Acknowledgements

This inaugural Building Energy Benchmarking Report 2014 is published by the Building and Construction Authority (BCA) of Singapore to share analytical findings from the 2013 building energy benchmarking data. The building information and energy consumption data were collated from the annual mandatory submission of building information and energy consumption data, a new key requirement under the Building Control (Amendment) Act 2012. A panel of technical consultative members comprising representatives from the government, industry and academia, were engaged for their feedback on this report.

We would like to express our gratitude to the members of the Technical Consultative Panel for their valuable insights:

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Mr. Lam Siew Wah [Deputy CEO, Industry Development, BCA]

Panel Members:
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Leong-Kok Su Ming [Director] • Toh Eng Shyan [Director] • Thomas Pang [Senior Manager] • Kong Jia Hng [Senior Manager] • Leow Yock Keng [Senior Manager] • Benjamin Huang [Executive Manager] • Lim San Teng [Executive Manager] • Wee Kai Siong [Executive Manger]

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Climate change has caused extreme weather conditions to be experienced worldwide. We all have a role to play in mitigating climate change by reducing carbon emissions. Singapore’s building sector consumes up to 38% of the nation’s electricity. With a focus on addressing the environmental impact caused by buildings, the Building and Construction Authority (BCA) of Singapore formulates and charts green building policies to track and improve the energy efficiency of the built environment in Singapore under our Green Building Masterplan. These policies have met with much success, helping to trigger a green movement in the built environment sector, not just in Singapore, but also the region.

Riding on this green wave, we rolled out our landmark legislation for existing buildings under the Building Control Act in Dec 2012, to mandate environmental sustainability standards and monitor the overall energy performance of our building stock. For a start we targeted the commercial building stock comprising offices, hotels, retail buildings and mixed developments as they are the higher energy consumers within the building sector. Building owners are required to submit their buildings’ information and energy consumption data annually through our online submission portal, Building Energy Submission System (BESS) since 1 July 2013. The submitted data is analysed to better understand the commercial buildings’ energy consumption trends and help shape policies to improve building energy efficiency going forward.

In this inaugural publication, we are sharing highlights of the findings drawn from the first year’s data collected by BESS. With the building energy benchmarks, building owners will now be able to compare their buildings’ performances against similar building types and proactively improve their buildings’ energy efficiency. This report will be focusing on electricity consumption of commercial buildings. The Energy Utilisation Index (EUI) of commercial buildings has improved over the years based on analysed trending. The EUI data also show that Green Mark commercial buildings are more energy efficient than non-Green Mark commercial buildings. With this on track, focus has now shifted to building occupants and tenants as data showed their contribution to be 50% of the total electricity consumption in the buildings. In addition, we are profiling the top 10 better energy performers of each commercial building category to showcase building owners’ efforts in advocating and adopting green practices in their buildings, and to highlight the strong business case and energy savings potential for green buildings.

With the enabling strategies under our Green Building Masterplans, and continuous monitoring of the buildings’ energy efficiency. I am confident that we are on track to achieve our national target of greening 80% of Singapore’s building stock by 2030, and sustaining a low carbon, high quality built environment for everyone.

Dr. John Keung
Chief Executive Officer
This inaugural issue of the BCA Building Energy Benchmarking Report is a new milestone in BCA’s unrelenting drive to enhance Singapore’s energy resilience and achieve the national target of greening of 80% of the country’s building stock by 2030.

The Building Control (Amendment) Act 2012 provides the means for BCA to collect and analyse building information and energy consumption data which forms the basis for energy consumption monitoring and national benchmarking for buildings in Singapore.

The information provided is intended to spur stakeholders at all levels to initiate and implement improvements in building energy efficiency, individually or collectively.
Why Singapore Needs Building Energy Benchmarking

The national building energy benchmarks provided in this inaugural report will benefit key stakeholders in many ways:

**The Government**
- means to monitor energy consumption and efficiency of buildings
- insights to formulate measures to reduce the impact of buildings on the environment

**Building Owners, Facilities Managers & Tenants**
- awareness of the energy performances of their buildings
- information to take necessary steps to improve energy efficiency of buildings

**Consultants & Designers**
- new ideas, designs and best practices in designing/retrofitting a green building

**Research & Education Communities**
- research and studies using shared data to further advance green building technologies and solutions for the future
Implementation of Legislation: A Concerted Effort to Success

In December 2012, a new legislation for existing buildings was enacted. One of the requirements mandated building owners to complete the annual submission of their building information and energy consumption data through BCA’s online submission portal, Building Energy Submission System (BESS). For the first year, commercial buildings consisting of offices, hotels, retail buildings and mixed developments were targeted to complete the submission. The overall period of submission was between 1 July and 31 December 2013. In addition, BCA supported with extensive public outreach efforts to drive submissions.

Operational Challenges Faced

To address the challenge of securing credible and quality data, energy consumption data were obtained directly from utilities suppliers, while building information was furnished by building owners. The following were some of the challenges encountered during the process:

- Lack of informative system-generated reports for building owners and policy makers by BESS
- Building owners’ unfamiliarity with the information required by legislation
- Building owners’ oversight leading to data entry error in the submission
- Inadequate knowledge of terminology used for technical fields in BESS submission form
- Lack of up-to-date contact information of targeted building owners

BESS performed optimally throughout the first year of submission with data smoothly extracted for the purpose of analysis. Moving forward, the system will be enhanced to improve the submission process and the quality of data submitted by the building owners through more engagement and education.
Key Findings and Observations

Submission Compliance Rate: 99%

Number of Buildings Included In This Report

Existing buildings

884

Equivalent to 92% compliance as of 31 December 2013

Commercial Buildings Gross Floor Area (GFA)

Type of Air-conditioning Systems Used

- Larger commercial buildings with ≥15,000 m² of GFA commonly used the water-cooled chilled water plants air-conditioning system due to its high load capacity and good efficiency
- Smaller buildings (<15,000 m²) generally preferred split-units or unitary air-conditioners due to their lower cooling demand and greater occupant control over the operation of the air-conditioning system

General Electricity Consumption Patterns

- Between 2008 and 2013, there was a yearly increase in electricity consumption for commercial buildings. This increase was largely attributed to the increase in the commercial building stock, as the rate of GFA growth was higher at 20% in comparison to the increase in total annual electricity consumption at 14% over the five-year period.
- Energy utilisation index (EUI) has also improved by 5% over the five-year period, attributed to the energy efficiency improvement works conducted by 279 commercial buildings.
- Tenants of commercial buildings are significant electricity consumers, consuming as much as their building owners

Existing buildings

- Offices: 52%
- Hotels: 16%
- Retail Buildings: 24%
- Mixed Developments: 8%

Equivalent to 92% compliance as of 31 December 2013
National Building Energy Benchmarks

Energy Utilisation Index (EUI) of Commercial Buildings

- Among the four main commercial building types, retail buildings recorded the highest median EUI at 405 kWh/m².yr. This could be attributed to the wide variety of tenant mix and the design concept of retail shops, which require higher lux levels to enhance the appeal of their products.

- Hotels recorded a lower median EUI at 292 kWh/m².yr. Compared to retail buildings, hotels demand a lower cooling load due to the lower human density and stable occupancy rate within its premises.

- Offices had the lowest median EUI at 218 kWh/m².yr. This low EUI was due to shorter operating hours and stable operations with a fairly fixed occupancy rate.

The table below shows four quartiles of the range of EUIs obtained for the four major building types gathered from the 783 commercial developments that were benchmarked. This information allows building owners to evaluate their buildings’ energy performance.

<table>
<thead>
<tr>
<th>EUI by Building Type (kWh/m².yr)</th>
<th>Top Quartile (1%-25%)</th>
<th>2nd Quartile (26%-50%)</th>
<th>3rd Quartile (51%-75%)</th>
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<td>405 - 554</td>
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<td>Mixed Developments</td>
<td>212</td>
<td>212 - 264</td>
<td>264 - 357</td>
<td>&gt; 357</td>
</tr>
</tbody>
</table>
Green Mark Commercial Buildings Perform Better Than Non-Green Mark Commercial Buildings

- The average EUI of Green Mark commercial buildings was lower than the average EUI of similar non-Green Mark commercial buildings.

