Table of Contents

DIGITAL ROADMAP ON GREEN BUILDINGS IN MALAYSIA

Introduction

The adoption of sustainable construction and green buildings has become an important issue in Malaysia recently. It has been duly highlighted under the Malaysian Construction Industry Master Plan (2005–2015).

Green technology presents a solution to balancing the needs for economic development and responsibility towards the environment. As a growing global need to deal with climate change, sustainable development and green technology must go hand in hand in driving the economy, creating jobs and attracting investments.

In 2015, at the United Nations Climate Change Conference (Conference of Parties, COP21) in Paris, the Government of Malaysia committed to reducing Greenhouse Gas (GHG) emissions by 45 per cent by 2030, based on the 2005 GDP. This target was set for 35 per cent on an unconditional basis and 10 per cent on a conditional basis upon receipt of climate finance funding, technology transfer, and capacity building from developed countries.

Government’s Initiatives in Green Energy

The green technology agenda in Malaysia consists of a range of initiatives and policies which aim to increase the use of environment-friendly approaches in every sector to reduce the reliance on fossil fuels and environmental impact. This plan will spur Malaysia's economy and social well-being, drive the services/system providers, and motivate companies to acquire assets that have been verified as green. As part of Budget 2020 measures, the Government continues to prioritise green adoption to spur economic multiplier effects by extending the Green Investment Tax Allowance to purchase green technology assets and Green Income Tax Exemption on green technology services until 2023. The ITE has also been extended for companies undertaking solar leasing activities to increase interest and participation in the Net Energy Metering Scheme (NEM), which was introduced by the Sustainable Energy Development Authority (SEDA).

Green Technology Incentives: Towards Achieving Sustainable Development in Malaysia's development trajectory on a low carbon and climate resilience pathway.

The National Green Technology Policy (NGTP), launched in 2009, recognised green technology as a driver to accelerate the national economy and promote sustainable development. It emphasises four focus areas of green initiatives: energy, building, transportation and waste management.

Provisions of an Investment Tax Allowance (ITA) for the purchase of green technology assets and an Income Tax Exemption (ITE) on the use of green technology services, including green buildings and systems, were necessary to strengthen the utilisation of green applications. These initiatives encourage investments in green equipment production and the adoption of green technology by services/system providers, as well as motivate companies to acquire assets that have been verified as green.

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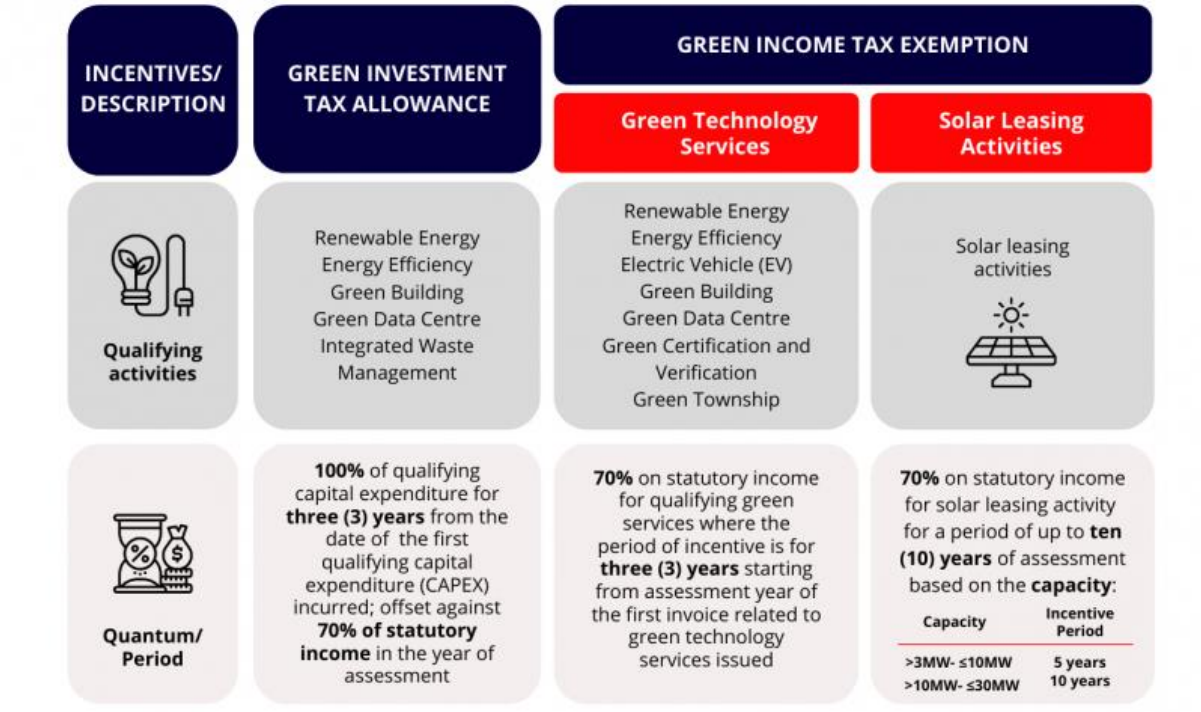

Figure 1: Green Investment and Income Tax Exemptions

Companies are advised to apply for Investment Tax Allowance before incurring the first qualifying capital expenditure (CAPEX) on the related project or assets. As for Income Tax Exemption, companies are advised to apply to MIDA before issuing the first invoice for qualifying business sales.

In 2019, 427 green technology projects were approved, with an investment amount of RM4.33 billion and 12 green services projects with a total investment of RM31.67 million.

From January to September 2020, MIDA approved 479 green technology projects with investments amounting to RM2.23 billion despite the challenging global economic environment, an encouraging indicator of potential high investment flows and interest in green technology in Malaysia. Over the past five years of the incentive initiatives, MIDA has seen positive outcomes in an increased renewable mix of power generation, green technology services providers and better waste management.

Amid the COVID-19 pandemic, MIDA received more than 900 applications from January to December 2020. This reflects a positive trend in companies that are committed to minimising the degradation of the environment, reducing greenhouse gas emissions, promoting a healthy life and increasing the use of renewable energy and natural resources. It is in line with the Government's aspiration toward sustainable development goals (SDGs), as aspired by the United Nations.

Definition and Benefits of Green Buildings

Green buildings indicate the quality and characteristics of the actual structure created utilising the standards and methodologies of sustainable construction.

Buildings are estimated to be worth US$7.5 trillion per year, contributing to around 10 per cent of global GDP (Betts and Farrell 2009). Buildings create direct employment for over 111 million people around the world, with 75 per cent in developing countries and 90 per cent in micro firms having less than 10 employees (UNEP 2007). Buildings are also critical consumers of natural resources such as raw materials, energy and water and produce considerable waste in solid, liquid and gaseous forms.

The benefits of Green Buildings are as follows:

- Improved air quality, higher water quality, and reduced energy and water consumption.
- Minimising adverse environmental effects and obliteration of the risks of environmental disasters.
- Contribution towards the development of natural resources.
- Reduction in non-renewable materials, water, emissions, wastes, and pollutants.
- Improvement to human health.
- Encourage technological innovation in society.
- The effectiveness of the entire economy is the effectiveness of the environmental activities of the society.
- Contribute to the effectiveness of the entire economy (when the environmental activities of the society are practical)

The following Figure shows the framework of green buildings in an eco-city.

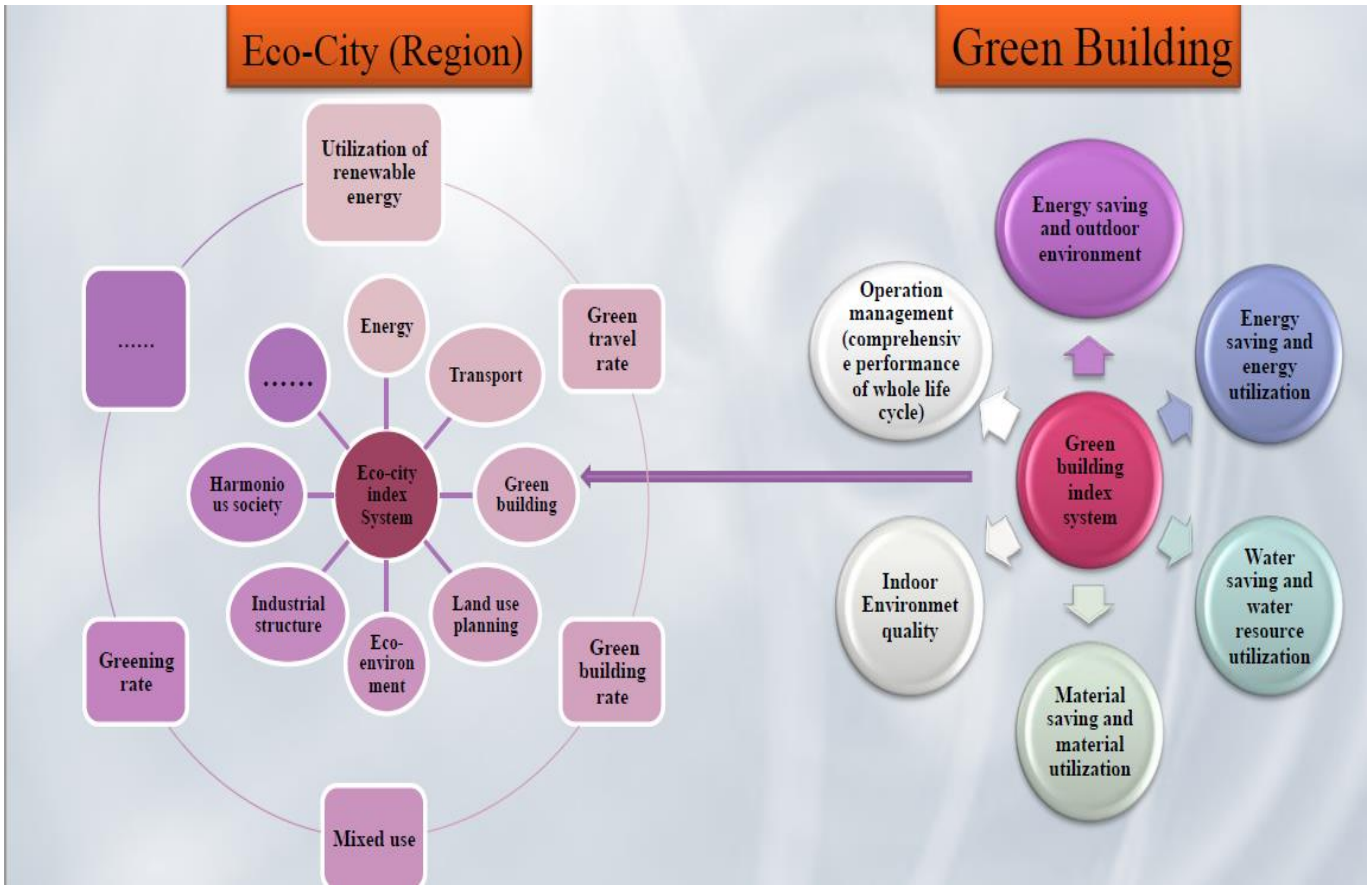

Figure 2: Framework of green buildings in an eco-city

Challenges of Green Construction

The construction industry is facing massive challenges in sustainable construction. In this respect, scholars in the field have articulated the challenges for sustainable construction adoption, which are as follows:

