Asia-Pacific
Economic Cooperation

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for Asia-Pacific Prosperity

Promotion Plan for Green Buildings with Cost-effective Renewable Energy Supply Solutions in the APEC Region

APEC Energy Working Group

April 2018

APEC Project: EWG 03 2016A

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APEC#218-RE-01.5

Contents

Executive Summary

As we all know, energy consumption from building sector accounts for a considerable proportion in the total energy consumption of both APEC region and other areas. This APEC project aims to develop recommendations for application of innovative solar technologies in green buildings (GBs) to Asia Pacific's various climatic regions, share information on relevant technologies, and promote energy efficiency of APEC region. Green building is one of measures been put forward to mitigate significant impacts of the building stock on the environment, society and economy. The theory of green buildings includes a lower environment load, higher energy efficiency and resource saving throughout a building's whole life cycle. At the same time, green buildings should provide comfortable, safe and healthy environments for people. Renewable energy utilization (REU) is one of the most important aspects of green buildings. Promotion plan funded by EWG 03 2016A is important to promoting green building with cost-effective renewable energy supply solutions in APEC region. This promotion plan will be divided into four main sessions, including session 1, why develop GBs with Cost-effective Renewable Energy Supply Solutions in the APEC region; session 2, GB's situation in the APEC region; session 3, critical barriers for GB development in the APEC region; and session 4, how to promote the spread and adoption of GBs with cost-effective renewable energy-supply solutions in APEC region.

From preliminary workshop and research, our team think that there exists an exciting opportunity for the development of cost-effective renewable energy supply solutions based on innovative solar technologies to promote green buildings in the APEC region. Our team hope the final recommendations including this promotion plan could make contributions to the sustainability development of all 21 member economies of APEC.

Project Description and Background

Buildings account for about 40% of global energy consumption; therefore renewable energy-supply solutions for buildings will greatly contribute to energy efficiency and energy security of Asia-Pacific region. Responding to 2015 APEC Energy Ministers' instruction for the EWG to "explore strategies to drive the shift towards green buildings including zero energy buildings", this project seeks to foster APEC members' collaborative efforts in developing cost-effective renewable energy-supply solutions based on innovative solar technologies for green buildings in APEC region.

This project aims to develop recommendations for application of innovative solar technologies in green buildings to Asia Pacific's various climatic regions, share information on relevant technologies, and promote energy efficiency of APEC region. A workshop with experts and attendance from renewable energy and green buildings field will be held in China in April 2017. A final research report on RE solutions for green buildings in APEC Region will be submitted.

Project Objectives

The project objectives are:

- To develop recommendations on technical solutions for promoting advanced solar applications in green buildings to Asia Pacific's various climatic regions.
- To make all partners clear about possible sustainable building energy-supply solutions and to enhance understanding of the innovative solar technologies by sharing results and experiences.
- To build interest of governments, investors, architect, manufacturers of building cladding products and photovoltaic companies in the innovative solar technologies and their applications for green buildings including zero energy buildings.

Aim and Objectives of Promotion Plan for Green Buildings with Cost-effective Renewable Energy Supply Solutions in the APEC Region

Recently, the economic growth in most of APEC member economies has significantly increased pressure on both the infrastructure and environment, particularly pressure of increasing demand for buildings, energy consumption, and waste and pollution management. Green building (GB) emerged from the green movement around 1970s-1980s as a solution to meet building demand while reducing the construction industry's energy consumption. Studies have shown that the greening technologies and design applied in GB can increase the efficiency of buildings by up to ten times in terms of resource utilisation. Compared to average conventional buildings, certified GBs in Australia and New Zealand

emit only 1/3 greenhouse gases, consume 1/3 electricity and 1/2 potable water, and recycle almost 96% of demolition waste. The ‘Promotion Plan on for GBs with Cost-effective Renewable Energy Supply Solutions in APEC Region’ funded by EWG 03 2016A aims to facilitate and accelerate the spread and adoption of the cost-effective renewable energy-supply solutions for green buildings in APEC region.

Session I: Why to develop GBs with Cost-effective Renewable Energy Supply Solutions in the APEC region

1.1 To reduce CO_2 emission

Building emission mainly refers to the consumption of resources and greenhouse gases produced from consumption throughout the lifecycle of buildings, so it is closely related to human daily life and work. 50% people may cause carbon-emission by using vehicle, 30% people may be involved in industrial production, but there must be more than 90% or even more people causing endless carbon-emission because of their daily life and work. So the “energy-saving” and “low-carbon” in construction are destined to become a hot topic. Study has shown that the global construction industry and its related fields caused 70% of greenhouse effect from the production of building materials to construction and use of buildings, the whole is a huge emitter of greenhouse gases

The Tables below shows that global carbon emission in most of the member economies will experience a further expand from 2013 to 2040. Research show that to ensure the global warming within 2◦C, the global carbon emission must be deeply cut by 2020. In fact, among all elements, buildings account for around half of primary energy consumption, hence develop GBs with Cost-effective Renewable Energy Supply Solutions in APEC region will be useful for cutting CO_2 emissions.

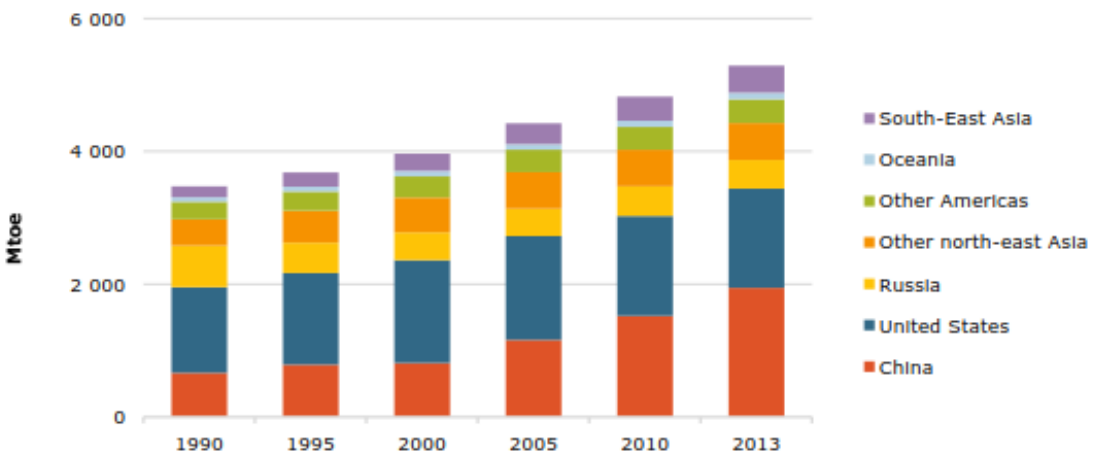
Carbon emission of APEC Member economies in 2013 and 2040