- The average EUI of Green Mark commercial buildings ranged from 16% lower for offices, to 7% lower for retail buildings and 5% lower for hotels.

### Average EUI Comparison Chart

<table>
<thead>
<tr>
<th></th>
<th>Offices</th>
<th>Hotels</th>
<th>Retail Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Green Mark</td>
<td>271</td>
<td>309</td>
<td>527</td>
</tr>
<tr>
<td>Green Mark</td>
<td>228</td>
<td>295</td>
<td>492</td>
</tr>
</tbody>
</table>

- Officess
- Hotels
- Retail Buildings

Green Mark Commercial Buildings are more energy efficient than non-Green Mark Buildings.
Case Studies: Four Green Mark Commercial Buildings

Out of the top 10 commercial buildings, four Green Mark buildings were identified as case studies for this report. The case studies focus on the adoption of energy efficient (EE) solutions and the economic benefits reaped through its energy savings.

<table>
<thead>
<tr>
<th>Building Name</th>
<th>Health Promotion Board HQ</th>
<th>Maptree Business City</th>
<th>Novotel Singapore Clarke Quay</th>
<th>International Plaza</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Use</td>
<td>Public Office</td>
<td>Private Office</td>
<td>Hotel</td>
<td>Mixed Development</td>
</tr>
<tr>
<td>Years in Operation</td>
<td>18</td>
<td>4</td>
<td>31</td>
<td>38</td>
</tr>
<tr>
<td>Certification</td>
<td>Green Mark Platinum</td>
<td>Green Mark Platinum [re-certification]</td>
<td>Green Mark GoldPLUS</td>
<td>Green Mark GoldPLUS</td>
</tr>
<tr>
<td>GFA (m²)</td>
<td>32,148</td>
<td>183,900</td>
<td>26,546</td>
<td>137,948</td>
</tr>
<tr>
<td>Electricity Savings (kWh/yr)</td>
<td>1,100,939</td>
<td>15,020,093</td>
<td>2,839,852</td>
<td>2,115,007</td>
</tr>
<tr>
<td>Years to Recoup EE Costs</td>
<td>7.7</td>
<td>6</td>
<td>7.2</td>
<td>6.4</td>
</tr>
<tr>
<td>Project Details</td>
<td>Utilised Guaranteed Energy Savings Project (GESP), an initiative under the Public Sector Taking the Lead in Environmental Sustainability (PSTLES) programme, to improve the building’s energy efficiency</td>
<td>Proven sustainable green building design and good operational practices</td>
<td>Demonstrated collective effort between Mapletree and office occupants in maintaining optimal building energy efficiency</td>
<td>Tapped into BCA’s Green Mark Incentive Scheme for Existing Buildings (GMIS-EB) to enjoy funding support for the energy efficient retrofits</td>
</tr>
</tbody>
</table>
Singapore’s Green Buildings: The Journey Thus Far

In recent years, there has been a higher take-up rate for Green Mark buildings locally. Here are the facts and figures:

- **90%** approximated overseas Green Mark projects in Malaysia, China, Indonesia and Vietnam.
- **60%** average year-on-year growth from 2008 to 2013.
- **>2,100** buildings (GFA ≈ 62 million m²) awarded Green Mark certification to date.
- **>250** overseas projects applied for Green Mark certification from 2005 to July 2014.
- **>25%** national target achieved to date of ‘greening’ 80% of Singapore’s building stock.
Key Challenges to Meet the National Target of Greening 80% by 2030

Although it is well established that retrofitting buildings for higher EE results in increased capital value of the property, and that savings achieved after the retrofits could pay off the cost of the projects typically in three to eight years, key barriers include:

(i) Competing uses of capital
Building owners could have non-energy efficiency related projects that achieve higher rates of return than that of energy efficient projects, consequently placing less priority on improving the buildings’ EE. This may deter building owners from utilising capital to green their buildings.

(ii) High upfront costs
Without legislation and financial incentives, building owners are more unlikely to bring forward EE retrofitting works. They are still reluctant to take up loans for EE projects due to the impact of loans on their balance sheets. With this, the momentum of EE improvement is expected to slow down and eventually even hit a plateau.

(iii) Principal-agent issues
Principal-agent problems arising from the split incentives between building owners and their managing agents are still preventing building owners, in particular, the Management Corporation Strata Title (MCST) and Small and Medium Enterprises (SMEs) from undertaking EE retrofits for existing buildings.

(iv) Entrenched business values and behaviours
Deep behavioural adjustments of building occupants and tenants, and changes in business processes are required to achieve more energy reduction over time.

Solutions & Strategies
(i) Review standards and legislations to raise EE levels

(ii) Extend incentive schemes and create innovative financing schemes to help businesses undertake EE retrofits

(iii) Drive concerted research and development efforts to test-bed new technologies, business models and solutions for the tropics

(iv) Step up capability development initiatives

(v) Raise awareness of the importance of sustainable energy consumption behaviour
The Road Ahead

Our Target
Greening 80% of Singapore’s building stock by 2030

Leading The Way: Singapore’s Green Building Masterplan
BCA’s 3rd Green Building Masterplan provides the blueprint of outlining our vision to make Singapore a global leader in green buildings with special expertise in the tropics and sub-tropics, enabling sustainable development and quality living.

The latest Green Building Masterplan is anchored on three strategic goals:

1) Lead - to uphold and advance Singapore’s leadership in green buildings
2) Engage - to engage public and private stakeholders in the green movement
3) Sustain - to address information gap by measuring and monitoring building performance

These goals can be achieved through a suite of measures, such as collecting data and sharing information with industry, disclosing energy performance of buildings, and enhancing current financing schemes to encourage building owners to adopt green retrofits.

What’s Next?
Going forward, BCA will continue to focus on monitoring commercial buildings’ energy performance due to its significant electricity usage.

- The annual mandatory submission will be expanded to other building types such as institutions and healthcare in the next phase
- New $50 million Green Mark Incentive Scheme for Existing Buildings and Premises (GMIS-EBP) to encourage building owners and tenants to adopt of EE improvements within their buildings and premises.
- Greater emphasis will be placed on the tenants’ consumption through the existing occupant centric Green Mark schemes and green partnerships
Singapore’s Commercial Building Stock

Singapore is a city state with a population of 5.4 million and a total land area of about 716 km². Energy efficiency is an integral part of the country’s policy planning. An Inter-Ministerial Committee on Sustainable Development (IMCSD) was set up in 2008 to:

1. formulate a national strategy for Singapore’s sustainable development, and
2. manage the growing energy demands of the built environment

In 2009, IMCSD set a national target to green at least 80% of Singapore’s building stock by 2030.

The country’s high temperature (between 25°C and 33°C) and relative humidity (mean value of 84%) has resulted in a high demand for air-conditioning in commercial buildings to provide optimal thermal comfort for building occupants.

Given the need for more cooling, commercial buildings are thus the higher energy consumers within the building sector, taking up about 38% of the nation’s total electricity consumption in 2012.

Therefore, there is a greater need to first focus on the energy efficiency of commercial buildings.
Background
The 1st and 2nd Green Building Masterplans were rolled out by BCA to stimulate the growth of the nation’s green building stock. They included a comprehensive suite of initiatives, comprising policy levers, guidelines and standards as well as incentives for the development of green buildings. With these efforts, the stock of green buildings jumped from 33 in 2006 to over 2,100 in July 2014.

Riding on the earlier successful implementation of the various green building initiatives, the 3rd Green Building Masterplan was developed with a vision to develop Singapore as

“A global leader in green buildings with special expertise in the tropics and sub-tropics, enabling sustainable development and quality living”.

The 3rd Green Building Masterplan

Three Key Strategic Goals
The 3rd Green Building Masterplan has been structured to focus on three key strategic goals:

**Lead**
Builds on BCA’s continual leadership and support of the green building advancement in the region.

**Engage**
Focusses on the Government taking a greater lead in championing change, with emphasis on collaborative efforts to raise community involvement.

**Sustain**
Monitors energy consumption, demonstrates building energy performance, shares relevant information to ensure continued building energy compliance to higher standards, improving the quality of the built environment and occupant well-being.
LEGISLATION FOR EXISTING BUILDINGS

Annual Mandatory Submission of Building Information and Energy Consumption Data

Effective July 2013, one key requirement under BCA’s legislation for existing buildings mandates building owners to participate in the Annual Submission of Building Information and Energy Consumption Data (under Section 22FJ of the Building Control Amendment Act 2012).

