglass or foam panels don't offer, as they usually end up in landfills.

Similarly, the use of "Textile Tabletop" and "Textile Felt" in interior design offers a durable, ready to use surface that requires no additional finishing. Although their production involves some emissions, part of the environmental impact is offset by energy recovery at the end of the product's life cycle (Really, 2023). The results underscore the environmental advantages

of materials designed with disassembly, recyclability, and energy reclamation in mind. Overall, Kvadrat's materials support emission reduction, minimize landfill contributions, and enhance indoor air quality, positioning them as a more sustainable alternative for interior applications.

The Edge's interior design minimizes embodied environmental impacts through rigorous material selection and durability criteria. From the outset, all primary finishes flooring, wall systems, and fixtures were chosen based on full life-cycle assessments to ensure low embodied energy and extended service lives. By prioritizing high-performance, recycled-content materials and low-VOC coatings, the building avoids frequent tear-outs common in conventional offices, thereby reducing construction and demolition waste and associated emissions over time. These findings establish The Edge as a benchmark example of performance-driven, circular interior design practice.

Interior material selection at The Edge further enhances its sustainability profile. Passive strategies like the north-facing atrium maximize daylighting without overheating, while LED lighting powered via low-voltage Ethernet reduces electrical loads by up to 90% compared to traditional systems (Jalia2019 ). Many of the interior elements are modular, durable, and selected based on full life cycle assessments, facilitating disassembly and recycling at end of life. These conscious design choices reflect a shift from linear consumption models to circular design, significantly lowering the embodied environmental costs of interiors.

The success of The Edge's sustainable interior design has been formally recognized through prestigious international certifications. It achieved a BREEAM-NL Outstanding score of 98.36 percent the highest ever recorded globally at the time highlighting its excellence in sustainability, energy performance, and user well-being. Additionally, the building earned WELL Core & Shell Platinum precertification, affirming its commitment not only to environmental metrics but also to health-focused design (Jalia, 2019). These achievements collectively position The Edge as a benchmark for the future of environmentally responsible interior architecture and interior design, proving that performance, sustainability, and comfort can coexist within a single integrated design system. These certifications validate that the project's design decisions translate into tangible sustainability achievements.

The R128 House in Stuttgart is a radically different approach to a standard type of housing construction, and a challenge on how the sustainable quality of a living space can be implemented within the logic of daily life and in total symbiosis with interior design. Designed by architect Werner Sobek, the house is entirely recyclable, energy self-sufficient, and

emission free, serving as a model of closed loop building systems. Its interior is designed with much the same principles, each element was conceived with the idea of being easily dismantled and repurposed, with no glues or composites to hinder recycling. Ample use of transparent materials and simple elements serve to ensure natural light is used to its greatest advantage, and reducing the need for artificial lighting, which is further supported by intelligent automation systems that regulate energy use efficiently.

Interior elements are modular and prefabricated, enabling adaptability and extension of service life without generating waste. Unlike traditional interiors that rely on decorative layers and disposable components, the R128 interior integrates functional aesthetics with environmental responsibility. Furniture and surfaces are selected not only for visual harmony but also based on their environmental certifications and recyclability. No harmful finishes or toxic glues are used, aligning with strict C2C principles. The lightweight materials, combined with the building's structural transparency, create a climate-responsive interior that eliminates the need for conventional HVAC systems (Ferreira Silva, 2020). The outcome is a radically reduced material and energy footprint without compromising comfort or function.

The environmental impact in R128 shows the importance of sustainable design, especially in interior design, by minimizing material consumption, avoiding embodied carbon-intensive components, and enabling full material recovery at end-of-life (Sobek., n.d.). The design supports not only operational energy neutrality through integrated photovoltaic systems but also reduces renovation and maintenance needs by focusing on longevity and flexibility. In comparison to traditional interiors often characterized by material waste, non-recyclable finishes, and energy-intensive systems R128 showcases how sustainable interiors can achieve higher performance across environmental indicators without compromising usability or aesthetics.

As global environmental concerns escalate, the R128 highlight the urgent need to rethink interior design as a system of renewable flows and zero-waste logic, Case study evidence reinforces the argument that circular interior design not only benefits the environment but also aligns with emerging green policy frameworks like the EU Green Deal. the results across all case study confirm that sustainable interior design practices especially those focused on circularity, smart maintenance, and certified materials yield significant environmental benefits compared to conventional alternatives.

