Ministry of Sustainability
& Climate Resiliency
and Wellness
Cayman Islands Government

Energy Efficiency Guidelines for Residential Construction

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ECONOLER

Abbreviations

AAC	Autoclaved aerated concrete
AC	Air conditioning
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
CARICOM	Caribbean Community
CCP	Climate Change Policy
CFL	Compact fluorescent lamp
CHEER	Cayman Home Energy Efficiency Retrofit (Programme)
CIRC	Cayman Islands Residential Code
CREEBC	CARICOM Regional Energy Efficiency Building Code
CROSQ	CARICOM Regional Organisation for Standards and Quality
CUC	Caribbean Utilities Company Ltd
DHW	Domestic hot water
EE	Energy efficiency
EER	Energy efficiency rating
ESO	Economic and Statistics Office
EU	European Union
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
FSC	Forest Stewardship Council
gpm	Gallons per minute
GWP	Global warming potential
HSPF	Heating seasonal performance factor
HPWH	Heat pump water heater
IAQ	Indoor air quality
ICC	International Code Council
ICF	Insulated concrete form
IEA	International Energy Agency
IECC	International Energy Conservation Code
IRC	International Residential Code
LED	Light-emitting diode
LEED	Leadership in Energy and Environmental Design
Low-e	Low emissivity
MEPS	Minimum energy performance standards
NEP	National Energy Policy
NHDT	National Housing Development Trust
PEEB	Programme for Energy Efficiency in Buildings
Psi	Pounds per square inch
PV	Photovoltaic
RE	Renewable energy
RESEMBID	Resilience, Sustainable Energy and Marine Biodiversity (Programme)
SEER	Seasonal energy efficiency rating
SHGC	Solar heat gain coefficient
UNEP	United Nations Environment Programme
US EPA	United States Environmental Protection Agency
UV	Ultraviolet
V2G	Vehicle-to-grid
VLT	Visible light transmission
VOC	Volatile organic compound

Glossary

Airtightness	The resistance to unintentional inward or outward air leakage (infiltration or exfiltration) through the building envelope. Airtightness is typically measured as air change rate or air changes per hour (ACH) at a given pressure difference between indoor and outdoor air (e.g. 50 Psi).
Albedo	Albedo is the ability of a building's exterior surfaces to reflect sunlight (and thus heat from the sun). Light-coloured surfaces return a large part of the sunrays away from the building (high albedo). Dark surfaces absorb the rays from the sun (low albedo).
Bioclimatic architecture	Is a way of designing buildings based on the local climate and conditions, with the aim of ensuring thermal comfort using environmental resources, and blending buildings into their natural surroundings.
Embodied carbon	Is defined as the greenhouse gas emissions that occur during the production, transportation, and installation of building materials. It also includes emissions from the construction process itself, and the disposal of materials at the end of a building's life.
Passive building design	Is defined to use natural sources of heating and cooling, like the sun and wind, to maintain a comfortable temperature for a building. Passive design can reduce the need for heating and cooling systems, which can lower energy bills and greenhouse gas emissions.
R-value	The R-value (e.g. R-30) is indicative of the thermal resistance of the material (resistance to heat conduction) through its thickness or depth, and is typically measured in Btu/h·ft^2·°F (imperial units), or in m2.K/W (SI units). Thus, a higher R-value indicates more resistance to heat transfer and thus better insulation properties, while a lower R-value indicates less resistance to heat transfer. The thermal performance of certain materials is sometimes expressed in terms of thermal conductivity, which is the opposite of thermal resistance (good insulation materials have low thermal conductivity properties).
Solar Heat Gain Coefficient (SHGC)	The SHGC measures how much of the sun's heat comes through the window. It can range in value from 0 to 1.
Solar chimney	Is a passive heating and cooling system that uses the sun's heat to create natural air circulation within a building by essentially acting like a tall, vertical chimney where warm air rises, drawing cooler air in to replace it, thus providing ventilation.
Thermal conductivity	The thermal conductivity of a material is a measure of its ability to conduct heat. Heat transfer occurs at a lower rate in materials of low thermal conductivity than in materials of high thermal conductivity. The reciprocal of thermal conductivity is called thermal resistivity.
U-value or U-factor	The U-value (or U-factor) of a window provides a measure of how well the window insulates. For windows it ranges from 0.20 to 1.20 W/m^{2}K. The lower the U-value, the better the window insulates.

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Foreword

The Cayman Islands Government Ministry of Sustainability & Climate Resiliency and Wellness (Ministry) received a grant from the European Union under their Resilience, Sustainable Energy and Marine Biodiversity (RESEMBID) Programme to implement a Residential Building Energy Efficiency Programme. This programme, under the remit of the Ministry and in accordance with the National Energy Policy (NEP), is intended to reduce energy consumption in the residential sector of the Cayman Islands with a particular focus on the most vulnerable residents. To ensure the sustainability of the Residential Building Energy Efficiency Programme, there is a need to develop data-driven policies and strategies to promote energy efficiency (EE) in the residential sector in new and existing buildings. The Ministry contracted Econoler to carry out a consultancy that is focused on developing guidelines to support and ensure the effective implementation of EE measures in the residential sector.

Introduction

Overview

The built environment – from homes to commercial and public buildings – requires significant amounts of energy in daily operations. According to the International Energy Agency (IEA), in 2022, the operations of buildings accounted for 30% of global final energy consumption. In fact, the IEA estimated that the energy used by buildings accounts for 28% of the global emissions that drive climate change. As buildings and the equipment used inside are typically built to last many years, it is necessary to ensure that their future emissions are minimised.

Construction activities consume energy and contribute to overall global emissions. According to a recent report from the United Nations Environment Programme (UNEP), energy-related carbon dioxide emissions from building operations and construction rose to 10 gigatonnes (GT CO2) in 2022, which represented 37% of global carbon dioxide emissions. Moreover, consumption and emission levels will continue to increase with population growth, economic development, and increased access to energy, further increasing local and global climate change risks.

Primarily due to their low-lying geography, the Cayman Islands are highly vulnerable to climate change. The physical risks facing the Islands include rising sea levels, elevated temperatures, increased hurricane intensity, coral bleaching, and disruption to marine ecosystems. The Islands also face economic risks due to their reliance on tourism, a sector that heavily depends on a healthy marine environment and calm, sunny weather. Cayman Islands residents also face significant health and economic challenges from temperature-related heat stress, reduced water quality and availability, as well as increased risk of vector-borne diseases from changing weather patterns.

The Cayman Islands have also seen their population grow by an estimated 23% since 2021,[1] contributing to a significant increase in housing and living costs as well as higher overall demand for electricity and, in turn, increasing the need for additional electricity generation mostly supplied by diesel plants.

One of the most cost-effective and fastest ways to reduce climate-related risks in the long term and household electricity costs in the near term is to maximise the energy efficiency of new and existing buildings. This can be achieved by adopting more energy efficient building construction and retrofit practices by selecting energy efficient systems and equipment and promoting energy conservation behaviours and habits among building occupants. Additionally, as the Cayman Islands electricity grid becomes increasingly powered by renewable energy (RE), buildings also become less carbon intensive. A greener grid also has the potential to reduce monthly utility bills especially for low-income households that have historically faced higher barriers to accessing the benefits of clean energy.

This document presents a closer look at how energy-efficient buildings and construction practices can help to address climate challenges and increase sustainability in the Cayman Islands.

Objectives

The primary objective of this document (hereinafter the "Guidelines") is to provide practical guidelines and recommendations to help stakeholders in the Cayman Islands residential construction sector integrate energy-efficient practices into their projects. The guidelines are intended to serve as an educational and reference document by incorporating best practices for optimising energy use in residential buildings, selecting equipment and appliances, and adopting energy-efficient construction practices that are appropriate for the Cayman Islands.

[1] *Based on the June 2024 population estimate and the 2021 Census of Population and Housing published by the Cayman Islands Economics and Statistics Office (respectively available at https://www.eso.ky/ and https://www.eso.ky/the-cayman-islands-2021-census-of-population-and-housing.html).*

About this Document

The Guidelines are aimed at the Cayman Islands government policymakers, residential builders and contractors, project developers, architects and engineers, large residential building operators, appliance and equipment retailers and suppliers, as well as other stakeholders involved in prioritising energy efficiency in the residential construction sector. The best practices presented herein are suitable for use by builders and users of the different types of residential buildings on the Cayman Islands.

Three primary research and analysis activities were carried out during the development of this document. An assessment of international and regional documents, standards, methodologies, and other information sources served to establish a comprehensive knowledge base of energy-efficient buildings, construction practices, and equipment. One of the major documents used in the assessment is the well-established regional building code developed by the Caribbean Community (CARICOM). This document also draws on other resources that can directly affect equipment and components used by Cayman Islands builders – namely those of the United States Environment Protection Agency (US EPA) ENERGY STAR® programme that provides guidance and specifications for both building practices and equipment imported onto the islands.

Organisation of This Document

This document consists of four main sections as described below.

Section 1 **Overview** *This section presents an overview of the current regulatory, technical, and market situation in the Cayman Islands;*

Section 2 **New Construction** *This section provides relevant and cost-effective energy efficiency measures and best practices for improving energy efficiency in new construction at the design stage;*

Section 3 **Existing Buildings** *This section provides relevant and cost-effective energy efficiency measures and best practices for improving energy efficiency when retrofitting existing buildings; and*

Section 4 **Other Opportunities** *This section describes supplementary opportunities to improve building sustainability and energy performance.*

The measures, practices, and opportunities presented in this document are those that are considered the most impactful and appropriate for the Cayman Islands in terms of energy efficiency, sustainability, and building occupants.

Note: While Sections 1 and 4 may be relevant to all stakeholders, Sections 2 and 3 are aimed at different building categories, and thus builders looking for specific information for new construction can omit Section 3 (Existing Buildings), while builders looking for specific information for existing buildings can omit Section 2 (New Construction) if they so choose.

01 Current Situation

The current state of energy efficiency in the Cayman Islands reflects both progress and challenges. While there is growing awareness about energy-efficient practices, such as the use of higher seasonal energy efficiency rating (SEER) air conditioners in most new constructions and the use of duty waivers on insulation materials, significant gaps remain in regulations and their adoption.

A careful assessment of the current situation in the Cayman Islands with respect to residential energy performance and construction practices was conducted to support the preparation of this document. The assessment included an examination of existing climate and energy policies, their implementation status and challenges, regional and international activities focused on these topic areas, field visits, and discussions with key stakeholders on energy-efficient building practices and components. Available data specific to the construction sector and energy efficiency in residential housing, both for the Cayman Islands and other islands in the region, were also reviewed and evaluated.

1.1 Current Energy Policies

There are currently no national energy efficiency requirements or standards in force in the Cayman Islands. The current Cayman Islands Residential Code (CIRC) is adapted from the 2009 International Residential Code (IRC) with the exclusion of Chapter 11 that pertains to energy efficiency. Therefore, the current CIRC does not include energy efficiency requirements. Additionally, there are no mandatory minimum energy performance standards (MEPS) currently in force for air conditioning or other key appliances, leaving the market to self-regulate. The absence of an enforced energy efficiency code has been noted by several stakeholders involved in the residential buildings sector, particularly after an earlier code drafted in 2016 faced resistance and a lack of uptake from designers and contractors due to increased design and installation costs and limited participation in code training sessions. Building inspections vary in scope and depth due to the varying expertise of inspectors and limited inspector training.