Data collection was carried out in stages, starting with commercial buildings for offices, hotels, retail buildings and mixed developments.
BESS provides the seamless submission process to enable building owners to submit the required information online conveniently.

- For the first year, building owners are required to provide all necessary information.

- For subsequent years, building owners are only required to update their building information online annually, if there are changes.

- BESS streamlines the online submission process by extracting the previous year’s monthly electricity consumption data of targeted buildings directly from utility suppliers.

www.bca.gov.sg/bess
Public Outreach Efforts
Extensive communication platforms were established to reach out to key stakeholders so as to ensure successful implementation of the nation-wide data collection exercise. Outreach efforts included:

- A series of industry briefing sessions to share the objectives and processes of the annual mandatory submission with building owners (BO) and their building submission representatives (BSR) to prepare them for the official submission of data. BSRs include representatives such as the Management Corporation Strata Title (MCST), managing agents and facilities managers.
- Exhibition booths and information banners were set up at strategic public locations to create awareness of the implementation of the new legislation.
- A training video was also produced to inform BOs on the aims of the landmark legislation and encourage action. The video, together with other self-help tools, were made available under ‘useful links’ at www.bca.gov.sg/bess.

Support & Assistance
A dedicated team was mobilised to provide assistance to the BOs and BSRs through hotlines, emails and one-to-one consultations throughout the submission period.

Site visits were made where no response was received to ensure that the targeted BOs were informed of the new requirement and took action to complete the submission.
The Target
About 1,000 commercial buildings in Singapore’s building stock were targeted to complete annual mandatory submission from 1 July 2013.

$\approx 1,000$

Offices, Hotels, Retail Buildings and Mixed Developments

99% * Overall Compliance

92% = 884 Buildings Analysed

* The full list of submitted commercial buildings can be found at https://www.bca.gov.sg/BESS/UsefulLinks/UsefulLinks.aspx
Percentage Breakdown of 884 Commercial Buildings

- Offices: 47%
- Hotels: 28%
- Retail Buildings: 19%
- Mixed Developments: 6%

Total Gross Floor Area (GFA) Recorded At 18.6 million m²

- Offices: 52%
- Hotels: 16%
- Retail Buildings: 24%
- Mixed Developments: 8%
Growth of Commercial Building Stock
The submitted data revealed that 400 commercial buildings, comprising offices, hotels, retail buildings and mixed developments were constructed between 1980 and 2000, when the nation was focusing on driving economic growth.

No. of Commercial Buildings by Year of Completion (TOP) & Building Type

GFA by Year of Completion (TOP) & Building Type
Type of Air-conditioning Systems Used
Information on the air-conditioning system and data on the building’s electricity consumption were collected to better monitor its energy efficiency.

Key observations:
• Generally, larger commercial buildings (GFA ≥15,000 m²) favoured centralised air-conditioning systems, particularly the water cooled chilled water plants.

• Smaller commercial buildings (GFA <15,000 m²) preferred split-units and unitary air-conditioning systems.

• Centralised air-conditioning systems are generally selected when the building has a high cooling demand with extended but stable operating hours. These are also preferred by the building’s facilities management team as they can be controlled and scheduled via a building management or automation system.

• Of the centralised plants, water cooled chilled water plants are typically preferred over air cooled chilled water plants as they are more energy efficient and can maintain their efficiency over time.

• Split-units and unitary air-conditioning systems are usually chosen for building with uneven cooling demand as they can be operated individually to give more control flexibility to the occupants of the building. These systems also offer lower capital costs and are less space intensive. They are, however, less energy efficient than central cooling systems.

Type of Air-Conditioning System Usage by Size
The Findings: Trend of Electricity Consumption for Commercial Buildings

The total electricity consumption for a commercial building is a critical piece of information needed for accurate benchmarking of the building’s energy performance, as electricity is the main source of energy for buildings in Singapore. As such, energy utilisation index (EUI) will only focus on electricity consumption. Data collection was a challenge for multi-tenanted buildings as some tenants purchased their own electricity and were separately metered from the landlord’s account. BCA overcame this challenge when it was empowered under section 22FJ of BCA Building Control Act to secure required data directly with Singapore’s utility providers who could provide extensive and accurate databases of the total electricity consumption data for whole buildings.

Key observations:
- The total annual electricity consumption has been increasing yearly.
- This rise appears to have been largely driven by the increase in the number of commercial buildings over the years, as highlighted in the section “Growth of Commercial Building Stock”.
- It is noted that the 14% increment for total annual electricity consumption was lower compared with the rate of GFA growth of 20% in the five-year period from 2008 to 2013.
The Findings: Trend of Energy Utilisation Index (EUI) of Commercial Buildings

An analysis was conducted on the EUI of commercial buildings to study their overall energy performance between 2008 and 2013.

Key observations:

- There was a 5% improvement in EUI over the five-year period. This could be attributed to energy efficiency improvements in the buildings.

- Out of the 884 commercial buildings, 162 are Green Mark buildings, four of which are showcased under the “Business Case of Green Buildings” section in this publication.

- Of the 162 Green Mark buildings, 41 buildings underwent energy efficient retrofits during this five-year period and achieved a 16% improvement in EUI.

- Another 117 non-Green Mark buildings also underwent upgrading and retrofitting of the air-conditioning system (chillers; split-units; AHUs and FCUs) and collectively improved their EUI by 11%.
The Findings: Building Owners’ and Tenants’ Electricity Consumption Relationship

Typically, building owners own and operate the centralised air-conditioning system, common facilities such as lifts and escalators, as well as mechanical ventilation fans, lighting and plug loads in the common areas.

To achieve the most substantial electricity savings, BCA has been engaging the building owners to improve their buildings’ energy efficiency and reduce carbon emissions to the environment. Riding on the successful adoption of green practices by building owners, the focus has now shifted to include tenants and occupants within the buildings. Building occupants generally account for a significant percentage of the building’s electricity usage.

To further analyse the building owners’ and tenants’ electricity consumption pattern, the overall buildings’ electricity data were segregated into building owners’ and tenants’ consumption.

Key observations:
- Building owners and tenants account for approximately an equal share of the total buildings’ electricity consumption.
Impact of Findings

• In view of the tenants’ significant share of the overall electricity consumption, both building owners and tenants need to work together to achieve optimal energy consumption reduction for the entire building.

• **Tenants can take a more active role** in improving the energy efficiency performance within their premises.

• To encourage an active pursuit of sustainability among building occupants and tenants, BCA launched various occupant-centric Green Mark Schemes targeting different types of tenants. These include Green Mark for office interiors, restaurants, supermarkets, retail and data centres.

• As office buildings make up a significant percentage of the commercial building stock’s GFA in Singapore, sustainable design and operation of an office are paramount to improve energy efficiency and reduce the carbon footprint of offices.

• Building owners can further engage tenants to operate and maintain the building’s sustainability performance through the adoption of green leasing practices. These specify the building owners’ and tenants’ commitments to jointly minimise environmental impact in their daily operations.
DATA ANALYSIS AND ENERGY BENCHMARKING

The data collected on building information and energy usage were processed and analysed to yield:

- Comprehensive and detailed information for benchmarking and monitoring of building energy performance.
- Deeper understanding of the operational use behaviour of different building types, as well as analytics to meaningfully compare energy usage of buildings which have been incorporated with energy efficiency measures (including Green Mark buildings) against buildings which have not undergone energy efficiency improvements.

The building energy benchmarking results are shared with building owners through two platforms:
1. Building Energy Submission System, and
2. The BCA Building Energy Benchmarking Report 2014

This information is aimed at raising building owners’ awareness and spurring action in reducing energy consumption through:

1. Low or no cost energy use behavioural changes;
2. Green retrofits to improve the overall buildings’ energy performances in the long term; and
3. Engaging tenants/occupants through the sharing of information and gaining their collaboration in energy efficiency improvement efforts to reap optimal cost, energy savings and environmental benefits.
Individual Building’s Results of Submitted Data for Commercial Buildings Generated by BESS

One of the key functions of BESS is to help building owners track their electricity use in their buildings by displaying the previous year’s consumption over 12 months, and manage their electricity use as compared to other similar building types.