1. The "circle of blame" among the project participants. Service providers, namely the contractors and consultants, often comment that clients do not ask for sustainability. The design team persists in the old ways and is reluctant to make the first move to new territory. Clients, on the other hand, are afraid that the building will cost more and take a longer time. They also expect the service providers to take the lead in improving their services.

2. Sustainability is treated as a discrete problem with an isolated solution, which creates difficulties in blending it into the construction process. Introducing sustainability issues later than the design stage causes changes in the plan or design, which can incur more costs than savings.

3. Construction faced difficulties in guiding good environmental practices in construction. Proper guidance needs to be formed to resolve this matter.

4. There are claims that numerous barriers to sustainability arise because today's technological systems and governing institutions were designed and built for permanence and reliability, which inhibits many change efforts.

5. Change resistance involves a change in individual values, whether at a personal, corporate, or collective level. Although the values are generally in the right place, the problem is how to enact them.

Green Construction Initiatives in Malaysia

In 2010, CIDB formed the Technical Committee on Best Practice in Green Technology in the construction industry, comprising representatives from government agencies, professional bodies, academicians and societies related to the construction industry. The committee is to assist the CIDB in identifying the preparation and development of the construction industry's standards, guidelines, manuals, technical reports and training modules related to green technology. Furthermore, CIDB is currently running an eco-label program. This programme encourages manufacturers and producers of construction materials to make environmentally friendly construction materials. Green labelling can boost the green building assessment system or index, and green procurement is to be implemented by the Government soon. Green Performance Assessment System in Construction CIDB is developing Construction Industry Standard (CIS) primarily to assess the impact of building construction work on the environment. The title of the standard is Green Performance Assessment System in Construction (Green Pass).

The CIDB recognises the need for a performance-based standard in addressing green construction to provide a framework linking sustainability with performance in order to mitigate climate change (CIDB, 2012). This standard underscores low-carbon building performance without compromising the desired comfort level of the building. Green PASS is designed to meet these needs through standard conformance that promote sustainable construction in an integrated manner with other Construction Industry Standard (CIS). It is an independent construction standard that assesses and rates the impact of building construction on the environment. Green PASS is founded on the principle that a model standard must address building performance beyond those captured by rating systems or other evaluation guides.

Therefore, it shall be usable, adaptable and stringent, making it an effective system for the construction industry. The standard, once applied, will establish minimum requirements for buildings and systems using prerequisites and performance-related provisions and compliments existing standards to form a comprehensive standard for green construction (CIDB, 2012). The objectives of the Green PASS are:

a. To provide a foundation for CIDB to establish a reliable and robust database on construction carbon footprint.

b. To accommodate the need for a performance-based standard in addressing green construction.

c. To provide a framework linking sustainability with performance.

d. To drive towards sustainable construction Green PASS estimates the carbon emissions from building construction works throughout a building's life cycle. The building life cycle defined within this standard covers pre, during and post-construction stages, with carbon emissions divided into embodied carbon and operational carbon. These provisions apply to new and existing buildings. Embodied carbon is emitted as CO2 emitted throughout the pre and construction stages. Operational carbon is CO2 emitted throughout the post-construction stage to the end of the life of any building. The Certification level will be named Diamond Rating.

Green Building Index (GBI)

In Malaysia, green buildings are designed and accredited according to the Green Building Index (GBI).

The GBI offers guidance and rating tools for developers to understand and create buildings that align with green design's efficiency and positive environmental goals.

There are six (6) major areas measured in Green Building Index (GBI) as follows:

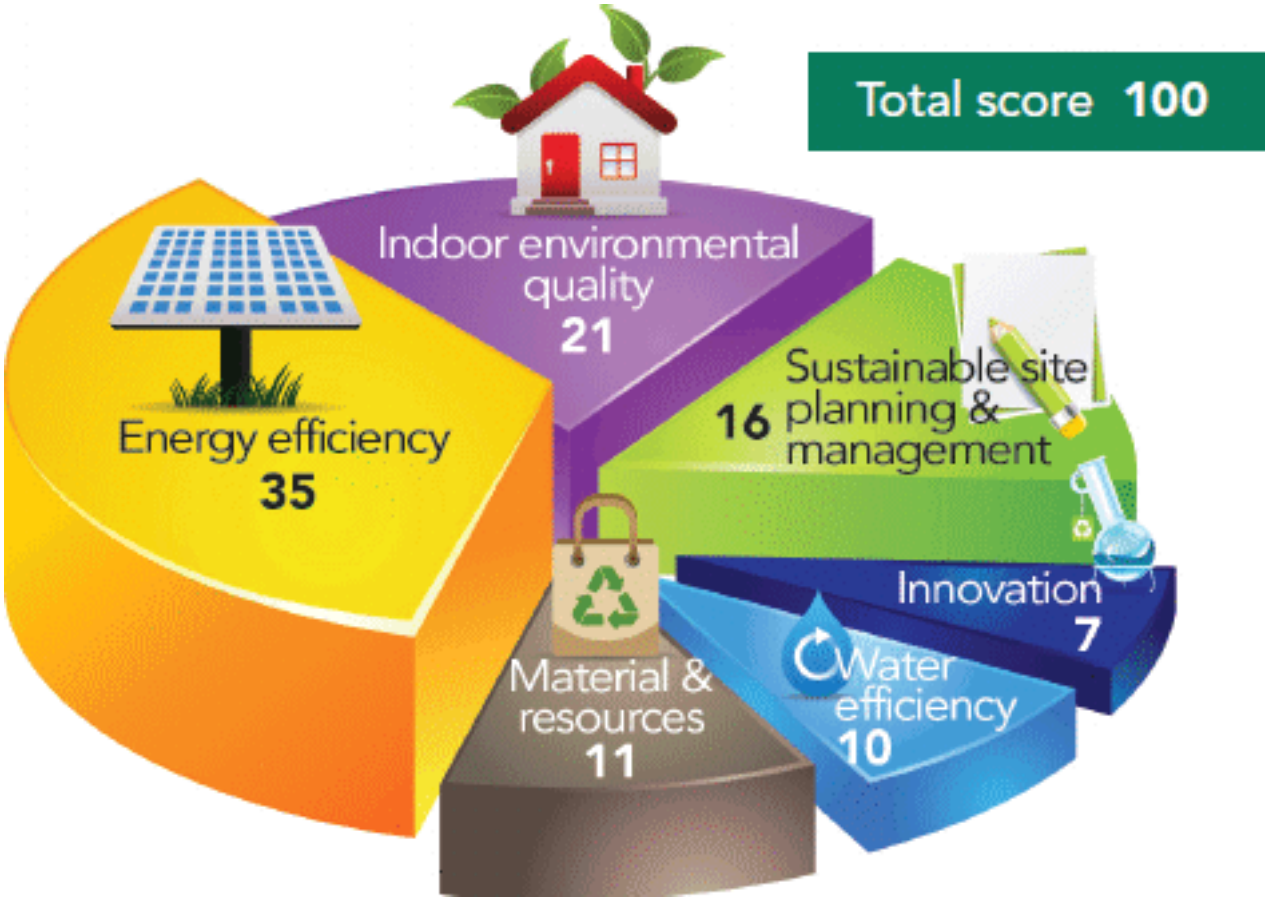

Figure 3: Six (6) major areas measured in Green Building Index (GBI)

1. Energy efficiency

The approach to commercial construction has changed over the years, with a growing focus on designs that look great and are environmentally friendly and efficient. Hence, the establishment of the Leadership in Energy and Environmental Design (LEED) certification by the U.S. Green Building Council is adopted by the Malaysian CIDB GBI.

In constructing any green buildings, i.e. retail stores, office buildings, academic institutions, hotels, hospitals, or any other structure, many architects and designers follow LEED to meet these green standards and achieve a specific certification level—certified, silver, gold or platinum.

Many components encompass an energy-saving building design, including interior glass, an up-to-date HVAC system, an efficient water heater, and LED lighting.

The Government of Malaysia played a crucial role in promoting the significance of (EE). This was through implementing different EE initiatives that covered incentives, education and subsidiaries over the last three decades. It is worth mentioning that energy efficiency is not considered an issue that needs to be highlighted by professionals.

Sustainable preservation guarantees the energy system will be executed as anticipated beyond 12 months of Defects. The Liability period has to be attained by establishing the Energy Monitoring Committee (EMC) and supplying the maintenance office with a permanent maintenance team from one to three months before practical fulfilment.

There are five aspects of energy efficiency, which are as follows:

(a) Improve energy consumption

i. Glass Outer Wall

Glass may earn buildings GBI points due to its energy-enhancing capabilities, specifically when it comes to sunlight.

According to glass industry resource Glass Magazine: “The use of glass in both the building envelope and interior components aids in harvesting site energy by increasing daylighting properties throughout the space and reducing the requirement for electric lighting.”