Nationally, the Cayman Islands has committed to achieving carbon neutrality by 2050. **The government has taken several steps in recent years to address climate change and promote energy efficiency in all sectors, including**:

- The adoption of the National Energy Policy[2] (NEP) that states four goals: Increase public awareness and education about the environmental impacts of energy use; position the Cayman Islands as a leader in small island sustainable energy practices; ensure that energy supplies are produced and distributed competitively, safely, reliably, efficiently, and affordably; and support the growth and development of the sustainable energy industry and the Caymanian economy. Through these goals, the NEP is intended to achieve the following targets by 2045: 100% renewable energy; 100% new vehicle sales of electric vehicles (EV); and 100% GHG emission reductions from electricity supply relative to 2019 levels.
- The adoption of the Climate Change Policy[3] (CCP) whose aims are to: Become more resilient to climate change; achieve a sustainable, low-carbon economy; and govern climate action fairly and transparently with future generations in mind.
- Waiving import duties on energy efficiency products such as wall and roof insulation materials.
- **Energy efficiency programmes such as:**
    - The Residential Buildings Energy Efficiency Programme, funded by the European Union initiative RESEMBID and delivered by the Ministry of Sustainability & Climate Resiliency and Wellness, provided 10 National Housing Development Trust (NHDT) homes with air-conditioning and roof insulation upgrades as well as rooftop solar panels.
    - The Cayman Home Energy Efficiency Retrofit (CHEER) Programme to help eligible Caymanian homeowners reduce their energy bills by enhancing the overall energy efficiency of their homes. The programme provided eligible homes with an energy audit as well as energy-saving upgrades such as insulation, air conditioning, light-emitting diode (LED) lighting, and energy-efficient appliances.

[2] *Cayman Islands National Energy Policy 2024-2045. Available at https://www.gov.ky/publication-detail/national-energy-policy-2024-2045 (last accessed 27 January 2025).*

[3] *Cayman Islands Climate Change Policy 2024-2050. Available at https://www.gov.ky/publication-detail/climate-change-policy---2024-2050 (last accessed 27 January 2025).*

Regionally and internationally, there are a number of key initiatives underway in the Caribbean region and elsewhere to address challenges in the buildings sector, which can support the Cayman Islands' **focus on improving the energy efficiency of buildings and construction practices, including:**

- The CARICOM Regional Energy Efficiency Building Code (CREEBC), which is a comprehensive collaboration between CROSQ (Caribbean Regional Organisation for Standards and Quality), the CARICOM Energy Unit, the International Code Council (ICC), and ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers). The code covers both commercial and residential construction practices and building components with a focus on ensuring energy efficiency within those types of buildings and references the International Energy Conservation Code 2018 (IECC 2018).
- The CARICOM Regional Energy Efficiency Labelling Scheme is focused on the voluntary use of energy labels on electrical appliances to help guide consumers in selecting and purchasing energy-using equipment. Categories covered by this initiative include lighting products, air conditioners, refrigerators, and other appliances.
- Initiatives underway in the region and elsewhere include ENERGY STAR labelling for appliances and Leadership in Energy and Environmental Design (LEED) certification for buildings in North America, products and building labelling regulations in the EU and Mexico, and others.

Discussions with stakeholders and data from the Economic and Statistics Office (ESO) indicated that as of 2024, there has been a significant increase in residential construction in the Cayman Islands driven by both local demand and international interest particularly from expatriates and investors. Locally, there is growing awareness about the importance of energy efficiency in the construction industry and residents of the Cayman Islands, driven by the high cost of energy, particularly electricity, and environmental considerations.

In addition, the Cayman Islands Government, regulatory bodies, and other stakeholders are beginning to encourage energy-efficient practices, although adoption has been gradual and there is room for more stringent regulations. Some developers are incorporating LEED or similar green building standards in new developments, particularly luxury projects. There is also a push toward affordable housing particularly to address the needs of the growing overall Cayman Islands population and high cost of living.

Solar power adoption has increased in both residential and commercial developments, with many new homes including solar photovoltaic (PV) systems as standard or optional features. However, solar energy remains underutilised in the broader residential sector due to high upfront installation costs and limited available financial incentives (such as subsidies, rebates, reduced import duties, or other financial mechanisms). Given this situation, it is essential that greater emphasis be placed on using energy efficiency and sustainable building practices during construction and when selecting systems and equipment to meet customer needs and government requirements.

1.2 Challenges and Barriers

While there has been an increase in construction activities and customers are becoming more aware of energy efficiency and available options, builders on the Cayman Islands face a number of challenges and barriers to the adoption of energy-efficient and emission reduction measures, including:

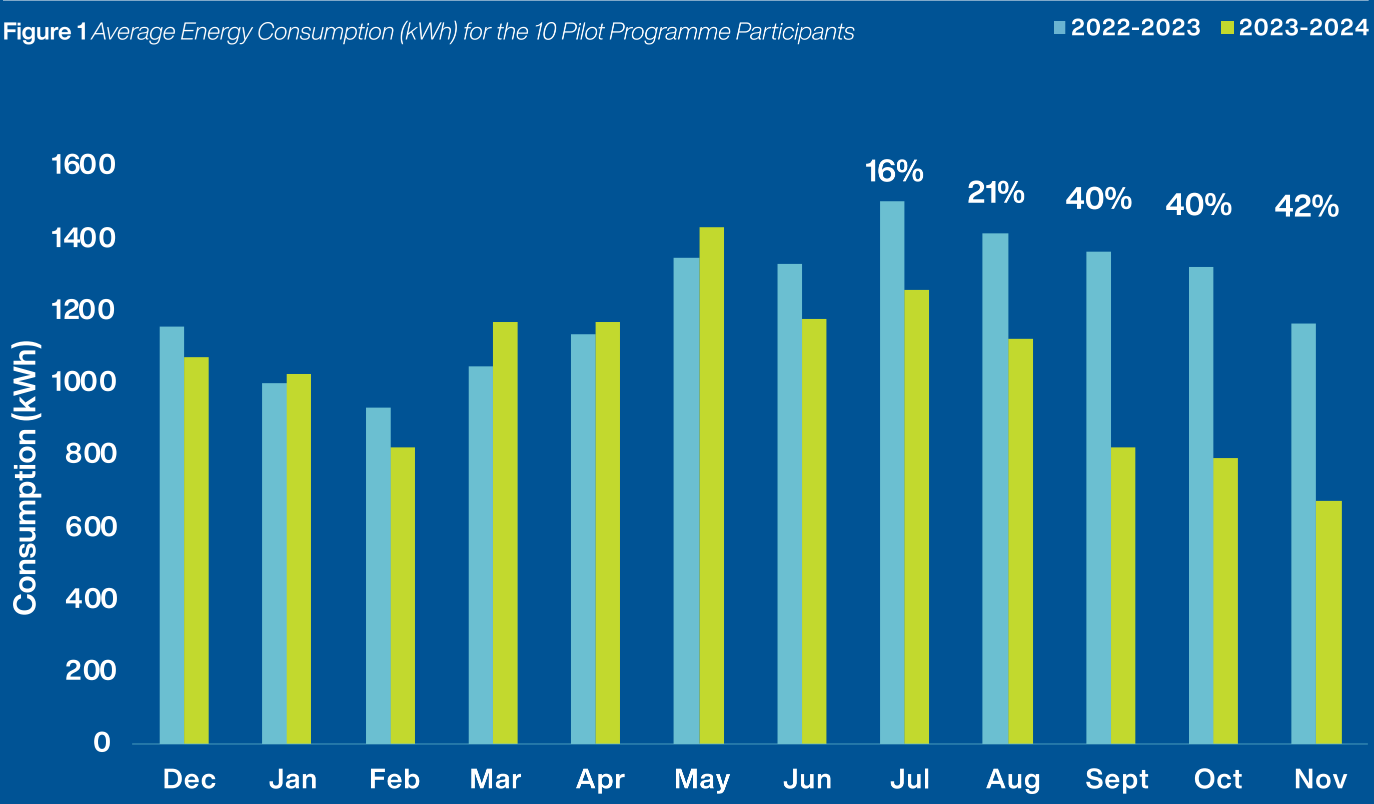
- **High Construction Costs:** Import duties on building materials along with labour shortages have led to increased construction costs, making energy-efficient components and green building practices less cost competitive and even prohibitive for smaller or mid-range residential projects.
- **Specific Guidance:** While the government has been promoting energy efficiency through the various initiatives described in the previous subsection, the lack of clear regulations, such as energy efficiency requirements in the residential building code and mandatory MEPS for equipment and appliances, has slowed the adoption of energy efficiency design and construction practices. For the regulations that are in place, effective enforcement remains a challenge. There is also a lack of financial incentives and rebates, the short-term presence of which would significantly contribute to increasing the uptake of energy efficiency practices as the industry adapts to new policies.
- **Market Resistance:** Some developers and homeowners still prioritise lower upfront building costs over energy efficiency, which hinders the widespread adoption of more energy-efficient building practices and components.

Overall, while the Cayman Islands is making progress in terms of energy-efficient residential construction practices and equipment; however, there is still room to increase the adoption and regulatory frameworks to fully support sustainable building practices.

1.3 Results from the RESEMBID Pilot Programme

In 2023, energy audits were conducted in 10 NHDT households as part of the RESEMBID Residential Buildings Energy Efficiency Pilot Programme. Following the energy audits, EE measures were implemented to improve cooling efficiency, including open-cell spray foam roof insulation (R-30) and high-efficiency air conditioning (SEER 20) in all 10 residential buildings. The roof insulation upgrades were completed between 24 June and 10 July 2024, while air-conditioning (AC) unit installations were completed between August 2 and 23 of 2024. **As illustrated in Figure 1 below**, which includes pre and post-retrofit average monthly electricity consumption for all participants, these measures generated very significant energy savings. On average, participating households reduced their monthly consumption by approximately 40% in the months of September, October, and November 2024, the first three months following the full completion of the retrofits. Consumption could be further reduced through other means such as the use of other energy-efficient appliances and slightly increasing the temperature setpoints. Based on the above results, cooling clearly represents a significant proportion of household energy consumption.

Figure 1 *Average Energy Consumption (kWh) for the 10 Pilot Programme Participants*



02 Guidelines for New Construction

This section is aimed at stakeholders involved in the design, construction, and operation of new residential buildings, including developers, builders, design professionals, residential equipment suppliers, and lending institutions. Together, these groups are responsible for all aspects of building development, design, and construction processes. As key players in designing, building, operating, financing, and leasing residential spaces, they are uniquely positioned to implement practices that optimise building construction and operation for greater energy efficiency and sustainability.

An energy-efficient building or dwelling is a structure designed and built to minimise energy consumption by utilising a comprehensive full-building approach that incorporates strategies like optimal insulation, high-performance windows, efficient appliances, and proper ventilation, resulting in reduced ventilation and cooling needs while maintaining comfortable indoor temperatures and ensuring improved indoor air quality (IAQ). An energy-efficient building uses less energy to perform the same functions as a standard building. Additional measures such as optimal fenestration distribution and building placement as well as the use of passive solar and shading strategies further improves building energy performance and reduces impacts on the environment.

Discussions with government agency representatives, builders, developers, designers, suppliers, owners, and other stakeholders indicated that there is a wide range of knowledge among industry actors regarding energy efficiency design and construction practices, which are not always aligned with best practices (e.g. improperly sizing AC systems) or with local climate requirements. The new construction guidelines were developed based on findings from these stakeholder discussions, as well as on established energy efficiency and building science principles. The guidelines focus on areas that will provide the most significant impacts on the energy efficiency of buildings and residential electricity costs, **including the following:**

Bioclimatic Design and High-performance Building Envelope *Minimise the energy needs of new buildings by optimizing building siting and orientation, and by including high levels of roof insulation, high-performance fenestration, shading, and high-albedo roof and exterior wall finishes.*

Energy Efficient Systems and Appliances *Ensure properly sized air-conditioning systems and integration of ventilation measures. Install energy-efficient equipment and lighting as well as water saving appliances.*

Renewable Energy Integration *Incorporate renewable energy sources like solar PV systems or solar water heating to further decrease reliance on the electricity grids.*

It should also be noted that it may not be possible to combine some practices – for example, the use of solar water hot water heaters may compete with solar photovoltaic panels for roof areas. The combination of some measures may also affect their overall cost effectiveness – for example, rooftop PV panels may reduce the need for light-coloured roof tiles or low albedo paint due to their shading impacts. Users of this document are recommended to carefully compare the benefits of each measure.

2.1 CARICOM Regional Energy Efficiency Building Code

The CREEBC consists of a comprehensive approach to energy-efficient buildings and construction practices. This code is an adaptation of the IECC 2018 published by the ICC. The CREEBC is designed specifically to meet the needs of Caribbean and other countries in tropical environments. It establishes minimum energy efficiency requirements for buildings by including prescriptive and performance-based provisions covering building envelopes, cooling systems, ventilation, pumping, lighting, and service water-heating systems in buildings.

It is recommended that builders and developers consider incorporating the residential provisions of the CREEBC, starting with the design stage (**see Figure 2 below**), and choosing a compliance path to follow.