Member economies	2013	2040
Australia	388(Mt)	382(Mt)
Brunei Darussalam	6.9(Mt)	9(Mt)
Canada	536(Mt)	551(Mt)
Chile	82(Mt)	149(Mt)
China	9(Gt)	12.5(Gt)
Hong Kong, China	46(Mt)	35(Mt)
Indonesia	425(Mt)	1163(Mt)
Japan	1250(Mt)	1000(Mt)
Korea	572(Mt)	564(Mt)
Malaysia	207(Mt)	363(Mt)
Mexico	460(Mt)	700(Mt)

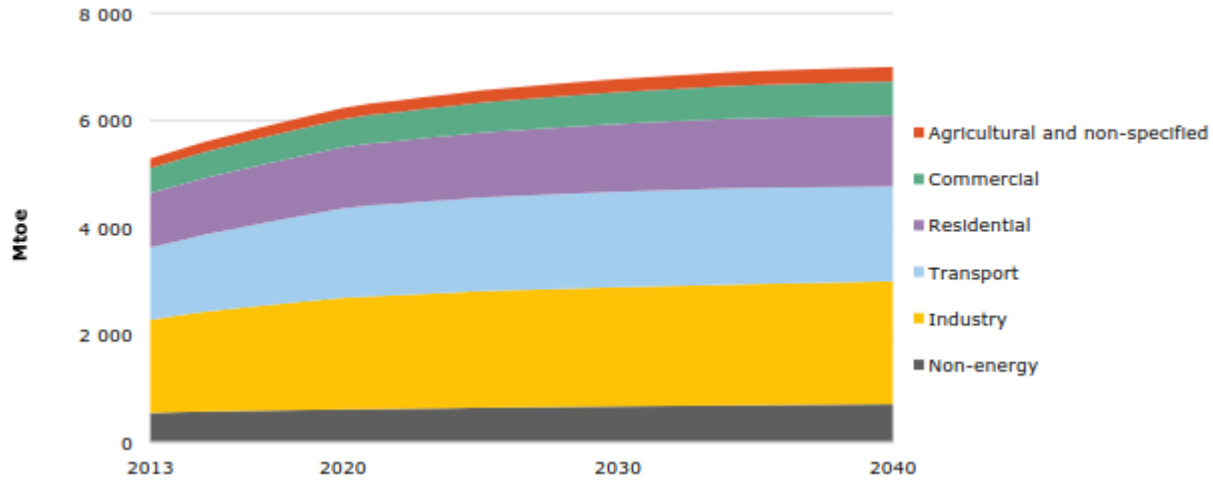
New Zealand	31(Mt)	32(Mt)
Papua New Guinea	6.3(Mt)	29(Mt)
Peru	46(Mt)	143(Mt)
Philippines	80(Mt)	261(Mt)
Russia	1.56(Gt)	1.53(Gt)
Singapore	45(Mt)	53(Mt)
Chinese Taipei	248(Mt)	375(Mt)
Thailand	247(Mt)	500(Mt)
United States	5.1(Gt)	4.9(Gt)
Viet Nam	120(Mt)	631(Mt)

1.2 To relieve the energy crisis

Industrial development and population growth have led to a surge in the global demand for energy in recent years. APEC is progressing in achieving its aspirational goals of reducing energy intensity by at least 45% by 2035, using 2005 as a base year, and in doubling the share of renewables in the APEC energy mix, including in power generation from 2010 to 2030. Despite the rising uptake of renewables, APEC remains reliant on fossil fuels to meet growing energy demand: fossil fuels account for 82% of the energy supply mix in 2040, down only slightly from 86% in 2013. Coal remains the leading source of power (41% in 2040) due to rapid growth in electricity demand, particularly in China and South-East Asia. This leads to a net addition of 670 GW of new coal-fired power generation capacity, which pushes up APEC demand for coal by 13% between 2013 and 2040. Natural gas shows the highest growth rate (AAGR of 2.1%) among fossil sources, with its share of the energy mix rising from 20% in 2013 to 27% by 2040. The abundance of low-priced gas in certain economies offers an attractive option to reduce energy-related emissions in the short-term. In certain economies, such as the United States, Canada, Mexico and Peru, rising shares of gas drive the energy mix, particularly in power generation.



Final energy demand by regional grouping, 1990-2013



Final energy demand in the BAU by sector, 2013-40

To reconcile the energy needed for economic growth with environmental sustainability, APEC economies need to meet growing energy demand while reducing CO2 emissions. Most economies have followed-through on previously committed action plans to improve energy efficiency; embarked on efficiency awareness raising campaigns; increased use of renewables; promoted good energy management practices and facilitated investment in energy efficiency. Buildings account for about 40% of global energy consumption; therefore renewable energy-supply solutions for buildings will greatly contribute to energy efficiency and energy security of Asia-Pacific region.

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Session II: Green building situation in the APEC region

2.1 Development of GB indicators in APEC region

2.1.1 Assessment standard for green building (China)

In order to carry out China's technical and economic policies, save resources, protect the environment, standardize the evaluation of green buildings and promote sustainable development, China has formulated the assessment standard for green building.

The assessment of green building should follow the principle of local conditions, combined with the climate, environment, resources, economy and culture of the region where the building is located, and comprehensively evaluate the performance of energy saving, land saving, water saving, timber saving and protecting environment during the whole life period of the building.

