MAS Monetary Authority of Singapore

NovA!

Methodology of Calculating Building Energy Conservation Certificate

This document serves as a methodology for calculating Building Energy Conservation Certificate

For any enquiry, please contact the point of contact at **info@nova-ai.org**

Revision Record

Version	Date	Description
Initial version	2023.11.11	The first version

Contents

Background

Singapore Sustainability Goals

Singapore has been committed to fulfilling its commitments under the Paris Agreement, even though Singapore contributes only 0.1% of global emissions. The Singapore 2030 Green Plan sets out specific targets for Singapore over the next 10 years, reinforces Singapore's commitments under the United Nations 2030 Agenda for Sustainable Development and the Paris Agreement, and positions Singapore to achieve long-term net-zero emissions by 2050 wishes. Singapore has pledged to reduce its emissions intensity by 36% from 2005 levels by 2030 and stabilize greenhouse gas emissions, aiming to peak around 2030. Reducing the building's carbon emission is an important part of meeting the Singapore 2030 Green Plan.

Singapore's Buildings Sustainability Goals

Singapore's buildings are a key focus for cutting the country's carbon emissions, consuming over half of its electricity. To address this, the Singapore Building and Construction Authority (BCA) and Singapore Green Building Council (SGBC) launched the fourth edition of the Singapore Green Building Masterplan (SGBMP) in March 2021, aiming to green 80% of buildings by 2030, push for 80% of new buildings to be Super Low Energy from 2030, and improve energy efficiency in best-in-class green buildings by 80% from 2005 levels by 2030. The Monetary Authority of Singapore (MAS) Project NovA![1] team works with the BCA SLEB[2] team to promote energy efficiency, supporting Singapore's commitment to sustainable development and energy security.

[1] NovA! is part of the National Artificial Intelligence (AI) programme in finance, aimed at helping financial institutions (FIs) to harness AI to generate insights on financial risks. Details about NovA! can be found at this link.

[2] SLEB Smart Hub is a national digital platform for green buildings, brims with a wealth of green building data, offering insights and analytical tools that promote building energy efficiency and built environment decarbonisation. Details about SLEB Smart Hub can be found at this link.

Green Mark Certification Scheme

The BCA has been leading the charge in promoting sustainable and energy-efficient building practices. A key component of this initiative is the BCA Green Mark Certification Scheme[3]. This is an internationally recognised green building certification program that evaluates a building's environmental impact and overall performance. It serves as a comprehensive framework to encourage sustainable design, as well as best practices in the construction and operations of buildings. It is under this umbrella that the BCA has launched the Super Low Energy Building (SLEB) Programme.

SLEB Programme

The SLEB Programme by BCA sets advanced benchmarks for building energy efficiency, focusing on energy conservation, renewable energy use, and smart management. The top accolade is the Green Mark for SLEB, awarded to buildings that cut energy use by at least 60% from 2005 Green Mark 2005 benchmarks. See Fig.1 for details.