In conclusion, the findings across the analyzed case studies demonstrate that sustainable interior design significantly outperforms traditional approaches in terms of lifecycle

emissions, resource efficiency, and health outcomes. The integration of environmental certifications, circular material strategies, and intelligent system design contributes to measurable environmental benefits. However, widespread adoption still depends on economic incentives, supply chain accessibility, and regulatory frameworks. These insights emphasize the need for policy support and industry commitment to mainstreaming sustainable practices in interior environments.

## 8 Conclusions

This thesis set out to examine the feasibility and implications of sustainable interior design through a comprehensive comparative analysis with traditional design approaches. By focusing on three core dimensions economic feasibility, durability, and environmental impact this study offers critical insights into whether sustainable interior design can serve as both a responsible and practical alternative to conventional practices.

The research found that sustainable interior design, while often associated with higher initial investment costs, provides significant long-term economic advantages. Through case studies and LCCA it was identified that sustainable materials and systems result in lower operating and maintenance cost, higher property values, and measurable productivity gains, especially in interior spaces. Economic benefits, advancements in technology, and increased market demand are driving sustainability more accessible financially rewarding for businesses and individuals, despite the initial investment.

Durability analysis showed that sustainable materials tend to have a offers an extended service life and requires less maintenance than conventional interior solutions alternatives. Explain the research that intelligently specified sustainable components, such as intelligent ventilation solutions or modular and adaptable furniture, can continue to deliver high performance over time. In addition, durable finishes, and textiles employed by companies such as Bolon and Kvadrat, showed that high design quality is not incompatible with long-term performance.

On the environmental level, the trade-offs between traditional and sustainable design were particularly pronounced, sustainable design approaches focused on energy efficiency, low-VOC materials, circular economy principles and smart technology integration all work to decrease carbon footprints, enhancing not just health and wellbeing but also indoor air quality.

Sustainable interior design is not merely an ethical trend, but a forward-thinking and practical approach that integrates durability, cost-efficiency, and environmental responsibility. The shift towards this approach responds to global ecological challenges while fostering innovation, enhancing well-being, and promoting a culture of long-term sustainability.

## 9 Outlook

As the urgency to address global environmental threats, including climate change, resource scarcity, and ecological degradation continues to grow, sustainable interior design is expected to shift from an optional practice to a fundamental requirement. The results of this study demonstrate that sustainability in the indoor design is not only economically and environmentally sustainable, but also increasingly demanded by users, businesses, and policy. In the future, the integration of sustainability principles, digital innovation, and intelligent systems will be a driving force behind the reedition of interior design practices.

Given the rapid advancement of AI, the field of sustainable interior design is undergoing a significant transformation. AI technologies are increasingly being embedded into the design process as strategic systems of insight, rather than merely instrumental tools. These systems enhance energy efficiency, optimize spatial configuration, and assist in selecting environmentally responsible materials. Through the support of an early-stage performance simulation and predictive modelling, AI contributes to reducing material waste and driving long-term environmental performance of interiors paces. This advancement represents a major step toward more responsive, resource efficient, and sustainable design outcomes aligned with global sustainability goals.

The next generation of interior design will depend more and more on AI to build smart, adaptive spaces. Interiors will be able to track air quality, lighting and energy usage in real time, enabling these conditions to be adjusted automatically to increase comfort and decrease waste. These technologies are set to be adopted across all homes and public places, making intelligent, sustainable design a universal standard.

These developments will drive the toward a more integrated approach blending ecological responsibility, technological innovation, and human centred design. In turn, this will lead to future interiors that are not only aesthetically, durable, energy efficient, resource-aware, and being used in both private and public spaces to help promote long-term health and well-being, both environmentally and socially.

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## 11 Appendices

### 11.1 Interview Questionnaire

- Besides flooring, does Bolon offer any other sustainable products?
- I would like to start by learning more about Bolon, its approach to sustainability, and what challenges it faced in the beginning?
- Why did Bolon choose to focus on sustainable flooring and rugs?
- What are the main challenges Bolon faced, especially in sourcing raw materials?
- What are the main raw materials you use in your products?
- How do they compare to more traditional materials like wood or ceramic in terms of sustainability?
- Does this mean Bolon's flooring helps reduce long-term costs for customers?
- In terms of lifespan, how does Bolon flooring stack up against other flooring options?
- Are Bolon's products recyclable at the end of their life?
- Is there a formal take-back program in place?
- Could you tell us which sustainability certifications Bolon has obtained for its flooring products?
- Do you provide any tools or data to help compare your flooring's environmental impact with traditional options?
- Over the past five years, how have you seen customer demand for sustainable flooring evolve?
- Could you describe any new technologies or innovations you're currently developing to further enhance the sustainability of your flooring products?
- How do you see the future of sustainable materials in interior design?
- How can government policies and regulations support sustainable material manufacturers like Bolon?
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## 11.2 Interview transcripts

