# Towards Sustainable Housing: Challenges in Architectural Design for Green Retrofitting in Malaysia

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## ABSTRACT

In Malaysia, there are several alternatives available to minimize the environmental impact from the construction industry, including the adoption of green building construction. Many studies, however, show that creating new green buildings may have negative influences on the environment, such as improper waste management and a rise in building stocks in Malaysia. Thus, green retrofitting is an effective measure since it utilizes existing buildings in Malaysia to retrofit buildings with sustainable elements, such as additional window openings for natural lighting. However, the application of the green retrofitting concept as a factor in sustainable development in Malaysia is still critically low, and it is not extensively applied in the construction industry. The aim of this paper is to gain an insight and in depth understanding on the challenges in implementing green retrofitting concept in Malaysia. Quantitative study is applied through the conduction of questionnaires distributed among architects working in Kuala Lumpur. It is showed that architects are aware and facing the challenges in designing green retrofitting concept for residential housing in Malaysia.

**Keywords**—Malaysia, construction industry, green retrofitting, architectural design, sustainable housing

## INTRODUCTION

Greenhouse gas emissions are a major driver of climate change, and their escalating impact on global warming is undeniably detrimental. This issue demands urgent attention and action [2] According to the UN Environment Programme and the International Energy Agency, the construction industry is responsible for 36% of global energy consumption and 39% of carbon dioxide emissions [3]. Despite its significant environmental footprint, the construction sector holds considerable potential to reduce emissions compared to other major polluting industries [4]

Malaysia has pledged to reduce greenhouse gas emissions by 45% by 2030 and has begun implementing initiatives such as the development of carbon-neutral cities [2]. A key strategy to mitigate the environmental impact of construction is the adoption of green building practices. These practices are widely recognized for promoting sustainability and reducing emissions.

Globally, buildings account for over 40% of primary energy use, with the residential sector contributing 6% of this total [4] In Malaysia, residential buildings dominate the national building stock, with 5,611,673 units recorded in 2019—representing 86.5% of total buildings. However, most of these were constructed with minimal attention to energy efficiency. Given the scale of residential energy consumption, retrofitting existing homes presents a critical and effective strategy for carbon reduction.

### The Significance of Green Retrofitting for Sustainable Housing

In recent years, there has been a significant growth in the amount of attention devoted to green retrofitting of residential property. This is because green retrofitting has the capability to improve energy efficiency and limit the impact that it has on the environment. Sustainable building retrofits in residential structures are not only acknowledged by researchers as an important method to increase the energy efficiency of existing buildings, but they are also believed to be an effective technique to reduce the amount of funds spent on energy and to improve the performance of the building [5].

For instance, the use of a multifunctional facade system for the retrofitting of apartment buildings in Finland and Russia, as well as the utilization of an alternative building envelope in the process of building retrofitting in Portugal Strategies for retrofitting external insulation in wooden-framed buildings in cool areas of the United States of America. Several countries, including Bulgaria, Serbia, Hungary, and the Czech Republic, conducted research on the optimization of cost and energy efficiency of multi-story residential structures in Sweden, as well as investigations into other prospective retrofit techniques [6].

Sustainable retrofit projects globally have incorporated a range of retrofit measures, such as the integration of energy-efficient devices, intelligent control systems, upgrades to windows and walls, advanced heating and cooling technologies, and the implementation of renewable energy systems. The retrofit measures differ based on the climatic conditions and locations of the projects [7]. The primary goal of the passive energy-saving approach, which is extensively used, is to minimise the energy consumption of the building envelope [8]. Increasing the airtightness of the building and decreasing its heat conductivity are both necessary steps in arriving at this goal. This concept offers an effective method for reducing the excessive demand for energy that has been observed. In addition, research emphasises the significance of using passive design solutions, which, when implemented in residential structures, it has the potential to cut overall energy usage by as much as fifty percent on average [9]. It is widely accepted that the use of suitable retrofit solutions is of the utmost significance for enhancing energy efficiency and cost-effectiveness. This is because the retrofit techniques that are selected have a significant impact on the level of success that can be achieved in a project aimed at enhancing the sustainability of an existing building [10].