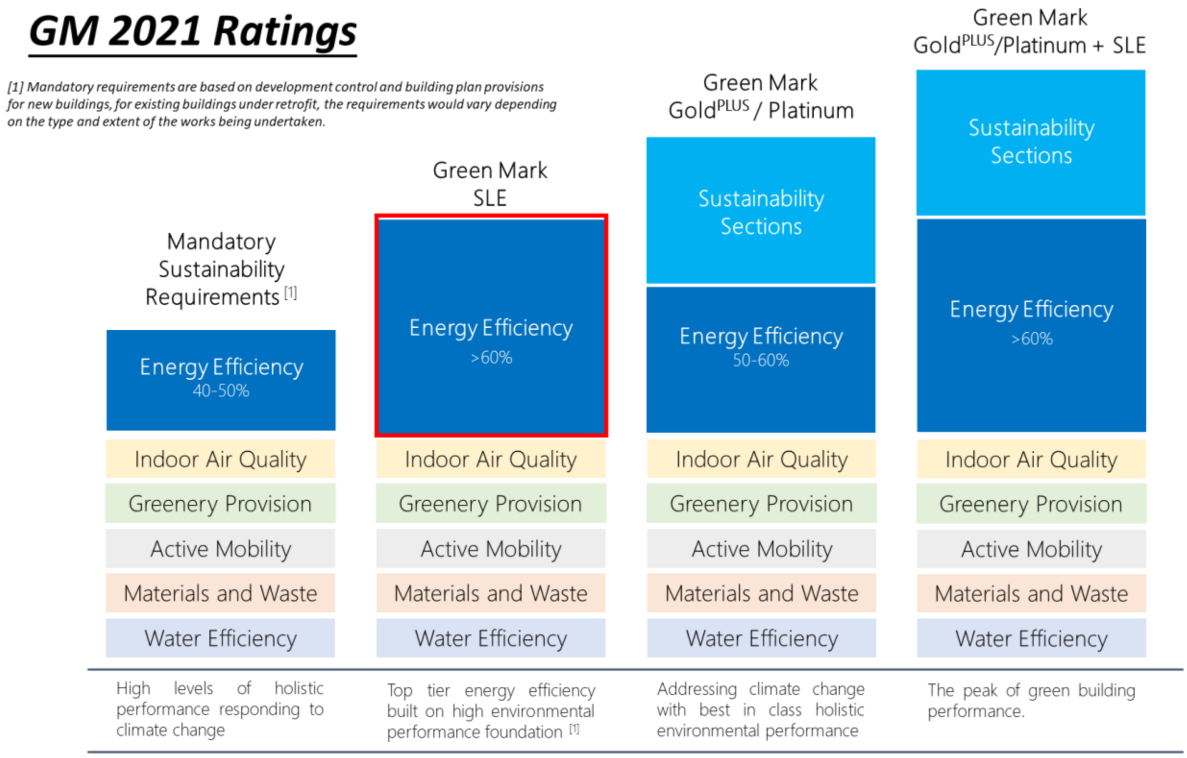

Figure 1 Green Mark Super Low Energy Building requirement

SLEB Smart Hub

To further support and facilitate the industry's move towards super low energy buildings, BCA has also launched the Super Low Energy Building Smart Hub in September 2019. This digital platform serves as a one-stop digital platform that enables super low energy buildings through its wealth of data, actionable insights, and advanced analytical tools. It aids in the sharing of best practices and successful case studies, encouraging the industry to continually innovate and raise the bar for energy efficiency in building design and management.

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[3] BCA Green Mark scheme and standards are available at https://www1.bca.gov.sg/buildsg/sustainability/green-mark-certification-scheme/

Project NovA!

Launched by MAS in June 2021 as part of the National Artificial Intelligence (AI) Programme in Finance, Project NovA! is on a mission to transform green financing. Its goal is to help Financial Institutions (FIs) use AI to streamline green loan applications, manage risks, establish sustainability performance targets (SPTs), and monitor real estate performance. By leveraging AI technology, NovA! generates actionable insights, enhancing decision-making efficiency for FIs while boosting overall productivity and reducing operational costs. This initiative represents a significant leap forward for green finance, supporting the real estate industry's transition towards net-zero emissions and fostering a more sustainable financial ecosystem.

AI-driven Building Energy Model

The MAS Project NovA! and the BCA SLEB Smart Hub team have collaborated, using data from the BCA Green Mark and Building Energy Submission System initiatives, to develop an AI-powered energy model for buildings, hereafter referred to as the 'AI model.' This innovative model stands as a robust alternative to traditional energy modeling methods. It offers precision that aligns with industry standards, yet requires fewer inputs and allows for quicker processing times. The AI model excels in accurately forecasting key energy metrics such as Energy Use Intensity (EUI) and energy savings in comparison to the Green Mark 2005 benchmark. Its effectiveness lies in simulating a building's energy profile, thereby significantly enhancing the analysis of energy efficiency.

Building Energy Conservation Certificate

What is a Building Energy Conservation Certificate?

The Energy Conservation Certificate (ECC) rewards buildings that achieve significant energy savings above the standard baseline, compared to the 2005 Green Mark benchmark. Refer to Table 1 for specific baseline settings. The ECC reflects a building's energy savings during the reporting period, with each certificate representing an abatement of one megawatt-hour (MWh) due to energy-efficient measures. It's an initiative that encourages and measures progress in building energy efficiency.

Table 1 The ECC baseline settings are illustrated in the table 1.

GM rating attained	ECC baseline	Applicable building types
Non-GM and GM Gold^{PLUS}	50%	Office, retail, hotel, mixed development (combinations of office, retail and hotel), healthcare, institutional and light industrial
GM Platinum	55%	
GM SLEB	60%	

Why Building Energy Conservation Certificate?

While the BCA Green Mark certification scheme acknowledges buildings that attain certain energy efficiency level, such as Gold^{PLUS}, Platinum Super Low Energy, Zero Energy, and Positive Energy standards, there is no additional recognition for building achieve additional savings. The ECC fills this gap, recognizing and quantifying energy conservation efforts that exceed the Energy Efficiency (EE) baseline. Furthermore, the ECC could potentially be converted into a tradable digital asset, providing an additional revenue stream for building owners who invest further in reducing building energy consumption.

In addition, there is a lack of trusted mechanisms for financial institutions to offer sustainability-linked loans to building owners or corporations. With ECC, financial institutions have a reliable reference to evaluate the sustainability efforts of building owners or corporations, enabling them to adjust interest rates based on these efforts.

The Benefits

Securing an ECC makes buildings or corporations eligible for green and sustainability-linked loans, allowing them to enjoy preferential interest rates by achieving superior energy savings. Additionally, ECC holders can potentially convert their certificates into tradable carbon credits. These credits can then be sold as commodities to entities requiring them to offset their carbon tax. Given that the Singapore carbon tax is set to increase to S$25/t$CO_2$e in 2024 and 2025, and S$45/t$CO_2$e in 2026 and 2027, aiming to reach S$50-80/t$CO_2$e by 2030, the potential revenue from selling carbon offsets could be substantial.