The Cayman Islands have not yet adopted the CREEBC. Therefore, some builders may elect to gradually adopt CREEBC requirements in a phased manner. Certain key practices are outlined below, which may be used by designers and builders to maximise energy efficiency, improve overall comfort, and reduce long-term operating costs for building owners and operators.

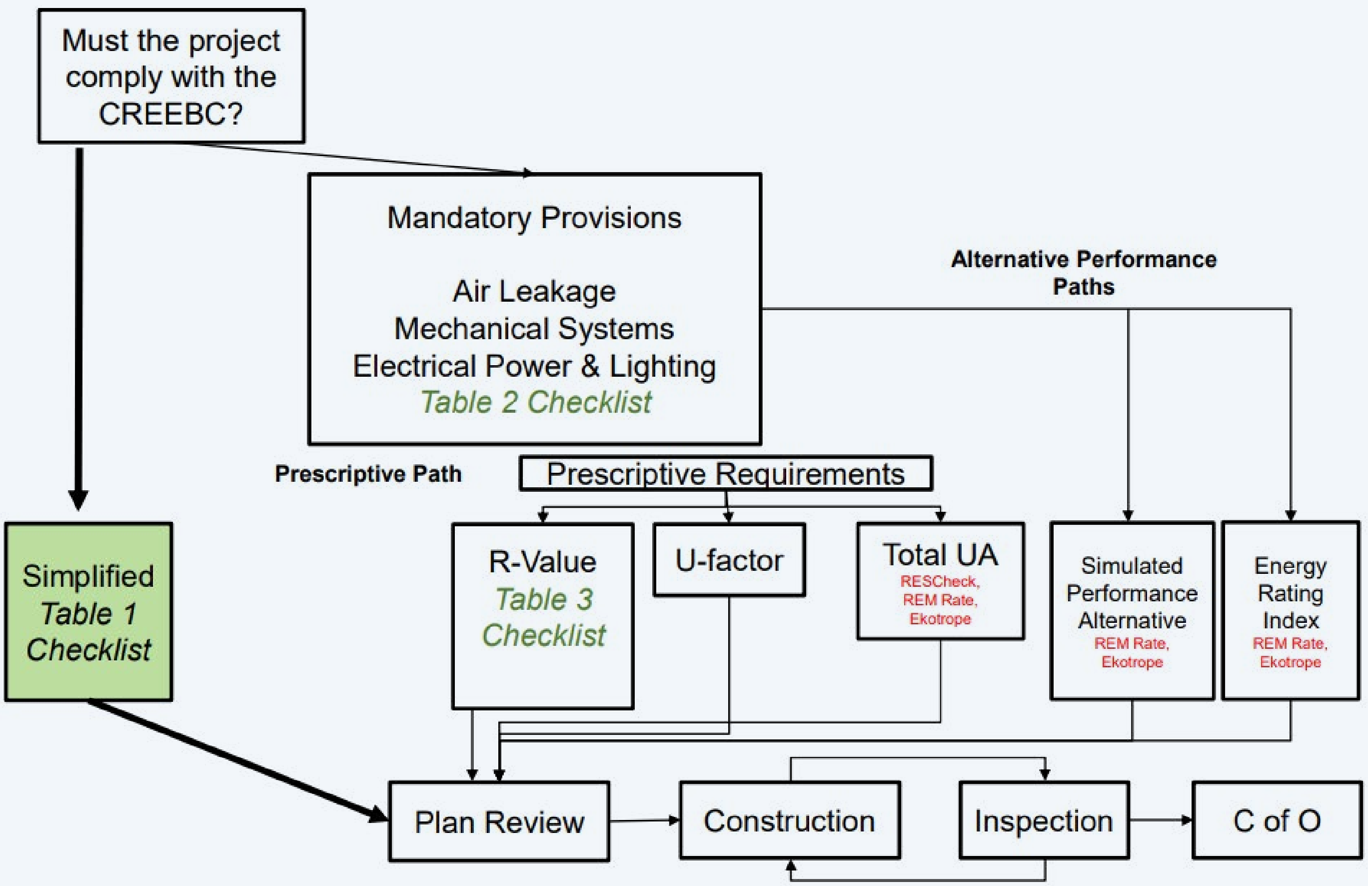


Figure 2 *CREEBC Residential Compliance Paths*

Source: *Caribbean Centre for Energy Efficiency and Renewable Energy*

2.2 Building Siting and Orientation

The siting and orientation of a building play important roles in its energy use and sustainability. These factors can affect building exposure to sunlight (solar gains), natural shading and wind, all of which impact building requirements for active heating or cooling. Applying bioclimatic architecture and passive building design principles at the development and design stages leads to greatly reduced building energy needs and increased occupant comfort.

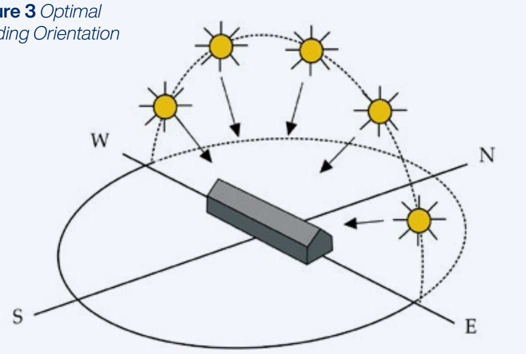
Bioclimatic architecture refers to a design and planning approach based on the local climate and aimed at reducing sunlight exposure and providing thermal comfort by relying on natural resources like sunlight, breezes, and shading. Passive building design principles are focused on reducing building energy demand by opting for optimal building shapes, orientations, materials, and layouts to minimise the needs for mechanical cooling and ventilation as well as lighting.

Drawing from these principles, important factors to consider when siting and designing a building located in a tropical climate zone include:

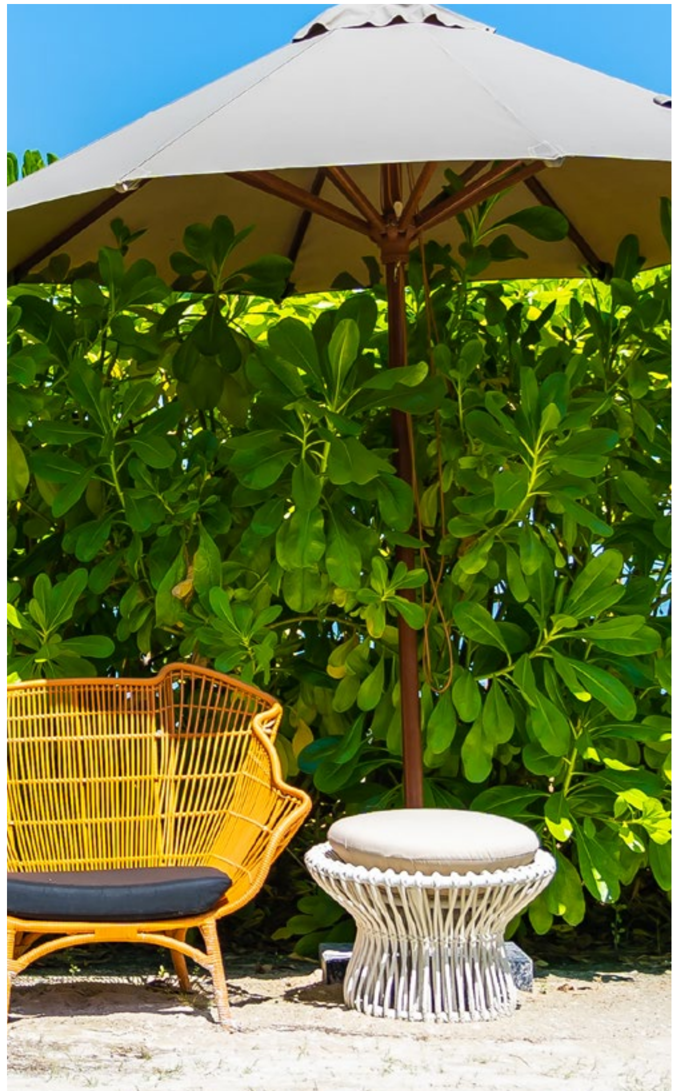
- **Site adaptation:** Take advantage of the site environment and surroundings such as vegetation and proximity to other buildings. Identify natural features such as slopes and drainage patterns to manage rainwater runoff and prevent flooding.

- **Building orientation:** As much as possible, buildings in a hot and humid climate should be oriented along the east-west axis (along the main path of the sun), thereby only exposing smaller façades to strong solar radiation at low angles. **This is illustrated in Figure 3.**

Figure 3 *Optimal Building Orientation*



Source: *The Programme for Energy Efficiency in Buildings (PEEB), GIZ, 2019*



- **Openings:** Building designs should plan for most doors and windows to face north or south to minimise sun exposure. Window positioning should optimise the use of daylight while avoiding excessive solar heat gains in living spaces. Include overhangs and other shading devices as needed to control heat gains.

- **Wind direction:** Consider aligning the building to take advantage of prevailing winds for natural ventilation.

- **Existing vegetation:** Consider retaining existing trees for shade and other vegetation to increase foundation stability.

2.3 Passive Cooling Strategies

Passive cooling leverages architectural design and properly selected construction materials to minimise temperature changes inside buildings, thus reducing the need for mechanical cooling and ventilation systems.[4] Passive cooling techniques often involve design strategies that maximise natural conduction, convection, and radiation to remove heat, facilitate ventilation, and help to maintain comfortable indoor temperatures. **Examples include:**

- **Natural ventilation:** Roof vents, ridge vents, and turbines (**see Figure 4 below**) are common ventilation methods for homes. Good air circulation and ventilation help to manage condensation and reduce the need for air conditioning. The selected natural ventilation devices should be hurricane proof. An example of such a device is a hurricane-rated ridge vent paired with securely attached soffit vents as they offer the best wind resistance and prevent water intrusion during strong storms.

Figure 4 *Examples of Roof Vent Types*[5]

- **Insulation:** Vegetation or green roofs can insulate the building and reduce heat absorption. Similarly, light-coloured or reflective roof surfaces reflect heat away from attics and upper floors, reducing the need for artificial cooling.

- **Shading:** Hurricane-rated roof overhangs, awnings, and screens or shade-providing vegetation help block direct sunlight. Proper shading, especially on the east and west sides, helps lower indoor temperatures and glare.

2.4 Building Envelope

Building envelopes include the exterior walls, roof, foundations, windows and doors. An energy-efficient building envelope is one that is designed and built to minimise heat transfer between indoor and outdoor air, notably through optimal roof and exterior wall insulation, building airtightness, and high-performance windows and doors.

2.4.1 Envelope Airtightness

Envelope airtightness is the resistance to unintentional inward or outward air leakage (infiltration or exfiltration) through the building envelope. Airtightness is often measured as air change rate or air changes per hour at a pressure difference of 50 psi between indoor and outdoor air (ACH50). Air leakage through the envelope can lead to considerable heat transfers between indoor and outdoor air; an airtight envelope can therefore significantly reduce the need for air conditioning. To achieve high levels of airtightness, it is recommended to **follow these general guidelines:**

- Install a continuous air barrier over the entire building envelope,

- Properly seal breaks or joints in the air barrier, including junctions between the roof, exterior walls, and foundations, as well as gaps around windows, doors, and penetrations through walls and ceilings.

2.4.2 Roof Insulation

Insulation is a key component of energy-efficient buildings. Properly insulating roofs and attics with quality insulation materials reduces the amount of heat penetrating into the living spaces below, thus reducing the need for cooling. In hot climates, builders should also consider the use of attic or roof radiant barriers. Several types of

[4] *In general, passive cooling techniques alone cannot match the efficiency of vapour compression technologies in coping with extreme climates or particularly intense heat waves.*
[5] *Source: https://structuretech.com/roof-vents-problems-and-solutions-2/ (2021).*

insulation materials and installation methods are available. These include spray foam, rigid foam boards, cellulose, fibreglass and mineral wool that can be blown or layered into cavities.

Although there is currently no mandatory insulation requirement for new buildings in the Cayman Islands, an insulation R-value[6] of R-30 is recommended for ceiling (roof) assemblies in accordance with **the CREEBC requirement outlined in Table 1 below**. A roof assembly with R-30 insulation minimises conductive heat transfer by 97% compared to an assembly with no insulation.