Sustainable retrofitting is an effective approach that extends a building’s lifespan, improves its performance, and prevents early deterioration or obsolescence [11]. It is also one of the main strategies to reduce energy consumption and greenhouse gas emissions in buildings. In Malaysia, there is a strong focus on constructing new green buildings, but the potential of existing buildings to contribute to sustainability is often overlooked. This situation leads to inefficiency and unnecessary use of resources. Constructing new buildings requires large amounts of materials and energy, which are becoming increasingly limited. As a result, a considerable amount of embodied energy is wasted, making the current pattern of construction unsustainable [11].

Although energy retrofitting is important, its adoption rate is still lower than expected due to many complex factors such as design characterization, prediction methods, and performance comparison issues [6]. Several challenges were identified when designing green retrofitting concepts for residential buildings, especially from the architects’ perspective. One major issue appears in the pre-design stage, where architects and engineers often have different approaches. Architects usually have limited understanding of energy modelling, while engineers rely heavily on these models to study building form and energy efficiency [12]. This knowledge gap makes it difficult for architects to design residential buildings that effectively integrate green retrofitting concepts.

Architects play an essential and multifaceted role in the success of sustainable retrofit projects for residential housing. They are responsible for integrating green retrofitting strategies into building designs and ensuring that every retrofit plan aligns with sustainability goals and environmental standards [13]. As design leaders, architects plan and develop retrofit solutions that improve building performance while minimizing environmental impact. Moreover, architects and builders are recognized as key professionals who provide expertise in home improvement projects. Their knowledge and influence can encourage homeowners to adopt low carbon retrofit measures, helping to promote more sustainable housing practices. This important intermediary role of architects in connecting technical solutions with homeowners has also been emphasized in previous studies [14]

During the design stage, architects also face problems in collecting data, which is often outdated or incomplete [15]. This lack of reliable information limits their ability to provide effective retrofitting solutions. Moreover, insufficient details in the existing building documentation create further barriers for architects when starting the design process [16]. Even though design costs form only a small part of the total project budget, the success of retrofitting projects strongly depends on the quality of the design approach used [17].

Based on the RIBA (Royal Institute of British Architects) Plan of Work, architects play a crucial role in

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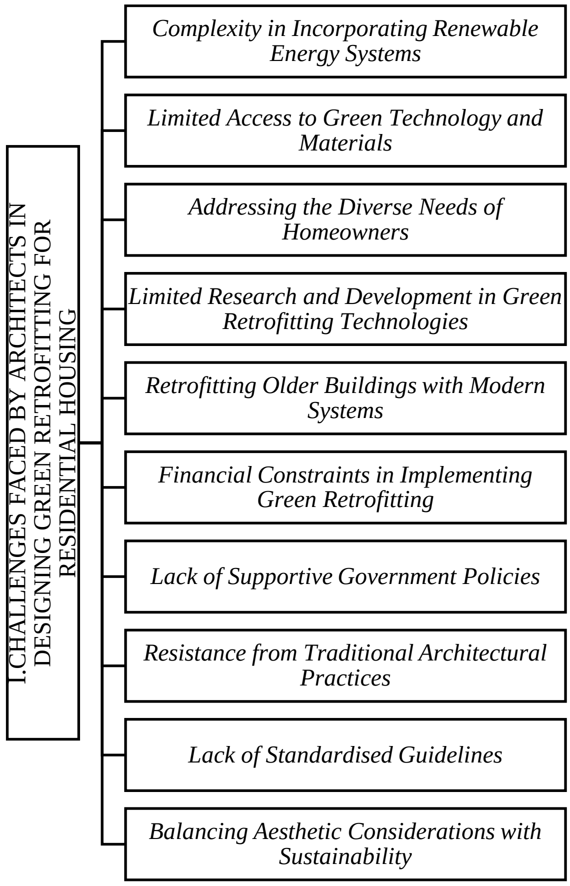
planning and implementing green retrofitting by integrating sustainable design principles at every stage of the process [18]. Their responsibilities include evaluating environmental impact, improving energy efficiency, and selecting effective retrofitting solutions through multi-method approaches that involve collaboration with various stakeholders [19]. Architects also apply performance modelling and multi-criteria decision-making tools to optimize energy-saving façade designs and overall building performance [15],[20]. In addition, they must consider homeowners' willingness to invest in energy-efficient upgrades and align design strategies with government policies and sustainability goals ([17], [21]. Overall, architects' involvement throughout the RIBA stages ensures that green retrofit projects are sustainable, efficient, and consistent with national carbon reduction and environmental objectives.