Green building, refers to the building's full life cycle to maximize resource conservation (energy, land, water, and materials) to protect the environment and reduce pollution, provide people with healthy, appropriate and efficient use of space, and harmonious society construction.

The evaluation of green building should be based on single building or building group. When evaluating a single building, any index that involves systematicness and integrity should be evaluated based on the overall evaluation of the project.

The evaluation of green building is divided into design evaluation and operation evaluation. The design evaluation should be carried out after the examination and approval of the construction drawing design document, and the operation evaluation should be carried out after completion of the building acceptance and put into operation for a year.

The applicant should carry out the technical and economic analysis of the whole life period of the building, rationally determine the scale of the building, select the appropriate construction technology, equipment and materials, control the whole process of the planning, design, construction and operation, and submit the corresponding analysis, test report and document.

The evaluation index system of green building consists of seven indexes, that is, land saving and outdoor environment, energy saving and energy utilization, water saving and water resources utilization, timber saving and material resources utilization, indoor environment quality, construction management and operation management. Each category includes a control item and a scoring item. When designing

evaluation, two kinds of indicators such as construction management and operation management are not evaluated, but relevant provisions can be pre evaluated. Seven kinds of indicators should be included in the operation evaluation. The evaluation results of control items are satisfied or not satisfied, and the scores of scoring items and bonus points are classified. The evaluation of green building should be determined according to the total score.

The total score of the seven indicators of the evaluation index system is 100 points. The scoring items of the seven types of indexes are Q1, Q2, Q3, Q4, Q5, Q6, Q7, according to the actual score values of the rating items of the evaluation architecture divided by the total score value applied to the building and then multiplied by 100 points.

2.1.2 Leadership in Energy & Environmental Design Building Rating System (United States)

The “Leadership in Energy & Environmental Design Building Rating System”, which is established and implemented by the American green building association, is called LEEDTM in the world. It is considered to be the most perfect and most influential assessment standard in all kinds of architectural environmental assessment, green building evaluation and construction sustainability assessment standards of all countries in the world.

The LEEDTM evaluation system consists of five aspects, which constitute its sustainable sites, water efficiency, energy & atmosphere, materials & resources, indoor environmental quality, innovation & design process. LEED certification evaluation elements:

- **Sustainable Sites (14 points):**

The sustainable site evaluation includes the control of soil and water conservation and surface deposition in the building process; maintaining and restoring public green space; reducing outdoor light pollution; reasonable tenant design and construction guidelines.

- **Water Efficiency (5 points):**

LEED-CS in the part of the construction of water saving, the section of the festival water as the "landscape water consumption, use of advanced science and technology to save water, reduce the average daily water" three items. Rainwater recovery technology and intermediate water reuse technology can be used.

- **Energy & Atmosphere (17 points):**

In the first building process, the minimum energy consumption standard must be reached. In the ASHRAE STANDARD, the minimum energy consumption in the building process is clearly explained. LEED is also a standard to determine whether the energy consumption is up to LEED in the light of the energy consumption standard. The main technical measures are not to use the refrigerant containing Freon; double Low-e glass; optimize the insulation and sun shading system; passive design; install the household metering system; choose energy saving air conditioning; install solar energy, wind energy and other renewable energy systems.

- **Materials & Resources (13 points):**

In view of the actual situation of building material waste, the scoring point of material and resource utilization is groundbreaking in the process of LEED certification. This scoring point is aimed at promoting the rational use of resources in the construction process, making full use of recyclable materials and manifests in the LEED certification process in the form of bonus. In the material and resource assessment, the following articles are mainly referred to: the storage and collection of recyclable articles, the management of the construction waste, the reuse of resources, the components of recycling and the utilization of local materials.

- **Indoor Environmental Quality (15 points):**

Indoor air quality monitoring is mainly to monitor the built environment and indoor environment quality. In the implementation process, the following are taken into consideration: minimum indoor environmental quality requirements, smoking environment control, new wind monitoring, enhanced ventilation, indoor air environment quality management, low volatile material application, use and control of indoor chemical substances, system controllability, thermal comfort and natural lighting and field of vision distribution. The technical measures adopted include installation of fresh air monitoring system and independent exhaust system in dangerous gas or chemical products storage and use area.

- **Innovation & Design Process (5 points):**

Design innovation means that in the process of building design, it adds a reasonable and pioneering design concept that has great benefits to energy conservation and environmental protection, and can get extra innovation score.

It is platinum, gold, silver and certification level to reflect the green level of building. LEED according to the indicators in every aspect: 1, sustainable site planning; 2, protection and conservation of water resources; 3, efficient energy utilization and atmospheric environment; 4, materials and resources issues; 5, indoor environmental quality. The total score is 110 points, and it is divided into four certification grades: Certification level 40-49; Silver grade 50-59; Gold grade 60-79; Platinum is more than 80.

2.1.3 Comprehensive Assessment System for Building Environmental Efficiency (Japan)

Comprehensive Assessment System for Built Environment Efficiency (CASBEE), an evaluation system for Japanese buildings, was launched in 2001, supported by the Ministry of land and transportation. It is mainly developed by JSBC, Japan's Sustainable Building Association, and its members are from enterprises, governments and academia. Since 2003 promulgated for evaluation of the new building standards, so far has promulgated for the existing buildings, the renovation of buildings, evaluation of the new independent residential, city planning, schools, and thermal effect, property assessment standards, and will be issued for urban evaluation standards.

CASBEE is a method for evaluating and rating the environmental performance of buildings and the built environment. It is a comprehensive assessment of the quality of a building, evaluating features such as interior comfort and scenic aesthetics, in consideration of environment practices that include using materials and equipment that save energy or achieve smaller environmental loads. The CASBEE assessment is ranked in five grades: Superior (S), Very Good (A), Good (B+), Slightly Poor (B-) and Poor (C).