Opaque Elements	Maximum Assembly U-Factor [imperial units (SI units)]	Minimum Insulation R-value [imperial units (SI units)]
Ceiling	**U-0.032 Btu/h·ft²·°F** (U-0.184 W/m²·K)	**R-30 c.i. h·ft²·°F/Btu** (R-5.3 m²·K/W)
Walls, Above Grade		
Mass[8]	**U-0.151 Btu/h·ft²·°F** (U-0.857 W/m²·K)	**R-5.7 c.i. h·ft²·°F/Btu** (R-1.0 m²·K/W)
Wood-Framed	U-0.084 Btu/h·ft²·°F (U-0.477 W/m²·K)	R-13 c.i. h·ft²·°F/Btu (R-2.3 m²·K/W)

c.i. = insulating material that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior or is integral to any opaque surface of the building envelope.

Table 1 *CREEBC Insulation Requirements by Component[7]*

A variety of materials can be used to reach an insulation level of R-30. Below are descriptions of the most relevant insulation materials, and Table 2 further below provides an indication of required thicknesses to achieve R-30 with each material.

[6] *See Glossary for more details on R-values.*

[7] *Based on: CREEBC 18th Edition (2018), Sections R402.1.2 and R402.2.*

[8] *The CREEBC defines mass walls as: 1) above-ground walls of concrete block, concrete, insulated concrete form, masonry cavity, brick but not brick veneer, adobe, compressed earth block, rammed earth, solid timber or solid logs,X or 2) any wall having a heat capacity greater than or equal to 123 kJ/m² × K (6 Btu/ft² × °F).*

Main Types of Insulation Materials

- **Spray Foam Insulation:** There are two types of spray foam insulation, closed-cell and open-cell. Each offers different benefits when it comes to cost and performance. Understanding the installation applications and differences between open and closed-cell spray foam insulation is necessary to ensure which is most appropriate for each application. Below are the key characteristics for each type along with the required thicknesses to achieve R-30 and recommended applications.
  - **Open-Cell Spray Foam:** Open-cell spray foam is made from polyurethane and expands after spraying, making it easy to use in hard-to-reach spaces. The open-cell structure is less dense and allows water and moisture movement, which helps prevent water from getting trapped and wooden roof structures getting damaged in case of a roof leak. Open-cell spray foam requires a thicker layer than closed-cell to achieve the same level of insulation, for instance a 9" layer of insulation must be applied to attain a thermal resistance of R-30.
    - **Applications:** Open-cell spray foam is generally recommended as the preferable option over closed-cell foam for new construction applications and especially for wooden roof structures. During the design phase, it is important to include large enough cavities in the roof for up to 9" of open-cell spray foam (R-30) as well as adequate water and vapour barriers.
  - **Closed-Cell Spray Foam:** Also made from polyurethane, this foam spray forms a closed-cell structure when sprayed, preventing water from penetrating the foam layer. Closed-cell spray foam must be applied to a depth or thickness of 4.25" to 6" to attain the resistance to conduction of R-30 insulation. Closed-cell spray foam uses a chemical blowing agent that might leave a residual odour for a short period. These blowing agents tend to have a higher global warming potential (GWP) compared to those used for open-cell spray foam (typically water), although more recently developed closed-cell blowing agents have helped to reduce this gap.
    - **Applications:** Closed-cell spray foam is better option for concrete roofs because they are less vulnerable to water damage due to roof leaks.
- **Rigid Foam Board:** Foam boards are rigid sheets of polystyrene or polyurethane; they are more commonly used in commercial buildings. They provide insulation in cases where continuous insulation is required to meet a code and are typically used in combination with external cladding systems. A thickness of 7.5" to 8.33" of rigid foam is required to achieve R-30, depending on the specific material. Foam boards are not recommended for roof insulation in residential situations.
- **Blow-In Insulation:** Either fibreglass or cellulose pieces are blown in using a pneumatic sprayer. This is another excellent method to insulate hard-to-reach spaces such as those in attics. Blown-in insulation can be used as a stand-alone strategy or in addition to existing insulation to increase the R-value (in ceilings for example). To reach an R-30 rating, a layer of 12.4" of blown-in fibreglass or 9.3" of cellulose is needed. In addition, cellulose insulation is seen as a more sustainable option because recycled paper fibre is used.
- **Mineral Wool:** Stone mineral wool is made of rock or furnace slag. It is a porous material that traps air, is fire-resistant and water-repellent, and does not contribute to the formation of mildew, fungi, or mould. It also has acoustic barrier properties that makes it an ideal material for insulation. It can be used in a variety of construction applications and climate zones.
  - A thickness of 10.9" of blown-in stone wool is needed to attain R-30.
  - A thickness of 8.87" of stone wool batt is needed to attain R-30.
- **Fibreglass Insulation:** Fibreglass insulation is made from molten glass that is spun or blown into extremely fine fibers. It is one of the most commonly used and is available in different forms of insulation: blanket (batts and rolls), loose-fill, and is also available as rigid boards. It can be an economical option for homeowners looking to save.

Insulation Material Type	R-30 Insulation Thickness
Open-Cell Spray Foam	9 in.
Closed-Cell Spray Foam	4.25 to 6 in.
Fibreglass batt	8.25 in.
Foam Board Insulation (Rigid Foam)	7.5 to 8.33 in.
Blown-in Cellulose	9.3 in.
Stone Mineral Wool – Blown-in	10.9 in.
Stone Mineral Wool Batt	8.87 in.

Table 2 *Thicknesses Required to Achieve R-30 for Different Insulation Materials* [9]

[9] *Adapted from: Airflow Academy (2023). "R30 Insulation Thickness for Different Materials" (list). https://airflowacademy.com/r30-insulation-thickness/ (last accessed 27 January 2025).*

The selection and application of insulation material require proper care and assessment. For instance, the introduction of insulation material may make a home more air-tight and necessitate some form of ventilation to maintain proper indoor air quality. Before introducing or adding additional insulation to a home, the home should be surveyed to check for existing or potential condensation. This verification should be carried out by a qualified professional.

Insulation should be installed in accordance with the product installation guide, home evaluation report recommendations, and building codes as applicable. Failure to install insulation correctly could trap moisture, affect the overall performance of the insulation material, and lead to increased energy consumption.

The R-value is a measurement that only takes conduction into account and not heat loss through convection or radiation. Adding foil-faced kraft paper may reflect the energy back to its origin and stabilise the temperature inside, leading to an increased R-value of the insulation. To optimise energy efficiency, builders should also consider the interactions between the insulation and other building components. This approach is known as whole-house systems design. Before insulation is applied to a new home, it is also important to consider air sealing and moisture control. In well-insulated homes, air leakage and moisture can be challenging to address after the home is built.

2.4.3 Exterior Wall Insulation

Insulating exterior walls is also key to minimize heat transfer through the envelope, thereby further reducing the need for air conditioning. The main types of wall insulation available in the Cayman Islands include open-cell or closed-cell spray foam, fibreglass and mineral wool batts, and rigid foam boards (including those used for insulated concrete forms [ICFs]). Table 3 below provides a sample of combinations of wall structures and insulation materials.

Wall/Material Type	Description	R-Value
Insulated Concrete Form (ICF)	ICF walls comprise two layers of rigid foam insulation with a concrete core.	**R-22 to R-30**
Wood Framing with Insulation	Wood framing requires additional insulation (e.g. spray foam or mineral wool) for thermal resistance.	**R-13 to R-21**
Masonry Cavity Wall	Masonry walls require added insulation in the cavity between the interior and exterior layers.	**R-13 to R-20**
Concrete Block	Concrete blocks are not great insulators, but they offer mass that can help with thermal mass effect.	**R-1.5 to R-2**
Brick	Solid brick walls offer very little insulation but are highly durable and can provide thermal mass.	**R-0.2 to R-0.5 per inch**
Autoclaved Aerated Concrete (AAC)	AAC blocks are lightweight and have some insulating properties but require external insulation to improve thermal resistance.	**R-1.25 to R-1.5 per inch**

Table 3 *Combinations of Wall Structure Types and Insulation Materials*

Source: US Department of Energy

While there is currently no mandatory insulation requirement for new buildings in the Cayman Islands, it is recommended that CREEBC requirements be applied for exterior wall insulation (**see Table 1 in Subsection 2.4.2**).

2.4.4 High Performance Fenestration

High-performance fenestration (sometimes called glazing) refers to windows, doors, and other openings in a building to maximise natural light intake while minimising heat transfer (heat gain from the outside). Considering factors like glass type, frame material, and orientation contributes to overall home energy efficiency. Key aspects of energy high-performance fenestration include:

- **High-performance glazing:** High-performance glazing window systems (glazing refers to the glass) reduce both solar heat gain and ultraviolet (UV) radiation (see Table 4 below). In addition, the use of laminated or tempered glass is beneficial for safety and durability in hurricane-prone areas.
- **Well-insulated frames:** Various materials are available, including fibre-reinforced composite frames, which are more energy efficient than traditional wood or vinyl frames. However, properly sealed wood frames can also be very energy efficient.
- **Low-emissivity (low-e) coatings:** Low-e coatings are used to reduce heat transfer through windows by reflecting a portion of infrared heat and ultraviolet light, while still allowing natural light to pass through. Solar tinting is another option to minimise heat transfer, but it also reduces the amount of daylight through the windows[10].

Window Characteristic	Recommended Value*
U-Value	**Fixed windows:** maximum 2.84 W/m^2·K (0.5 Btu/h·ft^2·°F) **Operable windows:** maximum 3.69 W/m^2·K (0.65 Btu/h·ft^2·°F)
Solar Heat Gain Coefficient (SHGC)	0.25 to 0.4, depending on window orientation and sunlight exposure
Coating Type	Soft coat low-e coating is generally more energy-efficient.

** U-values and SHGC values based on CREEBC (2018) Table R401.2.1 (values for vertical fenestration).*

Table 4 *Recommended Window Characteristics*

In addition to energy efficiency, there are other specific requirements for windows, doors, and skylights in terms of impact resistance due to the Cayman Islands' geographic location. Adding hurricane shutters or impact-resistant windows protects against storms while also improving insulation and reducing heat gain and air infiltration. The CREEBC allows several pathways for builders to meet these requirements, including the installation of shutters.

2.4.5 High-Albedo Exterior Finishes

Raising the albedo (solar reflectance) of exterior walls and roofs is typically achieved by choosing light-coloured or reflective exterior finishes and materials, which makes it a cost-effective strategy to significantly increase the energy efficiency of the building envelope. High-albedo finishes reflect more sunlight and absorb less heat, thereby reducing daytime heat flow into building occupied spaces. This decreases the need for air conditioning and increases occupant comfort.

2.5 Ventilation and Air-Conditioning Equipment and Systems

2.5.1 Ceiling Fans

For a climate such as that of the Cayman Islands, ceiling fans offer several energy efficiency benefits by helping to reduce reliance on air conditioning while maintaining or improving comfort in indoor spaces. Reasons builders should consider the use of ceiling fans include:

- **Enhanced Comfort:** Ceiling fans help circulate air and create a cooling effect, making the environment feel cooler without lowering the temperature. This reduces the need for air conditioning.
- **Energy Savings:** By using ceiling fans to improve comfort, occupants can increase their thermostat setpoint (typically by 2-4°F), resulting in reduced AC use.
- **Better Air Distribution:** In rooms with poor air circulation, hot spots (direct sunlight) and humidity can make a room uncomfortable, even if it is air-conditioned. A ceiling fan ensures that room air (and cooling) is evenly distributed, improving comfort without overcooling the space. Ceiling fans are especially beneficial in large spaces like living rooms, open-plan areas, and large bedrooms.
- **Cross Ventilation:** Ceiling fans enhance the effect of cross-ventilation, promoting airflow through open windows and doors. Fans can be used to avoid the need for AC in certain conditions.

Builders considering the use of ceiling fans should specify fans that meet the requirements of the US Environmental Protection Agency (EPA) ENERGY STAR programme, which are up to 60% more energy efficient than conventional fans without the ENERGY STAR label[11].