For instance, consider a 20,000 sqm building that saves 20 kWh/m^2 annually, resulting in an energy savings of 400 MWh/year. The equivalent CO_2 emissions reduction, based on Singapore's grid emission factor of 0.4057 kgCO_2/kWh in 2021, would be 162.28 tonnes of CO_2 (tCO_2e). With the projected carbon tax of S$50-80/t$CO_2$e, the estimated annual revenue from selling carbon offsets could range between S$ 8,000 and S$ 13,000 by 2030.

The Energy Conservation Certificate (ECC) plays a pivotal role in realising Singapore's Green Plan 2030. It does so by supplying reliable energy saving data and implementing strategic mechanisms that guide the decarbonization process within the built environment. This pivotal initiative underscores the commitment towards achieving a sustainable future in line with the city-state's broader environmental goals.

Who are eligible to get Energy Conservation Certificate?

Buildings that are capable of reducing their energy consumption beyond the benchmark set by the Super Low Energy level qualify to receive the Energy Conservation Certificate (ECC). This certificate serves as recognition for those properties that significantly contribute to environmental sustainability through advanced energy-saving measures.

Methodologies for Building Energy Conservation Calculation

Consistent with BCA Green Mark standards, ECC could be applied to building projects for:

- Retrofitting

Project Boundary	Period Boundary
The areas of the building impacted by the retrofitting.	Starting from the date when the building reaches 80% occupancy or maintains its pre-retrofitting occupancy rate.

- In Operation

Project Boundary	Period Boundary
The areas of the building in use and under continuous energy performance monitoring by the accredited parties.	Starting from the date when the building is under continuous energy monitoring by the accredited parties.

Overall process

The determination of energy conservation outcomes is conducted via a meticulous and robust process, depicted in Figure 2. The process encompasses the collection of factual data, including variables such as the actual energy consumption of the building, intrinsic characteristics of the building, key performance indicators of the building's energy usage, and corresponding weather data.

This collected raw data is subsequently analysed and utilized in a calibration process, leveraging advanced AI-powered building energy models to deduce attributes specific to the building in question.

Upon obtaining these building-specific attributes, they act as a foundation to create a baseline model. This baseline model is instrumental in the calculation of the baseline energy consumption. The latter serves as a benchmark, setting the stage for the calculation of energy savings.

The measurement of energy savings is performed by comparing the actual energy consumption with the predetermined threshold derived from the baseline model. The energy savings are then quantified as the difference between the actual and threshold energy consumption. This highlights the quantity of energy consumption that has been successfully avoided, reflecting the effectiveness of energy conservation efforts. And the following sections explain the calculation methodology in detail.

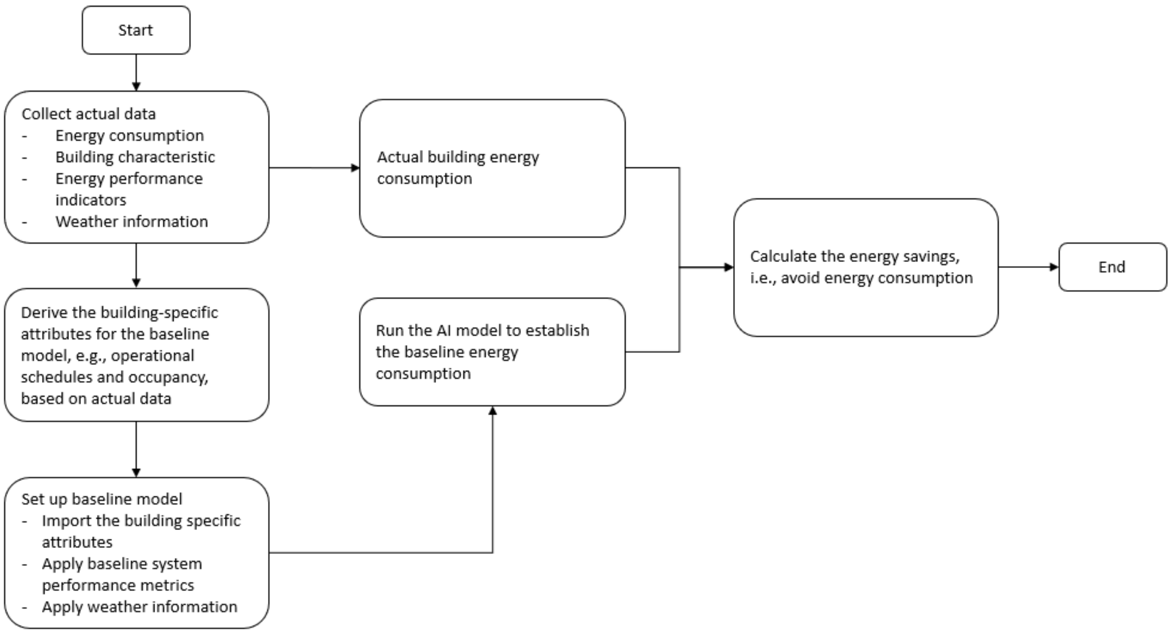

Figure 2 Process of Energy Conservation Calculation

Derivation of building-specific attributes

Building-specific attributes (e.g., gross floor area, operation schedule, and occupancy density) are needed to generate the baseline energy consumption. It encompasses various data that can be obtained or derived from the collected data. Some attributes, such as the gross floor area, can be directly obtained through user input. However, acquiring accurate values for other attributes, like occupancy density, can be more challenging. In such cases, a calibration process can be employed to determine these values.

