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Green Building in Existing Development: A Review of Current Status, Challenges, and Implementation Strategy

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Abstract Green building development is on the rise with more new constructions receiving green building certification locally and globally. Starting with 247 papers in the first cycle searching of greening an existing building, this paper conducts a literature review over 30 relevant publications related to the effort towards greening the existing development from various countries especially in Malaysia, since three specific case studies on implementation of greening existing building were analyzed from this country. Regarding to the review on current development status, there occur several challenges of existing building standards from the regulatory that will slow the target achievement towards a sustainable plan besides the cost implication and project feasibility that resulting in most existing buildings do not embed green building elements. Therefore, retrofitting the existing structure might contribute to a positive, sustainable impact, including cost-saving, living comfortability, and environmental preservation. However, the decision-making on retrofitting action needs detailed analysis. This is especially in identifying expenditure on current building performance, potential cost benefits through lifecycle assessment and cost-benefit analysis. This paper presents three case studies of green retrofitting project in Malaysia and highlights twenty effective strategies towards successful retrofitting for sustainable development. According to the summative analysis of the strategies, the most important element to be addressed in retrofitting action towards a green building is thoroughly assessing the current performance and needs of the development to meet the sustainability impact. It is recommended for future researchers to conduct a survey on the details of the procedure from specific stakeholders with focus on regional-based existing building conditions.

Keywords Retrofitting, Green Building, Existing Building, Retrofitting Challenges, Green Building Benefits

1. Introduction

Infrastructure development refers to transforming urban areas into basic infrastructure and systems that include transportation, water management, communication, residential, public buildings, hospitals, government offices, religious institutions, educational institutions, etc. As a result of increasing growth, urbanisation and industrialisation, the world is dealing with climate change, deforestation, rising global temperatures, rising sea levels, natural resource depletion and other serious environmental challenges [1]. The more perturbing things are: all these activities have affected the earth's natural ecosystem and negatively impacted the environment [2]. As a result, the level of human health and other well-being is declining and threatened with extinction.

In 2015, United Nation (UN) in collaboration with 193 Member States worldwide has outlined 17 Sustainable Development Goals (SDGs). UN is optimistic about achieving all the envisioned plans by 2030. Sustainable cities and sustainable infrastructure construction are part of the 17 goals in the SDGs agenda. Through the clarity agenda, most developed and developing countries have started to adopt the sustainable international policy by constructing infrastructure and building with the green element for the entire building lifecycle to achieve the maximum sustainability impact [3]. In addition, the agenda will create opportunities to be awarded, certified, and recognised internationally by the established Green Building Rating System, thus increasing the country's value and reputation.

As a result, we can see today that significant infrastructure developments have included sustainability elements as one of the mandatory criteria before the local authority approves the development project. This is a proactive action that positively impacts the rate of economic growth, increasing living standards, and most importantly, the preservation of the environment. However, all the construction of new infrastructure is implemented with sustainability elements; meanwhile, millions of existing building stocks and infrastructure are still in day-to-day operations but do not apply sustainable features throughout the entire building life-cycle.

As of 31st March 2020, according to the Green Building Index (GBI) Malaysia Executive Report, the numbers of certified Non-Residential Existing Building (NREB) and Industrial Existing Building (IEB) are 22 and four respectively, with a total percentage of only 4% among both implementations. This indicates a significant gap in green building implementation between existing buildings and new construction buildings. It is due to the high certified numbers of Non-Residential New Construction (NRNC) and Residential New Construction (RNC), 296 and 210 respectively with the total percentage for both being 89%. According to the research published in 2019 by the International Energy Agency (IEA) the significant numbers of existing buildings [4] and construction industries consume approximately 36% of energy and release around 39% of (CO_2) emissions.

This paper aims to review the current status, challenges and implementation strategies for retrofitting an existing building to become a green building for further discussion as there are only a few retrofitting actions and the actions are still not extensively explored [4] generally worldwide and particularly in Malaysia.

2. Green Buildings Overview

Although there are several different terms for different areas or countries such as "Sustainable Building", "Eco-Friendly Building", "Green Building", "Energy Efficiency Building" or even "Net Zero Energy Building", the objective remains the same: to improve the efficiency performance of building functions and in the same time, able to conserve the environment. The objective can be achieved by applying sustainability elements from the designing stage of new development and continuing the sustainability practice along the building lifecycle. Other ways are to increase the efficiency and performance of the existing building [5] through renovation, refurbishment and retrofitting. A study from Che Husin et al., [6] mentions slightly different interpretations of renovation, refurbishment, and retrofitting definition.