This can decrease energy costs and contribute to LEED's "Optimise Energy Performance" credit requirements, which can earn up to 20 points. The more points, the more prestigious the certification. For example, a building that has earned 40 to 49 points is certified, while a building that has earned more than 80 points is platinum.

ii. Up-to-Date HVAC System

Another energy-saving building component is a proper heating and cooling system. LEED even awards buildings up to four points if they utilise a "Very High-Efficiency HVAC" (heating, ventilation and air conditioning) system and have it installed properly. ENERGY STAR®, a program of the U.S. Environmental Protection Agency, even emphasises how "improper installation" of an HVAC system can reduce system efficiency by up to 30 per

cent - costing one more on one’s utility bills and possibly shortening the equipment's life.

iii. LED Light Bulbs

When insufficient, lighting can make up a significant portion of a building’s energy costs, which is why LEED developed credit requirements concerning electricity efficiency.

One way to improve lighting effectiveness is using light-emitting diode (LED) bulbs. According to the U.S. Energy Information Administration (EIA), a federal agency that calculates and analyses official energy statistics, energy for lighting in commercial buildings has decreased over the years, as more people have been utilising such technology.

The EIA states explicitly: "The total amount of energy used for lighting has decreased 46% from 2003 to 2012," which are the most recent statistics available, "a large change partly due to the increasing use of compact fluorescent and LED bulbs as replacements for lower efficiency incandescent bulbs."

iv. Efficient Water Heating

Water efficiency is also a crucial part of energy-saving building designs, which is why there are several prerequisites buildings must fulfil if they want to be LEED certified and additional credits for more points. This includes the "Hot Water Distribution" credit, aiming "to reduce energy consumption and the burden on water supply and wastewater systems by increasing the efficiency of hot water distribution,” as LEED explains on its official website.

(b) Minimising solar heat gain

Solar Gain, also referred to as solar heat gain or passive solar gain, is a term that refers to the increase in temperature in a space or building due to solar radiation. There are many ways to control and manage solar gain for effective results. The sun's light can be broken down into 3 main parts; ultra-violet rays, infrared radiation and visible light. The 'infra-red' element of the sun's light causes overheating in highly glazed areas. The sun's radiation travels in short wavelengths through the glazing. The objects inside the living space absorb

these short wavelengths of radiation and emit heat at longer infrared wavelengths.

These waves cannot travel through glazing and will be contained within the living space, increasing the internal temperature. This causes the infrared radiation to be trapped within the space and can cause overheating, referred to as Solar Gain.

Controlling Solar Gain

Controlling solar gain in a highly glazed environment is possible with the use of Solar Control coatings. These coatings reduce the amount of solar radiation that can enter a space through the glazing and thus reduces the amount of solar gain. Using tinted glass will mean more sun rays will be reflected than emitted, altering the natural light transmission. Modern glazing technology using a transparent coating, such as a solar control coating, will reduce the G Factor of the glazing, reducing the amount of infrared radiation entering a space, with only a slight reduction in the visible light transmission.

G-Factor

The G Factor, also known as the solar factor, is represented as a percentage of the total incident radiation that enters through the glass. This includes the direct radiant influx and the infrared radiation that the glass absorbs and then re-emits internally. For example, a 53% total radiant influx will be a G Factor of 0.53. The G Factor is measured using a standard testing method EN 410 under the assumption of standard daylight light settings with the internal and external temperatures equal. Many elements can alter the G Factor of a glass installation if required.

Solar heat gain can be reduced by:

- Horizontal shading.
- Limiting the area of openings.
- Orientating openings away from the sun path.
- Reducing solar transmittance through openings, for example, by reflective glazing.
- Purging heat gains by the introduction of ventilation.
- Solar shading helps reduce solar gain – particularly if fitted externally to glazing.

The heat from the sun's rays is a significant cause of overheating in buildings, resulting in discomfort to occupants and increased energy use to remove the unwanted heat. Solar shading helps to reduce and control solar gain, improving the well-being and productivity of occupants and reducing cooling loads.

The problem – excessive solar heat gain

The sun's power is infinitely variable – it is a dynamic force, and glazing is typically static. Therefore, it cannot adequately cope with the variability of the sun's irradiation. Thermally inefficient glazing units have interior surface temperatures that differ from the other surfaces' temperatures and the mean air temperature. This results in uncomfortable internal conditions, and energy-intensive mechanical air-conditioning and the poorly insulated transparent envelope can also result in local thermal discomfort due to non-uniform thermal radiation – for instance, in perimeter zones of the building.

The solution – solar shading

Solar shading can help regulate solar gain in buildings by reflecting excess heat. This is particularly true of external shading or shading within ventilated facades. Correctly specified internal shading with reflective coatings can also help control excess solar irradiation. Shading goes hand in hand with ventilation strategies, as warm air needs to be removed from buildings to help regulate internal temperatures. Linking solar shading to environmental systems or controls ensures that the shading position is optimised through building automation. Solar shading is identified as a key, passive solution to overheating.

Key measurement

The g-value is the measurement of total solar energy transmittance through an object, such as glazing – but g_{tot} is a far more relevant measurement, as this is the total solar energy transmittance through the glazing and blind combined.

The Shard in London is a fully-glazed building with a double-skinned façade containing automated blinds. Its architects have acknowledged that this iconic building would not have been possible without solar shading. With its interstitial blinds lowered, The Shard achieves a g_{tot} of just 0.12 (88% heat rejection) for a building covered entirely in glass.

Figure 4: The Shard of London

(c) Harvesting natural light

Daylight Harvesting

Electrical power consumption for lighting is a significant factor in the energy use of buildings. Office buildings typically use 17% of their energy consumption for electric lighting, and for schools, the figure is even higher, i.e. 30%. Low lighting costs are among the most easily achievable for existing buildings, dimming and switching lights off (demand reduction) and installing more efficient light bulbs (system efficiency).

Daylight harvesting is how new green buildings are designed to collect and utilise natural daylight in the interior of buildings, when available, to reduce the need for energy-consuming artificial lighting. All buildings have windows that provide some daylight nearby. Still, green buildings are designed to maximise that light and distribute it effectively deeper into the building.

Older buildings have electric light systems that are turned on whenever the building is occupied – day or night. Still, buildings that utilise daylight harvesting have automatic lighting control systems that measure the amount of natural

light in each space and adjust the electric lights dimming accordingly to provide just what is needed to provide the correct illumination level. The need for electric lighting will change depending on the time of day – day or night, the position of the sun – and with the weather.

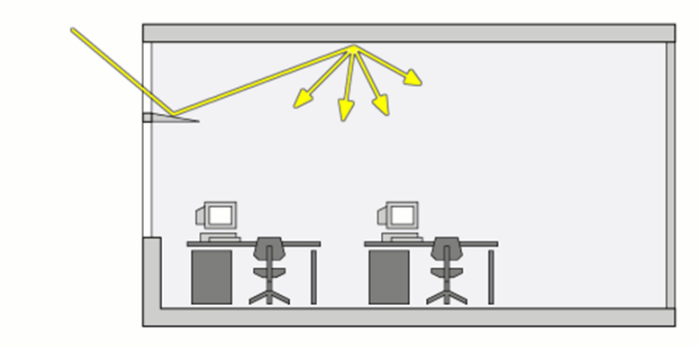

Figure 5 (a): Example of natural light harvesting.

A typical design of daylight harvesting uses passive devices known as "light shelves" to direct daylight back up and further into space by bouncing it off the ceiling. The light shelf may be polished or reflective, and the ceiling must be of a light colour with good reflective qualities. This method of providing "indirect" natural light provides a good quality of light – diffuse and glare-free – superior to direct daylight and especially direct sunlight. Another, more efficient type of light shelf is shown below. Both of these diagrams show that the lower window could have a blind to shield the room from the glare of the direct sun (but allow outdoor views). Yet, each of the desks would benefit from receiving natural light.

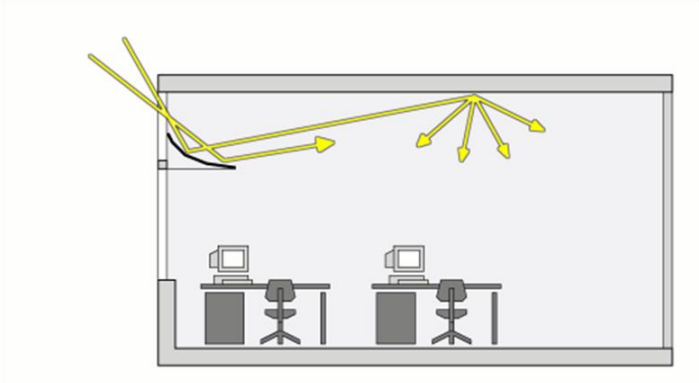

Figure 5 (b): Example of natural light harvesting.

Natural light is more pleasing, healthful and psychologically beneficial than artificial light. Daylight harvesting can reduce energy consumption and costs of building lighting by over 25%. As usual, the “green” choice is the best choice for several reasons, reminding us of the “Triple Bottom Line” of green building: environmental benefit, economic benefit, and health and welfare benefit!

(d) Adoption of renewable energy

Solar PV or Photovoltaic Glass

Harvesting solar energy while using transparent photovoltaic (PV) glass for buildings, which uses photovoltaic glass as a material for building purposes and as an electricity-generating material to capture the sunlight and turn it into electricity. The panes are made of layers of heat-treated safety glass which can provide the same thermal and sound insulation as conventional architectural glass, not to mention that they also let natural light go through the same way as conventional glass. Thus, photovoltaic glass panes could be installed, replacing the conventional glass on building facades, curtain walls, atriums, canopies and terrace floors, among other architectural applications. These glass panes could additionally be installed on a wide variety of existing buildings and facilities, therefore contributing to their enhancement both from an aesthetic and energetic point of view.

Providing the same thermal insulation as conventional glass and the capacity to generate free clean electricity from the sun enables buildings to drastically improve their energy efficiency, decrease operation and maintenance costs, and reduce their carbon footprint.