Challenges Faced by Architects in Designing Green Retrofitting for Residential Housing




The main goal of green retrofitting design is to improve energy efficiency and reduce carbon emissions by applying sustainable practices to existing buildings[12]. Energy efficiency is an essential part of sustainable building design [22]. For decades, architects have used energy-efficient design strategies to enhance building performance [23]. However, as key members of the design team, architects face complex challenges when implementing these strategies [17].

**Complexity in Incorporating Renewable Energy Systems**

Traditional architectural design methods, which focus mainly on form, function, and space, often fail to include energy simulations needed for efficient buildings. Many architects are unfamiliar with these scientific modelling tools [15]. This creates a gap between architects and engineers, especially in the early design stage, since architects may not fully understand energy models while engineers depend on them for assessing building form and energy use [12]. Architects therefore face difficulties in using energy optimisation tools effectively [17].

**Limited Access to Green Technology and Materials**

Various optimisation software such as Matlab, modeFrontier, and GenOpt can help integrate energy simulations in design [20] However, these platforms are not tailored for architectural use, making them difficult for architects to navigate. Tools like Google SketchUp also lack integration with energy simulation applications [14]. As a result, architects must switch between modelling and optimisation environments, which slows down the design process and increases the chance of error [24].

**Addressing C. the Diverse Needs of Homeowners**

Architects are central to promoting low-carbon housing because they lead the early design stages of projects [14]. Yet, they must deal with diverse housing types, ownership patterns, and client needs [15],[25]. Balancing these differences is difficult in sustainable retrofit projects. Architects must also be well-informed about the benefits of green features to help clients choose measures that fit their goals [26].

**Limited Research and Development in Green Retrofitting Technologies**

Retrofitting involves many stakeholders and complex issues like building age and deterioration [27]. Even though design costs are small, they strongly affect project success [16]. Architects often face missing or outdated information from stakeholders [28], making it hard to create accurate retrofit designs. Many old building records lack full structural details or are inconsistent [15]. This uncertainty makes retrofitting more difficult than building new green structures [26].

**Retrofitting Older Buildings with Modern Systems**

Upgrading older structures requires knowledge of history, preservation, materials, and life-cycle costs. Although principles like air tightness apply to all buildings, older ones require tailored solutions. Heritage buildings pose extra challenges due to their historical and aesthetic value [26]. Designing for such buildings requires balancing preservation and modern energy needs—something not often taught in architectural education.

**Financial Constraints in Implementing Green Retrofitting**

Lack of financial resources is one of the biggest obstacles to full adoption of green retrofit features. Although interest in green retrofitting is increasing, practical implementation remains low due to high costs [29]. Green retrofits offer energy savings and health benefits [30], but limited homeowner budgets and unclear payback periods create financial risks [31]. High upfront costs and low returns discourage investment, highlighting the need for new funding models and government incentives.

**Lack of Supportive Government Policies**

Government policies are vital for supporting green retrofitting through funding, tax incentives, and financial aid [6]. However, inconsistent or weak policies can slow progress. For example, the UK's Green Deal failed to attract private investment and burdened taxpayers. Effective policy frameworks with clear incentives are necessary to encourage developers and homeowners to invest in green retrofits [32]. In Malaysia, the lack of consistent and targeted government policies remains a key barrier to green retrofitting, particularly for residential and small commercial buildings. While national initiatives such as the National Energy Transition Roadmap (NETR) and the Energy Efficiency and Conservation Act (EECA) 2024 signal progress, they primarily focus on large-scale infrastructure and energy-intensive sectors, leaving smaller-scale retrofits under-supported. Financial incentives, such as tax relief or grants, are limited, and public awareness of retrofit benefits remains low.

**Resistance from Traditional Architectural Practices**

Some architects resist adopting green retrofitting because traditional design practices often conflict with sustainable approaches. The construction industry's reliance on conventional methods makes change difficult. Balancing heritage preservation with modern sustainability goals is a major challenge. Many architects also lack awareness of the benefits of green retrofitting. Overcoming this resistance requires a shift in mindset and integration of sustainability principles into architectural education and practice.

**Lack of Standardised Guidelines**

The absence of clear and consistent standards leads to variations in retrofit practices and results. Without proper guidelines, it is difficult to assess energy performance and maintain quality. Standardised procedures are needed to help architects design effective and cost-efficient retrofit packages [33]. Having these standards would provide a solid framework for decision-making and improve design efficiency.