Refurbishment: A method of restoring a building's or the system's original condition, while addressing the forces of physical obsolescence. Normally apply on historical and heritage buildings to sustain the building structure and history.

Renovation: A method of advancing refurbishment by incorporating improvements to the building's physical attributes. It can be applied to any desired extension, change of functionality and repairing of building fracture.

Retrofitting: A process of replacing and upgrading systems and technology in existing building to address its technological or environmental obsolescence. Beneficially apply to the building that have potential to increase the building performance with sustainability element.

In line with the definition, this paper will focus on reviewing the greening and sustaining of existing building through retrofitting decision making onto retrofitting action which needs detailed analysis [2], especially in the identification of expenditure on current building performance [6] and potential of cost benefits including the initial cost for retrofitting action and operational cost after retrofitting [4]. Green retrofitting action has also been touted as a solution to achieve the government sustainability target in reducing the GHG emission and declining total energy consumption of the building [5]. Therefore, it is important to outline the target of achievement and understand the green building design and principles [7] to ensure the worthiness of effort towards retrofitting an existing building to become a green building.

3. Green Buildings Design

The green building principles consist of optimal site potential [7]. First, the site must be integrated with existing development or natural surroundings to minimize the negative impact during the development or retrofitting of the existing building [7]. The second principle is about optimization of energy use, where the green building must consume energy at a very minimum rate but still sufficient to provide power for building occupants' comfort [7]. Currently, the most demanding equipment for thermal comfort of the building is Heating, Ventilating and Air-Conditioning (HVAC) systems. Still, this operation consumes high energy of the building [8]. Therefore, the green building must come with approaches in reducing the energy consumption from the operation of building equipment, including utilization of natural energy sources, and solar power systems using photovoltaics [9]. In addition, adopting of passive design [10] that captures optimum natural lighting and natural ventilation will help the building to consume less energy for indoor building environment comfortability with the installation of energy efficiency equipment [11] such as sensor lighting, LED bulb, split unit inverter air conditioner and the high star rating of energy-saving facilities. Attention must be given to existing buildings requiring frequent maintenance to ensure the energy consumption of building operation is performing due to the early design requirement [2].

The principle of green building is about the ability to protect and conserve water [7]. It is easier to apply sustainable water technology to new development than the existing building. However, in order to be recognised as a proper green building, both new and existing development need to be able to consume water efficiently. This includes regular check-up of water leakage [12], installation of dual flush sanitary system [13] and smart water fittings. Another approach would be recycling or re-use of water to reduce high consumption of the main water supply. The techniques involve rainwater harvesting, greywater recycling, or water desalination [12]. Several characteristics of building material such as reuse and recycle content [14], zero or low off-gassing of harmful air emissions, zero or low toxicity will promote the efficiency of green building and resource conservation. Furthermore, sustainably harvested materials, high recyclability, durability, longevity, local production, sustainable construction materials and consumption of local products will help the building sustain its performance for the entire building life cycle with continuous monitoring on maintenance practice [2].

4. Barriers and Challenges of Greening Building through Retrofitting

Considering Malaysia's development status, most of the building stock was ascendancy to the existing building [2]. According to the Valuation and Property Services Department Malaysia [15], in 2019, the overall performance of Malaysia's property stock of existing buildings was approximately 6.67 million units (as shown in Figure 1). The significant number of existing buildings that were not adopting sustainable building design and principles will distract the national target towards Near Zero Energy Building in 2040. The existing unsustainable building consumes 40% of the world's energy generation. In Malaysia, however, residential and commercial structures use around 15% of the energy, which is rising over time [16]. Therefore, green retrofitting action toward the high density of existing buildings in Malaysia will contribute at least 80% potential national emission target [6] and is a feasible solution to reduce environmental impact [2] rather than relying only on new sustainable development initiatives. The following subtopics will determine the barrier and challenges on retrofitting action of existing buildings into green buildings.