The reports detail four categories with regard to the building’s energy performance.

The building has a gross floor area (GFA) of 25,631 m². The building’s total electricity consumption is 2,049,804.00 kWh, or 79.97 kWh/m².yr. The EUI is a general efficiency indicator of the building’s electricity usage level. The indicator bar below shows the building’s estimated EUI as compared to similar building activity type.

* EUI = Total Electricity Consumption/ GFA

The chart illustrates the building’s monthly electricity consumption for the previous calendar year.

The chart illustrates the building’s annual total electricity consumption.
Key Benchmarking Findings of Analysed BESS Data

Commercial Buildings in the Benchmarking Exercise
As at 31 December 2013, BESS recorded 884 successful submissions. To achieve a more robust energy benchmarking for buildings, all newly constructed or retrofitted buildings which had not been in operation for a full year in 2013 were omitted. Similarly, the benchmarking exercise excluded buildings on district cooling plants, and mixed developments with electricity consumption that could not be separated as there was no sub-metering. As a result, a total of 783 buildings were used for benchmarking.

Size of Commercial Buildings

351 Offices
- GFA<15,000 m²: 56%
- GFA≥15,000 m²: 44%

230 Hotels
- GFA<15,000 m²: 80%
- GFA≥15,000 m²: 20%

145 Retail Buildings
- GFA<15,000 m²: 51%
- GFA≥15,000 m²: 49%

57 Mixed Developments
- GFA<15,000 m²: 40%
- GFA≥15,000 m²: 60%
The table below shows four quartiles of the range of EUIs obtained for the four commercial building types. This information enables building owners to see where their buildings’ energy performance stand in comparison with other similar building types.

### Energy Utilisation Index by Building Type

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<td>212</td>
<td>212 - 264</td>
<td>264 - 357</td>
<td>&gt; 357</td>
</tr>
</tbody>
</table>
Energy Utilisation Index (EUI) of Office Buildings
A total of 351 office buildings were analysed. Of these, 44% were larger-sized buildings with GFA more than or equal to 15,000 m². Office buildings with higher EUI were generally larger buildings with 24-hour daily operations and large data centres. However, this does not suggest that buildings with longer operating hours or large data centres are energy inefficient. Further studies will be required to establish the correlation between various factors and energy efficiency of a building.

Energy Utilisation Index (EUI) of Hotels
Of the 230 hotels studied, 80% were smaller hotels with GFA less than 15,000 m². It was observed that hotels with higher EUI are older, smaller-sized hotels using split-unit air-conditioning systems. However, this observation does not imply using split-unit air-conditioning systems is energy inefficient for smaller-sized hotels, as other factors such as user behaviour can also contribute to high energy usage.
Energy Utilisation Index (EUI) of Retail Buildings
Of the 145 retail buildings analysed, 51% were smaller retail buildings with GFA less than 15,000 m². It was observed that retail buildings with higher EUI were smaller-sized buildings with long operating hours and using split-unit air-conditioning or air cooled centralised chiller systems. However, this does not result in an energy inefficient building.

Energy Utilisation Index (EUI) of Mixed Developments
For mixed developments, larger-sized buildings with GFA more than or equal to 15,000 m² made up 60% of 57 mixed developments that were studied. Mixed developments with higher EUI were larger-sized buildings with retail components and operate longer hours. Nevertheless, this observation does not mean that mixed developments with retail components and longer operating hours are energy inefficient buildings, as the high energy consumption can be attributed to various factors.
Green Mark Commercial Buildings Perform Better Than Non-Green Mark Commercial Buildings

The average EUI of Green Mark commercial buildings was lower than the average EUI of similar non-Green Mark commercial buildings. The average EUI of Green Mark commercial buildings ranged from 16% lower for offices to 7% lower for retail buildings and 5% lower for hotels.

Average EUI of Green Mark & Non-Green Mark

<table>
<thead>
<tr>
<th>Building Type</th>
<th>No. of Non-Green Mark Buildings</th>
<th>No. of Green Mark Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offices</td>
<td>84</td>
<td>51</td>
</tr>
<tr>
<td>Hotels</td>
<td>50</td>
<td>15</td>
</tr>
<tr>
<td>Retail Buildings</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>149</strong></td>
<td><strong>81</strong></td>
</tr>
</tbody>
</table>

Green Mark and non-Green Mark commercial buildings compared have similar characteristics such as building size, activity types and air-conditioning systems.
Using the first year’s benchmarking result, the top 10 commercial buildings have been identified for each building type based on a comparison of the building’s EUI. These top performers have put in lots of effort to sustain their buildings’ energy performances and serve as exemplary showcases for the building sector to emulate when improving the energy efficiency of their buildings and premises.
Top 10 Offices (Government Buildings) in alphabetical order

<table>
<thead>
<tr>
<th>Building Name</th>
<th>Green Mark Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connection One</td>
<td>Certification in Progress (Platinum)</td>
</tr>
<tr>
<td>Environment Building</td>
<td>Platinum</td>
</tr>
<tr>
<td>Health Promotion Board</td>
<td>Platinum</td>
</tr>
<tr>
<td>JTC Summit</td>
<td>Platinum</td>
</tr>
<tr>
<td>Ministry Of Manpower HQ</td>
<td>Platinum</td>
</tr>
<tr>
<td>Ministry Of Manpower Services Centre</td>
<td>Platinum</td>
</tr>
<tr>
<td>Monetary Authority of Singapore</td>
<td>Not Certified</td>
</tr>
<tr>
<td>Supreme Court</td>
<td>Gold</td>
</tr>
<tr>
<td>Tourism Court</td>
<td>Not Certified</td>
</tr>
<tr>
<td>Treasury</td>
<td>Gold</td>
</tr>
</tbody>
</table>
### Top 10 Offices (Private Buildings) in alphabetical order

<table>
<thead>
<tr>
<th>Building Name</th>
<th>Green Mark Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>AXA Tower</td>
<td>Platinum</td>
</tr>
<tr>
<td>City House</td>
<td>Gold</td>
</tr>
<tr>
<td>Concourse</td>
<td>Platinum</td>
</tr>
<tr>
<td>Equity Plaza</td>
<td>Gold</td>
</tr>
<tr>
<td>Icon @ IBP</td>
<td>GoldPLUS</td>
</tr>
<tr>
<td>Keck Seng Tower</td>
<td>Not Certified</td>
</tr>
<tr>
<td>Keppel Tower &amp; GE Tower</td>
<td>Gold</td>
</tr>
<tr>
<td>Mapletree Business City</td>
<td>Platinum</td>
</tr>
<tr>
<td>Tampines Grande</td>
<td>Platinum</td>
</tr>
<tr>
<td>Tong Eng Building</td>
<td>Platinum</td>
</tr>
</tbody>
</table>
## Top 10 Hotels in alphabetical order

<table>
<thead>
<tr>
<th>Building Name</th>
<th>Green Mark Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copthorne King’s Hotel</td>
<td>GoldPLUS</td>
</tr>
<tr>
<td>Crowne Plaza Changi Airport Hotel</td>
<td>Certified</td>
</tr>
<tr>
<td>Furama Riverfront</td>
<td>Platinum</td>
</tr>
<tr>
<td>Grand Hyatt Singapore</td>
<td>Not Certified</td>
</tr>
<tr>
<td>Holiday Inn Singapore Orchard City Centre</td>
<td>Not Certified</td>
</tr>
<tr>
<td>M Hotel Singapore</td>
<td>Gold</td>
</tr>
<tr>
<td>Novotel Singapore Clarke Quay</td>
<td>GoldPLUS</td>
</tr>
<tr>
<td>Park Avenue, One Rochester</td>
<td>Gold</td>
</tr>
<tr>
<td>Regent Singapore</td>
<td>GoldPLUS</td>
</tr>
<tr>
<td>Swissotel Merchant Court</td>
<td>Platinum</td>
</tr>
</tbody>
</table>
### Top 10 Retail Buildings