[11] *See https://www.energystar.gov/products/ceiling_fans for more details.*

[10] *While low-e coatings reduce solar heat gain, they also reduce visible light transmission (VLT). If maximising daylight is important, choose low-e coatings with a slightly higher VLT and a low SHGC as these still reduce energy costs.*

2.5.2 Air Conditioning

Air-Conditioner Energy Efficiency Ratings

While the SEER is currently the most widely used energy efficiency rating in the Cayman Islands, it is recommended that the EER (energy efficiency rating) be used for air-conditioning selection and sizing given that it is better suited for hot and humid climates. **Here are the key differences between both ratings:**

- The SEER measures cooling efficiency over a range of outdoor temperatures, typically from 65°F to 95°F (with an average of 77°F), and therefore provides a broader measure of efficiency across an average cooling season.

- The EER measures cooling efficiency at a constant outdoor temperature (typically 95°F) and is ideal for evaluating efficiency under peak heat load conditions. The EER is particularly useful at providing a more accurate estimate of real-world performance for regions where air conditioners operate almost continuously due to consistently high temperatures, such as in the Cayman Islands.

- The SEER2 is a newer rating system that was introduced by the US Department of Energy in 2023. This rating relies on an updated testing method which more accurately represents conditions seen in the field, namely by better incorporating the influence of ductwork and external static pressure on the overall efficiency of HVAC systems. However, this rating system is relatively new and may not yet be utilised by all manufacturers. It is recommended that building professionals and AC installers only compare AC units with similar ratings (i.e. SEER with SEER, and SEER2 with SEER2).

For these reasons, building designers as well as air-conditioning and ventilation installers and suppliers should consider the EER when assessing the energy efficiency of air-conditioning units for a project. That said, the EER should be used in parallel with the SEER as the latter is more commonly used and understood by the general public.

Specifications and Sizing of Air-Conditioning Systems

Properly sizing an air-conditioning system is crucial, especially in hot and humid climates, to ensure both comfort and efficiency. A correctly sized unit runs at steady, appropriate intervals to remove excess moisture from the air and maintain a pleasant indoor environment without leaving it feeling clammy. This sustained operation also reduces the strain on the equipment and prolongs its lifespan. Ultimately, a properly sized air conditioner provides more consistent cooling, better humidity control, and greater energy savings, enhancing the overall comfort and value of the home.

In contrast, poorly sized air-conditioning systems can have significant negative impacts. **Here are the potential consequences of installing oversized or undersized AC systems:**

- An oversized air-conditioning system may cool your home too quickly, causing the system to cycle on and off more frequently. **This is termed "short cycling" and can lead to:**

  - **Poor Humidity Control:** By running for shorter periods, the system removes less moisture from the air, leaving the indoor environment feeling clammy and uncomfortable.

  - **Lower Energy Efficiency:** Frequent starts and stops waste energy and can drive up utility bills, negating any intended benefits of having a powerful system.

  - **Excessive Wear and Tear:** Rapid cycling puts added stress on components, shortening the lifespan of the equipment and increasing the likelihood of costly repairs.

  - **Uneven Temperatures:** Rooms may cool too quickly or inconsistently, making it more difficult to maintain a comfortable, uniform indoor environment throughout the home.

- An undersized air-conditioning system may struggle to reach the desired indoor temperature, causing it to run continuously, **and constant operation can lead to:**

  - **Inadequate Cooling:** The system cannot sufficiently lower room temperature, leaving occupants feeling warm and uncomfortable even on cooler days.

  - **Poor Humidity Control:** Despite running nonstop, it may fail to remove enough moisture, resulting in a clammy, muggy indoor environment.

  - **Increased Energy Use:** Running constantly to compensate for its limitations, the system consumes more electricity, driving up utility bills.

  - **Premature Wear and Tear:** The extra strain from nonstop operation puts added stress on components, potentially shortening the unit lifespan and increasing maintenance costs.

In general, it is recommended that builders adhere to CREEBC recommendations when selecting and sizing ventilation and air-conditioning equipment and systems. **The installed equipment should be properly sized for the intended location, with careful consideration for all factors impacting the cooling load, such as the following:**

01 Home size and layout, including total conditioned area and ceiling height.

02 External heat gains that are affected by building envelope performance (e.g. insulation levels, type of windows, etc.), natural and constructed shading, house orientation, and sunlight exposure.

03 Internal heat gains that are affected by the number of occupants, heat-generating appliances, electronics, and lighting.

The efficiency of central systems is also affected by the length and type of ducting. As such, ducting runs should be optimised to be as short as possible, the number of corners in the runs should be minimised, and round and rigid ducts should be prioritised over square or flexible ducts to enhance airflow and reduce energy losses.

The cooling and heating equipment section of the CREEBC states that:

01 Heating and cooling equipment shall be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methodologies, based on building loads for the directional orientation of the building.

02 The manufacturer and model number of the outdoor and indoor units (if split system) shall be submitted along with the sensible and total cooling capacities at the design conditions described in Section R302.1. This Code does not allow designer safety factors, provisions for future expansion, or other factors that affect equipment sizing.

03 System sizing calculations shall not include loads created by local intermittent mechanical ventilation such as standard kitchen and bathroom exhaust systems. New or replacement heating and cooling equipment shall have an efficiency rating equal to or greater than the minimum required by applicable laws in CARICOM countries for the geographic location where the equipment is installed. [12]

Recommended Air-Conditioning Efficiency Requirements

For new residential buildings, central or mini-split air-conditioning systems should have a SEER value of 20 (approximately equivalent to 14.4 EER) to achieve significant energy savings. At a minimum, a SEER of 16 should be selected (12.8 EER). Table 5 below provides a sample of equivalent SEER, SEER2 and EER values. These values are approximate equivalences aimed at providing guidance. Actual conversions from SEER to EER vary based on climate conditions.

SEER (SEER2)	EER
13 (12.4)	**11.2**
16 (15.3)	**12.8**
18 (17.2)	**13.7**
20 (19.1)	**14.4**
22 (21.1)	**15.0**

Table 5 *Typical SEER, SEER2 and EER Values*

Another consideration in the selection of AC units is the refrigerants that they use. Internationally, countries have agreed to phase out the use of hydrofluorocarbon (HFC) compounds due to their high global warming potential (GWP). Builders should note that many modern AC systems now come with refrigerants that are more environmentally friendly. Many countries, including those in North America, have agreed to phase out the use of HFCs, which will affect products available to builders in the Cayman Islands.

[12] *This minimum requirement has not yet been set for the Cayman Islands.*

2.5.3 Smart or Programmable Thermostats

New residential buildings should include smart thermostats or programmable AC controls to allow occupants to schedule air-conditioning operation. This allows occupants to adjust setpoint temperatures throughout the day and turn off units at set times, helping to optimise energy consumption. Smart thermostats or programmable controls should include the capability to set back or temporarily operate the system to maintain room temperatures up to 85 °F or higher[13].

Air conditioning set point temperatures have very significant impacts on energy consumption, and it is important that the AC contractor or supplier educate building occupants on how to properly select and adjust set points. Below are the general guidelines that should be followed when selecting and scheduling setpoints for AC systems. However, recommended cooling set point temperatures may vary depending on building occupancy and schedules (e.g. how long residents leave their homes during the day), occupant tolerance to heat and temperature changes, indoor and outdoor humidity levels, types and efficiency of AC systems, and the ability of each building to passively cool down.

When residents are home	When residents leave their home for a few hours or less	When residents leave their home for extended periods of time (e.g. all day)
The cooling temperature should be set at a minimum of 78 °F, or at the highest comfortable temperature. The setpoint should be raised by 3-4 degrees during nighttime.	The cooling temperature should be set at 85 °F. Doing this can extend the lifespan of AC systems and reduce the risk of high humidity levels and mould.	The AC unit should be turned off.

Figure 5 *General Guidelines for Setting AC Temperature Setpoints – New buildings*

The thermostat or controller should initially be programmed by the installer with a cooling temperature setpoint no lower than 78 °F. The installer should provide building occupants with clear instructions on how to operate their smart thermostats or programmable controllers, ideally in the form of a short on-site explanation of thermostat or control functionalities along with written instructions.

2.6 Appliances and Lighting

Where available, builders should equip new homes with ENERGY STAR labelled appliances (only qualified products can carry the label – see below), including refrigerators (maximum consumption of 637 kWh per year depending on the type), dishwashers, washers, dryers, and dehumidifiers. On average, these appliances use about 10-30% less energy than non-ENERGY STAR-qualified appliances (in the US, they usually substantially exceed minimum federal standards). They can also serve as a selling point in a competitive market. It should be noted that there is no scale or rating on this label. See Appendix I for details on the labels in use.

Similarly, no less than 90% of permanently installed lighting fixtures should be high-efficacy lamps. Where screw-in type bulbs are used, they should be equipped with ENERGY STAR LED lamps. LED lamps use up to 90% less electricity than traditional incandescent bulbs, last longer, create less heat, can be turned on instantly, and can easily be paired with dimmers to further improve lighting energy efficiency. The minimum efficacy recommended for general service residential lighting is 90 lumens/watt[14].

2.7 Water Efficiency Measures

Water efficiency measures include those aimed at reducing the amount of potable water used in buildings.

2.7.1 Water Conservation

New buildings should include efficient plumbing fixtures such as low-flow faucets and showerheads as well as faucet aerators. These

[13] *Based on CREEBC (R403.1.1).*

[14] *The Collaborative Labeling and Appliance Standards Program (CLASP) recommends the adoption of technology-neutral national lighting minimum energy performance standards (MEPS) of 90 lumens/watt or greater to phase out CFLs and incandescent lamps (https://www.clasp.ngo/worlds-best-meps-2023/).*

measures help reduce water usage and costs, which in turn reduce the amount of energy required to produce domestic hot water. Reduced water usage also has benefits at the electricity grid level given that water desalination, distribution (pumping), and treatment plants are among the largest electricity consumers in the Cayman Islands.

Water cisterns for rainwater collection should also be considered for new buildings to reduce demand for desalinated and treated water. They are becoming more common in new builds as a response to environmental concerns. At a minimum, builders should use the specifications for water fixtures shown in the following table.

Plumbing Fixture or Fixture Fitting	Maximum Flow Rate or Quantity
Lavatory Faucet	2.2 gpm at 60 psi
Shower Head	2.5 gpm at 80 psi
Sink Faucet	2.2 gpm at 60 psi
Water Closet	1.6 gallons per flushing cycle

For SI: 1 gallon per minute = 3.785 L/m, 1 pound per square inch = 6.895 kPa.
a. A handheld shower spray shall be considered to be a shower head.
b. Reporting tolerances shall be determined from referenced standards.

Table 6 *Recommended Low-Flow Plumbing Fixtures Water Consumption*[15]

Alternatively, builders can look for the WaterSense label, which is developed by the US EPA to recognize products and programs that save water without sacrificing performance or quality. Typically, WaterSense products are 20% more water-efficient than average products in the same category. **Additional information about the label is included in Appendix I.**

2.7.2 Domestic Water Heating

Several options exist when selecting energy-efficient domestic water heating systems, and the most appropriate system should be selected depending on building constraints, available systems and occupant needs.

Solar Water Heaters

In tropical climates, one recommended option is solar water heating systems. This type of system uses solar collectors to capture and convert sunlight into heat, providing a reliable and eco-friendly source of hot water. These systems are highly efficient and can be sustainable and cost-effective options for tropical regions. Compared to colder climates, people in the tropics may require less hot water due to naturally warm ambient temperatures, potentially allowing for smaller water heating systems. **Builders should take into account these design considerations when specifying and installing solar hot water heating systems:**

- **Collector Orientation:** Solar collectors should be positioned optimally to maximise sun exposure. A rule of thumb is 20 square feet of collector area for the first two persons in the household and eight square feet per additional person[16].
- **Storage Tank Size:** The tank size needs to be calculated based on water usage patterns and available site-specific solar radiation. A two gallon of storage tank capacity is recommended per square foot of collector area.
- **Thermosyphon Design:** Utilising a thermosyphon system can simplify design and reduce energy consumption.

Instantaneous Water Heaters

Another recommended energy-efficient choice for hot water heating (where a solar water heating system is not feasible) is an electric tankless or instantaneous water heating system that produces hot water on demand. Unlike traditional storage heaters, tankless models heat water directly as it passes through the unit, preventing storage problems and heat loss.