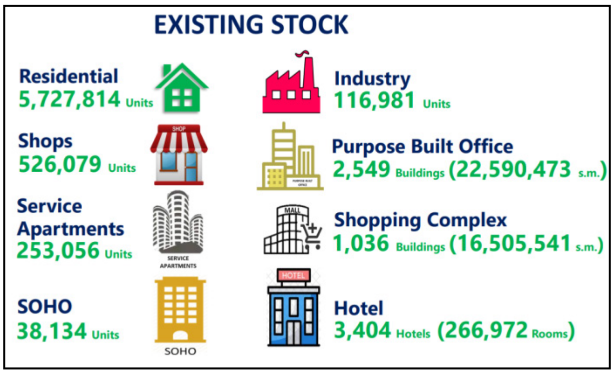

Figure 1. Malaysia's Property Stock 2019 [15]

4.1. Climate

The unstable climate condition has a significant impact on building performance. With most countries in the tropical zone subject to hot and humid weather throughout the year, the building structure and finishes are readily corroded [17]. Most of the time, the esthetical building appearance is not sustaining more than 10 years, especially to the structure such as the wall, roof, walkway and corridor which are openly exposed to sunlight, raindrops and extreme weather events [6]. As a result of the deteriorating building structure [18] caused by the climate, difficulties such as leaks from the roof area, cement plaster cracking, flocculation at the rain gutter and parasitic trees growing on the wall are more likely to occur.

4.2. Building Design

In 2009, Green Building Index (GBI) Malaysia was introduced as a tool to recognise new development or existing building categories with Certification, Silver, Gold or Gold Platinum award as Green Building. However, according to the latest GBI Malaysia Executive Report 2020, only 4% of the existing building are certified as green buildings. It shows that only 4% of Malaysia's 6.67 million building stock contributes to the National Agenda for Near Zero Energy Building [16]. Meanwhile, others continue to operate as usual, emitting around 40%

to 50% of GHG emissions [6] without taking into account the recommended energy requirements. Even many of existing great buildings in Malaysia experienced refurbishment, renovation and restoration. For example, the Sultan Abdul Samad Building and National Mosque in Kuala Lumpur, Seri Menanti Castle in Negeri Sembilan, Ipoh Railway Station in Perak, the Stadthuys in Malacca and Sultan Abdul Halim Gallery in Kedah. However, all of the retrofitting action of the building did not meet with green building criteria [18] due to the intention to sustain the detailing of the historical building that adopted colonial British building design. In fact, by adhering to those four fundamental principles can minimise the impact on a building's integrity and preserve as much of the original building fabric as possible, and sympathetic upgrades, reversibility, retention of historic fabric and life-cycle benefit [36].

4.3. Building Operation

Buildings that are frequently occupied and have high utilization capacity will eventually decline in building performance. This requires high maintenance costs [2] and frequent maintenance operations to ensure that the building provides maximum functionality with high utilization capacity. Moreover, the building that provides essential services [11] has to continue operating for 24 hours a day (such as healthcare buildings) to ensure comfort and a high level of safety for staff and patients who need treatment. This includes the deterioration of old wiring standards [2] in ageing hospital buildings, resulting in short circuits for electric overload capacity. The old wiring cannot adapt with the latest sophisticated hospital equipment and increasing numbers of patients over time, potentially resulting in fire and endangering the building occupants. Therefore, the Ministry of Health (MOH) Malaysia conducted a programme with a local development company to implement the energy management programme for 32 hospital buildings in Malaysia [19]. The programme aims at improving the energy performance of existing hospital buildings and at the same time helping to reduce the environmental emission from the overall operation of these buildings.

4.4. Occupants' Behaviour

Building occupants are the stakeholders who uphold more prominent roles and higher responsibilities towards building performance, as they consume and utilize building facilities. The occupants' behaviours are usually influenced by their cultural background, household income, age group, lifestyle [6] and the building ownership. Assuming that the building occupants maintain the facilities and structure according to a set schedule, the functionality and robustness of the building may be able to sustain until the end of the building's life as per design [20] during the planning stage. However, if the building occupants do not pay attention to the maintenance needs of the equipped facilities, the lifespan of the building will also decrease earlier than estimated. It will become a conflict between the building owner and building occupants on who should afford the cost of retrofitting and either the action is worthwhile [6] or a waste. A study from Masrom et al., [4] also mentioned that the retrofitting action will become a hassle due to the disconnection of cost and benefit, where the owner needs to bear on the cost versus the comfortability. Comfortability refers to where the current building occupants or tenants enjoy cost-saving on utility expenses and other benefits.

4.5. Cost Implication

Relatively, the allocation of funds for operation and maintenance activities is more negligible than the new development budget [4]. Therefore, it is more challenging to retrofit the existing building into a green building because generally in the market, the experts' fees to redesign and install green features are higher than the conventional construction methods [21]. In addition, high upfront payment [17] requires the building owner to conduct and emphasise a Cost-Benefit Analysis (CBA) study to ensure that they earn a good Return of Investment (ROI) outcome. Therefore, the building owner feels that transformation towards green development is only an additional burden that can be neglected [8] and comes with the decision to practice current retrofitting action since cost implication is among the challenges to be presumable.