*in alphabetical order*

<table>
<thead>
<tr>
<th>Building Name</th>
<th>Green Mark Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bukit Timah Plaza</td>
<td>Gold</td>
</tr>
<tr>
<td>City Square Mall</td>
<td>Platinum</td>
</tr>
<tr>
<td>Ngee Ann City</td>
<td>Certification in Progress</td>
</tr>
<tr>
<td>OG Orchard Point</td>
<td>Not Certified</td>
</tr>
<tr>
<td>Parklane Shopping Mall</td>
<td>Not Certified</td>
</tr>
<tr>
<td>Parkway Parade</td>
<td>Platinum</td>
</tr>
<tr>
<td>Plaza Singapura</td>
<td>Gold</td>
</tr>
<tr>
<td>The Star</td>
<td>Gold</td>
</tr>
<tr>
<td>Wisma Atria Shopping Centre</td>
<td>Not Certified</td>
</tr>
<tr>
<td>Building A*</td>
<td>Not Certified</td>
</tr>
</tbody>
</table>

* Building owner is not ready to be identified
## Top 10 Mixed Developments
in alphabetical order

<table>
<thead>
<tr>
<th>Building Name</th>
<th>Green Mark Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adelphi</td>
<td>Not Certified</td>
</tr>
<tr>
<td>Atrium @ Orchard</td>
<td>Gold</td>
</tr>
<tr>
<td>Concorde Hotel &amp; Shopping Mall</td>
<td>Not Certified</td>
</tr>
<tr>
<td>HarbourFront Centre</td>
<td>Platinum</td>
</tr>
<tr>
<td>International Plaza</td>
<td>GoldPLUS</td>
</tr>
<tr>
<td>Mitsubishi Electric Building</td>
<td>Platinum</td>
</tr>
<tr>
<td>Palais Renaissance</td>
<td>Platinum</td>
</tr>
<tr>
<td>Tang Plaza</td>
<td>Certification in Progress</td>
</tr>
<tr>
<td>United Square</td>
<td>Not Certified</td>
</tr>
<tr>
<td>Wheelock Place</td>
<td>Gold</td>
</tr>
</tbody>
</table>
BCA, in partnership with the industry and academia, carried out two key studies on:

1. 54 retrofitted commercial buildings
2. The valuation of retrofitted green buildings

These studies aim to highlight the tangible and intangible benefits of a retrofitted green building, which include:

- a reduction in energy consumption and operating expenses for building owners
- increment in capital value for these buildings

**Study on Retrofitted Commercial Buildings**
Following a previous study that was published in 2013 on 40 retrofitted commercial buildings, BCA enlarged the pool of retrofitted buildings to 54 to include commercial buildings which completed Green Mark assessment in 2013.

The latest data revealed the following:

- Chiller plant retrofits continued to improve chiller plants’ operating efficiency by an average of 38%, from 1.05 kW/RT to 0.65 kW/RT.

- Along with other energy improvement retrofits, there was an average total annual electricity savings of 16%. The additional 14 commercial buildings contributed an additional 30 GWh of total electricity savings per annum, increasing the combined total electricity savings of retrofitted existing buildings to 120 GWh per annum. This amounts to about S$30 million in savings each year.

Retrofitted Existing Buildings Save $30 Million

EUI of Retrofitted Existing Buildings

![Graph showing EUI of Retrofitted Existing Buildings](image)

More Insights

Further insights into the EUI and electricity savings were made possible by breaking down the data into the various categories of commercial buildings:

- Retail buildings, offices and mixed developments were shown to achieve an average of 9% to 13% reduction in their annual total building electricity consumption after retrofitting.

- For hotels, the electricity savings were even higher at 21% on the average, as hotels typically operate 24 hours daily, and do not have many tenants within the premises.

### Energy Utilisation Index by Building Type

<table>
<thead>
<tr>
<th>Building Type</th>
<th>No. of Buildings</th>
<th>EUI Before Retrofit [kWh/m².yr]</th>
<th>EUI After Retrofit [kWh/m².yr]</th>
<th>Percentage Improvement</th>
<th>Average Percentage Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail Buildings</td>
<td>10</td>
<td>173 - 362</td>
<td>132 - 302</td>
<td>5 - 17%</td>
<td>9%</td>
</tr>
<tr>
<td>Offices</td>
<td>25</td>
<td>114 - 366</td>
<td>106 - 339</td>
<td>3 - 37%</td>
<td>13%</td>
</tr>
<tr>
<td>Hotels</td>
<td>10</td>
<td>163 - 444</td>
<td>98 - 403</td>
<td>14 – 40%</td>
<td>21%</td>
</tr>
<tr>
<td>Mixed Developments</td>
<td>9</td>
<td>195 - 511</td>
<td>160 - 440</td>
<td>6 – 23%</td>
<td>13%</td>
</tr>
</tbody>
</table>
Chiller Plant Efficiency Improvement

In Singapore’s tropical climate, air-conditioning is an essential service in a commercial building to meet the high cooling demand. Thus, there is a strong business case to retrofit an air-conditioning plant if it is no longer energy efficient. A large portion of the electricity savings is a result of replacement or upgrading to a more efficient central air-conditioning system.

Before retrofitting, the average chiller plant system efficiency of the existing buildings stood at an average of 1.05 kW/RT, which was very inefficient. After the retrofit, the chiller plant system efficiency improved tremendously in the range of 7% – 62% with an average of 38% in improvement. The new chiller plant efficiency for most of the 54 buildings was in the range of 0.6 – 0.7 kW/RT. Such performance standard is comparable to a new building with a Green Mark GoldPLUS or Platinum rating.

Retrofitted Green Buildings Have Higher Value

In 2011, BCA formed a Green Valuation Committee to study the value of retrofitted green buildings. The Committee comprises members from the National University, Royal Institute of Chartered Surveyors (RICS) and six leading real estate consultancy firms, namely CB Richard Ellis (CBRE), Colliers International, DTZ Debenham Tie Leung, Jones Lang LaSalle, Knight Frank, and Suntec Real Estate.

The findings showed that green retrofits and energy savings had a significant and direct impact on the valuation of the building, specifically:

- For retail buildings, an average savings of 13.5% from operating expenses can be achieved, which in turn translates to a 2.7% increase in capital value.

- For office buildings, there was an average reduction of 11.6% in operating expenses, which translates to a 2.3% increase in capital value.

The study proves that there is a strong business case for retrofitting existing buildings. With the energy efficiency improvements, green buildings can reduce their operating expenses and increase their capital value.

Study on Green Tenants

The findings from the above 2 studies affirmed the need to improve tenants’ electricity consumption in the buildings. While energy efficiency improvements are made to the building, tenants must also improve the energy efficiency of their premises as they account for a significant share of the overall electricity consumption. To encourage an active pursuit of sustainability among building occupants and tenants, BCA launched various occupant-centric Green Mark Schemes targeting different types of tenants such as Green Mark for office interiors (GMOI), restaurants, supermarkets, retail and data centres respectively.

- More office tenants are recognising the value of a more sustainable working environment.
- There has been a decreasing trend in the average Energy Efficiency Index (EEI) for GMOI projects compared to the year before, based on a Green Mark Study on 10 GMOI premises.
- Recently, BCA introduced a Green Lease Toolkit (available at http://www.bca.gov.sg/sustain/sustain.html), a guide to bring building owners and tenants together to achieve requirements for environmental objectives of the building through joint commitment, and to further encourage green partnership between the building owner and tenants.
- Supermarkets are usually one of the anchor tenants in large retail buildings. A study has shown that Green Mark supermarkets can achieve a lower EEI over non-Green Mark Supermarkets by incorporating green features such as energy management/monitoring system (EMS), variable speed drives for refrigeration systems compressors, and high efficiency light fittings.

Office Interior EEI (kWh/m².yr) Improvement

![Office Interior EEI Graph](graph1.png)

Supermarket EEI (kWh/m².yr) Improvement

![Supermarket EEI Graph](graph2.png)

EEI = (TBEC - DCEC)/(GFA excluding carpark - DCA)*55/0H where:
- a) TBEC: Total building energy consumption (kWh/year)
- b) DCEC: Data centre energy consumption (kWh/year)
- c) GFA excluding carpark: Gross floor area exclusive of car park area (m²)
- d) DCA: Data centre area (m²)
- e) 55: Typical weekly operating hours of office buildings in Singapore (hrs/week)
A whole-of-government approach was adopted to implement the various measures to improve energy efficiency and achieve energy reductions across the various sectors. The public sector has jointly formulated environmental sustainability measures under the Public Sector Taking the Lead in Environmental Sustainability (PSTLES) programme. In line with this, all new public sector buildings and those undergoing major retrofitting works have to meet minimum standards of environmental sustainability equivalent to the Green Mark Certified level since 1 April 2007. In 2009, all new medium or large air-conditioned public sector buildings of 5,000 m² and above are required to achieve the highest Green Mark Platinum rating. In addition, all existing buildings with air-conditioned floor area of 10,000 m² and above are also required to attain Green Mark GoldPLUS rating after retrofitting works.