Photovoltaic glass is environmentally friendly and a high-tech product for construction. It can use solar radiation to generate electricity. Photovoltaic Glass is composed of glass, CdTe cell film, PVB and special metal wires. It is a kind of power generation glass that uses the CdTe semiconductor interface's photovoltaic effect to convert light energy directly into electricity so that buildings can significantly improve their energy efficiency and reduce their carbon footprint. Photovoltaic glass also has heat insulation and sound insulation properties.

It’s a new material interlayer of Cadmium Telluride (CdTe) Thin Film Solar Cells. It is a special glass that can use solar radiation to generate electricity by laminating into solar cells and has related current extraction devices and cables. It's a technology that uses the photovoltaic effect of the semiconductor interface to convert light energy into electrical energy.

For Building Integrated Photovoltaic, it's also easier to realise a truly sustainable building because the CdTe film has better absorption of the full spectrum. Its power generation performance is significantly better than traditional crystalline silicon cells under low light conditions such as early morning and evening. The use of CdTe thin film photovoltaic power generation glass as a building component not only has the beauty of ordinary translucent roof and curtain wall, as well as the function of heat insulation but also can generate tens of thousands of kilowatt-hours of electricity each year, which is a genuine realisation from passive energy saving to active power generation.

Advantages of Photovoltaic Glass

- High Light Transmittance, Strong Pressure Resistance

  Photovoltaic glass generates free and clean electricity thanks to the sun, turning buildings into vertical power generators. Tempered glass has a higher strength to withstand more significant wind pressure and more remarkable temperature changes between day and night.

- CdTe Cell Film, Weak Light Can Still Power

  CdTe closely matches the solar spectrum and is most suitable for photoelectric energy conversion. It is a thin-film solar cell based on the heterojunction of p-type CdTe and n-type Cd. It has high theoretical conversion efficiency.

- New Energy Building, ECO Preferred Choice

  As green building materials, photovoltaic glass can enjoy long-term energy savings. Some local authority strongly supports the development of building integrated photovoltaics for solar electrical power generation and has introduced some supportive policy measures. It is a valuable way for the new energy to be continuously promoted.

- Waterproof, Heat Insulation, Decoration

  Since the photovoltaic glass is equipped with CdTe cell film, it has a higher waterproof coefficient. Photovoltaic glass also has strong filtering capacities, whose sunlight absorption rate is more than 95%. In addition, Customers can choose the shape, colour, size, thickness, optical requirements and transparency level of the glass to promote its integration in numerous projects and designs, with Low-E coating or Digital Printing process for composite structures of photovoltaic glass.

Application of Photovoltaic Glass

As a "green building" material, Photovoltaic Glass is widely used in curtain walls, building facades, photovoltaic roofs, shading, fences, solar power generation systems and other fields.

Photovoltaic Glass can be used in the solar power system in traditional industrial power stations, commercial and industrial buildings, and glass-forming houses. As the material on the building surface, it can be used for building curtain walls, sunshade components (sun blinds, decorative shutters), building lighting roofs, solar glass roofs, sunshades, and building fences. Photovoltaic glass can be used in the automotive sector for auto-management parking lot systems and sun-shielding on the roof and bus platforms.

Green Building-Photovoltaic Power Glass

"Green" in "green building" represents a concept or symbol, meaning that the building is less harmful to the environment and can fully utilise natural resources. The so-called green building refers to a new type of building that does not destroy the necessary ecological balance of the environment during construction and consumes less material and energy during the survival period than traditional buildings. It is also called a sustainable building.

In planning for the future of sustainable cities, more and more construction developers or engineering designers are working towards sustainable development, focusing on minimising the impact on the environment and ecology. Solar energy is a sustainable building technology. In green buildings, solar energy is usually active and passive. Active solar energy uses solar energy systems to absorb solar radiation for heating and power generation, reducing the use of electricity or gas. Passive solar energy heats the room through sunlight from the windows and the heat-absorbing surface, reducing the need for heating during cold weather.

(e) ensuring proper testing and maintenance

Scheduled maintenance of all building aspects and proper testing of all new equipment installed should be adhered to save energy bills.

2. Indoor environment quality

Good indoor air quality, acoustics, visual and thermal comfort. Use low volatile organic compound materials, quality air filtration, temperature control, movement, and humidity. Indoor air quality should be ensured to be high quality and devoid of any dangerous breathable substances. These substances should be avoided, including mould, radon, asbestos, formaldehyde, and more. Not ensuring good indoor quality can negatively impact tenants of a building with existing respiratory issues such as asthma. Areas where wildfires are prevalent, should also consider this when building and keeping air quality in mind despite those increased challenges posed by wildfires.

An energy-efficient strategy can be integrated into a passive strategy primarily included in the design stage. It can also be integrated into an active design strategy primarily included in the mechanical factors' installation. The equipment and

instruments for natural air conditioners and ventilation have caused a high cost for green building projects to be implemented.

The building is needed to fulfil the ventilation rate's minimum requirements in the indoor air quality (IAQ) process of ASHRAE 62.1 or the local building code. Specifying minimum ventilation rate and indoor air quality that will be accepted by human inhabitants and are aimed to minimise the possible harmful health influences are the main goals of the standard of ASHRAE 62.1. Different techniques introduced in ASHRAE 62.1 include ventilation system control, exhaust dust location and natural ventilation.

3. Materials and resources

The utilized materials significantly decrease the environmental effect caused throughout the extraction and virgin resources' processing through utilizing the products and pre-consumer content or post-consumer recycled content materials. An important role is played by waste management of construction in diverting the waste of construction or debris from the disposal of landfill. The reusable materials are redirected to the relevant site, and recyclable materials are redirected to the manufacturing factories. A suitable storage area, together with a recycled bin, should be made ready for storing the non-hazardous materials for recycling to decrease waste. Since local plants are used to produce timbers, certified wood-based materials' proof should be gained to identify that the utilized materials are not illegal and can result in the encouragement of environmentally responsible forest management. Ozone Depleting Potential (ODP) with environmentally friendly products of refrigerants and cleaning agents can be utilized to decrease the environmental effects.

Sustainable materials as well as proper construction waste management systems. The following are some examples of sustainable materials for green building construction as the main secondary structure of accessorial structures.

(a) Bamboo

Bamboo is considered one of the best eco-friendly building materials. It has an incredibly high self-generation rate, with some reported growing up to three feet within 24 hours. It continues spreading and growing without having to be re-planted after harvest. Bamboo is a perennial grass, not wood and grows on every continent except Europe and Antarctica. It also has a high strength-to-weight ratio, even greater comprehensive strength than concrete and brick, and lasts incredibly long. It is, therefore, the best choice for flooring and cabinetry. Unfortunately, bamboo requires treatment to resist insects and rot. If left untreated, bamboo contains starch that attracts insects and could swell and crack after absorbing water.

Figure 6: Bamboo trees as green and sustainable materials

(b) Precast Concrete Slabs

The slabs are formed at a manufacturer's site and shipped to construction sites in whole sections. Some are made entirely of concrete but have large hollow air spaces, like concrete blocks. Pre-cast concrete slabs are used for walls and building facades as they hold up well to all sorts of weather, while others can be used for floor and flat roofs. Concrete is an excellent way of controlling heat within a building and is affordable as a building material. The sustainability of pre-cast concrete slabs is higher than many traditional concrete options as the slabs often take much less energy to produce and assemble. Pre-casting concrete also properly allows the material to cure in a controlled environment, rather than exposing it to various unfavourable weather conditions while curing at a construction site. As such, pre-cast concrete slabs avoid cracks and structural faults within the concrete and eventual demolitions.

Figure 7: Pre-cast concrete as green material

(c) Cork

Just like bamboo, cork multiplies. It can also be harvested from a living tree, which continues to grow and reproduce more cork, which is tree bark. Cork is resilient and flexible and reverts to its original shape even after enduring sustaining pressure. Its resilience and resistance to wear make it a common element in floor tiles. It also excellently absorbs noise, making it perfect for insulation sheets. Due to its excellent shock absorption qualities, it is perfect for sub-flooring. It can also be an excellent thermal insulator as it is fire resistant, especially if untreated, and does not release toxic gases when it burns. Cork, being nearly impervious, does not absorb water or rot. Unfortunately, it can only be sourced from the Mediterranean, making shipping a bit costly. Fortunately, it is incredibly light and requires less energy and emissions to ship.

Figure 8: Cork sheets as green and sustainable materials

(d) Straw Bales

It is another green building material that can be used as a framing material. The straw bales have good insulation properties and can act as soundproof material. It can also be used as fill material in between columns and in beams framework/ as they cannot allow air through, they can have some fire resistance properties. Straw can be harvested and re-planted easily with minimal environmental impacts. Making straw into bales also has a negligible influence. They can also be placed on walls, attics, and ceilings, to contribute to cooler the house on a hot day and warmer temperatures on a cold day.

Figure 10: Straw Bales as green and sustainable materials

(e) Recycled Plastics

Rather than sourcing, mining and milling new components for construction, manufacturers are using recycled plastic and other ground-up trash to produce concrete. The practice is reducing greenhouse gas emissions and giving plastic waste new use, rather than clogging landfills and polluting plastic pollution. A blend of recycled and virgin plastic is also used to make polymeric timbers for fences, picnic tables and other structures while saving trees. Plastic from two-litre bottles can be spun into fibre to produce carpets. Reused plastic can design products like cable pipes, roofs, floors, PVC manholes cover, and PVC windows.

Figure 11: Recycled Plastic blocks as green and sustainable materials

(e) Reclaimed Wood

Reclaimed wood is one of the most environmentally responsible ways to save trees and reduce the amount of lumber in landfills. Reclaimed wood can be found in retired barns, excavation companies, home remodelling contractors and companies, salvage yards, and shipping crates and pallets. Reclaimed wood is suitable for structural framing, cabinetry, and flooring. It is lightweight but has less strength, and each piece's integrity should be assessed and chosen for an appropriate project. Also, most wood is susceptible to insects and degradation, meaning it needs reinforcement and additional treatment.