Figure 3 illustrates the process of deriving building-specific attributes. Available data, including obtained building-specific attributes, system performance metrics, and weather data, are input into an AI model. Simultaneously, different values of the building-specific attributes to be derived are also input into the AI model in an iterative process. The building-specific attributes which allows the AI model to generate an output energy consumption that closely matches the actual energy consumption data will be selected as the output and utilized in the baseline model.

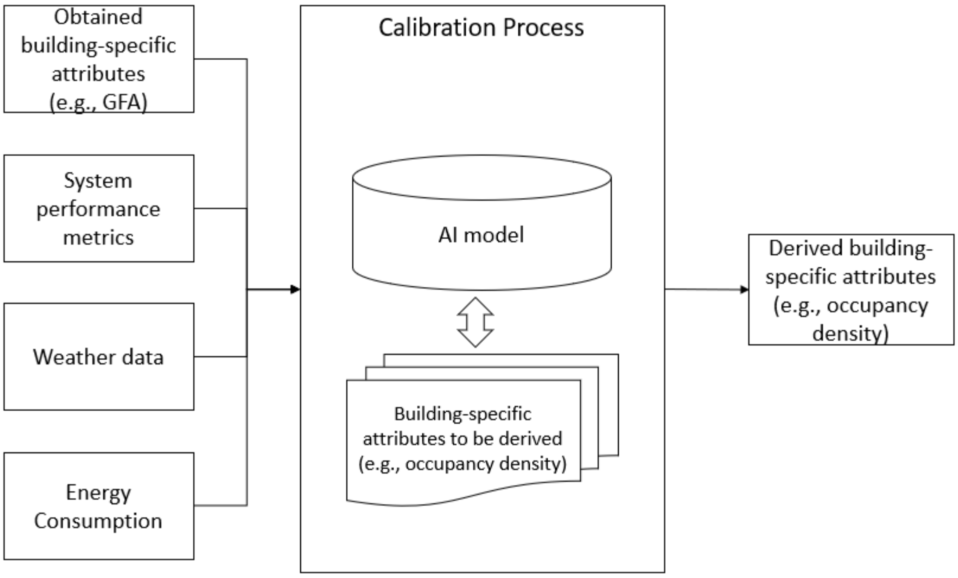

Figure 3 Building-specific attributes derivation process

Baseline model set-up

The baseline model is constructed using various input data, encompassing building characteristics (e.g., gross floor area, air-conditioning area), operation schedules, occupancy density, weather data and system efficiencies (e.g., air-conditioning system efficiency). These data can be classified into three categories: baseline system performance metrics, building-specific attributes and weather data, as shown in Figure 3.

Baseline system performance metrics refer to key indicators of the system's initial performance. These include measures like the baseline Envelope Thermal Transfer Value (ETTV), efficiency of the air-conditioning system, and other pertinent factors impacting the building’s energy efficiency.

Building-specific attributes, on the other hand, comprises information that should accurately reflect the actual building's attributes. This includes details like gross floor area, operation schedule, and occupancy density, ensuring that the baseline model is representative of the specific building being analyzed. The building-specific attributes can be obtained or derived from the collected information, as explained above.

Weather data involves data that captures the prevailing weather patterns and conditions surrounding the building. This data accounts for the influence of external factors, such as temperature, humidity, and solar radiation, on the building's energy performance.

The AI model receives input data consisting of the three types and utilizes its algorithms to generate the baseline energy consumption. The AI model is a powerful tool that leverages comprehensive datasets and advanced algorithms to generate the baseline energy consumption. It incorporates building system modelling algorithms and machine learning algorithms to ensure accuracy and reliability.