4.6. Project Feasibility

Building occupants are hesitant to convert to green buildings because they believe the new technology is complicated and challenging to understand [21]. Unlike the design approach of new development, the design parameters in greening existing buildings through retrofitting action are restrained by the current condition [22] of the building that needs to be adopted, including the deteriorating structure, ageing building and decreasing of aesthetic appearance. Furthermore, building occupants think that the new technology introduced is fragile in performance, difficult to operate, and requires extensive maintenance [23]. Besides the lack of knowledge and exposure regarding green building among the building occupants, the experts from construction backgrounds also seem to be reluctant to include green elements in their design [4] and most of the stakeholders are considering more toward cost implementation with good return value rather than considering the impact on the environmental and social balance of the community [17]. Through the existing building condition that is difficult to be evaluated [4] of its status and performance, lack of knowledge, cooperation and integration from every stakeholder [4], including the project management team, the contractors, the workforce and even building occupants, the greening approach on the existing building will generate potential challenges [5] towards green building implementation.

4.7. Regulatory Enforcement

Although the government is the most powerful stakeholder in the green retrofitting action of the existing building, lack of government interference in policies, guidelines, and even lack of incentives discourage the action [21]. The government has the intention but lacks knowledge in green building implementation. Moreover, the overlapping of several functions in government agencies, such as the existence of several green building assessment systems has caused people to be confused. As a result, people tend to dispute the level of effectiveness of the green building assessment tools with the issues in [14] inconsistency introduction of various law, regulation, standards and norms. In addition, the lack of awareness of programs and promotion towards sustainable development [4] has resulted in slow uptake in implementing green building principles from the contractor and slow demand from building owners, thus reflecting unsporting attitude towards the government agenda.

5. Case Study: Retrofitting Implementation towards Different Building Characters in Malaysia

As discussed in the previous topic, the type of building operation is one of the barriers and challenges of green building implementation. Therefore, this paper has selected three different types of existing buildings (non-residential, hospital and historic buildings) as a case study, in line with the category of existing building in Green Building Index reference guides. The criteria of those buildings and the level of green building recognition based on their retrofit efforts will be discussed.

There are six primary criteria to be examined according to the Green Building Index (GBI) created by PAM (Pertubuhan Arkitek Malaysia/Malaysian Institute of Architects) and ACEM (the Association of Consulting Engineers Malaysia). The six primary criteria are based on Energy Efficiency, Indoor Environment Quality, Sustainable Site Planning & Management, Materials & Resources, Water Efficiency, and Innovation; each requires evaluation of a number of components.

Based on the literary output, the Low Energy Office (LEO) Buildings in Putrajaya is chosen as a non-residential structure, the Sultanah Maliha Hospital in Kedah is chosen as a hospital building and the Penang Town Hall is chosen as a historic building. The LEO Buildings' location in Putrajaya provides a good opportunity to fulfil the GBI requirement. Putrajaya's extensive waterways and greenery landscaping help create the ideal local microclimate. Other design elements, such as the pairing of exterior shading and glazing, allow 65% of light to pass by. Since no historical element to be maintained, most of the green building element has been added at architectural finishing.

Meanwhile, Sultanah Maliha Hospital takes about four years in its retrofitting process. Implementing an adequate air ventilation system that can remove hazardous chemical particles from the building results in a healthy indoor environment. A systematic waste management system for both chemical and food wastes has contributed to the point. Utilizing rainwater harvesting and a detention pond has reduced both potable and non-potable water usage. Similar to LEO building, installing solar panel and LED has increased energy consumption efficiency.

In contrast to Penang Town Hall, which is an old structure, minimum retrofitting is allowed to maintain the building's historical value. Hence, the efficiency of the use of energy and water is the main focus. With the different character of building, five criteria can be compared that are reflected in the GBI criterion assessment. Those criteria have been fulfilled to meet the Green Building Recognition, including building design features, energy consumption and carbon foot print, water performance, waste management and architectural finishing. Refer to Table 2 for the summative analysis of the retrofit process.

Table 2. Summative Analysis of Retrofitted Building in Malaysia.