CASBEE was developed by a research committee established in 2001 as part of a joint industrial/government/academic project. The first assessment tool, CASBEE for Offices, was completed in 2002, followed by CASBEE for New Construction in July 2003, CASBEE for Existing Buildings in July 2004 and CASBEE for Renovation in July 2005. The CASBEE assessment tools were developed on the basis of the following three principles:

a) Comprehensive assessment throughout the life cycle of the building

b) Assessment of the Built Environment Quality and Built Environment Load

c) Assessment based on the newly developed Built Environment Efficiency (BEE) indicator

Space-scale classification and time-process classification

CASBEE is comprised of assessment tools tailored to different scales: construction (houses and buildings), urban (town development) and city management. These tools are collectively known as the CASBEE Family.

2.1.4 National Australian Built Environment Rating System (Australia)

NABERS is a national rating system that measures the environmental performance of Australian buildings, tenancies and homes. Put simply, NABERS measures the energy efficiency, water usage, waste management and indoor environment quality of a building or tenancy and its impact on the environment.

NABERS provides four environmental rating tools, including NABERS Energy, NABERS Water, NABERS Waste and NABERS Indoor Environment, to measure the actual operational performance of existing buildings.

NABERS can be used to rate commercial offices, shopping centres, hotels and homes.

NABERS ratings for offices can be used to measure the performance of a tenancy, the base building or the whole building. The tenancy rating includes only the energy or resources that the tenant controls. A base building rating covers the performance of the building's central services and common areas, which are usually managed by the building owner.

A whole building rating covers both the tenanted spaces and the base building, and is typically used in an owner-occupied building, or where there is inadequate metering to obtain a base building or tenancy rating.

The NABERS 6-star rating scale

The strength of the NABERS program is its ability to convert detailed technical information about a building's environmental impacts into an easily understood star rating that accurately demonstrates how a building or tenancy is performing compared to others in its location.

A NABERS rating is the first step in understanding what opportunities there may be to improve the efficiency and performance of a building or tenancy and increase its rating. Building owners and managers commonly use NABERS to set star rating targets for building or portfolio upgrade projects.

The NABERS Energy and Water tools for offices, shopping centres and hotels measure performance on a rating scale from 0 to 6 stars, as does the NABERS Indoor Environment for offices tool.

The NABERS Waste for offices tool measures performance on a rating scale from 0 to 5 stars.

The NABERS rating scale:

For NABERS Indoor Environment, Energy and Water tools for offices, shopping centres and hotels:

6 stars	Market leading performance
5 stars	Excellent performance
4 stars	Good performance
3 stars	Average performance
2 stars	Below average performance
1 stars	Poor performance
0 stars	Very poor performance

For NABERS Waste for offices:

5 stars	Market leading performance
4 stars	Excellent performance
3 stars	Good performance
2.5 stars	Average performance
2 stars	Below average performance
1 stars	Poor performance
0 stars	Very poor performance

It does this by using measured and verified performance information, such as utility bills, and converting them into an easy to understand star rating scale from one to six stars. For example, a 6 star rating demonstrates market-leading performance, while a 1 star rating means the building or tenancy has considerable scope for improvement.

The NABERS approach to rating the environmental performance of buildings is world leading and unique. It takes real, measured impacts and communicates these in a clear and simple way.

Through NABERS, the Australian property industry has a credible standard to confidently communicate results, and to judge environmental initiatives by their actual results in star

ratings. NABERS ratings are used throughout the property sector to drive deep cuts in environmental impacts, and evaluate the real results of initiatives. NABERS star ratings are now common language.

This deep knowledge of building performance and potential for improvement has transformed the Australian property industry, which is now acknowledged as an international leader in the greening of buildings. It has led to a real, measured and significant reduction in environmental impact.

2.1.5 GB tools (Canada)

In 1996, Canada launched a "Green Building Challenge" activity, the initial participation in the activity of more than 14 countries, after the study of 35 projects, the final introduction of a set of building environment evaluation system for many countries ——GB Tools.

The GBC's evaluation system is called “The Green Building Tool”, or the “GB Tools”, which is built on the excel platform. The evaluation system covers all aspects of the evaluation of the building environment because the number of countries involved in the development of the project and the content of the project involved in the practice are involved in all areas of the building. The GB Tools evaluation system is divided into 4 levels, consisting of 6 fields and 120 indicators. The range of GB Tool evaluation index is from -2 to 5, which only indicates the "green" degree of the evaluation building, so the evaluation scale of the GB Tool system belongs to the relative value, in which the -2 points, representing the performance of the building, are not required, and the 0 points are the benchmark, indicating the performance of the lowest acceptable requirement in the area; 1-4 points, representing different levels of architecture in the middle. The performance is 5 points, indicating the building environmental performance which is higher than the standard. The evaluation includes: energy consumption, indoor environmental quality, environmental management, economic burden, performance, quality of service.

Evaluation method: four level weight calculation: the values of each bottom line are multiplied by their respective weight percentages and then added. The value of -2 to 5 represents the degree of "green".

Advantages: each index is independent of each other, and the expansion of the system is also conducive to the objectivity of the evaluation. Disadvantages: complex structure and heavy workload.

2.1.6 Building Environment Assessment Method (Hong Kong, China)

BEAM provides building users with a single performance label that demonstrates the overall quality of a building, either a new or refurbished building or one that is already in use. A certified BEAM building is safer, healthier, more comfortable, more functional and more efficient than a similar building that does not achieve the level of performance prescribed in BEAM. BEAM is:

a) the leading initiative in Hong Kong, China to assess, improve, certify and label the performance of buildings;

b) a set of comprehensive standard procedures covering all building types, including mixed use complexes;

c) a means by which to benchmark and improve performance;

d) a voluntary scheme developed in partnership with, and adopted by the industry, at a level that makes it one of the leading schemes in the world; a driver for and means by which to sustain healthy, efficient, and environment friendly working or living environment.

BEAM embraces a range of good practices in planning, design, construction, management, operation and maintenance of buildings, and is aligned with local regulations, standards and codes of practice.

Credit Weightings and Overall Grade

The weighting system, i.e. the relative number of credits given for compliance with a particular aspect, is a critical part of a building performance assessment method. It is logical that BEAM should seek to assign credits or weightings to assessment criteria in accordance with the significance of the impact.