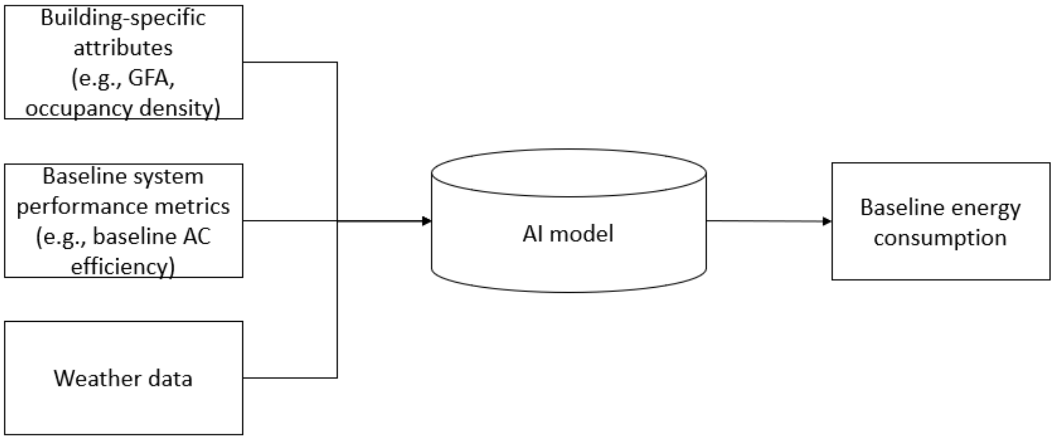

Figure 4 Baseline energy consumption calculation process

Energy conservation calculation method

Figure 4 demonstrates the method for calculating energy conservation in both retrofitting and operational building projects. This involves annually measuring the building's energy use and comparing it to a pre-determined ECC baseline.

The ECC baseline is determined based on the assumed energy consumption from a 2005 virtual energy model. A target percentage for energy savings (for example, 60%) is set relative to the energy levels of 2005 to define this baseline.

Energy conservation is then quantified by subtracting the building's actual energy consumption from the ECC baseline. The resulting figure indicates the degree of energy saved in comparison to the ECC baseline. A positive value signifies energy conservation, showing that the building's energy usage is lower than the ECC baseline. On the other hand, a negative value indicates that the building's energy consumption surpasses the ECC baseline.

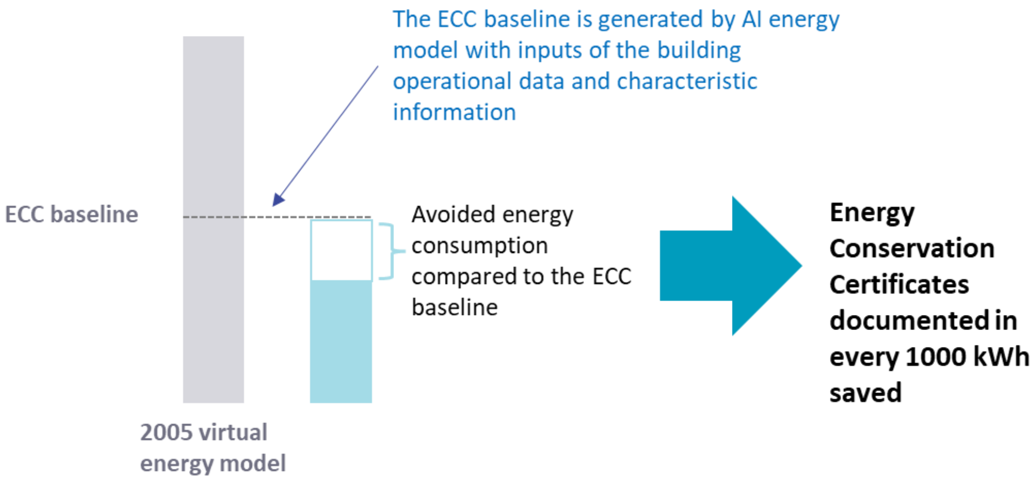

Figure 5 Building Energy Consumption vs Baseline Consumption

Process for Issuing the Energy Conservation Certificate

Utilizing a centralized monitoring, reporting, and verification portal, the process of issuing the Energy Conservation Certificate (ECC) has been fully digitized and automated, thereby ensuring accuracy and efficiency. Here's how it works:

Step 1: The applicant registers as a member on SLEB.sg, designating themselves as the building owner, and grants permission for data-sharing.

Step 2: The applicant then utilizes the 'My Building' feature of the SLEB platform to submit their building data. This data can be automatically populated if it's already available on the SLEB platform. Alternatively, the building's energy management system can be connected to SLEB via APIs to feed in the relevant information.

Step 3: The SLEB-NovA! AI model then computes the energy savings above the established threshold, subsequently determining the number of MWhs of consumption that have been avoided.

Step 4: After computing the energy savings, these results are then converted into Energy Conservation Certificates (ECCs). Upon redemption of the ECCs, a redemption certificate confirming their cancellation is issued. This step is crucial to prevent any possibility of double-counting the energy savings.

Alignment with the Singapore Government's Seven Principles for Carbon Credits

The ECC scheme is designed to align with the Singapore Government's seven principles that form the eligibility criteria for the use of international carbon credits[4]. Each of these principles and how the ECC scheme adheres to them are elucidated below.

Not double-counted

"The certified emissions reductions or removals must not be counted more than once in contravention of the Paris Agreement."

To prevent double-counting, when ECCs are generated from buildings in Country X and subsequently purchased by an entity in Singapore, the emissions reductions can only be attributed to Singapore's climate targets, not those of Country X. Wise versa. Conversely, the same principle applies should the scenario be reversed.

Additional

"The certified emissions reductions or removals must exceed any emissions reduction or removals required by any law or regulatory requirement of the host country, and that would otherwise have occurred in a conservative, business-as-usual scenario."

