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Greening existing buildings [GEB] strategies

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HIGHLIGHTS

- Cut energy emission from existing buildings significantly reduce the global warming.
- Locate the green potentials with improvement plan using the green audit award system can serve the purpose.
- Case study successfully confirmed the above result.

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ABSTRACT

Global warming has raised a global concern on climate change. One of the effective measures to combat this global warming is to limit/conserve the energy uses globally. It is a common scientific consensus that around 30% in average of the total energy uses in modern countries comes from the energy uses from the existing building blocks.

This article gives a systematic manner to develop strategies of how to effectively greening the existing buildings [GEB]. The findings concluded that using the above GEB strategies can achieve a total of energy savings in a range of 40%–60%. This high energy savings will contribute to carbon intensity reduction in the range of 20%–30%.

A Green Audit Award [GAA] is postulated to help to identify the green potential/deficiencies of the existing buildings with the aim to wrap up a green improvement plan so that the existing buildings can become green within the constraints of the existing building under the assessment. A pilot test in terms of a case study confirmed that the GAA assessment scheme coupled with the GEB strategies is feasible and cost effective to turn the existing building green.

Government support and promotion is crucial for the sustainability of these GEB strategies and a survey from previous study of cost coming from the illness and the pay to avoid this illness points out that the proposed funds to be subsidized for both greening and maintenance of existing buildings with age $\geq$ 40 years is justifiable for GEB promotion.

With the advance of GEB strategies focusing on the rate of return for energy savings, GAA assessment will be an effectual tool to attain the **objective of this paper to transform the existing buildings to green with ease and cost effectively**, and with the effort of each existing building in adopting the above GEB strategies, an enormous effect will be anticipated in combating the global warming in return.

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1. Introduction

The vast use of electricity and burning of natural fuels like coal has made the Earth's average temperature rising to as much as 1 °C over the last century. Recent research also predicts that the average global temperature may raise as high as 6 °C by the year of 2100 (Braford, 2013). This temperature rises effect is drastic. If all the ice at the poles and tops pf mountains melt, the sea level will rise to 30–50 m inundating most of the countries of the earth. The temperature rises will also increase the frequency of adverse/severe storms and climatic changes.

Measures to combat this global warming has raised global grave concern and a Paris Climate Agreement to limit the temperature rise to 2° C has finally taken effective on 4 November 2016 (Wikipedia, the free encyclopedia, 2016) (though the present US President Donald Trump has announced on 1 June 2017 to withdraw from this Agreement claiming to renegotiate for better terms for America).

One of the prime measures to achieve the reduction of global warming is to limit/conserve the energy uses globally. Research shows that the building in existence consumes around 30% of the accumulated energy uses in modern countries and may induce almost 30% of carbon emissions due to energy use (Eurostat, 2009). For example, in US/UK/EU, existing buildings consume in average

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of almost 40% of accumulated energy use 30%–40% in the east Asia (Peŕez-Lombard et al., 2008; U.S. Green Building Council, 2007; The Energy Conservation Center, 2008). Energy consumption by existing buildings in some modern countries like EU and US has even exceeded those in the industrial and transportation sectors. Thus, turning the existing buildings green can significantly help in limiting/conserving the energy uses and greenhouse gas emissions globally.

Thus, the objective of this paper in greening the existing buildings **[GEB]** with energy reduction can be undoubtedly considered as an effective and sustainable tool to combat both the temperature rises and its climatic changes effect in the future. With the development of the GEB strategies focusing in the reduction of the operational energy uses like HVAC, lighting, electrical equipment/appliances which are contributing to as much as 80% of the total building energy consumption (Ihm et al., 2009), it is believed that the energy uses in the existing buildings can be largely reduced/conserved to make the existing buildings green (Lowe, 2000; Hastings, 2004) and more livable (Ernst et al., 2010; Sweatman et al., 2010).