Four Green Mark rated buildings representing public buildings, offices, hotels and retail/ mixed development will be showcased. They have shown encouraging energy improvements with the adoption of energy efficient technology solutions and sustainable operational practices.

These buildings have been identified from:
- the study on 54 retrofitted commercial buildings, and
- the list of top 10 commercial buildings.

Public Buildings

Health Promotion Board (HPB)

<table>
<thead>
<tr>
<th>Age:</th>
<th>18 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>8-storey building with a basement carpark</td>
</tr>
<tr>
<td>GFA:</td>
<td>32,148 m²</td>
</tr>
<tr>
<td>Certification:</td>
<td>Green Mark Platinum</td>
</tr>
</tbody>
</table>

HPB implements health and dental programmes that reach out to the population, specifically children, adults and the elderly. In support of the PSTLES programme, HPB embarked on the journey to achieve a Green Mark Platinum rating for their building, starting with the Guaranteed Energy Savings Project (GESP) in year 2012. The GESP contract assists government agencies to engage Energy Service Companies (ESCOs) to carry out energy audit, recommend and implement energy efficient measures, and ensure system efficiency and/ or annual savings over a period of five years. Through the energy improvement works, HPB achieved a total annual electricity savings amounting to 1,100,939 kWh, equivalent to S$275,000 and a payback period of 7.7 years.
Air-Conditioning System
- Entire chiller plant system, excluding the cooling towers, was replaced with three new highly efficient water cooled chillers which included three sets of efficient chilled water and condenser water pumps, all equipped with Variable Speed Drives (VSDs).
- Cooling towers were installed with VSDs to reduce power during low loads.
- Chillers were oil-free centrifugal chillers which optimised heat transfer and used the refrigerant HFC-134a, which has no ozone depletion potential.
- Automated tube cleaning system was installed for the three chillers, easing the hassle of maintenance and maintaining the efficiency of the chillers.
- Chilled and condenser water piping systems were modified into a common header.

After the retrofit works, there was an improvement in the air-conditioning plant efficiency of 1.01kW/RT to 0.609kW/RT, an improvement of 40%.

Lighting
- Office and 24-hour operating public car park lighting were changed to light-emitting diode (LED) tubes with no ballast loss.
- Switches were located prominently at the corridors and entrances/ exits of offices to encourage staff to control the lights when needed.
- Reminders were attached to the switches to encourage staff to save energy and switch on the lights only when necessary.
Due to Singapore’s tropical climate, air-conditioning is an essential part of a hotel’s daily operation. Thus, retrofitting efforts were focused on increasing the energy efficiency of the air conditioning system.

**Novotel Singapore Clarke Quay** (Novotel Clarke Quay)

- **Age:** 31 years
- **Description:** 4-star hotel, 25 storeys, 403 rooms, 4 restaurants, a swimming pool, gym, several meeting rooms and ballrooms
- **GFA:** 26,546 m²
- **Certification:** Green Mark GoldPLUS

Novotel Clarke Quay is under the Accor Group which has implemented a group sustainable development program, PLANET 21, with 21 commitments and objectives in favour of sustainable development. Novotel Clarke Quay began its Green Mark journey when the hotel underwent renovations in 2012.

Novotel Clarke Quay was a successful applicant of the Green Mark Incentive Scheme for Existing Buildings (GMIS-EB) and through this incentive scheme, the building has undergone major energy efficiency retrofitting with a total annual electricity reduction of 2,839,852 kWh, amounting to S$709,963 and a period of 7.2 years for investment recovery.

**Key Energy Efficiency Features**

**Air-Conditioning System**
- Chiller plant was retrofitted to a high efficiency chiller using R134a with zero ozone depletion potential.
- Chilled water pumps, condenser water pumps and cooling towers were equipped with VSDs to reduce the power during low or part load conditions.
- A measurement and verification system was installed to effectively monitor and optimise the chiller plant operations at 0.65 kW/RT.
- Aging air handling units were replaced, leading to 15% energy savings.

**Lighting**
- Most light fixtures were upgraded to energy efficiency types, such as LED.
- Motion sensors were installed at hotel common toilets and back of house to limit lighting usage based on demand.

**Heat Recovery System**
- The heat pump system was upgraded to a more efficient one, which recovers energy from the chillers to provide hot water for the hotel.
Offices

For office buildings, having a Green Mark certification brings the additional benefit of appealing to companies with a strong corporate social responsibility.

Mapletree Business City (MBC)

Age: 4 years  
Description: 4 high-rise office blocks along Pasir Panjang Road  
GFA: 183,900 m²  
Certification: Green Mark Platinum

During its redevelopment, MBC installed a high efficiency water cooled chilled water plant with feedback control for demand control optimisation, which was operating with a system efficiency of 0.6 kW/RT. MBC saw an overall annual electricity savings of 15,020,093 kWh, which is equivalent to S$3,755,023 with a period of six years for investment recovery.

Key Energy Efficiency Features

Façade & Landscape Design

- High performance building envelope, consisting of low-emissivity double glazed glass and insulated glazed spandrel panels, effectively reduced heat gain into the building blocks.

- Building facades were oriented to avoid direct exposure to the afternoon sun, further reducing heat gain.

- Landscaping with lush greenery provided superior insulation from solar heat gain and reduced urban heat island effect.

Energy Efficient District Chilled Water Cooling Plant

- An efficient chilled water plant was designed to serve the four blocks with VSDs for pumps and cooling towers to reduce power when equipment were running at part load conditions.

- Optimisation strategies included low-flow low-pressure variable chilled water and condenser water flow system; pressure reset control for pumps as well as variable air flow for cooling tower fans.

- A high precision building automation system was installed to monitor and optimise plant performance

These strategies allowed MBC to achieve plant efficiency of less than 0.60 kW/RT under normal operating conditions.
Carbon Dioxide (CO₂) Sensors Integrated
The cooling of fresh air contributed significantly to electricity consumption. By monitoring the indoor CO₂ concentration, fresh air intake to the air handling units (AHUs) can be regulated by controlling the fresh air damper based on demand. With this, the overall cooling load of the building was reduced.

Energy Recovery Heat Exchangers
Run-around coils were incorporated at the pre-cooled AHUs to cool down the outdoor air by harnessing the cooled toilet exhaust air, so as to reduce the cooling requirement at the central cooling plant, thus achieving energy savings.

Waste Heat Recovery System
A heat recovery system was set up to recover waste heat from the chiller plant to cater for hot water requirements. A new chiller was installed to pre-cool a portion of the returning chilled water of the main chiller plant and simultaneously produce hot water through the condensing circuit of this chiller.

Energy Efficient Light Fittings
Energy efficient T5 fluorescent tubes and compact fluorescent lamps (CFLs) with high frequency electronic ballast were installed throughout MBC. The lighting system helped save electricity and reduced its lighting power budget, while maintaining the desired illumination levels.

Flexible Lighting Controls
Office spaces were zoned for flexible lighting control which users can switch off when not in use. In addition, motion detectors were installed for toilets and staircases so that lights were switched on when necessary to reduce electricity wastage.

Energy Efficient Carpark Ventilation System
A smaller and more energy efficient ductless mechanical ventilation (MV) jet fan system was used to ventilate the air. Carbon Monoxide (CO) sensors were also installed to turn on the MV jet fans when the CO level is above the acceptable limits.

Energy Efficiency Improvement Plan
Mapletree Investments Pte Ltd has established an energy policy and management improvement plan to reduce the building’s energy consumption and drive efficient use of natural resources, thereby reducing their carbon footprint. To ensure a successful energy efficiency program, MBC’s Property Management organisation has taken the lead in energy efficiency through the setting up of an Energy Leadership Team and a multi-year energy reduction target over a period of three years. The scope covers all controllable energy consumption which includes power, lighting and cooling systems and other related building systems. The improvement plan covers design and installation of systems as well as the monitoring of the building’s operation.