Figure 12: House constructed from reclaimed wood as green and sustainable materials

(g) Reclaimed or Recycled Steel

Steel can be used for the framing process in place of wood, increasing the durability of a structure against earthquakes and high winds. A 2,000-square-foot house requires about 50 trees to build, but a frame made from recycled steel requires the steel equivalent of just six scrapped cars. Steel is 100% recyclable and significantly reduces the ecological impact of new construction. Mining, heating and shaping products made from aluminium and steel requires a lot of energy, but properly and efficiently reusing or recycling them into new products lowers the energy used and makes the material more sustainable. The recycled metal is long-lasting and does not require frequent replacements. It does not burn or wrap and is therefore perfect for roofing, building facades and structural support. Additionally, recycled steel is water- and pest-resistant.

Figure 13: Recycled steel /Aluminium as green and sustainable materials

(h) Plant-based Polyurethane Rigid Foam

Rigid foam has long been used as insulation material in buildings. It was first used after a top manufacturer of surfboard material was fined by the EPA and subsequently put out of business for using a toxic material. The new surfboard material was made from plant-based polyurethane rigid foam from bamboo, kelp and hemp, rejuvenating the surfboard industry. It is now used in manufacturing, including turbine blades and furniture. The material is rigid and relatively immovable, which can be used for insulation. Additionally, it offers protection against mould and pests. It is also heat resistant, protects against mould and pests, and can be perfect as sound insulation.

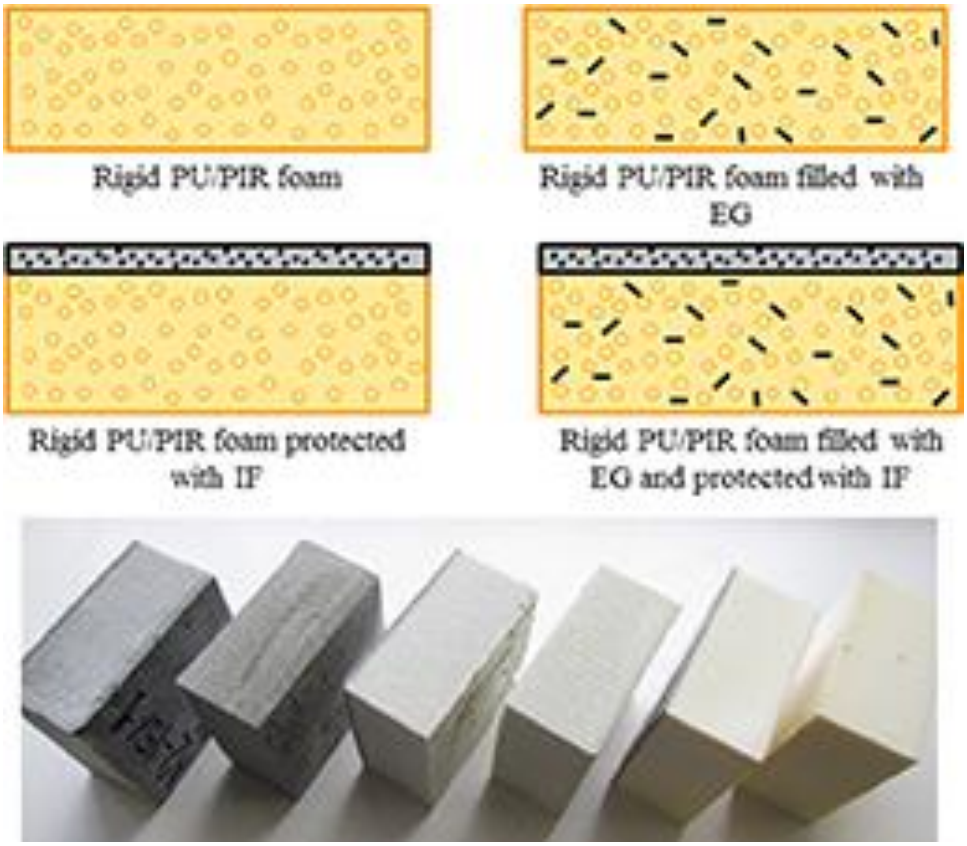

Figure 14: Plant-based PU foam as green and sustainable materials

(i) Rammed Earth

It is a technology that has been used throughout human civilization for thousands of years and lasts a very long time. It is a popular and affordable solution to creating firm foundations, floors and walls through natural materials such as chalk, earth, gravel or lime, and then compacting them. When pressed tightly in wooden forms, it creates walls that have a similar feel to concrete. Buildings made from rammed earth are safer or fortified using rebar or bamboo. Mechanical tampering can significantly reduce the labour required to create sturdy walls. Rammed earth walls and floors can be used as thermal storage, allowing the sun to warm them during the day and slowly release the warmth in the cooler evenings.

Figure 15: Wall made from rammed earth as green and sustainable materials

(j) HempCrete

It is a concrete-like material created from the woody inner fibres of the hemp plant. The fibres are bound with lime to create concrete-like shapes that are strong and light. Hemp concrete blocks are lightweight, dramatically reducing the energy used to transport the blocks. Hempcrete is sturdy, has good thermal and acoustic insulation qualities and is fire resistant. Additionally, its most prominent sustainable property is that it is CO2 negative, meaning it absorbs more CO2 than it emits. Hemp itself is a fast-growing and renewable resource.

Figure 16: Hempcrete block as green and sustainable materials

(k) Mycelium

It is a building material that is natural. Mycelium is a natural unicellular organism comprising fungi and mushrooms' root structures. It could be encouraged to grow around a composite of other natural materials, such as ground-up straw, in moulds or forms. It is then air-dried to create lightweight and robust bricks or other shapes. Combined with pasteurized sawdust, mycelium could be formed into almost any shape and be used as a surprisingly sturdy building material. There is the potential for creating bricks and uniquely shaped building segments that are both strong and lightweight. The mushroom-based building material can withstand extreme temperatures, making it an organic and compostable alternative to home insulation, Styrofoam and even concrete.

Figure 17: Mycelium concrete as green and sustainable materials

(l) Ferrick

It is relatively new material. It uses recycled materials such as steel dust from the steel industry, or ferrous rock leftover from industrial processes, usually sent to the landfill. It creates a concrete-like building material, more robust than the concrete itself. It traps and absorbs carbon dioxide as part of its drying and hardening process. This makes ferrock carbon neutral and a lot less CO2 intensive as compared to traditional concrete. It is a viable alternative to cement and can be mixed and poured to form driveways, staircases, pathways, and more structures. Some researchers believe ferrock is more resilient to weather than concrete.

Figure 18: Ferrick tiles as green and sustainable materials

(m) Timbercrete

This exciting building material is made from a mix of sawdust and concrete. It is lighter than concrete and reduces transportation emissions. The sawdust also reuses a waste product and replaces some of the energy-intensive components of traditional concrete. Timber concrete could also be formed into traditional shapes like pavers, bricks and blocks.

Figure 19: Timber concrete blocks as green and sustainable materials

(n) Terrazzo

This is a mosaic style of flooring where small pieces of marble or granite are set in polished concrete or epoxy resin. When well maintained, terrazzo floors can last up to 40 years without losing brilliance. The original terrazzo was set in cement and was modelled after 20th-century Italian work. Today, 90% of terrazzo floors are made with epoxy resin. A company like Terrazzo & Marble Supply Company manufactures 'forever floors' from their epoxy, which incorporates materials like brass, aluminium, and zinc, along with recycled glass, beer bottles, marbles and porcelain. A terrazzo floor might be more expensive than carpets, but you will have to replace carpets. Terrazzo floor, on the other hand, can last for over four decades, making it a sustainable building material. Additionally, before pouring terrazzo into place, you can use the colour of your choice and make the floor of your choosing. It makes for easy-to-clean floors, which can also be installed in high-traffic areas like schools, airports, and stadiums.

Figure 20: Terrazzo tiles as green and sustainable materials

The above are some examples of materials used in green buildings or construction. Many more materials contribute to less carbon or a negative carbon footprint.

4. Sustainable planning and management

Appropriate sites with access to public transportation, open spaces, and landscaping. No damage to environmentally sensitive areas. Reducing the strain on existing infrastructure capacity.

A site planner should consider minimising the disturbed area and how to do it for the project. The main factor in minimising the disturbed area is the extent to which open space and habitat are created and preserved. In this section, a critical role is played by choice of site. The minimum density of 20,300 m² per hectare net is needed to construct the building. Moreover, it would be in the best condition when it is located within 1km of a residential zone or at least ten essential services. The current site's redevelopment can decrease the site's exploitation in which the natural environment is preserved.

The activities should be done throughout the earthworks so that the loss of soil, stormwater sedimentation and air pollution is prevented with the help of executing an ESC Plan. The design of stormwater must be in a way that decreases the disruption of natural water courses by providing on-site infiltration of contaminants, minimising impervious surfaces and promoting groundwater recharge. The utilisation of greenery on rooftops can reduce urban heat islands and influence the cooling and shading of the buildings.

5. Water efficiency

If the supply of edible water is inadequate, and the percentage of water usage remains, there will be suffering from water difficulty soon. The GBI has introduced the rainwater harvesting system to reuse the rainwater, and grey water, i.e. all waste produced in the home is incredibly encouraged for recycling for building consumption or irrigation. The type of plant for redesigning could also contribute to the water reduction, such as the native and flexible plant. Another means to lessen the water utilisation will be to use a sufficient water framework such as automatic closing toward oneself gear to dispose of further water wastage.

Water recycling is incorporated into the green strategy to achieve water efficiency. Recycling involves recovering the water that would otherwise be directed to the waste system and cleaning it for reuse in potable water.