**J. Balancing Aesthetic Considerations with Sustainability**

Architects often struggle to maintain visual appeal while integrating green features such as energy-efficient systems and sustainable materials [34]. Sustainable elements like green roofs may offer environmental benefits but may not fit traditional aesthetic expectations [35]. The lack of clear design guidelines makes it difficult to balance aesthetics and sustainability, forcing architects to weigh beauty, cost, and environmental goals in each project [36].

## METHODOLOGY

This study employed a quantitative research approach to investigate the challenges faced by architects in designing green retrofitting concepts for residential buildings in Malaysia. Data were collected through a structured questionnaire distributed to a target population of 138 architects registered with Lembaga Arkitek Malaysia (LAM) in Kuala Lumpur. The survey instrument was designed to capture both demographic information and perceptions of professional challenges.

The questionnaire comprised two sections. Section A gathered demographic data, including educational qualifications, years of experience in the construction industry, and the number of green retrofitting projects undertaken. Section B focused on identifying specific challenges encountered in the design of green retrofitting for residential buildings. Responses in Section B were measured using a five-point Likert scale ranging from “strongly disagree” to “strongly agree.”

Table I Interpretation of Average Index Analysis (A.I)

| **Average Index (A.I)** | **Evaluation Level** |
|---|---|
| 4.50 ≤ Average Index < 5.00 | Very Poor |
| 3.50 ≤ Average Index < 4.50 | Poor |
| 2.50 ≤ Average Index < 3.50 | Moderate |
| 1.50 ≤ Average Index < 2.50 | High |
| 1.00 ≤ Average Index < 1.50 | Very High |

Data analysis was conducted using SPSS version 26. The Average Index (A.I.) method was applied to quantify the level of agreement on each item in Section B. Interpretation of the A.I. scores followed the classification framework proposed by [37], providing a systematic indicator of consensus among respondents regarding the challenges assessed.

## RESULTS & DISCUSSION

The survey of this study has gathered a total of 81 responses out of 138 questionnaires distributed which constitute 60% of response rate. The respondents in this study are professional architects registered in

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Malaysia, selected for their relevance to the investigation of challenges in designing green retrofitting concepts for residential buildings. The demographic data shows that most respondents possess strong academic qualifications, with 53.4% holding a master's degree and 34.6% a bachelor's degree. A smaller proportion hold a PhD (4.9%), Diploma (4.9%), or Secondary School qualification (1.2%). This distribution reflects a well-educated group with substantial theoretical and practical grounding in architectural practice.

**Table Ii Demographic Analysis of Respondents**

| Criteria | Demographic | Frequency | Percentage (%) |
|---|---|---|---|
| **Education Qualification** | Secondary School | 1 | 1.2 |
| | Diploma | 4 | 4.9 |
| | Bachelor's Degree | 28 | 34.6 |
| | Master's Degree | 44 | 54.3 |
| | Doctor of Philosophy (PhD) | 4 | 4.9 |
| **Working Experience in Construction Industry** | Less than 5 years | 3 | 3.7 |
| | 5 to 10 years | 6 | 7.4 |
| | 10 to 15 years | 43 | 53.1 |
| | 15 to 30 years | 25 | 30.9 |
| | More than 30 years | 4 | 4.9 |
| **Total Number of Projects Involved or Handled with Green Retrofitting** | Less than 5 projects | 75 | 92.6 |
| | 5 to 10 projects | 6 | 7.4 |
| | 10 to 15 projects | – | – |
| | 15 to 30 projects | – | – |
| | More than 30 projects | – | – |

In terms of professional experience, 30.9% of respondents have worked in the construction industry for 15 to 30 years, while 53.1% have 10 to 15 years of experience. Only 3.7% reported less than five years of experience, and 4.9% have more than 30 years. These figures indicate that over 84% of respondents have more than a decade of industry experience, suggesting a mature and professionally seasoned sample. However, when it comes to direct involvement in green retrofitting projects, 92.6% of respondents have handled fewer than five such projects, and none reported experience beyond ten. This highlights a significant gap between general professional experience and specific exposure to sustainable retrofitting practices.