Retrofitting Building in Malaysia	Low Energy Office (LEO) Building (Putrajaya) [5]	Sultanah Maliha Hospital (Kedah) [11]	Penang Town Hall (Penang) [17]
Building Character	A six-floor government office building with gross floor area of 38,600 m^2. Inaugurated in 2004, its retrofitting was completed in 2011.	A complex consisting of two-storey hospital buildings, a three-storey main block building and several small individual buildings that was connected through a walkway. The gross floor area is 42,323m^2 and first established in 1995. Retrofitting action started in 2015 and was completed in 2019.	The British Colonial of two-storey masonry building started construction in 1879 and was inaugurated in 1880. It is categorised as Grade 1 heritage building: any retrofitting, renovation, or refurbishment must be maintained in its original design. It consists of 70,711f^2 land area constructed of classical arches, columns, pilasters, quoins, ornamental on roof parapet and balustrades.
Green Building Recognition	GBI (Malaysia) Silver Certified (December 2011) - Non-Residential Existing Building (NREB)	Gold Certification Level on 12 May 2020 under LEED – (United States) v4 O+M Existing Building	UNESCO World Heritage Site Category Building – Moving towards GBI Certification on Non- Residential Existing Building (NREB)
Building Design Features	Site and Climate: Putrajaya's green layout and huge water areas contribute to the creation of ideal local microclimatic conditions for buildings and people.	Site and Climate: Located at the most popular tourist location in Langkawi, the hospital was built to preserve and restore the natural ecosystem. Landscape and green area consist of 59.1% which is up to 200,667m^2 from total area.	Site and Climate: The Town Hall was exposed to high local temperature with an average of 33^{o}C and high outdoor moisture content in the range of 64.1% - 69.8% relative humidity since it was located near the Straits of Malacca's coastal area.
	Thermal Comfort: The windows are oriented to the polar side that receives less direct sunlight. The combination of exterior shading and glazing allows 65% of light and only 51% of the heat to pass by. Natural lighting and ventilation at atrium with two storey of solar chimney on top of the building create better hot and fresh air circulation, improve indoor comfort and less energy use.	Thermal Comfort: Healthy indoor environment quality achieved through utilization of sufficient air ventilation system that can eliminate hazardous chemical particles in the building. The amount of CO_2 and outdoor air monitoring projects were conducted to meet the comfortability of building occupants with the hospital's indoor atmosphere.	Thermal Comfort: Since the design needs to comply with UNESCO requirements, the green element is difficult to be applied in a typical green building approach with usual energy efficient features installation.
Energy Consumption and Carbon Foot Print	Lighting and Motion Sensor: When an office is unoccupied, the daylight responsive control system integrated with a motion detector will automatically shut off lighting and minimises cooling. When daylight is sufficient, the artificial lighting will automatically turn off to meet the lighting requirement of 300-400 lux.	Energy Management System (EMS): The installation of EMS in the hospital building will help in monitoring and controlling energy consumption.	Energy Management System (EMS): Installation of EMS to monitor the building's energy performance during building operation will help to control the energy consumption.
	Energy Efficiency: Application of energy efficiency office equipment able to reduce from 25 to 10kWh/ m^2 /y, thus reducing cooling load about 10kWh/m^2/y. When idle, it is also able to shut off automatically. Installation of LED and T5 with high efficiency light fixtures reduces half of the lighting load. Installation of high efficiency motors for mechanical and electrical (M&E) equipment, relocation of Air Handling Unit (AHU) from centralised control to individual rooms and zoning relocation by floor are able to reduce the energy consumption at 25^{o}C set temperature.	Energy Efficiency: Installation of building integrated solar PV for clean and renewable energy. Retrofitting project for chiller, enhancing refrigerant management and changing of conventional lighting to LED and T8 contributes to the optimization of energy performance with carbon emission reduced by 92 tonnes per year since 2017. Scheduled maintenance of chiller plant and air handling unit to optimize the performance.	Energy Efficiency: The old HVAC system caused a rotting issue of the ceiling due to water leakage, condensation and termite attacks, thus bringing poor indoor environment quality to the building. Therefore, thr high efficiency of an air conditioner with new ducting system help to improve the IEQ of the building. The retrofitting project also included new LED fittings with motion sensors from the conventional lighting system. A minimum of 30% natural lighting will cover every floor of the building.