Having reviewed local and international assessment schemes and other relevant information, a weighting for each environmental performance category has been assigned to reflect its importance and global trends as follows：

Category	**Weighting (%)**
Site Aspects (SA)	25
Materials Aspects (MA)	8
Energy Use (EU)	35
Water Use (WU)	12
Indoor Environmental Quality (IEQ)	20
Total	**100**

Credits have been broadly allocated to each assessment criterion by taking into account the international consensus as given by an analysis of weightings used in similar assessment methods operating elsewhere, as well as surveys and informed opinions of those who have contributed to the development of this BEAM version. The award of fractions of a credit is possible under BEAM.

Determination of Overall Grade

The Overall Assessment Grade is determined by the percentage (%) of the applicable credits gained under each performance category and its weighting factor. Given the importance of SA, EU and IEQ, it is necessary to obtain a minimum percentage (%) of credits for the three categories in order to qualify for the overall grade. In addition, a minimum number of credits may be earned under the category of Innovation and Additions (IA). The award classifications are:

	Overall	**SA**	**EU**	**IEQ**	**IA**	
Platinum	75%	70%	70%	70%	3 credits	Excellent
Gold	65%	60%	60%	60%	2 credits	Very Good
Silver	55%	50%	50%	50%	1 credit	Good
Bronze	40%	40%	40%	40%	——	Above Average

2.1.7 Green Mark (Singapore)

The Building and Construction Authority (BCA) Green Mark Scheme was launched in January 2005 as an initiative to drive Singapore's construction industry towards more environment-friendly buildings. It is intended to promote sustainability in the built environment and raise environmental awareness among developers, designers and builders when they start project conceptualisation and design, as well as during construction.

BCA Green Mark provides a meaningful differentiation of buildings in the real estate market. It is a benchmarking scheme which incorporates internationally recognized best practices in environmental design and performance. This can have positive effect on corporate image, leasing and resale value of buildings. Benefits of BCA Green Mark include:

a) Facilitate reduction in energy, water and material resource usage;

b) Reduce potential environmental impact;

c) Improve indoor environmental quality for better health and well-being and;

d) Provide clearer direction for continual improvement.

Assessment framework

The environmental performance of a building development shall be determined by the numerical scores (i.e. Green Mark points) achieved in accordance with the applicable criteria using the scoring methodology (as shown in Appendix A and B) and the pre-requisite requirements on the level of

building performance as specified in this Standard. Under this assessment framework, points are awarded for incorporating sustainable design features and practices, which would add up to a final Green Mark Score. Depending on the level of building performance and Green Mark Score, the building development will be eligible for certification under one of the four rating namely BCA Green Mark Certified, Gold, Gold Plus or Platinum (see Table 5.2). The design of the building development shall also meet all the relevant mandatory requirements regulated under Part IV of the Building Control Regulations 2003.

The Green Mark score of the building design is the total of all the numerical scores (i.e. Green Mark points) assigned based on the degree of compliance with the applicable criteria. The following table states the corresponding Green Mark Score to the respective Green Mark rating and the pre-requisite requirements to attain the BCA Gold Plus and Platinum Rating.

Green Mark Score	Green Mark Rating
90 and above	Green Mark Platinum
85 to < 90	Green Mark Gold Plus
75 to < 85	Green Mark Gold
50 to < 75	Green Mark Certified

Residential Building Criteria

a) Building envelope design with Residential Envelope Thermal Transmittance (RETV) computed based on the methodology and guidelines stipulated in the Code on Envelope Thermal Performance for Buildings and this Standard.

Green Mark Gold Plus – RETV of 22 W/m^2 or lower

Green Mark Platinum – RETV of 20 W/m^2 or lower

b) To be eligible for Green Mark Platinum Rating, ventilation simulation must be carried out to identify the most effective building design and layout. The simulation results and the recommendations derived are to be implemented to ensure good natural ventilation. Details and submission requirements on ventilation simulation can be found in Appendix C of this Standard.

Non-Residential Building Criteria

a) Air-Conditioned Buildings

Building envelope design with Envelope Thermal Transfer Value (ETTV) computed based on the methodology and guidelines stipulated in the Code on Envelope Thermal Performance for Buildings and this Standard.

Green Mark Gold Plus – ETTV of 42 W/m2 or lower

Green Mark Platinum – ETTV of 40 W/m2 or lower

To demonstrate the stipulated energy savings over its reference model using an energy modelling framework set out. Details and submission requirements on energy modelling can be found in Appendix D of this Standard.

Green Mark Gold Plus – At least 25% energy savings

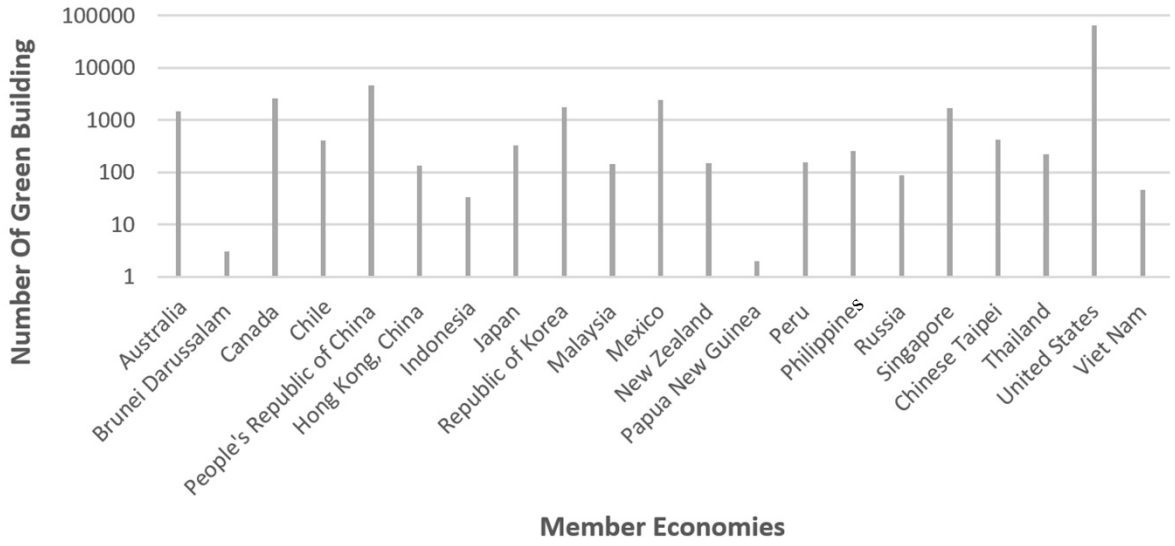
Green Mark Platinum – At least 30% energy savings