Taken together, these findings suggest that green retrofitting remains a developing area within Malaysia's residential sector. The limited project experience among respondents points to broader systemic issues—such as market demand, regulatory support, or client awareness—that may be hindering the adoption of sustainable retrofitting practices. Given the depth of professional experience among the architects surveyed, their responses offer credible insights into the practical challenges and constraints that must be addressed to advance green retrofitting in Malaysia.

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Table Iii Average Index (A.I) Analysis on Challenges in The Design of Green Retrofitting for Residential Buildings

| **Challenges in the design of green retrofitting for residential buildings** | **Average Index (A.I)** | **Evaluation Level** | **Rank** |
|---|---|---|---|
| Financial constraints | 4.21 | High | 1 |
| Lack of supportive government policies | 4.13 | High | 2 |
| Difficulties in retrofitting older residential buildings with modern energy-efficient systems | 4.01 | High | 3 |
| Diverse needs and preferences of homeowners | 3.93 | High | 4 |
| Lack of standardized guidelines and protocols | 3.89 | High | 5 |
| Resistance from traditional architectural practices | 3.85 | High | 6 |
| Complexity when incorporating renewable energy systems | 3.81 | High | 7 |
| Green retrofitting for residential housing in densely populated urban areas | 3.72 | High | 8 |
| Balancing aesthetic considerations with green retrofitting requirements | 3.65 | High | 9 |
| Limited development in green retrofitting technologies | 3.60 | High | 10 |

Table III clearly highlights the most pressing challenges faced by architects in implementing green retrofitting for residential housing in Malaysia. Financial constraints stand out as the most significant issue, receiving the highest A.I. score of 4.21. This reflects a strong consensus among respondents that budget limitations hinder the full integration of sustainable features in retrofit projects. Supporting literature reinforces this concern, noting that the absence of a suitable financial framework, coupled with low return on investment, poses substantial risks to project viability [31]. High initial costs, uncertain payback periods, and limited access to financial resources further complicate the execution of green retrofitting initiatives [22].

The second-highest ranked challenge, with A.I. score of 4.13, is the lack of supportive government policies. Respondents expressed strong agreement that policy gaps obstruct the adoption of green retrofitting practices. This aligns with findings by [32], who emphasize the importance of government incentives—such as subsidies and financial compensation—in encouraging developers and homeowners to invest in sustainable upgrades. Inadequate policy support can lead to poor uptake, as illustrated by the UK's Green Deal, which failed to mobilize corporate participation and resulted in high costs to taxpayers.

Retrofitting older residential buildings with modern energy-efficient systems ranked third, with an A.I. score of 4.01. This challenge involves navigating complex design requirements, including historical preservation, structural assessments, and compatibility with existing materials. Sustainable integration into heritage buildings often lacks clear guidance, making it difficult for architects to balance aesthetic, technological, and functional demands [26]. The absence of comprehensive training in architectural education further limits practitioners' ability to manage these complexities effectively.

These findings, supported by both empirical data and scholarly research, underscore the multifaceted nature of barriers to green retrofitting in Malaysia's residential sector. Financial, regulatory, and technical challenges each play a critical role in shaping the feasibility and success of retrofit projects. Addressing these issues requires coordinated efforts across policy development, industry practice, and professional education to enable broader and more effective implementation of sustainable design strategies.

## CONCLUSION

This study has thoroughly explored the concept of green retrofitting for residential buildings in Malaysia, with a focus on the challenges encountered by architects during the design process. The study successfully met its objectives by identifying key barriers and aligning them with insights from existing literature. Among the challenges, financial constraints were consistently recognized by architects as the most critical. They highlighted that limited financial resources, high retrofitting costs, and uncertain payback periods significantly hinder the implementation of sustainable design features. These concerns are well-documented in prior studies, which emphasize the lack of a suitable financial framework and the low return on investment as major deterrents to green retrofitting.

In addition to financial limitations, the absence of supportive government policies was identified as a substantial obstacle. Architects stressed the need for clear legislative support and financial incentives to encourage broader adoption of retrofitting practices. Furthermore, the technical complexity of upgrading older residential buildings with modern energy-efficient systems presents considerable design challenges. These require specialized knowledge and a nuanced understanding of building conditions, historical context, and material compatibility.

The findings underscore the need for coordinated efforts across policy development, financial support mechanisms, and professional capacity-building to enable the practical application of green retrofitting in Malaysia. Strengthening institutional frameworks and improving access to resources will empower architects to overcome existing barriers and contribute to the development of environmentally responsible residential environments.

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