The existing green rating system like **LEED [EB]** (Leadership in Energy and Environmental Design for Existing Buildings) mainly used in USA and Canada, **BREEAM** (Building Research Establishment Environmental Assessment Methods) in UK and **GREEN STAR** in Australia and New Zealand are all have common global coverage but mainly they are focusing on the ***design perspective*** with green standards laid down for the retrofit of the existing buildings. The **novelty** of this study is to build up a unique green audit tool called the **Green Audit Award [GAA]** scheme to assess the buildings in existence aiming to evaluate the buildings' green potentials with implementation measures to turn the existing buildings green in a cost effective manner. The green improvement results can also be assessed and certified by the same GAA. In this way the city/countries will gradually turn green ultimately.

2. Methodologies of the Research

To select and adopt the best/optimal GEB strategies/technologies to each subject existing building among its various kinds of greening technologies in the market, the optimal solution involves a tradeoff within a number of constraints and limitations like project budget, existing building conditions/characteristics, financial benefit, social and stakeholders'/tenants' perspectives, etc.

In order to realize and maximize the benefits in energy reduction in the subject existing building, this paper will:

1. **Develop a number of GEB strategies** to optimize the selection of green improvement measures to the existing buildings in order to assist decision-makers to maximize the best environmental inputs within the specified greening improvement budget while upgrading the building energy operational performance and efficiency.
2. **Establish a new Greening Rating System for existing buildings naming as "Green Audit Award [GAA]".** This GAA system is developed under the guidance of the Leadership in Energy and Environmental Design for existing buildings (LEED-EB) protocol. Unlike LEED-EB advocating design measures to convert the existing buildings to green, the GAA will assess an existing building condition by a qualified and recognized Green-Pro with certification in order to identify green potentials of the existing building from the pragmatic/construction perspective with an aim to arrive an effective and energy efficient green improvement plan.
3. **Put forward an energy-efficient GEB improvement plan** to integrate all effective and available energy saving GEB measures ensued from a greening assessment exercise using GAA
4. **Demonstrate how the GAA is worked. A pilot test in terms of a case study** will be used to actually assess the subject existing building together with a green improvement plan proposed by the Green Pro after the assessment
5. **Reassess/recertify the subject existing building** using the same GAA assuming the application of the green improvement plan has been done. This will evaluate how effective is the green improvement plan has been achieved to the subject existing building.

The GAA assessment and its green improvement plan that follows is ***unique*** and applicable to this subject existing building only and may not be applicable to another existing building. We need to assess again for another building by the same GAA developed under this paper in order to arrive another green improvement plan to this existing building. Many references of GEB strategies/green improvement plans has been made particularly drawing from the well-developed countries' experience like those in US in order to ensure that the GEB strategies/green improvement plan in wake of a GAA assessment to a subject existing building is more pragmatically technical viable, value added, and appealing to the end-users or stake-holders to all other countries alike.

The integration of GEB strategies with the GAA assessment and certification under a recognized Green-Pro will strengthen the strategies by providing a method that optimize the energy savings/performance of the subject existing building and achieve a green building status, making the existing buildings, and so future cities, more green. The LEED-EB basis for the GAA has been designed by leading experts in the building industry and has been tested (though on a design perspective) to improve the existing buildings to be economically viable, environmentally sustainable and livable with good indoor environmental quality. The flexibility and contingency approach of GAA developed in this paper to each existing building will allow the end users to create a unique green improvement plan focusing on the environmental/energy savings/performance goals of the buildings in existence. GAA certification and re-certification in wake of the improvement plan delivered will drive long term cost savings for existing buildings while increasing the existing building value of the end users' investment over time.

3. Literature review

3.1. Key elements influencing GEB

The success of a GEB program depends on many factors. Fig. 3.1 shows the key factors that have grave impacts on GEB, including the occupants' behavior, the GEB methods of applications, Government's support, property owners' intent, the building's design criteria, and other factors (Ma et al., 2012).

1. The Occupants' Behavior

The occupants' behavior towards thermal, visual and acoustic comfort and their expectations on the requirements of indoor air quality will largely determine the comfort zone requirement of the energy input. Various studies like that use by Yohanis (2012) and Santin (2009) shows that the occupants' characteristics can affect the energy use of around 4%.