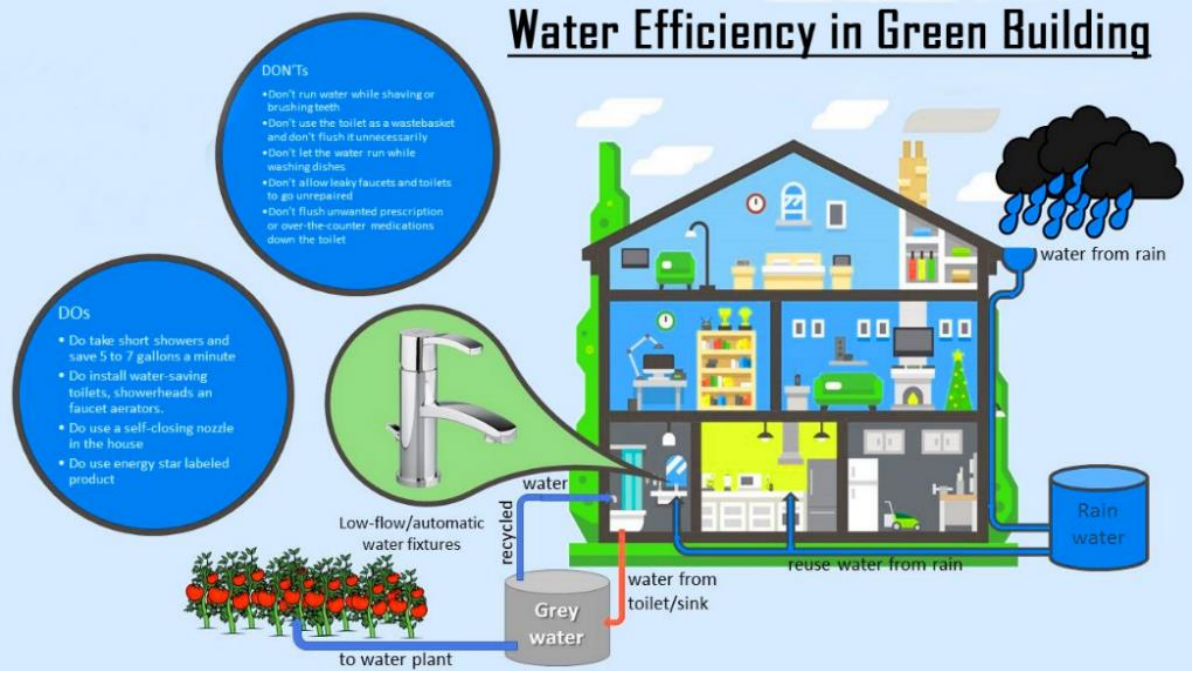

Figure 21: Water efficiency in green building.

The Green Building Index (GBI) Water Efficiency component focuses on water efficiency and conservation in buildings at the city level. GBWE has a unified focus on promoting green buildings by undertaking a series of committed activities through research, policy advocacy, awareness and capacity building etc.

As the access to fresh water continues to be a source of worry in many areas of the world, water efficiency strategies in green building practices have become paramount to both new and existing construction efforts.

Green building mentions a building structure designed to be environmentally friendly and makes nominal and efficient use of natural resources. Such buildings are resource-efficient and eco-friendly throughout their lifespan, from construction to demolition. A Green building design primarily emphasises using natural resources like water, energy, etc., while reducing several harmful effects on the environment and the occupant's health during its use.

Considering water efficiency in Green Buildings, today, several technologies are being used rainwater harvesting, recycling and reusing grey water, low-flow fixtures, sensors etc. Water efficiency measures in residential and commercial buildings can significantly reduce water waste, yield lower sewage volumes, reduce energy use, and bring financial benefits.

(a) Rain Water Harvesting

Many of us are aware of this one as it has recently been grabbing a lot of attention. In simple terms, it is the active collection and distribution of rainwater which is put into use in daily life rather than going to the sewage. Typically, rainwater is collected from the rooftops and deposited in a reservoir with filtration. Once the water is purified, it can be used for cultivation, gardening, and other domestic uses. One of the most effective uses of rainwater harvesting is in drier states with a lower rainfall rate. They can store this water and can later purify it to make using water or can use it for washing or watering plants.

(b) Grey Water Recycling

Grey water can be defined as untreated waste water which has not come into contact with water closet waste. Basically, it emanates from showers, bathtubs, bathroom wash basins, washing machines, and dishwashers. Treatment of grey water can include:

- Filtering
- Settlement of solids
- Flotation and separation of lighter solids
- Aerobic or anaerobic digestion
- Chemical or UV disinfection

Although such water is never safe to drink, it can be used for flushing toilets, washing clothes and irrigation purposes. One of the significant benefits of recycling grey water is that it is a vast source with a low concentration of organic matter.

(c) Water Pressure Reduction

These days, pressure-reducing valves are commonly installed in high-rise residential and commercial buildings to help to maintain consistent water pressure at the water fixtures across the entire building from top to bottom. With these higher pressures, water flows through the system with greater flow through the terminal fixtures beyond rated flow capacities. This additional water is wasted and serves no extra benefit to the rated performance. Most plumbing codes demand pressure-reducing valves on systems where water pressures exceed 80 psi. In most cases, pressures can be depressed by implementing supplementary pressure-reducing valves. In addition, higher pressures could break pipes and damage fixtures, resulting in even greater water waste in domestic settings.

(d) Cooling Towers

Green buildings use evaporative cooling systems to save energy, and such systems use water for cooling. Keeping in mind the considerable need to conserve water, the water used in such cooling towers is non-potable; the same is not drained out but recycled and reused and again.

(e) Low-Flow Plumbing Fixtures

Low-flow plumbing fixtures like faucets, shower heads, and toilets have become an increasingly common feature in green homes today, and for a good reason. Large quantities of water are saved using plumbing fixtures designed to operate with less water. For example, toilets were once made to function using 7 gallons per flush. Still, these days they can efficiently operate using only 1.3 gallons, meaning water savings of over 80 per cent.

Key Components of Water Efficiency in Green Buildings

The three key components of water efficiency in green buildings according to the GBI are as follows:

1. **Reduce Indoor Potable Water Use**
2. **Reducing Water Consumption to Save Energy**
3. **Improve Environmental Well-Being**

The strategies and technologies involved in a green building aim at reducing the amount of potable water consumed in buildings. Today there are several water conservation strategies that involve a low implementation cost and have a rapid payback.

6. Innovation

Innovative design solutions that meet other GBI goals. Examples of Innovation may be vertical gardens to utilise the empty walls outside the building. At the same time, it reduces the energy to cool down the room. At the same time, it traps the rainwater while slowing down the rushing of the water to the ground. It also acts as a CO2 absorber and releases O2.

Having at least one leading participant in the project for the purpose of being the GBI facilitator to promote the design integrated with the need of GBI and streamline the certification and application procedures is needed.

The Government has taken various initiatives to reduce the impact, including from the construction industry, to support the carbon footprint reduction of 40% as pledged by the Prime Minister. Various strategies, such as the Malaysian Carbon Reduction and Environmental Sustainability Tool (MyCREST), have been established to promote green building development in Malaysia. Recent studies suggested that selecting sustainable materials can reduce the overall carbon emission of a building. Still, the cost has been identified as the main barrier.

MyCREST tools will assess separately according to the design, construction, operation and maintenance phases.

In 2021, a case study was conducted on an apartment hostel building located in the district of Kota Samarahan, about 30 km away from Kuching. This four-storey building has a gross floor area of 1127 m2 divided into four units on the 1st, 2nd, and 3rd floors, consisting of five bedrooms, a living room, a sitting area, four bathrooms and a drying yard per unit. The following tables show the comparison of selective materials for carbon emission and the cost of conventional and sustainable materials in the case study.

Item	Conventional Materials	Sustainable Materials
1	Concrete Grade 30	30% of BFS Concrete Mixture
2	Well burnt clay brick	Aerated Autoclaved Concrete (AAC) Block
3	Steel Roof truss	Recycled steel roof truss Timber roof truss
4	Metal Roof Sheet	Clay Roof Tile

Table 1: Comparison of selective materials for carbon emission

Item	Conventional Materials	RM	Sustainable Materials	RM	Remarks
1	Concrete grade 30	132,956.00	30% of BFS Concrete Mixture	122,479.03	7.88% reduction
2	Clay brick	18,754.74	AAC Block	27, 212.76	31.08% addition
3	Steel roof truss	27,862.13	Recycled steel roof truss	27,168.88	2.50% reduction
4	Metal roof sheet	24,396.12	Clay roof tile	27,106.80	10.00% addition

Table 2: Cost between Conventional Materials and Sustainable Materials

From the study, it can be concluded that conventional buildings in Malaysia produced higher carbon emissions than sustainable buildings throughout the construction phase. The substitution of sustainable materials, according to the MyCREST rating tool, can potentially reduce carbon emissions throughout the building construction. The results show that sustainable materials such as 30% BFS concrete mixture, Aerated Autoclaved Concrete (AAC) block, and recycled steel roof truss can reduce carbon emission throughout the construction process. It also shows that some of the sustainable materials are slightly cheaper than the conventional materials except for the AAC block and clay roof tiles. Therefore, the potential of the carbon emission

reduction approach by using MyCREST as a guideline tool can assist in reducing the environmental impact of buildings.

Who Decides If a Building Is Green?

The Green Building Index and its accreditation panel were established by the Malaysian Institute of Architects (*Pertubuhan Akitek Malaysia*/PAM) in 2008.

The aim was to provide a trusted and consistent source of information and accreditation for the country's growing number of green buildings.

GBI buildings are rated in four categories depending on how green they are deemed to be, with a points-based rating system:

Platinum – 86-100 points

Gold – 76-85 points

Silver – 66-75 points

Certified – 60-65 points

That means any building which scores above 50 in the GBI assessment qualifies for the term green building, with different categories describing improved performance over and above this score.

Benefits of GBI Certification

Green building practices can diminish a building's working cost by as much as 9 per cent, raise building values by 7.5% and realise a 6.6 per cent rise in return on investment. Therefore, green buildings do not simply bode well – they bode well as well. As mentioned earlier, green technology projects can benefit from Green Investment Tax Allowance (GITA) and Green Income Tax Exemption (GITE).

A GBI certification provides a measurable evaluation that shows how "green" or sustainable a building is. Hence, when a building is being certified, the building is being given the recognition that it has the following features:

1) Designed in a way that minimises the toxic substances' emission during their life cycle, saves resources and energy and recycles materials.
2) In harmony with traditions, local climate, surrounding environment and culture.
3) Capable of sustaining and improving the quality of human life while preserving the ecosystem’s capacity at global and local levels.