b) Non Air-Conditioned Buildings

To be eligible for Green Mark Platinum Rating, ventilation simulation must be carried out to identify the most effective building design and layout. The simulation results and the recommendations derived are to be implemented to ensure good natural ventilation. Details and submission requirements on ventilation simulation can be found in Appendix C of this Standard.

2.2 Achievement of the GB in APEC region

In recent five years, GB in APEC region develops rapidly. According to the statistical data of a variety of GB evaluation system such as LEED and three-Star rating system, GB in most APEC member economies developed at an alarming speed every year. With the increase of GB, the energy consumption required for GDP growth will drop correspondingly. Take China as an example, during the “11th five-year plan” period of China, Chinese GB demonstration area reached 13,000,000m2, the accumulative total GDP energy consumption fell 19.1%, the building energy saving contributed 20% of the energy saving.



The development characteristics of GB in APEC area can be discovered from the figure above. GB has and will still have a great potential for development in APEC area. According to research, APEC has 81108 GBs up to now, which only occupies a very small proportion in the overall current buildings. Therefore, it is very important to continue to promote the development of green buildings with cost-effective energy solutions.

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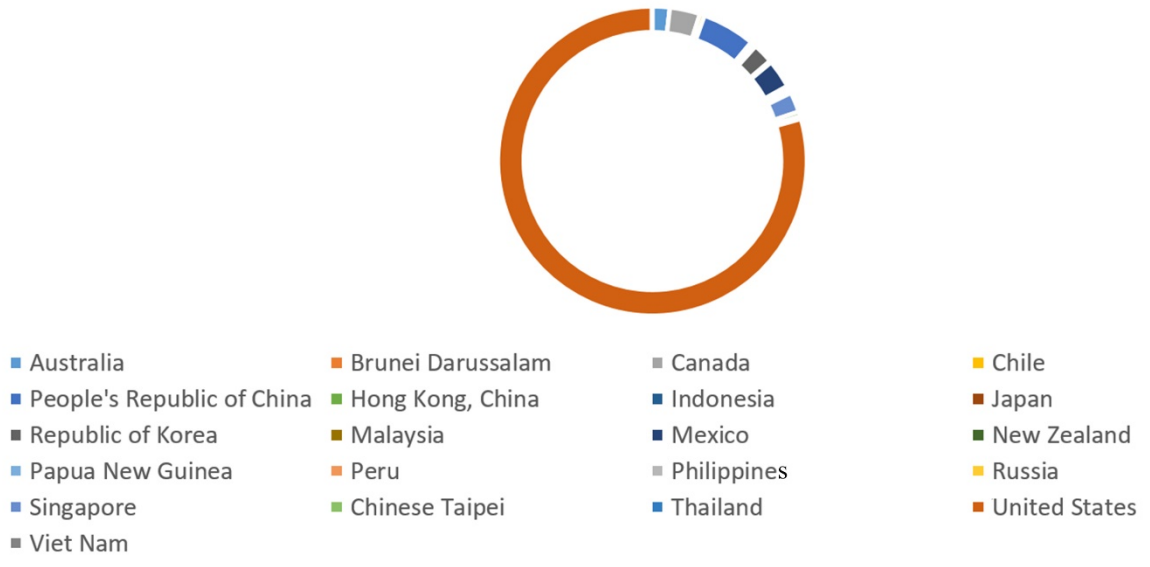

Also, unbalanced regional development of GB also existed in APEC region. In fact, there are huge differences in the development level of GBs among different member economies. As shown in the figure above, counted by economies, the United States ranks the first, accounting for nearly three quarters of the total, and it is followed by China. But it only accounts for nearly 5% of the total. The

development of GBs usually reflects the economic situation of one economy. The number of GBs with high economic development level is obviously higher than that of low economic development level.

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Session II: Critical barriers for the development of GB with cost-effective renewable energy supply solutions in the APEC region

Although GB have been advocated in the APEC region to address sustainability issues, their adoption is still plagued with barriers. Green building is considered “the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's lifecycle”. It has been viewed as an effective alternative to traditional building, which has a significant role in reducing or eliminating the negative impacts of construction activities on the environment and climate change. GB with cost-effective renewable energy supply solutions still face challenges in APEC region. What are the stumbling blocks that prevent the GB market from growing and expanding? There is a need to better understand the barriers to the implementation of green building to help find ways and means to overcome them. Previous studies have investigated the barriers hindering the development of green building in APEC region. For instance, cost, implementation time, and the shortage of knowledge and awareness of GB are well-documented in previous research.

According to the author’s knowledge, below are some current barriers for development of GB with cost-effective renewable energy supply solutions in part of APEC member economies:

Australia	1. Lack of government incentives; 2. Lack of knowledge and experience; 3. Lack of building codes and regulations; 4. Poor relationship between stakeholders.
United States	1. First cost premium; 2. Long payback periods; 3. Tendency to maintain current practices; 4. Limited subcontractors’ knowledge and skills; 5. Higher costs of green products and materials.
Singapore	1. Higher costs of green equipment and materials; 2. Lack of interest and communication amongst project team members; 3. Lack of research; 4. Lack of interest from clients and market demand; 5. Lengthy preconstruction process; 6. Uncertainty with green equipment and materials.
Hong Kong, China	1. Higher upfront costs; 2. Lack of education; 3. Lack of incentives;

	4. Lack of awareness.
New Zealand	1. Cost and lack of information
Malaysia	1. Lack of knowledge and expertise; 2. Lack of incentives; 3. Lack of databases and information.
China	1. Higher costs; 2. Lack of demand from clients; 3. Unavailability of sustainable materials and products; 4. Lack of information and awareness; 5. Inadequate expertise.
Indonesia	1. Inadequate knowledge and information; 2. Lack of awareness; 3. Negligence; 4. Lack of building management role i.e. exemplary behaviors; 5. Lack of supervision (absence of reward and penalty scheme) ; 6. Deficient financial support; 7. Unclear regulations and codes.
Chile	1. Lack of financial incentives; 2. Governmental bureaucracy; 3. Lack of knowledge on sustainable technologies; 4. Lack of environmental concern.