**Company Name:** Bolon

**Interviewee:** Mr. Hakan Nordin

**Position:** Director of Sustainability, Bolon

**Interviewer:** Majd Ismail

**Interviewer:** Hallo, Mr. Nordin. Thank you for your time,

**Mr. Nordin:** You're welcome.

**Interviewer:** My name is Majd Ismail, I am a master's student in Communication and Design for Sustainability program in Hochschule Neu-Ulm. I appreciate the opportunity to speak with you today as part of my thesis research on sustainable interior design.

**Mr. Nordin:** You're welcome, Majd. A pleasure to be part of your academic journey and share insights from our work at Bolon.

**Interviewer:** Besides flooring, does Bolon offer any other sustainable products?

**Mr. Nordin:** Bolon company produces only flooring and rugs.

**Interviewer:** I would like to start by learning more about Bolon, its approach to sustainability, and what challenges it faced in the beginning?

**Mr. Nordin:** That's a bit hard for me to answer in detail, because I've only been with the company for the past five years, and Bolon was founded more than 75 years ago. So, I wasn't there at the beginning to witness those early struggles. But what I can say is that, like many companies that started small and grew over time, they definitely faced a lot of challenges from finding the right machinery, to sourcing quality materials, to training skilled employees. But our company name, "Bolon," is derived from the Swedish words for "bomull" (cotton) and "nylon," highlighting the innovative blend of materials we used from the beginning. Over time, Bolon has evolved from a local rug maker into a global design brand, without compromising its environmental ethics.

**Interviewer:** Why did Bolon choose to focus on sustainable flooring and rugs?

**Mr. Nordin:** The company's commitment to sustainability started from day one with the use of waste materials. Today we live that vision in everything we do from our design, sourcing, and manufacturing. We believe sustainability and design must go hand in hand. That is why some of our flooring includes recycled and bio-based materials and is produced with regard for minimum climate impact.

**Interviewer:** what are the main challenges Bolon faced, especially in sourcing raw materials?

**Mr. Nordin:** Honestly, I also knew that the company faced it's been quite a challenge. It's not just about finding recycled materials, you need to make sure they're available in the right quantities, with consistent quality, and most importantly, that they're free from any hazardous substances. That can be really difficult, especially when you're working with post-consumer or industrial waste. Over the years, though, we've managed to tackle these issues by building strong supply chains and working closely with reliable local suppliers. That's helped a lot. But still, it's a complex process, and it requires ongoing attention.

**Interviewer:** Now, what are the main raw materials you use in your products?

**Mr. Nordin:** Over time, and through a lot of research, trial and error, and working closely with our partners, we've developed a really solid material base for our products. Today, our flooring is made from a smart combination of sustainable materials, we use chalk, which from industrial marble offcuts it's an incredible material with a very low impact on the climate. recycled and bio-sourced PVC, from waste in the pulp and paper industry, plasticisers, The remainder is a mishmash reinforcement, stabilisers, pigments, all of which are needed for product integrity and looks.

**Interviewer:** And how do they compare to more traditional materials like wood or ceramic in terms of sustainability?

**Mr. Nordin:** That's a great question. Our flooring material, relative to products made of wood or ceramic, has a number of sustainability advantages. First of all, it's significantly lighter around 3 kilograms per square meter and this represents a significant reduction in terms of energy usage in transport and installation, contributing to less overall emission, as well. That might sound like a small detail, but it really adds up when you're working on large scale projects. Another pressing point is maintenance. With wood, for instance, you're paying someone to sand it down, apply varnish and do that over the course of time to keep wood looking good. Ceramic tends to be durable, but it's heavy and breakable, and can easily

crack or chip. On the other hand, our floor does not require that sort of regular upkeep. It's built to be low maintenance, yet it continues to look good and perform well over time.

**Interviewer:** Does this mean Bolon's flooring helps reduce long-term costs for customers?

**Mr. Nordin:** Yes, definitely because of their durability and low maintenance needs, our floors offer savings over time. They're easier to clean and don't require renovation, which adds long-term value.