The company has also recognised that its tenants need to be aligned to achieve greater energy efficiency. To achieve this, it actively promotes awareness of the Green Mark certification and MBC’s energy efficient design through an energy efficiency programme. To encourage tenants to embrace Mapletree’s green movement, every tenant has been issued a set of interior fit-out and operational guidelines that complies with BCA’s Green Mark Office Interior criteria. Most anchor tenants have attained Green Mark Platinum or GoldPLUS certification for their premises, led by very proactive companies, such as HSBC and American Express International Inc.

“Mapletree seeks to achieve the highest building environmental standards by incorporating eco-friendly features and infrastructure in our developments.”

Mr Tay Chin Khim
Head, Singapore Investments, Mapletree Investments Pte Ltd
Green building retrofits lead to lower utility costs for building owners and tenants. Retrofitted retail properties stand to gain an average savings of 13.5% of total operating costs, and an increase in capital value of buildings by 2.7%, based on the Green Building Valuation study.

**International Plaza (IP)**

- **Age:** 38 years
- **Description:** Mixed development comprising apartments, sports facilities, offices and a retail mall
- **GFA:** 137,948 m²
- **Certification:** Green Mark GoldPLUS

IP was a successful applicant of the GMIS-EB and through the scheme, has undergone major energy efficiency retrofitting with a total annual electricity reduction of 2,115,007 kWh, amounting to S$528,752 with a period of 6.4 years for investment recovery.

**Key Energy Efficiency Features**

- **Air-Conditioning System**
  - Two existing chiller plants were replaced with high performance chiller systems which were optimised and operated at an efficiency of less than 0.68 kW/RT.
  - New retrofits incorporated the use of VSDs for pumps and cooling towers
  - Environmentally-friendly refrigerant was used with refrigerant leak detection and automatic condenser tube cleaning systems.

- **Chiller Plant Automation System**
  - Chiller Plant Automation system was installed along with highly accurate permanent instrumentation equipment for measurement and verification of the chiller plant system efficiency.

- **Lighting Systems**
  - Energy efficient lighting systems such as CFLs, ceramic discharge metal halides (CDMs) and LEDs were widely used within the building premises.
  - Lighting at the staircase was equipped with dimmable control functions using occupancy sensors.

- **Escalators**
  - Escalators were installed with passenger movement sensors, which would activate the escalators when there were approaching passengers, to conserve energy during off-peak periods.

- **Sustainable Operation & Management**
  - The building management’s environmental policy was displayed at various parts of the building to raise awareness among occupants.
  - Green procurement was practised by the building management to prioritise the use of environmentally friendly products and equipment, such as sustainable and environmental-friendly products certified under the Singapore Green Label Scheme (SGLS).
GREENING OF SINGAPORE’S BUILDING STOCK

In the past eight years, BCA has implemented many initiatives to encourage the industry to improve environmental sustainability standards of the nation’s buildings. These include:

- legislation for new and existing buildings to meet minimum environmental standards
- multiple incentive schemes which offer cash or other forms of bonus for developers and building owners to adopt energy efficient technologies and sustainable practices, and attain higher-tiered Green Mark ratings

Lists of BCA’s Incentive Schemes
- Green Mark Incentive Scheme for New Buildings (GMIS-NB)
- Green Mark Incentive Scheme for Existing Buildings (GMIS-EB)
- Green Mark Incentive Scheme for Design Prototype (GMIS-DP)
- Green Mark Gross Floor Area (GM GFA) Incentive Scheme

With legislation and incentive schemes in place, BCA’s engagement with developers, building owners and other industry players has made positive impact for the built environment. Singapore is on track to green 80% of our buildings by 2030.
Many countries in the region have grown to value the benefits of green buildings, and BCA’s leadership in the green building movement has also been recognised beyond our shores. Regional demand for our Green Mark certification has been rising.

- More than 250 overseas projects in more than 70 cities from 15 countries have applied for BCA’s Green Mark certification since 2005
- Approximately 90% of overseas Green Mark projects in Malaysia, China, Indonesia and Vietnam
- BCA’s Green Mark scheme has served as a good reference for many countries that are developing their own green building rating system

Green Mark Progress Indicators

- **60%**
  Average year-on-year growth of Green Mark building projects from 2008 to 2013

- **≈ 62 million m²**
  Total green GFA

- **>25%**
  Of Singapore’s total GFA has been awarded the Green Mark certification

- **33 to over 2,100**
  Growth in Green Mark building projects from 2006 to 2014

Do you know?

- More than 250 overseas projects in more than 70 cities from 15 countries have applied for BCA’s Green Mark certification since 2005
- Approximately 90% of overseas Green Mark projects in Malaysia, China, Indonesia and Vietnam
- BCA’s Green Mark scheme has served as a good reference for many countries that are developing their own green building rating system

**Green Mark Building Projects in Singapore (Cumulative)**
BESS had performed optimally throughout the first year’s submission. Feedback and observations on the online submission portal and submission process were recorded for future system enhancement works and improvement in administration.

**Lack of Detailed System Generated Reports**
In comparison with other more established energy data submission portals, such as the United States Environmental Protection Agency’s (EPA) Energy Star Portfolio Manager, BESS’ simple building energy performance reports are still lacking in variety and in the number of reports generated. For example, reports on operational carbon emitted by the buildings.

A Business Intelligence (BI) tool will be developed and integrated into BESS to provide more dynamic data analysis using various parameters available. With more informative graphs and constructive reports generated by the BI tool, BESS will be in a better position to provide more in-depth reports on energy performance and benchmarking, which will:

- assist building owners in making better decisions on improving their buildings’ energy efficiency performance.
- support policy makers in monitoring impact of current policies and charting new directions for the built environment.
Gathering of Required Information
BOS/ BSRs of older buildings have reported that they had submitted approximated building data [e.g. GFA, air-conditioned floor area] because of unavailability of official building documentation or their unfamiliarity with submission requirements.

The current user submission manual and technical guidebook will be revised with more information for reference by BOS and BSRs.

Minimising Data Entry Error
Data entry errors were identified during the data cleaning phase. These errors could be due to typographical errors, incorrect interpretation of units of measurement and a lack of understanding of the required information.

The system validation during data submission will be improved for identification and prompting for these errors when the data is entered.

More Data to be Collected
The existing submission form will be improved by better defining the submission fields, and expanding them to cater for additional input within key categories, based on feedback by BOS and BSRs. For example, under Building Services Information, the Air-Conditioning and Mechanical Ventilation (ACMV) field focuses on centralised chiller systems and does not allocate an appropriate field for information on smaller air-conditioning systems, such as split-units and unitary air-conditioners. Additional submission fields on air filtration systems are also required for our analysis and future policy decision on our built environment.

Issues with Contact Information of Targeted Building Owners
One key challenge during the first year of data collection was establishing contact with targeted building owners.

The issues mainly fell into two areas:
1) Owners who did not comply with the annual mandatory submission had to be found through alternative reliable databases; and

2) Owner’s registered contact details may not always be most up-to-date due to change in building ownership.

With the challenge of establishing contact with building owners due to the dynamic change in building ownership, the administration team will continue to search through the available databases and conduct necessary enforcement site visits to the buildings.
Strategies Moving Forward

Towards Voluntary Building Energy Display Certificate and Mandatory Energy Disclosure

A Wider and More Comprehensive Pool
Going forward, BCA will phase the inclusion of other building types, such as institutions, health-care facilities, for the annual mandatory submission. This is to provide a more comprehensive and holistic overview of the building energy performance of Singapore’s built environment.

More Sharing for Greater Awareness and Empowerment
In line with the 3rd Green Building Masterplan's strategic goal on proven sustainability performance, BCA will leverage on the continual benchmarking efforts and encourage better energy performing building owners to display their building’s energy certificate at prominent public locations.

With greater awareness of the benefits of good building energy performance, potential buyers and tenants are able to compare the operational cost of buildings with a view to lowering their future operating expenditure.