The ECC's benchmarking baseline, defined as the Green Mark SLE level, surpasses the Green Mark mandatory requirements by achieving 60% energy savings compared to the 2005 Green Mark benchmark. Projects must implement substantial energy efficiency measures to surpass the Green

[4] Singapore Sets Out Eligibility Criteria for International Carbon Credits Under the Carbon Tax Regime. https://www.mse.gov.sg/resource-room/category/2023-10-04-eligibility-criteria-for-international%20carbon%20credits

Mark SLE level, which would not happen under a business-as-usual scenario, thereby demonstrating additionality.

Real

“The certified emissions reductions or removals must have been quantified based on a realistic, defensible, and conservative estimate of the amount of emissions that would have occurred in a business-as-usual scenario, assuming the project or programme that generated the certified emission reductions or removals had not been carried out.”

The ECC quantification relies on the difference between actual building energy consumption and the ECC's benchmarking baseline. The ECC's benchmarking baseline is considered conservative because it represents top-tier energy efficiency at the Green Mark SLE level.

Quantified and verified

“The certified emissions reductions or removals must have been calculated in a manner that is conservative and transparent, and must have been measured and verified by an accredited and independent third-party verification entity before the ICC was issued.”

The ECC issuance involves the collection of actual building energy consumption data, and full disclosure of the ECC calculation methodology. The transparent data and methodology are available for third-party verification.

Permanent

“The certified emissions reductions or removals must not be reversible, or if there is a risk that the certified emissions reductions or removals may be reversible, there must be measures in place to monitor, mitigate and compensate any material reversal of the certified emissions reductions or removals.”

ECCs are exclusively issued to projects that demonstrate permanent and non-reversible energy reductions resulting from energy efficiency improvements.

No Net Harm

“The project or programme that generated the certified emissions reductions or removals must not violate any applicable laws, regulatory requirements, or international obligations of the host country.”

Buildings eligible for ECC must align with Singapore's pertinent laws and regulations.

No Leakage

“The project or programme that generated the certified emissions reductions or removals must not result in a material increase in emissions elsewhere, or if there is a risk of a material increase in emissions elsewhere, there must be measures in place to monitor, mitigate and compensate any such material increase in emissions.”

Enhancing energy efficiency in buildings must not lead to emissions increases in other locations. For instance, when a building employs a district cooling system that redirects a portion of cooling energy to a remote central cooling system, the ECC's benchmarking baseline will be determined based on the district cooling system type, excluding the energy redirected to prevent it from being counted as energy reduction.

Mutual Acceptance

For building projects located in temperate climate zones, this methodology accepts the 'Technical Specification for Identification of Carbon Emission Reduction Verification of Comprehensive Renovation Projects of Public Buildings' referred to as "Technical Specification". This Technical Specification, endorsed by the Chinese Society for Environmental Sciences, sets the standard in this field. More details can be found on the Technical Specification at this link. This methodology also supports a series of assessment, monitoring, reporting, and verification tools developed based on this specification.

This methodology, along with its associated software tools for assessment, monitoring, reporting, and verification based on this methodology has mutually been accepted by the Technical Specification.

Annex – Tables for Data Terms

The definitions of the data terms are provided in the SLEB Data Dictionary, which can be accessed by this link.

Information Required for Retrofitting Project

Data Terms	Input Value Range
Project Name	
Address	
Postal Code	
Gross Floor Area (m^2)	(0, ∞)
Project Status	New Development, Retrofitting Project, In Operation
Number of Buildings in Project	
Building Name	
Gross Floor Area of Building (m^2)	[0, ∞)
Building Type	{'Office Building', 'Retail Building', 'Hotel', 'Healthcare Facility', 'Educational Institution', 'Industrial Building', 'Residential Building', 'Mixed Development', 'Others'}
Mixed-Development Use Types (applicable to Mixed Development only)	{'Office Building', 'Retail Building', 'Hotel', 'Healthcare Facility', 'Educational Institution', 'Industrial Building', 'Residential Building', 'Others'}
Number of Storeys	[1, 300]
Year of TOP/CSC	
F&B Area (m^2)	[0, ∞)
Supermarket Area (m^2)	[0, ∞)
Data Centre/Server Room Area (m^2)	[0, ∞)
Operation Schedule (hr/week)	(0, 168]
Average Monthly Energy Consumption (kWh)	(0, ∞)
Percentage of Air-Conditioned Area (%)	[0, 100]
Air Conditioning System Type	{"Water-cooled Chilled Water Plant", "Air-cooled Chilled Water Plant",