4) Utilises resources efficiently, which has significant operational savings and enhances workplace productivity.
5) Delivers the accurate message regarding the green management of an organisation or company.

The Pros and Cons of Living in a Green Building

The green building concept is ultimately about building better places to live, with an environmentally friendly development that recognises both the practical and personal benefits of sustainable building. The following table shows the benefits of living in a green building and some of the financial implications.

Benefits of a green building	Downsides of a green building
Positive living environment	You pay for all these benefits
Greenspace and landscaping	Limited number available (but growing)
Low energy use	Tend to be luxury rather than affordable properties
Lower operational costs due to energy efficiency and renewable options	
Sustainable living choice	
Improved natural light and air quality	

Access to transport is a significant design feature.	
Designed to the highest standards	
Independently accredited for comprehensive oversight.	
Often include enhanced community services.	

Table 3: Benefits and Downsides of Green Building

Case Studies of Green Buildings in Malaysia

Here are some examples of green buildings from across the certified spectrum, with one example from each Certified, Silver, Gold, and Platinum GBI category.

1) Certified Rating – Leisure Farm Resort Central Spine @ Iskandar Malaysia, Johor

Size: 1,765 acres

Types of Property: Townhouses, semi-detached homes, bungalows, villas

Launch Price: RM480,000 – RM2,350,000

Figure 22: Leisure Farm Resort Central Spine @ Iskandar Malaysia

Leisure Farm Resort Central Spine @ Iskandar Malaysia represents the first GBI-certified property in this huge multi-billion Ringgit development corridor.

Leisure Farm benefits from the close proximity to Singapore and the significant development drive of the Iskandar Malaysia project in Johor.

It's built on the principle of Sustainability, Energy, Environment, Design, and Security (SEEDS) for a favourable, sustainable building policy.

Having won numerous awards for liveability, property achievements, and architectural excellence, the broader masterplan for this luxury eco-development incorporates extensive natural land to enjoy and a golf and country club.

Leisure Farm was first established in 1991 as a ‘haven for mind, body and soul’. And if that sounds a bit cheesy, well you can’t really fault them for delivering on the promise.

2) Silver Rating – Bandar Rimbayu Township @ Telok Panglima Garang, Selangor

Size: 60 acres

Types of Property: Condominiums, pool villas, double-storey terrace houses, commercial

Launch Price: RM420,000 – RM590,000

Figure 23: Bandar Rimbayu Township @ Telok Panglima Garang, Selangor

Bandar Rimbayu Township is designed to provide the comfort of environmentally friendly township development, offering a residential development in a natural setting while also delivering outstanding connectivity to major highways throughout the area.

Bandar Rimbayu also operates on a Crime Prevention Through Environmental Design (CPTED) principle that incorporates security into the landscaping of this extensive development. Homes are environmentally designed with eco benefits such as renewable energy and energy efficiency.

The community also benefit from an award-winning community space which incorporates the positive value of shared activities into the overall concept of green design.

3) Gold Rating – Bukit Bintang City Centre (BBCC) @ Kuala Lumpur

Size: 19.4 acres

Types of Property: Office towers, residential suites, a hotel and a shopping mall

Launch Price: N/A

Figure 24: Bukit Bintang City Centre (BBCC) @ Kuala Lumpur

Bukit Bintang City Centre's (BBCC) iconic development is among several flagship green building developments across Kuala Lumpur.

BBCC will also include what's soon to be Malaysia's tallest building, with the PNB 188 skyscraper set to stretch over 2,000 feet into the air above downtown Kuala Lumpur.

This integrated green development will include green outdoor areas and landscaping as part of a connected building ecosystem, with the highlight (literally) in the form of a stunning rooftop park.

This greenery is not only designed as part of the external space, but interweaves with the building structure to enhance the ambience, aesthetics, and green living environment for residents.

With state-of-the-art energy efficiency technology and comprehensive green design, BBCC takes Gold Rating in GBI certification.

4) Platinum Rating – Tun Razak Exchange (TRX)

Size: 70 acres

Types of Property: Offices, serviced residences, The Exchange Mall, Kuala Lumpur's new Central Business District (CBD)

Launch Price: RM1.44 million – RM2.48 million (serviced residences)

Figure 25: Tun Razak Exchange (TRX), Kuala Lumpur

Tun Razak Exchange probably needs no introduction to anyone with even the slightest appreciation of Malaysia's property market.

This multi-billion Ringgit 70-acre-development has been constructing its way into KL's skyline for over a decade.

The first residential release as part of this development, Core Residence@TRX, was launched in February 2020.

TRX brings green design to the heart of KL's business district, with extensive use of sustainable practices and materials.

The commitment to energy efficiency, sustainable materials, a positive built environment, and waste management earned it a Platinum GBI certification.

TRX has also picked up a provisional Gold Award for LEED recognition for Neighbourhood Development.

As the focus of development, this stunning green space is just the kind of positive natural environment a GBI building is expected to provide.

The Way Forward

The construction industry stakeholder needs to take a holistic approach along the construction value chain activities to achieve sustainable construction. The way forward for the Malaysian Construction industry is to address the issue of sustainability and green construction as follows:

1. Research and innovation are good ways of improving and expanding knowledge and technology.

2. The introduction and adoption of whole life cycle costing (WLCC) and green procurement in the construction industry.

3. Establishment of eco-labelling scheme for construction materials.

4. Benchmarking and technology transfer of best practices from developed countries in implementing sustainable and green construction plans.

Embedding Aspects of IBS to 10 Principles of the Green Sustainability for the Malaysian Construction

The construction industry plays a vital role in helping the efforts of the Government to attain sustainable development and green construction when there is a requirement for balance between economic growth, social expansion and environmental protection. Migration to a sustainable 'mentality' requires a lot of change in attitude, innovation, creativity, research and support from many stakeholders. The strategic direction, implementation strategies, research, and development must be driven in harmony. It is envisioned that all initiatives mentioned need to be taken forward simultaneously. Every stakeholder must stand together and react as a team, not as an individual champion. The construction industry must change its traditional approach to construction with little concern for environmental impact to a new mode that makes environmental concerns a centrepiece of its efforts. A strategic way of implementing sustainable and green technology could show the path to adopting Whole Life Cycle Costing (WLCC) and towards green procurement in the construction industry. The era of sustainability is currently taking its stand, and the construction industry must demonstrate that it can lead and take this forward. Green technology is a crucial element in the sustainability domain. Embedding aspects of economic viability, design principles and environment, for example within the IBS framework to adopt the 10 Principles of the Green Way discussed below will bring synergy towards green construction and implementation of sustainability in Malaysia.

10 Principles of Malaysian IBS Green Construction:

1. Focus on Big Picture: Green mindset from the onset, Holistic approach
2. Choose a Sustainable Site: Regeneration, Least damage to natural resources, Accommodate with existing facilities
3. Do the Math: Apply Cost Benefit Analysis (CBA), Return of Investment (RoI)
4. Site Plan Work for You: Site planning, Building Orientation
5. Landscape for Saving; Cost effective tools
6. Design for Greater Green: Design management, shapes, colours, orientation, materials used
7. Take Advantage of Technology: Creating innovation in building

8. Save and Manage Water: Rainwater harvesting, Conserving irrigation systems, Effective stormwater management system
9. Use Alternative Materials: 3R's (Reduce, Reuse, Recycle), Non-toxic alternative building materials
10. Construct Green: Construction Process, Recycle construction materials

Recommendations to accelerate the adoption of sustainable construction and green buildings in Malaysia are:

- To further incorporate and applies innovation in construction in the form of an Industrialised Building System (IBS). The fundamental idea of IBS is to move on-site work to a controlled environment on the manufacturing floor. IBS promote sustainability from controlled production environment minimisation of waste generation, practical usage of energy, efficient building materials, and adequate logistic and long-term economic stability which can contribute to better investment in environmental technologies

- Introducing and adopting whole life cycle costing and green procurement in the construction industry is a meaningful way forward. The concept refers to the total cost of ownership over the life of an asset. It is also commonly referred to as *cradle to grave* or *womb to tomb* costs. The primary benefit of whole-life costing is that costs which occur after an asset has been constructed or acquired, such as maintenance, operation, and disposal, become an essential consideration in decision-making. By introducing the whole life cycle costing and green procurement, the industry has the resources to plan for sustainability and use green materials when the investment is justified.

- Environmental considerations will be integrated into all stages of development, programme planning and implementation and all aspects of 20 Sustainability Today www.witpress.com, ISSN 1743-3541 (on-line) WIT Transactions on Ecology and The Environment, Vol 167, © 2011 WIT Press policy making. Environmental inputs shall be incorporated into economic development activities, including regional plans, master plans, structure and local plans.

- Human capital development is one essential element that must be taken into consideration. A system for formulation of grading and certification mechanisms for competent personnel in green technology is the way forward. The learning curve and education syllabus on sustainable and green construction should be included from primary education to the university level.

- Research and innovation are the best way to improve and expand knowledge and technology. The Government should increase grant allocation on the research related to sustainable and green construction and encourage research clusters on green issues. The research plan needs to include benchmarking and technology transfer of best practices from developed countries in implementing a sustainable and green construction plan.

- To achieve efficient environmental management and protection, integrated and effective cooperation and coordination among Government and other sectors shall be enhanced. Environment-related legislation and standards shall be reviewed regularly and revised to ensure laws' continued effectiveness and coordination. Particular attention will be paid to effective enforcement. However, there is a need for clarity in the agencies' roles to avoid confusion and overlapping roles and programs.

Proposed the Way Forward Framework

Establish an immediate national programme of "fabric first" home retrofit to make homes efficient and warm and transition away from fossil fuel heating. Bring forward the cut-off date for the sale of gas and oil boilers to 2030. Encourage green ratings for homes at the point of sale by 2028.

Remove VAT on energy-efficient devices.

Energy efficient devices to retrofit building works and introduce variable stamp duty linked to energy performance. Introduce direct government retrofit grants for low-income households.