After summarizing the problems encountered in the green development process of various member economies, five key factors that have the potential to hamper the adoption of GB with cost-effective renewable energy supply solutions in APEC region were identified. The primary barriers to GB development as higher costs, lack of government incentives/supports for implementing GB, lack of knowledge and awareness, lack of professional capabilities/designers and lack of availability of green materials and equipment.

3.1 Higher costs

The first crucial barrier for the development of GB with cost-effective renewable energy supply solutions is higher cost. Recently, a questionnaire survey study involving green building designers in APEC member economies including in Singapore, Hong Kong, China and the US showed that higher cost was an undeniable barrier holding back GB survival in the construction market.

As expected, ‘higher costs of GB’ was ranked high amongst the barriers to implementing GB in most of APEC member economies. The high criticality of cost in inhibiting the widespread adoption of GBTs is supported by the literature. Although many GBs can be built at comparable or even lower cost than non-GBs, GB demands the use and integration of new and innovative green technologies that usually cost more than their non-green counterparts, making stakeholders hesitant to implement them. The use of GBTs can increase project cost by 2–7%. In the construction industry, almost every stakeholder shows concern about cost in the first instance when considering the application of new technologies and new norms, which is a very obvious barrier in the field of green technology. The lack of knowledge and understanding of the real costs and benefits of GBTs might be one of the key issues exaggerating the concern about cost.

3.2 Lack of government incentives/supports for implementing GB

“Lack of government incentives/supports for implementing GB” was rated the second most significant barrier in APEC member economies mentioned above, which is justified as it is believed that government’s role in promotion of GB development is unquestionably important. For the adoption of GB development it is important to promote among, and motivate the industry stakeholders, particularly most countries in APEC region where GB is in its infancy.

Lack of government incentives is reported as a major barrier to the implementation of green innovations in other studies as well. Stakeholders would like to see policy makers’ and advocates’ direct intervention in the GBTs market in the form of more effective incentives to support their implementation of GBTs. Reasonable incentives can motivate market stakeholders to pursue GBTs. In some of APEC member economies local governments provide incentives, such as tax credit, expedited permits, and density bonus, to encourage the adoption of GBTs among construction stakeholders. These local governments have tried to prove that even modest incentives can stimulate market interest in GBTs by offsetting the higher cost. However, if stakeholders cannot receive sufficient government support, then it would be difficult for them to bear the higher costs of GBTs. Without sufficient government support, the expected economies of scale in GBTs are difficult to achieve in the current market mechanism.

3.3 Lack of knowledge and awareness of GB

Researchers found that lack of knowledge and awareness of GB with cost effective energy supply solutions was also the main barrier. This lack of knowledge and awareness can be linked to GB research and information gaps in the industry. Researchers have also identified lack of information, lack of reliable GB research, lack of education, and information on the benefits of GB as the obstacles to implementing GB projects in general.

The high rank of this barrier supports the findings of previous research that lack of knowledge and understanding from stakeholders, such as contractors, subcontractors, clients, and structural engineers, is a major barrier to the adoption of green building development in most of APEC member economies. It could be seen that there were no efforts in most of APEC member economies to create awareness programs that specifically target GBTs market opportunities among stakeholders. In practice, non-green thinking still prevails. While GBTs are increasingly capturing the attention of the construction industry, many stakeholders remain unaware of the wide-ranging benefits associated with them. The accumulation and sharing of knowledge is crucial to drive the sustainability agenda in the construction industry. Therefore, a lack of knowledge and awareness of GBTs cannot provide sufficient confidence to encourage most construction stakeholders to adopt GBTs.

3.4 Lack of professional capabilities/designers

Lack of professional capabilities/designers is perceived to be the joint 4th most significant barrier to the adoption of GB that a lack of skilled professionals limits the implementation of GB development. Compared to those traditional ones, GB construction projects require skilled design professionals to handle specialized green and sustainable designs; while the reality in APEC region is that competent and experienced local green design professionals are extremely deficient. The majority of construction professionals are unfamiliar/inexperienced with GB development, and those (very few) who are familiar with GB are either from neighboring countries, or local professionals educated overseas. It is clear that some countries in APEC region is lacking in the expertise necessary for the uptake of own, and tertiary education currently remains focused on conventional methods of construction, rather than providing knowledge of GB development for the future.

On the basis of current situation that shortage of GB education and training efforts in the construction sector, it can be stated that the number of stakeholders who have expertise in GBTs in APEC region is limited. However the complex nature of most GBTs, insufficient technical knowledge and expertise in them would greatly hinder GB successful implementation and development. GB knowledge and experience is the most important organizational factor to implement GBTs on construction projects. Hence, more technically competent stakeholders who are experienced and well versed with currently available GBTs are needed to move forward with the application of GBTs in APEC region.

3.5 Lack of availability of green materials and equipment

Lack of availability of green materials and equipment was ranked fifth in GB development barriers. This risk received a low rank in traditional building construction projects, but a high rank in green ones. This was probably because the green construction industry in APEC region was a young industry and thus the supply of green materials and equipment might be still limited; in contrast, the traditional construction industry had already been fully mature, and thus the common materials and equipment

were more widely available comparatively. This result was also argued that material supply and availability was more critical in green building construction projects compared to traditional building construction projects.