	“Unitary Air-conditioning System”, “District Cooling System”}
Air Conditioning System Efficiency (kW/RT)	(0, 3]
Air Distribution System Type	{“AHU-CAV”, “AHU-VAV”,“FCU-CAV”, “FCU-VAV”}
Air Distribution System Efficiency (kW/RT)	(0, 1]
Percentage use of LED lights (%)	[0, 100]
Total Mechanically Ventilated Area (m^2)	[0, ∞)
Percentage of Air-Conditioned Area	[0, 100]
Reduced Window to Wall Ratio [WWR]	[0, 0.4]
Insulation of Roof [Roof U-Value ($W/m^2 \cdot K$)]	[0.2, 1.5]
Insulation of External Walls [Wall U-Value ($W/m^2 \cdot K$)]	[0.2, 1.5]
Use of High Performance Glass [Glass U-Value ($W/m^2 \cdot K$)]	[0.5 , 2.8]
Use of High Performance Glass [Glass SHGC]	[0.1, 0.35]
Use of Solar Window Film [Solar Window Film U-Value ($W/m^2 \cdot K$)]	[0.05, 0.6]
Use of Solar Window Film [Solar Window Film SHGC]	[1 , 10]
Use of Thermally Broken Window Frames [Window Frame U-Value ($W/m^2 \cdot K$)]	[0.4, 1.2]
Use of Reflective Paint/Cool Paint [Solar Reflectivity]	[0.3, 0.9]
Installation of External Shading Devices [Shading Coefficient]	[0.1, 0.9]
Energy-Efficient Unitary Air-Conditioning System [Efficiency (kW/RT)]	[0.6, 1.1]
Energy-Efficient Chiller [Efficiency (kW/RT)]	[0.4, 0.9] (for “Water-cooled Chilled Water Plant”) [0.8, 1.5] (for “Air-cooled Chilled Water Plant”)
Energy-Efficient Chilled Water Pump [Efficiency ($kW/m^3/s$)]	[160, 350]
Energy Efficient Condensing Water Pump [Efficiency ($kW/m^3/s$)]	[140, 300]
Energy-Efficient Cooling Tower [Efficiency (L/s/kW)]	[1.7, 7]
Air Conditioning System Optimisation	{‘Yes’, 'No'}
Use of Variable Speed Drive (VSD) in AHU/FCU	{“AHU-VAV”, “FCU-VAV”}
Use of Alternative Cooling Technologies [Percentage of Application (%)]	[0, 100]
Energy Efficient Air Distribution Fan [Fan Efficiency (W/CMH)]	[0.05, 0.18] (for FCU-CAV) [0.2, 0.5] (for AHU-CAV) [0.3, 0.6] (for AHU-VAV) [0.06, 0.22] (for FCU-VAV)
Demand-Controlled Ventilation of AC Area	{‘Yes’, 'No'}
Use of Energy Recovery Ventilation System [Efficiency (%)]	[30, 95]

Use of Fans to Offset Cooling Load [Percentage of Application (%)]	[0, 100]
Use of Energy Efficient LED Lights [Efficacy (lm/W)]	[70, 200]
Use of Energy Efficient LED Lights [Percentage of Use (%)]	(0, 100]
Use of Smart Lighting Control [Percentage of Application (%)]	(0, 100]
Use of Daylighting [Percentage of Application (%)]	(0, 100]
Energy-Efficient Mechanical Ventilation Fan [Fan Efficiency (W/CMH)]	[0.05, 0.3]
Demand-Controlled Ventilation of MV Area [Percentage of Application (%)]	[0, 100]
Use of Smart Plug Load Control	{'Yes', 'No'}
Use of Energy Efficient Appliance	{'Yes', 'No'}
Use of Energy Efficient Hot Water System [COP]	[2, 5]
Use of Solar Hot Water Collectors [Percentage of Hot Water Supplied (%)]	[0, 100]
Use of Energy Efficient Lift	{'Yes', 'No'}
Use of Energy Efficient Escalator	{'Yes', 'No'}
Implementation of Building Energy Management System	{'Yes', 'No'}
Installation of Rooftop Photovoltaic (PV) [Rooftop Solar Panel Area (m^2)]	[0, ∞)
Installation of Rooftop Photovoltaic (PV) [Rooftop Solar Panel Efficiency (%)]	(0, 100]
Installation of Building Integrated Photovoltaic (BIPV) [BIPV Solar Panel Area (m^2)]	[0, ∞)
Installation of Building Integrated Photovoltaic (BIPV) [BIPV Solar Panel Efficiency (%)]	(0, 100]