Through extensive information sharing, BCA hopes to drive demand for green buildings among potential buyers and tenants. The growing demand for green buildings is prevalent in European Union (EU) cities where, with a mandatory disclosure of a building’s energy certificate at transactional stage, potential buyers and tenants are generally more willing to buy or lease more energy efficient buildings.

Incentivising Building Owners and Tenants
A new $50 million Green Mark Incentive Scheme for Existing Buildings and Premises (GMIS-EBP) has been introduced to encourage building owners and tenants to undertake and adopt energy efficiency improvements within their buildings and premises.

Assisting through Financing Scheme
The Building Retrofit Energy Efficiency Financing (BREEF) Scheme is a financing programme, introduced by BCA in collaboration with participating Financial Institutions (FIs), to assist building owners in overcoming the high upfront cost of carrying out energy efficiency retrofits. The BREEF scheme was in a two-year pilot trial for non-residential buildings with centralised air-conditioning plants. This financing scheme has been extended for another two years and enhanced to:

- include residential building owners
- increase the loan default risk share of 60% for BCA, up from 50% previously
Promoting Occupant-centric Initiatives

Of the Green Mark buildings, 82% are larger sized commercial buildings. The owners of these buildings recognise the benefits of green buildings and have secured substantial energy savings through the adoption of green technologies and sustainable practices. To establish a more holistic approach to improve the energy performance of commercial buildings, the tenants and building occupants play an important role as well.

To encourage the sustainability efforts of tenants, BCA has streamlined the application of Green Mark occupant-centric schemes through the Green Mark Portfolio Programme. The Programme provides tenants with economies of scale by letting tenants take advantage of the uniformity in buildings and interior designs and construction, as well as operations and management. The Portfolio Programme targets:

1. organisations which have multiple units or outlets in different locations; or
2. multiple tenants within a single building using shared and common building systems and facilities, such as the air-conditioning system, lighting design and fittings, or other applicable common facilities.

Additionally, to complement the above occupant-centric schemes, BCA recently rolled out a Green Lease Toolkit to guide building owners and tenants in their collaborative efforts to maintain the environmental sustainability standards of their buildings and premises. With this guide, BCA aims to raise awareness of appropriate practices to improve or maintain the building’s energy efficiency. This would help drive the appreciation of valuation and demand for green buildings amongst building owners and tenants.
Appendix A: Data Verification Methodology

Prior to analysing the submitted data and benchmarking, the dataset had been checked for any inconsistencies or data entry errors. The top and bottom 10% Energy Utilisation Index (EUI) of the dataset were examined individually and the BOs/BSRs were contacted to ascertain the information submitted. Over the course of the data verification process, the high and low EUI observed for the buildings could be attributed to these reasons:

**Gross Floor Area**

*Unfamiliarity with Gross Floor Area (GFA)*

Some of the BOs/BSRs were unfamiliar with the definition of Gross Floor Area and uncertain about how to obtain the information, leading to an over-declaration or under-declaration of the GFA and resulting in a lower or higher EUI respectively. The BOs/BSRs were guided to measure the GFA from existing floor plans or obtain the details from their official submissions to government bodies during their earlier project development stage.

*Oversight in Data Entry*

GFA over-declaration was also due to an oversight in data entry when the BO/BSR submitted the GFA information in square feet (ft\(^2\)) and not square metres (m\(^2\)), which led to a higher GFA and a lower EUI.

**Energy Consumption Data**

*Multiple Electricity Billing/Supply Address*

The electricity consumption data is obtained directly from utility suppliers, which is the most complete and accurate source of electricity information. However, certain development that spans across multiple plots of land along a road or street, and the building could have multiple electricity billing addresses or multiple electricity supply addresses. The electricity data captured would not be complete and would lead to a lower electricity consumption portrayed for the building and have a lower EUI. For benchmarking analysis, the electricity data for the entire development would be aggregated to have a better indication of the development’s energy performance.

*Multiple Buildings Sharing Electricity and/or Building Services*

Buildings could be sharing the electrical incoming supply or sharing certain building services, namely air-conditioning system, with neighbouring buildings. This led to an overestimation or underestimation of electricity consumption for the building leading to a lower or higher EUI respectively. Hence, the buildings sharing electricity or building services were aggregated together and taken as one development for the benchmarking analysis.

*Newly Constructed Buildings*

Buildings which were constructed in 2012 to 2013 may not have a full occupancy and full year of electricity consumption, leading to a lower EUI. These buildings’ data were accounted in the compliance rate and basic building information findings, but were removed from benchmarking analysis.

*Buildings Undergoing Major Renovation*

Buildings that were undergoing major renovation during 2012 were accounted in the compliance and GFA analysis, but removed from the benchmarking analysis. Major renovation comprised renovation works that affected the building’s operation such as changes to the interior and/or façade, or addition or alteration works to the building’s GFA.

*Non-Typical Commercial Buildings*

Certain buildings were identified to be non-typical commercial buildings, due to the nature of their activity, such as mechanically ventilated food centres, markets or buildings where the bulk of the electricity consumption was due to the car parking areas. These buildings’ data were accounted in the compliance rate and basic building information findings, but were removed from benchmarking analysis.
### Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>ACMV</td>
<td>Air-conditioning and mechanical ventilation system.</td>
</tr>
<tr>
<td>Average Energy Utilisation Index (EUI)</td>
<td>Weighted average of the energy utilisation indices of buildings is calculated based on electricity consumed using gross floor area as the weightage factor.</td>
</tr>
<tr>
<td>Business-as-usual (BAU)</td>
<td>Business-as-usual refers to an ongoing and unchanging state of affairs despite difficulties or disturbances. It refers to a &quot;without measures&quot;, &quot;baseline&quot; or &quot;reference&quot; projection.</td>
</tr>
<tr>
<td>Building Owners (BOs)</td>
<td>Individuals or companies who legally own the buildings or developments.</td>
</tr>
<tr>
<td>Building Submission Representatives (BSRs)/Building Submission Officers (BSOs)</td>
<td>Authorised personnel assigned by building owner to complete the annual mandatory submission. These personnel may include the building owners’ employees or managing agents engaged to manage the buildings’ facilities.</td>
</tr>
</tbody>
</table>
| Building Types | **Office** is a development with premises used as a place of business and for conducting administrative work.  
**Hotel** is a development used for accommodation purposes on a commercial basis. The predominant use of this development shall be hotel rooms.  
**Retail** is a development with premises primarily used for any trade or business where its primary purpose is the sale of goods or foodstuff by retail or provision of services.  
**Mixed Development** is a combination of any of the above three commercial building types. |
| Certificate of Statutory Completion (CSC)/Temporary Occupation Permit (TOP) | Certificate of Statutory Completion (CSC)/ Temporary Occupation Permit (TOP) is granted by the Commissioner of Building Control upon building completion. The building can only be occupied when a CSC or TOP is granted. |
| Centralised Air-conditioning System | A major air-conditioning system which distributes chilled water to heat exchangers for cooling and dehumidifying of air in multiple zones of a building. |
| Energy Utilisation Index (EUI) | Measures the total energy consumed in a building in a year, expressed as kilowatt hour (kWh) per gross floor area (m²). |
| Gross Floor Area (GFA) | All covered floor areas of a building, except otherwise exempted, uncovered areas for commercial uses and carpark area, are deemed the gross floor area of the building. |
| Large Buildings/ Small Buildings | Large buildings refer to buildings with GFA more than or equal to 15,000 m². Small buildings refer to buildings with GFA less than 15,000 m². |
| Management Corporation Strata Title (MCST) | A management group formed by all the subsidiary proprietors of the estate. The MCST has powers, duties and functions conferred or imposed by law to control, manage and administer the common property for the benefit of the subsidiary proprietors. |
| Managing Agent (MA) | A managing agent is a person or company appointed by the building owner(s) to manage their properties. |
For more information on the various BCA incentive and financing schemes, you may contact:

<table>
<thead>
<tr>
<th>BCA Schemes</th>
<th>Contact Person</th>
<th>Email Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green Mark Gross Floor Area (GM GFA) Incentive Scheme</td>
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<tr>
<td>Pilot Building Retrofit Energy Efficiency Financing (BREEF) Scheme</td>
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We had a successful IGBC 2014.
Thank you for your support

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International Green Building Conference 2015
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Sands Expo & Convention Centre, Marina Bay Sands

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Building and Construction Authority