Energy performance disclosure for non-domestic buildings.

Introduce mandatory in-use energy disclosure for non-domestic buildings.

Accelerate the roll-out of energy performance rating schemes across non-domestic sectors, followed by minimum standards and fiscal incentives.

Adoption of a design for performance approach to new buildings.

Reform building regulations to introduce Energy Usage Intensity (kWh/m2/yr) targets for new buildings from 2025. Alongside low carbon heating for all new buildings from 2025, introduce space unregulated vital appliances.

Whole life carbon measurements and agreed limits.

Introduce the regulation of embodied carbon for new buildings and major refurbishments. Support and invest in industrial decarbonisation of key construction material supply chains. Use planning reforms to prioritise the reuse of existing buildings and assets.

National infrastructure investment based on the net emissions impact.

Establish a National Infrastructure Integrator with complete oversight of carbon impacts. "The Net Zero Whole Life Carbon Roadmap pulls together disparate strands of recent Policy and action into one coherent pathway, with clear recommendations for National Government and Local Authorities, the private sector and the wider industry.

Case Study: Green Building Initiatives in China

China is the largest building construction market in the world, with up to 2 billion square meters constructed annually, accounting for nearly half of new construction globally in the coming decade.

In 2011, buildings accounted for just 28% of China's energy consumption. Still, urbanisation, economic growth and a rising population could increase this number by as much as 40% over the next 15 years. Adopting green building technologies and solutions is crucial to China's sustainability and environmental protection goals.

The 12th Five Year Plan for Building Energy Efficiency and Green Building Development required all public buildings to be certified in Green Building Energy Labelling (GBEL). Besides, all central government agencies must purchase building materials certified by China Environmental Labelling in line with a specification environmental standard coded as HJ/T223. From 2008 to 2015, public GBs accounted

for more than 50% of the existing certified Green Buildings. Public procurement for GB in China increased the government-guaranteed demand for Green Buildings.

China’s 13th Five Year Plan for Building Energy Efficiency and Green Building Development includes aggressive goals for green building construction and renovation, including a requirement for 50% of all new urban buildings to be certified green buildings. The plan also specifies pilot programs for constructing and renovating energy-efficient primary and secondary schools, community hospitals and public buildings.

As the national Five Year Plan is cascaded to provincial and municipal jurisdictions, nearly 20 cities have set even more ambitious targets. For example, Changde, Zhenjiang, Zibo, Wuxi, Suzhou, Shanghai, Beijing, Shenzhen, and Chongqing will require all new commercial buildings to be green. In pursuing even more sustainable buildings, more than 90% of China's commercial building owners plan to have at least one net or near-zero energy building in the next ten years.

Public-private partnerships are one of the most effective ways of overcoming these barriers. The East Asia launch of the Building Efficiency Accelerator (BEA), a global public-private partnership coordinated by the World Resources Institute (WRI), was held at the Thirteenth International Conference on Green and Energy-Efficient Building in Beijing.

The launch included Government, private sector and civil society stakeholders. It showcased the building efficiency policy best practices of three leading Chinese districts – Changning District, Wuxi City High-Tech Industrial Development Zone and Suzhou Taihu New City, as well as the BEA partner cities of Ulaanbaatar, Mongolia and Iskandar, Malaysia.

The Changning District deployed an energy monitoring platform that now tracks 160 of the district's 165 public buildings. To date, 32 buildings have been retrofitted to achieve an average of 20% energy saving. The district also provided subsidies to building managers, which in turn encouraged building managers to invest an additional 140 million yuan (USD 20.33 million) in improving building efficiency.

Wuxi City High-Tech Industrial Development Zone provided incentives for new buildings certified to the US Green Building Council's LEED or China's national three-star rating systems. Buildings that achieve the highest green building ratings in either certification program receive up to 500,000 yuan with similar incentives for using heat pumps, solar photovoltaic systems, and other clean energy technologies.

The Suzhou Taihu New City will house 200,000 residents, and all buildings will be designed to receive at least a two-star rating from China's three-star rating system. The city will also boast a green building demonstration area, constructing several projects like zero-energy schools and monitoring the building's energy performance.

Another essential public-private partnership is the US-China CERC Building Energy Efficiency Consortium. The CERC-BEE consortium collaborates with leading U.S. and

China researchers at national laboratories, research institutes, universities and 48 industry partners to advance state-of-the-art low-carbon and near-zero energy buildings.

The new Johnson Controls Headquarters Asia Pacific will be a living laboratory for the company's CERC-BEE research activities focused on advanced energy monitoring and control, indoor air quality management and building-to-grid integration. Finally, the facility will be used to convene public roundtables and forums to share industry best practices that can help local and provincial governments in China and across the region accelerate their urban efficiency initiatives.

Digital Roadmap for Green Building in Malaysia

Basic	Intermediate	Advance

• Malaysian Construction Industry Master Plan (2005–2015).
• Use of Sustainable Construction Material
• Malaysian Carbon Reduction and Environmental Sustainability Tool (MyCREST),
  ○ Target to reduce 40 % Carbon footprint
• CIDB's Green Technical Committee / Eco-Label Committee.
• In 2010, CIDB formed the Technical Committee on Best Practice in Green Technology in the construction industry, comprising representatives from government agencies, professional bodies, academicians, and societies related to the construction industry.
	• Reducing Carbon Footprint
	• Net Energy Metering Scheme (NEM) was introduced by the Sustainable Energy Development Authority (SEDA).
	  • To encourage homeowners to install solar PV panels in their homes.
	• Green Investment Tax Allowance (GITA) for the purchase of green technology assets & Green Income Tax Exemption (GITE) on the use of green technology services until 2023
	• The National Green Technology Policy (NGTP) (Launched in 2009) emphasises 4 focus areas of green initiatives: energy, building, transportation, and waste management
		• Specific Policy and Guidelines on Green Buildings
		• Malaysia's Aspiration towards UN SDG (Sustainable Development Goal)
		• The Government committed to reducing Greenhouse Gas (GHG) emissions by 45 % by 2030, based on the 2005 GDP. (United Nations Climate Change Conference (2015) (Conference of Parties, COP21) in Paris)
		  • 35 % of total greenhouse gas emissions on an unconditional basis & 10 % on a conditional basis upon receipt of climate finance funding, technology transfer, and capacity building from developed countries.

• The committee is to assist the CIDB in identifying the preparation and development of the construction industry's
  • standards,
  • guidelines,
  • manual,
  • technical reports and
  • training modules related to green technology
• Green Building Index: Six major areas are measured:
  • Energy efficiency – Improved energy consumption, minimising solar heat gain, harvesting natural light, adopting renewable energy, and ensuring proper testing and maintenance.
  • Indoor environment quality – Good indoor air quality, acoustics, visual and thermal comfort. Use low volatile organic compound materials, quality air filtration, temperature control, movement, and humidity.
  • Materials and resources – Sustainable materials and proper construction waste		

management systems. • Sustainable planning and management – Appropriate sites with access to public transportation, open spaces and landscaping. No damage to environmentally sensitive areas. Reducing the strain on existing infrastructure capacity. • Water efficiency – Rainwater harvesting, water recycling, water-saving fittings. • Innovation – Innovative design solutions that meet other GBI goals.		

Table 4: Digital Roadmap for Green Building in Malaysia

From the table above, the following description is summarised:

Basic Level

In the Basic Level, for a project to be green certified as a Green Building, a building must fulfil the six following criteria:

1. Energy efficiency – Improved energy consumption, minimising solar heat gain, harvesting natural light, adopting renewable energy, and ensuring proper testing and maintenance. (35 points)
2. Indoor environment quality – Good indoor air quality, acoustics, visual and thermal comfort. Use low volatile organic compound materials, quality air filtration, temperature control, movement, and humidity. (21 points)
3. Materials and resources – Sustainable materials and proper construction waste management systems. (11 points)
4. Sustainable planning and management – Appropriate sites with access to public transportation, open spaces, and landscaping. No damage to environmentally sensitive areas. Reducing the strain on existing infrastructure capacity. (16 points)

5. Water efficiency – Rainwater harvesting, water recycling, water-saving fittings. (10 points)
6. Innovation – Innovative design solutions that meet other GBI goals. (7 points)

These are points gained and GBI rating out of the six criteria mentioned:

POINTS	GBI Rating
86 to 100 points	Platinum
76 to 85 points	Gold
66 to 75 points	Silver
50 to 65 points	Certified

Intermediate Level

This level is meant for individual houses, buildings or big projects. Net Energy Metering (NEM) is an initiative initiated by SEDA. By 2025 Malaysia has targeted 31% of Renewable Energy, RE by several means. Net Energy Metering, NEM, Large Scale Solar, and Self-Consumption are among others. All are solar photovoltaic-based initiatives.

On top of that, tax benefits are given, i.e., Green Investment Tax Allowance (GITA) for the purchase of green technology assets and Green Income Tax Exemption (GITE) for the use of green technology services until 2023. In addition, the National Green Technology Policy (NGTP) (Launched in 2009) emphasises 4 focus areas of green initiatives: energy, building, transportation, and waste management. The Policy recognised green technology as a driver to accelerate the national economy and promote sustainable development.

Advanced Level

This level emphasises International Policies such as the Malaysia Renewable Energy Roadmap (MyRER), which targets Malaysia's global climate commitment to reduce its economy-wide carbon intensity (against GDP) by 45% in 2030 compared to 2005. Realising the Government's vision is crucial in supporting the nation to achieve its Nationally Determined Contributions (NDC) targets. The Malaysia Renewable Energy Roadmap (MyRER) is commissioned to support further decarbonisation of the electricity sector in Malaysia through the 2035 milestone. This is expected to drive a reduction in Green House Gas (GHG) emissions in the power sector to support Malaysia in meeting its NDC 2030 target of a 45% reduction in GHG emission intensity per unit of GDP in 2030 compared to 2005 and further reduction of 60% in 2035. Malaysia is also committed to fulfilling United Nations Sustainable Development Goal (UNSDG), Goal 7, to ensure access to affordable, reliable, sustainable and modern energy by 2030.

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