Table 2. Continued

Water Performance	Water Efficiency Efficient water fittings and minimum water consumption implemented in the building with promotion of water saving campaign.	Rainwater Harvesting 6 RWH tanks use for irrigation with signage at the outlet pipes reduced potable and non-potable water consumption.	Water Efficiency The installation of low flush toilet system and leaking detection will help to reduce the water consumption from main water source for sanitation purposes.
		Detention Ponds 1,200m^3 bioswale detention ponds absorbing water from silt through to the soil effect from heavy rain.	
Waste Management	Efficient environmental management with promotion of 3R campaign among the building occupants.	Medical Waste Treated appropriately by specific chambers. The recyclable waste is approaching 15% with a future target up to 50%. Food Waste: Recycled or composted into fertiliser using food waste composter. The fertiliser is used for hospital landscaping.	
Architectural Finishing	Shading Two types of window façade were applied, which are punch holes in lower floors and curtain wall windows with exterior shading louvers in the upper floors.	Passive Design The building orientation was facing South East which received the least heat from the sun, help in reducing the cooling load and maximizing the natural lighting.	Finishing A dilapidation survey found that the existing building had deteriorated so poorly that it needs structural rectification and remedial measures. However, no change to the façade and aesthetic is permitted. Therefore, the retrofitting action is still preserving its original architectural design including installing tessellated tiles as floor finishing to match the original design and colours of the initial timber flooring.
	Walls The 200mm lightweight aerated concrete with light colours helps in reducing solar heating through the walls.		
	Building Canopy The roof was 100m insulated and embedded with a second canopy roof to protect from direct solar radiation. In addition, the roof was installed with green landscaping as a shading and creates better aesthetics and fresh air.		

6. Strategies for the Successful Implementation of Green Buildings

Based on the identification of retrofitting action discussed in previous subtopics towards three types of buildings with different functionality, this can indicate that each building needs to maintain the original position of the building because strategic location factors can continue the access to health services, maintain historical value and provide the needs of other essential services. However, each building has its unique characteristic and different levels of difficulties [4] to evaluate existing building performance and condition. Therefore, proper plan and strategies need to be conducted before retrofitting action is decided [2], especially regarding the building Life Cycle Assessment [22] and Cost Benefit Analysis [11] besides the encouragement from government, coordination among construction industries, availability of technologies, skills and knowledge and responsibility behaviour of building owners to ensure that the decision is worthy in terms of economic, able to preserve the environment and increase the comfortability of the building occupants. As listed, Table 3 summarizes twenty significant strategies toward green retrofitting proposed by several researchers. Hence, this paper has classified all the strategies into five important categories, as discussed in the following subtopic.

Table 3. Comprehensive Strategy for Implementation of Sustainable Infrastructure

Significant Strategies Towards Green Retrofitting	[4]	[5]	[27]	[17]	[11]	[21]	[6]	[2]	[29]	[18]	[9]	[22]
S1: Clear National Sustainable Agenda		√				√						
S2: Financial Support in Sustainable Infrastructure Development (Incentive, tax exemption, subsidize)	√	√		√		√						
S3: Enforcement of Policy and Legislation	√	√				√						
S4: Scheduled Monitor System				√	√	√			√	√	√	
S5: Efficient Improving, Promoting Information and Awareness	√		√		√	√	√	√				
S6: Integrations of Policy Makers	√	√			√							
S7: Control the Political Influence	√											
S8: Collaboration and Government Co-funding with Research Institute					√	√		√				
S9: Standardize the Evaluation and Accreditation of Green Building Rating System	√		√				√					√
S10: Update with Sustainable Technology (RE)		√	√		√	√	√			√	√	√
S11: Integrate Passive and Active Design			√		√		√			√	√	√
S12: Sustainable Building Materials			√			√				√	√	√
S13: Providing Opportunity for FM Upgrading Abilities (Knowledge and Skills)		√							√			
S14: Schedule Building Maintenance				√	√				√	√	√	√
S15: Cost Benefit Analysis	√	√		√	√						√	√
S16: Structured Life Cycle Cost Analysis	√	√		√	√						√	√
S17: Perform Post-Occupancy Evaluation						√						
S18: Understand the Implication of Green Building (Sense of Belonging)			√			√	√			√		
S19: Practice 3R Principles (Reduce, Reuse, Recycle)			√				√			√		
S20: Integrate Building Occupants/Owners Substance		√		√	√	√		√	√		√	

6.1. Assessment of Existing Features

Different building construction features convey their essential responsibilities through various functions. However, the buildings all have the same purpose in terms of economic development: improving the living standards of the people and at the same time still being able to preserve the sustainability of the environment. Nevertheless, the existing building will experience wear and tear. This has caused a need for a higher cost and more frequent maintenance approach [2]. Every building has its life span which has already been estimated during the design phase. Therefore, as the building ages, its performance will decrease. However, the increasing population growth increases the building capacity with continuous operation hours, thus demanding more energy [6] for its usage.