This makes tankless water heaters suitable for warm climates since they allow full control of which water points receive hot water. The initial cost of a tankless water heater is greater than that of a conventional storage water heater, but tankless water heaters typically last longer and have lower operating and energy costs.

Heat Pump Water Heaters

Heat Pump Water Heaters (HPWH) operate like a reverse air conditioner, using electricity to extract heat from the surrounding air and transfer it to the water, rather than generating heat directly. This makes them two to three times more energy-efficient than traditional electric resistance water heaters, consuming up to 70% less electricity. Additionally, HPWHs are well suited to hot climates given that high ambient temperatures improve their efficiency. And because they extract heat from the air, they can help cool the surrounding area, which should be considered when choosing an installation location. And while HPWHs come with a higher upfront cost, they can significantly reduce energy costs for domestic hot water (DHW), leading to reasonable payback periods. These water heaters require proper installation[17], and they are most effective in well-ventilated areas with adequate space and airflow, such as garages, basements, or utility rooms.

[15] *Adapted from: 2018 International Residential Code (IRC), Section P2903, Table P2903.2.*

[16] *US Department of Energy. Siting Your Solar Water Heating System. Available at https://www.energy.gov/energysaver/siting-your-solar-water-heating-system.*

[17] *Energy Star. "Heat Pump Water Heater Design Considerations". Available at https://www.energystar.gov/partner-resources/residential_new/educational_resources/sup_program_guidance/heat_pump_water_heater_guide/design_considerations.*

03 Guidelines for Existing Buildings

This section presents energy efficiency guidelines for existing buildings and is targeted at homeowners as well as building professionals and suppliers who support homeowners wishing to improve the energy efficiency of their homes. The content of these guidelines is based on best practices for the hot and humid climate of the Cayman Islands as well as on discussions with representatives of various governmental entities, building designers and contractors, suppliers, homeowners, utilities, and other stakeholders.

The guidelines are focused on cost-effective (e.g. has short payback periods) retrofit measures to boost energy efficiency and improve occupant comfort in residential buildings.

3.1 Air Conditioning and Ventilation

Below are the key items to consider when replacing or upgrading existing residential AC systems, or when adding an AC system in an existing building.

- **Choose inverter air conditioners:** Inverter air conditioners continuously regulate compressor speed to maintain the desired temperature rather than cycling on and off like traditional units. This results in consistent cooling, reduced energy consumption (up to 30-50% in savings), quieter operation, and increased durability. Such systems are particularly effective in hot and humid climates where steady operation is key to managing high cooling loads.

- **Opt for inverter air conditioners with high energy efficiency ratings (see Subsection 2.5.2 for details on ratings and their meaning):**

  - Outdated or inefficient air conditioning units should be replaced with models that have a SEER value of 20 (approximately equivalent to 14.4 EER[18]) to achieve significant energy savings. At a minimum, a SEER of 16 should be selected (approximately 12.8 EER). Many modern systems also come with better refrigerants that further improve energy efficiency and are more environmentally friendly. **Table 7** below provides a sample of equivalent SEER, SEER2[19] and EER values (these values are approximate equivalences aimed at providing guidance; actual conversions from SEER to EER vary based on climate conditions).

SEER (SEER2)	EER[18]
13 (12.4)	**11.2**
16 (15.3)	**12.8**
18 (17.2)	**13.7**
20 (19.1)	**14.4**
22 (21.1)	**15.0**

Table 7 *Typical SEER and EER Values*

- Install smart thermostats and programmable AC controls to allow occupants to schedule air-conditioning operations (adjust setpoint temperatures throughout the day, turn off unit, etc.) and optimise energy consumption. Smart thermostat or programmable controls should include the capability to set back or temporarily operate the system to maintain zone temperatures up to 85 °F or higher. The thermostat or controller should initially be programmed by the manufacturer with a cooling temperature setpoint no lower than 78 °F.

- Ceiling fans and table/standing fans can be more energy-efficient alternatives to air conditioning, or they can serve to supplement AC systems to provide further cooling. They also help circulate air, ensuring optimal distribution of the cool air produced by the air conditioner, keeping the room cooler without excessive energy use.

Where ceilings fans can be added, it is recommended that those meeting the requirements of the US EPA ENERGY STAR programmes be used as they are up to 60% more energy efficient than regular ceiling fans. Similarly, if table fans are added to help with circulation and ventilation, these should also meet the ENERGY STAR requirements.

[18] *The EER is a measurement of AC efficiency at an outside temperature of 95 °F outside temperature and an inside (return air) temperature of 80 °F and 50% relative humidity, while the SEER measures efficiency over an entire cooling season (over a range of temperatures). AC units should be compared based on a single rating (e.g. comparing EER to EER or SEER to SEER), and different ratings should not be compared to one another.*

[19] *The SEER2 rating is a newer version of the SEER and is increasingly more common for new AC units. See Subsection 2.5.2 for details.*

3.2 Building Envelopes

Consider the following measures to improve the energy efficiency of building envelopes.

01 **Improving roof and wall insulation:** Many existing buildings have insufficient wall or roof insulation; adding or upgrading insulation can reduce the need for air conditioning. Notably, roof insulation is a particularly cost-effective (short payback period) retrofit measure to improve energy efficiency in existing buildings. Per the CREEBC, the following insulation levels are recommended.

Opaque Elements	Maximum Assembly U-Factor [imperial units (SI units)]	Minimum Insulation R-value [imperial units (SI units)]
Ceiling	U-0.184 W/m²·K (U-0.032 Btu/h·ft²·°F)	R-30 c.i. h·ft²·°F/Btu (R-5.3 m²·K/W)
Walls, Above Grade		
Mass[20]	U-0.151 Btu/h·ft²·°F (U-0.857 W/m²·K)	R-5.7 c.i. h·ft²·°F/Btu (R-1.0 m²·K/W)
Wood-Framed	U-0.084 Btu/h·ft²·°F (U-0.477 W/m²·K)	R-13 c.i. h·ft²·°F/Btu (R-2.3 m²·K/W)

c.i. = insulating material that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior or is integral to any opaque surface of the building envelope.

Table 8 *Recommended Roof and Wall Insulation for Existing Buildings*

02 Retrofitting older roofs with reflective roofing materials that reflect sunlight and absorb less heat reduces the need for air conditioning.

03 High-albedo exterior finishes such as white or light-coloured roofing materials and exterior wall finishes decrease heat absorption, leading to lower indoor temperatures and reduced air conditioning needs. This passive cooling strategy is both cost-effective and easy to implement.

04 Hurricane-rated roof overhangs, awnings and screens or shade-providing vegetation help block direct sunlight. Proper shading, especially on the east and west sides, lowers indoor temperatures and glare.

05 **More energy-efficient windows:**

- When replacing old windows, opt for well-insulated frames (see Table 4 for recommended U-values) and low-emissivity (high-reflectivity) glass to reduce heat gain from the sun.
- As an alternative to replacing windows, some improvements can be made to existing windows to improve their energy efficiency in a cost-effective way, such as:
  - Reflective solar films can be applied to existing windows to reduce solar infiltration, which is a low-cost way to reduce both heat gains from windows and cooling needs.
  - Transparent window inserts can be mounted onto existing windows to provide an "additional pane" (e.g. single-pane windows become double-pane), which increases the overall thermal insulating properties of window assembly (lower U-value).
  - Alternatively, hurricane window shutters can be installed on existing or new windows, which can also serve to create shading in homes to reduce cooling needs.

3.3 Building Operation and Occupant Behaviour

Energy efficiency in building operation and occupant behaviour are critical components to reducing energy consumption in residential buildings. Professionals retrofitting residential buildings should ensure that homeowners know how their daily actions and maintenance routines can significantly impact energy use and utility costs. One of the most impactful ways to reduce energy consumption through building operation and occupant behaviour is properly selecting AC setpoints. Below are the general guidelines that should be followed when selecting and scheduling setpoints for AC systems. However, recommended cooling set point temperatures may vary depending on building occupancy and schedules (e.g. how long residents leave their homes during the day), occupant tolerance to heat and temperature changes, indoor and outdoor humidity levels, types and efficiency of AC systems, and the ability of each building to passively cool down.

[20] *The CREEBC defines mass walls as: 1) above-ground walls of concrete block, concrete, insulated concrete form, masonry cavity, brick but not brick veneer, adobe, compressed earth block, rammed earth, solid timber or solid logs, or 2) any wall having a heat capacity greater than or equal to 123 kJ/m² × K (6 Btu/ft² × °F).*

When residents are home	When residents leave their home for a few hours or less	When residents leave their home for extended periods of time (e.g. all day)
The cooling temperature should be set at a minimum of 78 °F, or at the highest comfortable temperature. The setpoint should be raised by 3-4 degrees during nighttime.	The cooling temperature should be set at 85 °F. Doing this can extend the lifespan of AC systems and reduce the risk of high humidity levels and mould.	The AC unit should be turned off.

Figure 6 *General Guidelines for Setting AC Temperature Setpoints – Existing buildings*

Other key ways to reduce energy consumption through building operation and occupant behaviour include:

01 Optimising air-conditioning use:

- Programmable thermostats should be promoted to align cooling with occupancy patterns to ensure energy is not wasted.
- Closing all windows and doors properly while air conditioning and ensuring they are well sealed.
- Closing blinds or drapes during the day in rooms exposed to direct sunlight.

02 Improving Lighting and Appliance Usage:

- Residents should be encouraged to fully turn off lights, appliances, and electronics when not in use to prevent unnecessary energy consumption. These items also generate heat when turned on, thereby increasing cooling needs. Some devices may remain in stand-by mode which still consumes electricity, it is therefore important to use the power button to fully turn off such devices.
- It is important to promote the use of high-efficiency LED lighting and energy-efficient appliances, such as those with the ENERGY STAR label, which can substantially reduce electricity bills.

03 Maintenance and Upkeep:

- **Building occupants should be encouraged to:**
  - Replace or clean air-conditioning and ventilation filters every one to three months to ensure systems operate efficiently and avoid unnecessary strain. Clogged filters increase energy consumption by 5-15%. Regular maintenance checks ensure systems operate optimally.
  - Seal doors and windows to prevent air leaks and ensure optimal thermal performance.
  - Regularly inspect ductwork to prevent significant energy losses due to leaks.
  - Ensure that refrigerators and freezers are properly sealed and repaired if needed.

04 Behavioural Adjustments:

- Building occupants should use natural ventilation and ceiling fans to reduce reliance on air conditioning, particularly during cooler parts of the day.
- Simple actions, such as closing blinds or curtains during peak sunlight hours, significantly reduce indoor heat gain.
- Installing overhangs, awnings, or louvers provides shade to windows, minimising direct solar exposure and reducing cooling loads. Strategic placement based on sun angles enhances effectiveness.

05 Public Education:

- Providing homeowners with real-world examples of energy savings achieved through specific actions can motivate behaviour changes and investments in additional energy efficiency measures.

3.4 Other Building Components

Appliances and Lighting

- **Energy-Efficient Appliances:** Replace outdated appliances with high-efficiency models such as ENERGY STAR-qualified refrigerators and washing machines.

- **Efficient Lighting:** Encourage the use of ENERGY STAR LED lighting in all residential buildings as it is significantly more energy efficient than incandescent or compact fluorescent lamps (CFLs). Refer to Appendix I for more information on current label systems.

Water Conservation Measures

- **Rainwater Harvesting Systems:** Retrofitting homes with rainwater collection systems reduces reliance on potable water for non-essential uses such as irrigation or toilet flushing.

- **Low-Flow Fixtures:** Install water-saving fixtures such as low-flow showerheads and faucet aerators. Provide educational materials or workshops on easy upgrades to these fixtures.

04 Other Opportunities

Discussions with stakeholders, reviews of audit data, and site visits indicated that there remain other measures that builders and developers can offer alongside energy efficiency to reduce energy costs and make homes more sustainable. The private sector is increasingly taking the lead in sustainable construction with developers and architects offering more eco-friendly options to cater to the growing demand for energy-efficient and environmentally conscious living spaces.