**Interviewer:** Mr. Nordin, in terms of lifespan, how does Bolon flooring stack up against other flooring options?

**Mr. Nordin:** In terms of lifespan, one of the things our clients comment on time and again is just how enduring Bolon flooring can be. I'd say our floors really stand the test of time. While we offer a 10–15 years warranty, in practice we see installations lasting well over 25 years without any structural issues. Most people don't replace their floor because it's used up, that when companies and consumers decide to replace flooring, it is usually to update an image brand or refresh a space not because the material has worn out. We, and that longevity, take pride in that. From a cost perspective, when you consider cost, it pays off in the long run. There's virtually no need for major renovations, sealing or recoating like you'd have to do with wood, and unlike ceramic or stone, there's no concern about cracking or grout failure. The day-to-day cleaning process becomes fast and easy, Basically, you're saving time and cash – you'll cut down on labour bills, when you consider the cumulative effect fewer labour hours, you'll cut down on labour bills, keep things running without all the downtime,

**Interviewer:** Are Bolon's products recyclable at the end of their life?

**Mr. Nordin:** Absolutely, in fact, we've invested in our own dedicated recycling facility so that when a floor reaches the end of its useful life, we can take it back, break it down, and transform the material into brand new flooring. From a technical standpoint, our process is straightforward, we collect the old vinyl, clean and grind it, then remelt and reform it into fresh tiles or planks without losing any of the product's original performance characteristics.

**Interviewer:** Is there a formal take-back program in place?

**Mr. Nordin:** Not yet as a full-scale program, but we have a pilot initiative and the infrastructure to recycle returned products. It's not a technical issue, we've done it before, but the logistics and regulations need improvement to scale this process. Coordinating pickups from buildings around the world, packing used floors for safe transport, and

navigating the various import - export and waste-handling regulations can be complex. Such as Getting a pallet of old flooring from, say, London back to our plant in Sweden involves paperwork, cross border customs and careful handling to prevent contamination. We're actively working on partnerships and streamlined shipping solutions to make this process as smooth as possible our goal is to turn what many see as "waste" back into high-quality flooring with minimal environmental impact.

**Interviewer:** Could you tell us which sustainability certifications Bolon has obtained for its flooring products?

**Mr. Nordin:** Yes, we have, we have, think we have, round about 20 different certificates to meet the varied requirements of more than 50 markets worldwide. Because each region, whether it's North America, Europe or Asia, has its own standards, we've taken care to certify our processes and products to the highest levels. Today, you'll find us certified to ISO 14001 for environmental management, Floor Score for indoor air quality, M1 and Declare for material transparency, full Environmental Product Declarations EPDs, and many more regional labels. Our products contribute points toward building certifications like LEED and BREEAM. While there's no LEED certificate for a floor itself, our materials can support those standards. You can access all certificates by visiting the Sustainability section on our website, where all accreditation certificates are available.

**Interviewer:** Do you provide any tools or data to help compare your flooring's environmental impact with traditional options?

**Mr. Nordin:** Yes, we publish Environmental Product Declarations EPDs, which are based on life cycle assessments LCAs. These show the carbon footprint per square meter and allow direct comparisons. In fact, we've reduced our climate footprint by 53% since 2018. You can also access this information in the sustainability report on our website.

**Interviewer:** Over the past five years, how have you seen customer demand for sustainable flooring evolve?

**Mr. Nordin:** I think it really increase. Over the past five years especially, demand has risen globally. I would say Whether it's Sweden, the U.S., Taiwan, or Australia. That's for sure and it will continue to increase the next five years even more.

**Interviewer:** Could you describe any new technologies or innovations you're currently developing to further enhance the sustainability of your flooring products?

**Mr. Nordin:** Yes. We're focusing on increasing recycled content, expanding our take-back capabilities, and designing floors that don't require permanent adhesives. Glued floors are harder to recycle. So, developing glue-free installation methods is key to improving circularity.

**Interviewer:** How do you see the future of sustainable materials in interior design?

**Mr. Nordin:** It will definitely, grow demand is already increasing and will continue to do so, by younger generations and stricter environmental standards.

**Interviewer:** Finally, how can government policies and regulations support sustainable material manufacturers like Bolon?

**Mr. Nordin:** Government support is very important; one company can't solve all the logistical and regulatory challenges of take-back programs alone. Stronger national and European frameworks are needed to make circularity feasible at scale.

**Interviewer:** thank you very much for your time, Mr. Nordin. This information will be incredibly helpful for my thesis.

**Mr. Nordin:** You're welcome. Feel free to reach out if you have more questions. Best of luck with your research!