The decline of building performance versus the increasing functionality will result in a higher risk of the building's operation system. This is a threat on the safety of building occupants [4]. For example, the fire at Hospital Sultanah Aminah, Johor Bahru on 25th October 2016 at the hospital's Intensive Care Unit (ICU) claimed the lives of six patients and necessitated the evacuation of hundreds more [24]. Another fire reoccurred on 28th June 2020 at the women's ward where 24 patients had to be evacuated. According to the statement from Johor Fire and Rescue Department Director, the burnt capacitor in one of the ceiling lights had been identified as one of the burning causes [25] and the old wiring system formed high tendency of short circuit with an overload of electricity bypassing the deteriorated wiring [2].

There have been several other incidents, outside and inside the country due to the failure of the declining building system which has also claimed the lives and safety of building occupants. This resulted in huge losses in building repairing costs and affected the building's reputation as it had to stop for forensic and maintenance operation. Therefore, regular maintenance, including preventive maintenance must be closely monitored to ensure the building function and performance are still efficient [9]; and up to a certain limit there is the need to conduct retrofitting action with detail cost-benefits analysis to reduce the high maintenance cost and upgrade the building performance [5] with the application of sustainability element.

6.2. Stakeholders

The enhancement effort by the government in riding awareness [4] towards every stakeholder involved in construction industries, including the building owners, will positively impact green retrofitting action of the existing building stock, especially in Malaysia condition. There are established policies and guidelines for green building since 2009. The green building assessment tools have been introduced in Malaysia starting with Green Building Index (GBI), followed by several others including 'Penarafan Hijau JKR', Green RE, MyCrest, Melaka Green Seal, CASBEE Iskandar and Green Pass [26]. However, upon that listed, only GBI, GreenRE and PHJKR have evaluation categorised under sustainability of existing building meanwhile other only focuses on new development. Therefore, the authorities need to establish more policies and guidelines for existing building [6] to help the agenda achievement towards reduction of CO_2 and other GHG emissions because the majority of the existing building stock are not equipped with green features meanwhile great potential in energy performance in supporting national sustainability agenda is lying within this existing building stock [27].

Despite enhancing policy, guidelines, and legislation, the essential part is to ensure that all the information is directly delivered to the related stakeholder involved in construction [27]. Accurate information can be channelled through several methods such as intensifying activities that promote awareness [28] of the importance and benefits of retrofitting action as well as conducting more training programs related to the latest sustainability technology such as Building Information Modelling (BIM) to improve the knowledge and skills of workers in handling activities on construction sites [22]. Consequently, all the related stakeholders can decide on the suitable retrofitting implementation according to the current building performance to optimise the outcome [22] of retrofitting action. In addition, financial support, including tax exemption, subsidies and incentives [17] by the government for those who practice sustainable approaches will encourage more construction industries to embed green features in their retrofitting project.

6.3. Technology and Materials

There are available technologies and building materials in the market that support the sustainable development approach. This includes star rating for energy efficiency building appliances [2], eco label products [18], precast building segments [20] and intelligence building analysis that apply virtual and augmented reality. Since existing building condition is difficult to analyse for decision of retrofitting action [4], the Building Information Modelling (BIM) is the latest technology that consists of several levels which are able to analyse existing building condition and evaluate sustainable building performance [22] to minimise the mistakes, reduce the retrofitting cost and improve the time management. Furthermore, the BIM application is able to determine parametric modelling of the building materials' properties which can be altered and tested conveniently to initially examine on existing building sustainability [22] besides its ability to determine common parameters including building orientation, indoor thermal comfort, heating and ventilation, opening or windows for building enveloped and roof structure [22].

To increase the energy performance of the building, the installation of green building features that are adaptable with existing building conditions can contribute to energy saving during building operation after being retrofitted [27]. For example, of the case study on the Sultanah Maliha Hospital, LEO Building and Penang Town Hall Heritage Building, most of the conventional lighting were switched to new fittings of LED with motion sensor [5; 11; 17] to optimize the energy performance. This change has proven to reduce carbon emissions. Besides the lighting system, energy consumption for thermal and ventilation systems is also significant in green retrofitting [18] that might help increase the building lifespan and performance. Therefore, installation of high-efficiency motors for mechanical and electrical (M&E) equipment, relocation of Air Handling Unit (AHU) from centralised control to individual rooms and zoning relocation by floor is able to reduce the energy consumption [5] together with the implementation of the passive design maximizing natural lighting and natural ventilation. The energy consumption can also be utilized from natural resources by installing Solar Photovoltaic panels during roof retrofits action [11; 18; 22].