Given the increasing cost of energy and the renewable energy and GHG emissions reductions objectives established in the NEP, there is potential for the Cayman Islands to adopt more aggressive policies and incentives to encourage sustainable construction. This could include reducing import duties on energy-efficient materials and equipment or other types of publicly funded incentives to consumers (e.g. rebated building permit fees for energy-efficient homes, etc.), as well as building code revisions to incorporate more stringent energy efficiency standards and higher integration of renewable energy. These may also include sustainability measures and measures to achieve net-zero buildings, as discussed in the following subsection.

4.1 Solar Photovoltaic Systems

When possible, solar photovoltaic (PV) systems should be included in the design of new residential buildings or added to existing buildings (if structurally appropriate) as a way to reduce electricity costs for homeowners. The Cayman Islands Government is also promoting solar PV as a way for the Islands to reduce their overall greenhouse gas emissions. Thus, builders may want to consider providing a solar PV package for new homes or the option for homeowners. **In doing so, builders may want to consider the following factors:**

01 **Siting:** Not every building site is suitable for a solar installation. The first step in the design of a solar PV system is determining the suitability of the location, which includes shading (free from shading by nearby obstructions), orientation (optimal direction and angle), and area relative to system size (sufficient roof area for required modules).

02 **Mounting:** Solar modules are usually mounted on roofs. However, solar PV modules can be pole-mounted, ground-mounted, wall-mounted, or installed as part of a shade structure (e.g. garage or carport).

03 **Roof Types:** It is possible to install PV modules on all roof types. Typically, installation is simpler on roofs with composition shingles, whereas slate and tile roofs are more challenging. Building integrated PV (BIPV) modules can be integrated into the roof itself and should be considered for new construction.

04 **Grid Connection:** Most new PV systems are grid-connected residential systems without battery back-up, which is the least expensive configuration. Two interconnection programmes currently exist in the Cayman Islands for residential electricity customers[21]:

- A buy-all and sell-all programme, whereby all solar PV energy produced by the customer is purchased by the utility via monthly bill credits.
- A net-billing programme where customers avoid grid consumption charges where they self-consume solar PV energy. Under this programme, customers also receive bill credits for surplus electricity exported to the grid.

[21] *It should be noted that there are currently no interconnection programmes for distributed generation in either of Cayman Brac or Little Cayman. For more information on interconnection programmes available on Grand Cayman: https://www.cuc-cayman.com/renewable-energy/.*

05 **Components:** Pre-engineered PV systems come with all the required components for installation and may be available as a kit directly from dealers. A supplier can size and specify systems based on the site description and power requirements of the home or building. Key components of grid-connected PV systems include:

- Solar photovoltaic modules
- Grounding equipment
- Combiner box and surge protection
- Inverter
- Metres (system metre and kilowatt-hour metre)
- System disconnects

06 **Warranty:** It is important to verify the warranty periods of all system components including solar modules.

07 **Compliance with local requirements:** Persons installing solar PV systems on their premises should consult with their utility and relevant municipal agencies for any specific requirements.

Recommended steps for solar PV installation

Builders can follow the recommendations below in the design and installation of a solar PV system that maximises energy production, is cost-effective, and suits the environmental conditions of the Cayman Islands:

01 **Calculate potential energy consumption:** Start by estimating the daily kWh usage for the home.

02 **Calculate system size:** Use the Cayman Islands' solar insolation (~5 kWh/m^2/day).

03 **System Size (kW) =** Estimated Daily Energy Consumption (kWh) / (Average Daily Sun Hours × System Efficiency).

04 **Panel specifications:** Choose high-efficiency panels (15-22%) with appropriate wattages (300-450W).

05 **Inverter size:** The rule of thumb is to choose 10-20% larger than the system size.

06 **Compliance:** Review available utility interconnection programmes for any specific requirements.

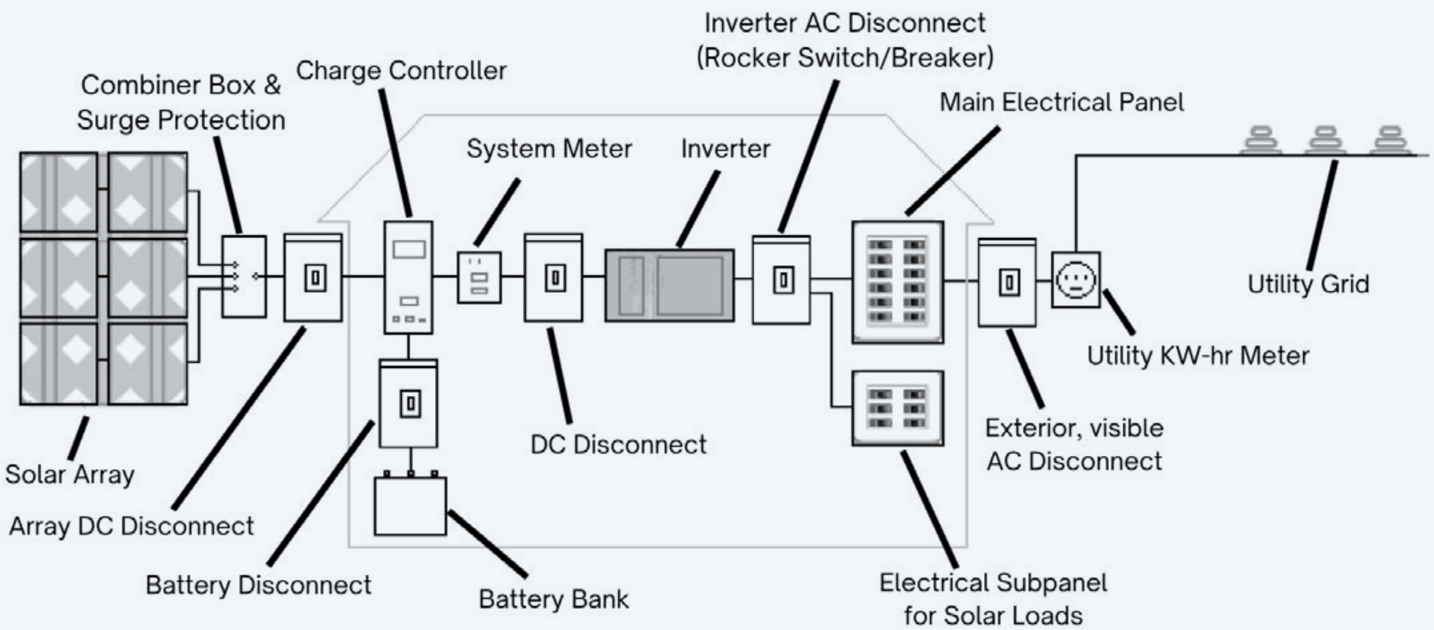


Figure 7 *General Example of a Grid-Connected Residential Solar PV System*[22]

[22] *Example provided for illustrative purposes only. For actual installation and interconnection scenarios currently available on Grand Cayman, refer to https://www.cuc-cayman.com/renewable-energy/. There are no interconnection programmes currently available in Cayman Brac or Little Cayman.*

Source for diagram: *Whitaker, C., Newmiller, J., Ropp, M., Norris, B. 2008. "Renewable Systems Interconnection Study: Distributed Photovoltaic Systems Design and Technology Requirements". https://www.energy.wsu.edu/documents/solarpvforbuildersoct2009.pdf).*

4.1.1 Battery Energy Storage Systems

A solar battery backup system stores excess electricity generated during the day, releasing that stored energy at night, during cloudy weather, or during power outages. These systems can add costs but provide extra security to homeowners in areas with low grid reliability. **Key selection points include:**

- **Battery types:** Common battery types include lithium-ion batteries, which are generally considered more efficient and long-lasting compared to older lead-acid batteries.
- **Sizing:** The size of the battery needed depends on estimated energy usage and desired backup time during a power outage.
- **Maintenance:** Batteries maintenance needs vary depending on the types and usage frequency.

Potential peak period benefits of battery energy storage

Many jurisdictions have also introduced behind-the-metre connections supplemented with energy storage batteries, allowing homeowners to maximise benefits from their PV systems by choosing when to use their solar-generated electricity. Including batteries also allows homeowners to feed stored energy into the grid at times when electricity demand is highest (e.g. between 4 pm and 8 pm on weekdays). Electricity supplied during peak periods is typically more valuable than if supplied during the day, and homeowners may receive higher credits on their utility bills. Increased credits for energy produced by customers and exported to the grid in the peak period are currently not available in the Cayman Islands, but they may become available in the future. Keep informed of changes to utility interconnection programme regulations.

4.1.2 Integrated Electric Vehicle Charging

As electric vehicles (EV) become more popular, builders will need to provide new homes or buildings with EV charging capabilities. The Cayman Islands' energy and climate policies also encourage the adoption of distributed energy resources, which can be achieved with a vehicle-to-load (V2L) feature that provides resiliency benefits or acts as a mobile power source.

In the coming years, builders should expect to see newer technology that will also allow for vehicle-to-grid (V2G) charging. V2G is a form of bidirectional charging that allows electric vehicles to accept and send electricity to the grid. V2G technology reduces stress on the electric grid during peak demand hours and increases the value of EV and home solar investments. In addition to V2G, smart electric vehicle supply equipment (EVSE) will also be available, which can be programmed based on rates structures (e.g. on-peak and off-peak charging) or directly interact with grid operator instructions in demand response programmes

4.2 Pool Pumps

A key component of many swimming pools is the electric recirculation pump. Pool owners are typically not aware of how much energy their pool pumps use or that energy-efficient alternatives exist.

All in-ground pools and the majority of above-ground pools have at least one pump, and many pools have multiple pumps. Pool pump speeds vary based on pool operation. Pool filtration – which is the typical pump operation – only requires half the flow rate typical of running a pool cleaner. Conventional pool pumps only have one speed and are set to run at the speed required for pool cleaning, thus using more energy by running faster than necessary[23]. The energy saved can be considerable: Reducing pump speed by one-half allows the pump to use just one-eighth as much energy. Multi-speed pumps run quieter, last longer, and can extend the life of the filtering systems. **Furthermore:**

- Energy-efficient in-ground pool pumps use 18% less energy than standard pool pumps.
- Energy-efficient above-ground pool pumps use 11% less energy than standard pool pumps.

The US EPA has an ENERGY STAR certified pool pumps programme that builders can use to select pumps or consult for further information.

[23] https://www.energystar.gov/sites/default/files/asset/document/ES_PoolPumps_FactSheet_2022.pdf

4.3 Sustainable Construction Materials and Practices

In addition to energy efficiency, building designers and contractors could reduce the environmental impact (carbon footprint) of residential construction projects by considering the use of sustainable construction materials and practices where appropriate:

- **Sustainable materials:** Lower the carbon footprints and environmental impacts of buildings by opting for recycled steel, plastic, and concrete (reducing virgin resource extraction) as well as low embodied carbon materials (e.g. wood, cellulose insulation, hempcrete, etc.). Consider environmentally friendly certifications and labelling such as the Forest Stewardship Council (FSC) certified timber or SMaRT[24]-certified sustainable building materials[25].
- **Locally sourced materials:** When possible, select building materials sourced nearby to minimise transportation emissions.
- **Materials with low volatile organic compound (VOC):** Choose paints, adhesives, and other finishes with low VOC levels to improve air quality.
- **Reduced material waste:** Use precise material quantity estimates and optimize material use (e.g. material cuts and distribution) throughout the building to minimize waste and reduce costs.

4.3.1 Solar Chimney

This is an architectural feature that is designed as part of the structure and provides an effective natural ventilation approach. In some specific cases, solar chimneys can he chimney helps to draw cool air from outside or underground pipes and then circulate the cool air throughout a house (**see Figure 8**).