Information Required for In-operation Building

Display Name	Input Value Range
Project Name	
Address	
Postal Code	
Gross Floor Area (m²)	(0, ∞)
Project Status	New Development, Retrofitting Project, In Operation
Number of Buildings in Project	
Building Name	
Gross Floor Area of Building (m²)	[0, ∞)
Building Type	{'Office Building', 'Retail Building', 'Hotel', 'Healthcare Facility', 'Educational Institution', 'Industrial Building', 'Residential Building', 'Mixed Development', 'Others'}
Mixed-Development Use Types (applicable to Mixed Development only)	{'Office Building', 'Retail Building', 'Hotel', 'Healthcare Facility', 'Educational Institution', 'Industrial Building', 'Residential Building', 'Others'}
Number of Storeys	[1, 300]
Year of TOP/CSC	
F&B Area (m²)	[0, ∞)
Supermarket Area (m²)	[0, ∞)
Data Centre/Server Room Area (m²)	[0, ∞)
Operation Schedule (hr/week)	(0, 168]
Average Monthly Energy Consumption (kWh)	(0, ∞)
Percentage of Air-Conditioned Area (%)	[0, 100]
Air Conditioning System Type	{“Water-cooled Chilled Water Plant”, “Air-cooled Chilled Water Plant”, “Unitary Air-conditioning System”, “District Cooling System”}
Air Conditioning System Efficiency (kW/RT)	(0, 3]
Air Distribution System Type	{“AHU-CAV”, “AHU-VAV”,“FCU-CAV”, “FCU-VAV”}
Air Distribution System Efficiency (kW/RT)	(0, 1]
Total Mechanically Ventilated Area (m²)	[0, ∞)
Design of Natural Ventilation [Percentage of NV area converted from AC area (%)]	[0, Percentage of Air-Conditioned Area]
Reduced Window to Wall Ratio [WWR]	[0, 0.4]

Insulation of Roof [Roof U-Value (W/m²·K)]	[0.2, 1.5]
Insulation of External Walls [Wall U-Value (W/m²·K)]	[0.2, 1.5]
Use of High Performance Glass [Glass U-Value (W/m²·K)]	[0.5 , 2.8]
Use of High Performance Glass [Glass SHGC]	[0.1, 0.35]
Use of Solar Window Film [Solar Window Film U-Value (W/m²·K)]	[0.05, 0.6]
Use of Solar Window Film [Solar Window Film SHGC]	[1 , 10]
Use of Thermally Broken Window Frames [Window Frame U-Value (W/m²·K)]	[0.4, 1.2]
Use of Reflective Paint/Cool Paint [Solar Reflectivity]	[0.3, 0.9]
Installation of External Shading Devices [Shading Coefficient]	[0.1, 0.9]
Air Conditioning System Optimisation	{'Yes', 'No'}
Use of Variable Speed Drive (VSD) in AHU/FCU	{"AHU-VAV", "FCU-VAV"}
Demand-Controlled Ventilation of AC Area	{'Yes', 'No'}
Use of Energy Recovery Ventilation System [Efficiency (%)]	[30, 95]
Use of Fans to Offset Cooling Load [Percentage of Application (%)]	[0, 100]
Use of Energy Efficient LED Lights [Efficacy (lm/W)]	[70, 200]
Use of Energy Efficient LED Lights [Percentage of Use (%)]	(0, 100]
Use of Smart Lighting Control [Percentage of Application (%)]	(0, 100]
Use of Daylighting [Percentage of Application (%)]	(0, 100]
Energy-Efficient Mechanical Ventilation Fan [Fan Efficiency (W/CMH)]	[0.05, 0.3]
Demand-Controlled Ventilation of MV Area [Percentage of Application (%)]	[0, 100]
Use of Smart Plug Load Control	{'Yes', 'No'}
Use of Energy Efficient Appliance	{'Yes', 'No'}
Use of Energy Efficient Hot Water System [COP]	[2, 5]
Use of Solar Hot Water Collectors [Percentage of Hot Water Supplied (%)]	[0, 100]
Use of Energy Efficient Lift	{'Yes', 'No'}
Use of Energy Efficient Escalator	{'Yes', 'No'}
Implementation of Building Energy Management System	{'Yes', 'No'}
Installation of Rooftop Photovoltaic (PV) [Rooftop Solar Panel Area (m²)]	[0, ∞)
Installation of Rooftop Photovoltaic (PV) [Rooftop Solar Panel Efficiency (%)]	(0, 100]
Installation of Building Integrated Photovoltaic (BIPV) [BIPV Solar Panel Area (m²)]	[0, ∞)
Installation of Building Integrated Photovoltaic (BIPV) [BIPV Solar Panel Efficiency (%)]	(0, 100]

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The development of this Methodology for Building Energy Conservation Calculation is a result of an extensive industry collaboration across the built environment and green finance value chain. The Project NovA! would like to extend our sincerest gratitude to all internal and external stakeholders for their invaluable support and contribution towards the development of this Methodology that will enable us to develop a sustainable environment for our current and future generations to come. In particular, we would like to thank the experts and professionals who contribute to this initiative.

List of experts and professionals

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Dr Wen Yong Gang – Associate Vice President of Nanyang Technical University

Dr Liang Hao – Director of China Ministry of Housing and Urban-Rural Development

Dr Li Xiang – CSO of Greenland Financial Technology Group

Dr Bai Bo – CEO of MetaVerse Green Exchange Singapore

Dr Lin Wujuan – Deputy Managing Director of Hitachi Asia Ltd.

Dr Jin Guang Yu – Senior Manager of Building and Construction Authority

Gary Wu – Deputy CEO of Green Link Digital Bank

Leo Lin – Founder of Arkreen Foundation

Lan Lan – Chief Researcher of Hitachi Asia Ltd.

Lum Choon Keen - Managing Director of Sumitomo Mitsui Banking Corporation (SMBC)

For any enquiry, please contact the point of contact at
info@nova-ai.org