6.4. Life Cycle Assessment

The most encouraging measure in retrofitting existing buildings is incorporating low-cost retrofit options and adopting passive design solutions [6]. Affordable cost for retrofitting with continuous money-saving after retrofitting due to increasing building performance will become the decided solution for existing building stock. Building Life Cycle Assessment and Cost-Benefit Analysis are two essential methods in analysing building performance and economic analysis. Ageing buildings that have been operated for several years will require periodic maintenance, retrofitting and modernization to maintain the quality of building services. A comprehensive maintenance [11] plan will prevent building structures or features from experiencing significant defects.

Nevertheless, immediate solutions for rehabilitation or retrofitting will reduce the capital and operational expenditure by minimising energy consumption and conserving the environment [11]. Therefore, the building's Life Cycle Assessment is a data-driven tool that provides facility manager information to a detailed account of the total cost of the retrofitting project along with its expected lifespan.

6.5. Cost Benefit Analysis

With the significant reduction in monthly utility bills, building occupants will be more motivated and attracted to conduct green retrofitting [22]. However, before financial savings on retrofitting activities can be achieved, a detailed cost-benefit analysis should be taken into account. The estimations consist of Net Present Value (NPV), Return of Investment (ROI), Benefit-Cost Ratio (BCR) and Payback Period [12]. It is essential to carry out the cost-benefit analysis before performing retrofitting as consultants, contractors, or building owners can estimate the optimisation of retrofitting measures to compare their final energy consumption and cost investment [22]. Furthermore, the BCR also helps the building owner tolerate building materials, green features and the best technologies suitable to be implemented with the value of the building. Furthermore, despite individual building owners, the enormous building owners, such as green retrofitting of a government office building can help related agencies better estimate the strength and weaknesses of the project risk.

Cost Benefit Analysis is able to increase the building performance, increase energy efficiency and reduce the carbon footprint during building operation while preserving cost-saving [11]. On the other hand, making structure changes, remodelling building space, switching conventional building operation systems, and installing new green building features require a considerable amount of investment [17].

7. Sustainability Impact After Greening Action

An action will only be appreciated when the impact of its implementation is obtained especially involving a tangible result. Similarly, with retrofitting the desired results being its effects on building operating cost savings, and increased comfortability of building occupants; the most significant is the ability to preserve the environment. Better thermal comfort and indoor air improvisation [6] from the retrofit of existing buildings could reduce the building's greenhouse gas emissions and carbon footprint [27]. According to Green Technology Master Plan Malaysia [16], the target achievement of emission reduction is 858.4 $ktCO_2eq$ for private buildings and 98.2 $ktCO_2eq$ for a government building in 2020, with a total number of green building estimation is 1750 in 2030. It shows that the environmental impact is vital to be addressed through greening the existing building despite being the only focus on new green development. The significant number of building stock that has not implemented green elements through the building life cycle will slow the uptake towards the national sustainable agenda.

Furthermore, retrofitting is beneficial to the environment and the economy since it can prevent global warming issues while also saving energy costs [18]. Using eco-label for building materials could reduce the depletion of natural resources because sustainable building materials are produced from eco-friendly elements and probably from recycled materials [2]. This will result in a reduction of the environmental pollution from excessive construction and demolition waste, preventing overconsumption of natural resources, and reducing the use of energy such as fossil fuel and natural gas [18].

Appropriate decision-making from building life cycle analysis and cost benefits analysis will give the contractor and building occupants a good investment return. Furthermore, retrofitting can save the new land opening for construction, avoid deforestation with massive earthwork, reduce site clearance activity and reduce inhabitant of natural life since it only utilizes the original location of existing development. Therefore, the transformation from the low performance of existing building conditions to green buildings will provide a healthy indoor environment and building comfort [27]. Furthermore, retrofitting the heritage building will increase awareness and appreciation of the sacrifices of previous generations for the development of present and future generations [18].

8. Conclusions

From this study, most of the researchers agree that retrofitting creates a good impact especially on the cost operation of the building. Retrofitting also creates social balance for building occupants with better building performance. In addition, it is also able to preserve the environment by switching to green development on existing building locations as well as reducing the energy consumption, amount of carbon release and GHG emission with the installation of energy efficiency building features. These positive impacts are derived from the appropriate decision-making by expert construction personnel and related stakeholders through building life cycle analysis and cost-benefits analysis. The government also upholds a significant responsibility in ensuring the national agenda towards sustainable development which is achievable by emphasising policy, guideline and regulation and standardising green building assessment tools.

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