Furthermore, more efforts must be put into the selection of more durable materials for the extension of buildings' lives and to minimize material consumption. It has been widely recognized that adequate material and equipment supply was an important determinant of any successful construction projects, and shortage of material and equipment would jeopardize the success of projects. In APEC region, the majority of construction equipment, materials and even plants designated for green residential building construction projects need to be imported from overseas, which normally requires a long period to be delivered on site.

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Session IV: How to promote the spread and adoption of GBs with cost-effective renewable energy-supply solutions in the APEC region

In fact, GB has risen to be a regional or even worldwide strategic action. All sectors in the APEC region should work together to develop the low carbon buildings, where update of consciousness is the foundation, technology innovation is the key, and appropriate and reasonable incentive is the important measure. For this part of report, we want to express our gratitude to Li et al whose research output provided us great help and inspiration. The promotion plan was summarized from three flowing aspects, including: to enhance the awareness of the stakeholders in APEC region; to strengthen technology research and communication in APEC region; and to increase appropriate and reasonable GB incentives in APEC region. Here, the promotion plan was not a detailed 'plan' that includes some concrete steps for implementing but some recommendations for stakeholders in APEC region to facilitate and accelerate the spread and adoption of the cost-effective renewable energy-supply solutions for green buildings.

4.1 To enhance the awareness of the stakeholders in APEC region

Generally speaking, sustainability development in APEC region can only be achieved by working hand-in-hand with our all stakeholders. As an officer from APEC region once said, "The biggest problem is how to improve energy saving awareness among residents who only care about the price and location when they choose residences". At present, in the process of GB development in part of APEC member economies, e.g. China, GB is mainly constructed by government through several of policies and specific plans. In fact, for most developers, the goal is to pursue profit, but for consumers, they care about good cost performance, whether green or not are none of their business. The social benefits of GB are not awarded, such as energy saving, environmental protection, comfort and low cost, they just have been accepted a bit. More measures must be taken into consideration to enhance awareness of stakeholders, especially the residents.

Firstly, each APEC member economies should further study how investments in GB contribute to a vibrant local economy like jobs, business and tax revenues. The government of APEC member economies can arrange some reports about the concept of GB, and issue statements supporting the economic, environmental and social interests of GB. For example, "air quality, lighting, heat and green building air conditioning and overall can be improved in GB, a more pleasant, healthier and productive place to live. The people who live and work in GB appears be healthier."

Secondly, each APEC member economies can be partner with building industry associations to set up workshops to demonstrate the statement mentioned above. It might present to developers the legal case and business case for GB to increase awareness and strengthen market valuation.

Thirdly, each APEC member economies should launch a communication campaign to inform developers and building owners or tenants that GB offers a higher net operation income, thus increasing the value of the building, offering lower operating costs and improving image in the community.

4.2 To strengthen technology research and communication in the APEC region

Lack of knowledge and backward of technology have become an obstacle to the GB development in most of APEC member economies. Key technologies, e.g. cost-effective renewable energy supply solutions, for GB are insufficient and bottlenecks for GB. Even now, most member economies of APEC including China does not have a complete technology system on GB construction. Rapid transformation of energy-saving construction market depends on new technologies particularly. Lots of institutions based on APEC region support research and development of energy-saving technology, however, many innovative technology are still in research stage and have not yet been commercialized due to lack of effective platform to promote, demonstrate and communicate new technologies. Meanwhile, part of APEC member economies and some non-APEC economies in other region have achieved great results in GB technology research, and complete technology systems have already formed during long time development, so we have to strengthen the technology research and communication with these economies to get valuable experience, only then can we get most in shortest time.

Each APEC member economies should continue to support energy saving technology research and development to promote technical communication, so as to improve the commercial level of innovative energy-saving technologies and market penetration ability; Institute and university in APEC region should strengthen the research, demonstration and test of innovative energy-saving technologies. In particular, stakeholders in APEC region should focus on the development of utilization technology of cost effective new energy and renewable energy supply solution to accelerate intelligent construction development. The development potential of green building with cost-effective renewable energy supply solutions is great, so it is considered to be a very important industry in APEC region.

4.3 To increase appropriate and reasonable GB incentives in the APEC region

To improve the effectiveness of incentives in promoting green building, strategies have been suggested in various studies. It could be seen that the government is more involved in providing incentives (financial and non-financial) than the private sector. However, it has been pointed out that the private sector including developer, owner and tenant also have significant roles, even as much as the government, in providing incentives for green building.

For most of APEC member economies including China, incentive policies to promote development of GB are insufficient in current stage. Incentive policies on finance, tax and economy are not sound, related sectors cannot get strong internal motivations to develop GB. Although there are some incentive

policies related to building energy saving, water saving and environmental protection tax, there is not specific policy for green building tax or finance. Real estate developers cannot get any incentives in terms of land acquisition, project examination and approval, finance when develop GB; Encouragement Measures are not evident when consumers purchase GB; so GB cannot realize a dominant demand in market. Efforts are necessary to set more incentive tools at the right level to improve energy saving and GB ratio.

To developers in APEC region: Taking China as example, in the current property rights regime in China, the land was owned by the government or collective. The developer has to pay an amount to government for land use right. To promote GB development, member economies similar to China could pay back a portion of money to developer if building turns out to be a GB. These member economies can model itself following the United States to grant reduced construction fees for projects which earn GB star label, where the fee cost varies as the label level. This would be an effective way to promote the developer take action to make buildings green.

To owner and tenant in APEC region: The incentives to the owner and tenant are also necessary. If tenant prefers to live in the energy-efficient buildings or consumer is inclined to choose GB, it will push the real estate industry to meet GB standard. But most people care about price when buy or rent GB because it is more expensive than the normal building. How to solve this problem? The answer lies in direct economic incentives, such as tax reduction. Government of APEC member economies can consider granting some tax reduction to people who purchase GB. However, this way may not be effective for the tenant for the short lease. The price, position and operating costs of houses are concerned with tenants. It might be effective to follow the energy certification approach of EU when a house is for rent. An energy performance certification must be made available to the tenant.

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