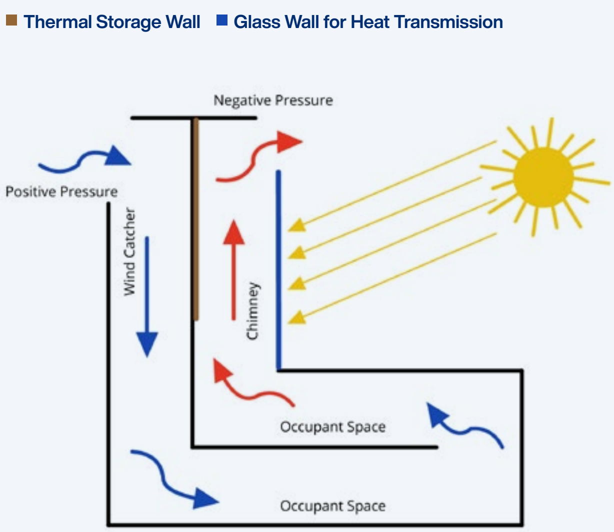


Figure 8 *Solar Chimney*[26]

[24] http://mts.sustainableproducts.com/SMaRT_Certified.html
[25] For more information on material certifications: https://elemental.green/23-green-certifications-to-look-for-building-remodeling-home/.
[26] Source : European Commission (2024). "Passive cooling: can we cool buildings with low to no energy consumption?". Available at: https://build-up.ec.europa.eu/en/resources-and-tools/articles/passive-cooling-can-we-cool-buildings-low-no-energy-consumption.

APPENDIX I

Energy and Sustainability Labels in Different Jurisdictions

This appendix presents some of the key energy and sustainability labels available in the market.

CARICOM Regional Energy Efficiency Labelling Scheme

The CARICOM Regional Energy Efficiency Labelling Scheme[27] was crafted by the CARICOM Regional Organisation for Standards and Quality (CROSQ). The scheme is based on the implementation of minimum energy performance standards and labelling requirements for light bulbs, refrigerators, and air conditioners.

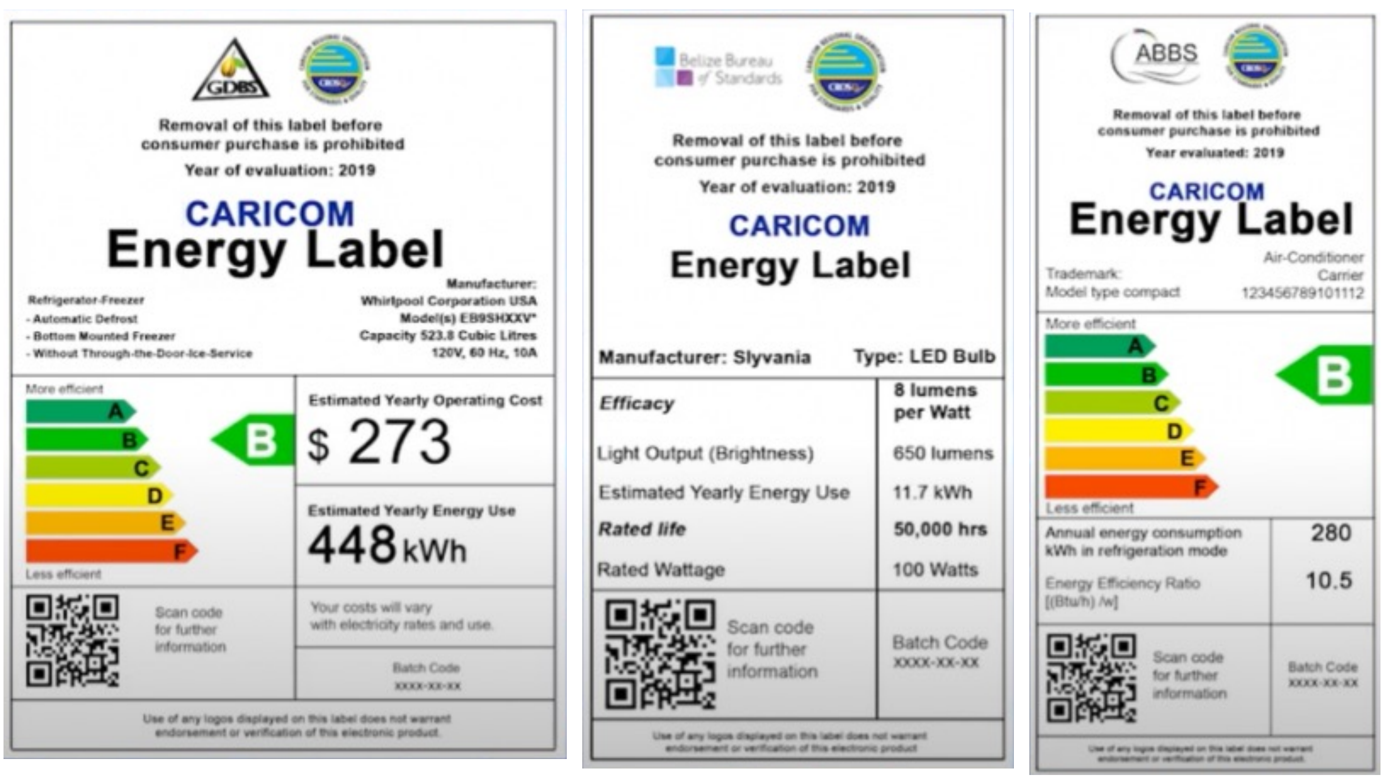


Figure 9 *Example of CARICOM Energy Label*

[27] *CROSQ. The CARICOM Regional Energy Efficiency Labelling Scheme – What You Need to Know. Online: energy.crosq.org/the-caricom-energy-efficiency-labelling-scheme-what-you-need-to-know/.*

Europe EcoDesign Label

The label below is based on the Europe EcoDesign Label. The following figure explains how to read the label.

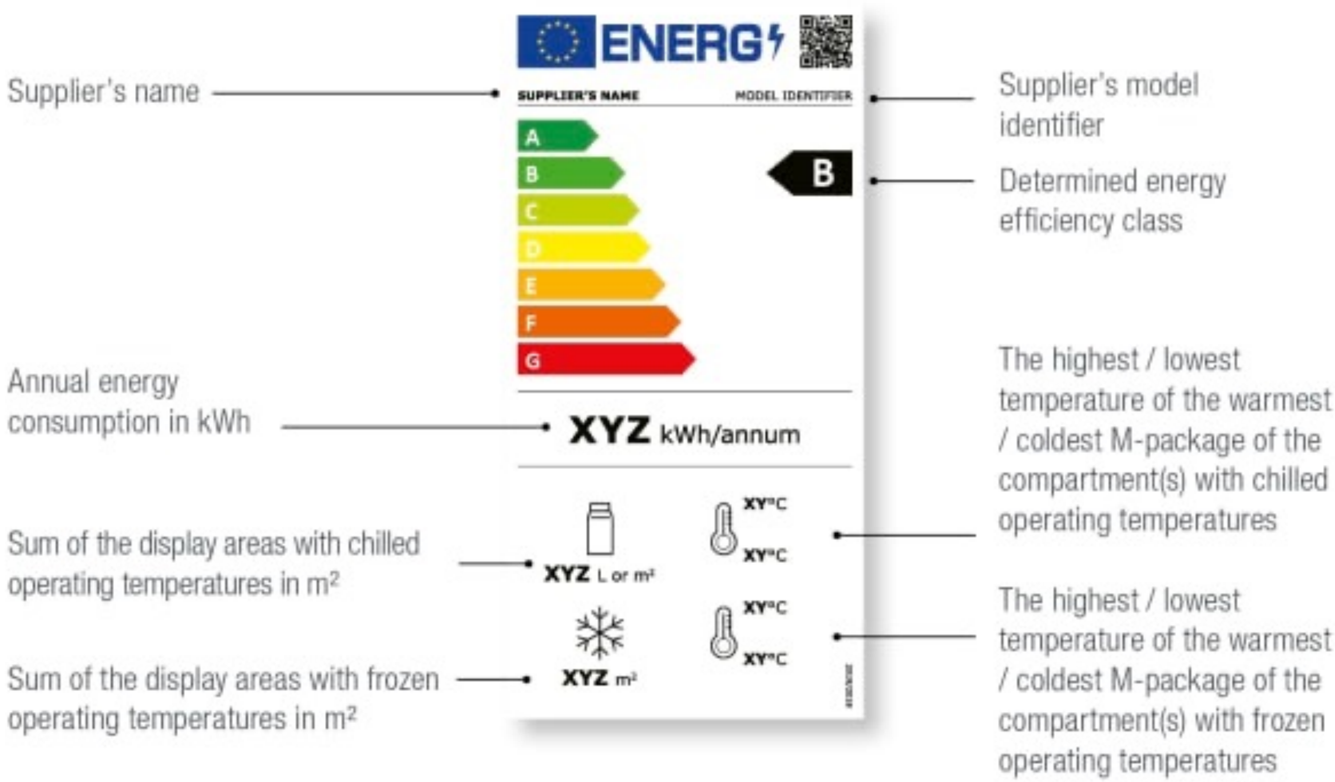


Figure 10 *How to Read the Europe EcoDesign Label*

EnergyGuide Label

The most commonly used label in the US, Canada, and Mexico is the EnergyGuide label illustrated in the figure below. This label is mandatory for all consumer appliances in North America.

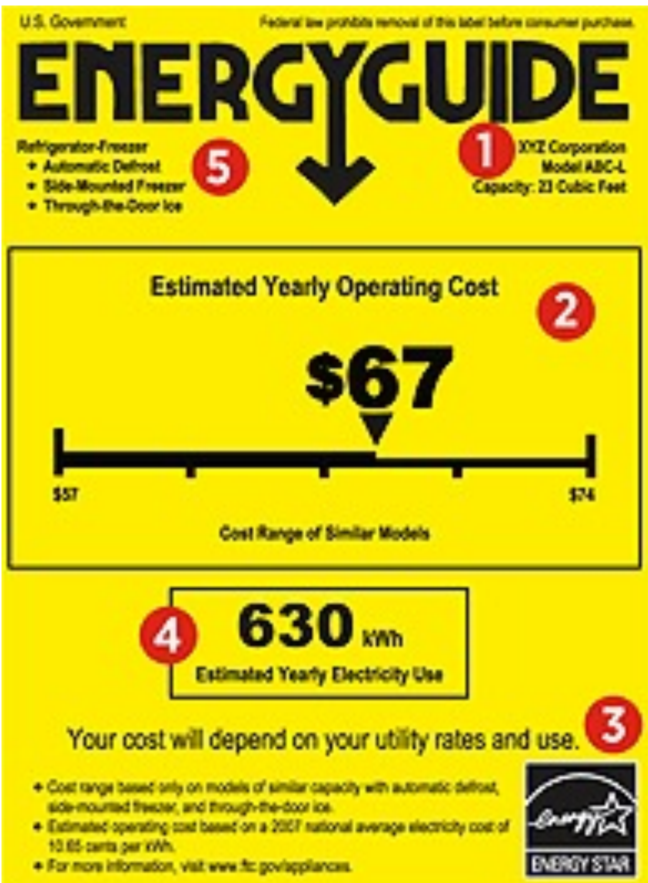


Figure 11 *How to Read the EnergyGuide Label*

01 Maker, model number, and size of the appliance.

02 Estimated yearly operating cost (based on the national average cost of electricity) and the range of operating costs for similar models.

03 The ENERGY STAR® logo indicates that this model meets strict energy efficiency criteria.

04 Estimated yearly electricity consumption.

05 Key features of the appliance and similar models that make up the cost comparison range.

ENERGY STAR Label

In the US and Canada, the US Department of Energy and US Environmental Protection Agency operate the ENERGY STAR label, a labelling programme that identifies products, homes, and buildings that are energy efficient. The label is used to help consumers and businesses make informed decisions about energy-efficient products and practices. Products with the ENERGY STAR label meet strict energy efficiency requirements and earn the ENERGY STAR label only after testing in an EPA-recognised laboratory, being certified by an EPA-recognised certification body, and meeting international standards for conformity assessments.

The US EPA monitors the market to help ensure that products carrying the ENERGY STAR label are more energy efficient and reliable than those without the labels while saving energy and money for consumers.

Figure 12 *The ENERGY STAR Label*

WaterSense Label

In the US, there is also a voluntary partnership program sponsored by the U.S. Environmental Protection Agency (EPA) called the WaterSense, which indicates both a label for water-efficient products and a resource for helping you save water.

The WaterSense label makes it simple to find water-efficient products, new homes, and programs that meet EPA's criteria for efficiency and performance. WaterSense-labeled products and services are certified to use at least 20 percent less water, save energy, and perform as well as or better than regular models. Products carrying the label include: residential toilets, showerheads, bathroom faucets, commercial toilets, urinals, and others.

Figure 13 *The WaterSense Label*

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