2. The GEB Methods of Applications

The methods of GEB applications may involve exterior insulation envelope like using insulated glass unit (IGU) and efficient energy savings appliances/lamps and HVAC system...etc. Survey can be conducted to find out the most cost effective and most acceptable GEB methods of applications. The choice of each GEB methods of applications depends very much on research, practical use experience.

Fig. 3.1. Key elements influencing GEB (Ma et al., 2012).

3. Government's Support

Government's financial incentives and support to the building owners can help promote the achievement of energy renovations to the existing buildings.

The Building Management and Maintenance Scheme in January 2005 implemented by the Housing Society of Hong Kong is a good example offering financial assistance with a funding of HK$1 billion in its first launch to implement the scheme granted for aged owners.

4. Property Owners' Intent

Most of the investment decisions made by the property owners in GEB focused on the payback period to choose what kinds of GEB methods of applications to be adopted (Harris et al., 2000). Thus the most cost effective GEB techniques will be highly favored by the property owners. However, a study by Alajmi (2012) showed that a significant capital investment of applying GEB technologies can save energy consumed of almost 50% annually. A precise payback period with the choice of GEB methods of applications should be carefully evaluated case by case for each existing building to comply the property owner's intent.

5. Building Design Criteria

The building design data specifically adopted is significant to the effectiveness of the GEB methods of applications. The building orientation, energy saving appliances/HVAC system used, the exterior envelope of the building structures, the life cycle of the insulation materials used…etc., all affect the choice of GEB methods of applications and their energy saving performance.

6. Other Factors

Other detailed GEB energy savings methods should be securitized carefully for each building as each building is unique and different from the other. This will ensure that no possible best energy savings alternatives are left behind.

3.2. The GEB strategies—the systematic approach

Fig. 3.2 shows the flowchart for the systematic approach (Ma et al., 2012) to identify and implement the GEB Strategies.

The figure indicates a flow of activities that will lead to disclose the green deficiencies of any type of existing buildings with the aim to apply the GEB measures. The GEB identification activities consists of three parts:

1. **Pre-GEB activities**
2. **GEB strategy determination**
3. **Post-GEB activities**

The pre-GEB activities commence with a pre GEB survey and energy audit to see if GEB is required. Coupled with the data base of GEB measures, various GEB measures can be provided and assessed using the cost–benefit/risk analysis for the property owner's decision. Once the GEB strategy is proceeded, the GEB measures adopted will be evaluated with a GEB report to see if the measures are satisfied. A regular monitoring and review is also required to assure that this greening performance is sustained.

3.3. The GEB technologies

Fig. 3.3 illustrates the major possible GEB technologies types that can be used in existing buildings application (Ma et al., 2012).

The GEB technologies can be grouped as follows:

I. Energy Requirement Control

The GEB measures aim at reducing and controlling the HVAC demand, the use of energy savings appliances/ equipment.

The control mechanism consists of exterior building insulation like using laminated/insulated glazing, energy savings LED lightings, time switches, motion sensors…etc. The GEB measures can be found in articles in Barlow et al. (2007), Xing et al. (2011), Krarti (2011), Baker (2009) and Fusion (2010).

II. Energy Supply Control

The GEB measures may use renewable energy for the supply of electricity. This includes installation of roof photovoltaic panels converting the exterior lighting to renewal energy lighting.

III. Energy Use Mode

The exterior insulation approach as illustrated in Fig. 3.4 (Fusion, 2010), will have a less cost input than using the electricity metering control. Concentration on these energy insulation control patterns will ensue better energy performance in the long run for the property owners.

3.4. Key findings from previous GEB studies

The following GEB studies on different types of existing buildings are summed up below where the most cost effective and feasible GEB technologies have been adopted.

The buildings selected included all types of existing buildings as far as possible. They are the commercial office buildings, residential buildings and other type of building like a University building. Data were summed up below to evaluate what and how the current GEB technologies can improve their energy efficiency and sustainable performance.

3.4.1. Commercial office buildings

Five office buildings types in Europe (Dascalaki et al., 2002)

The potential energy uses was investigated for five office buildings types in South Mediterranean, Continental, Mid-Coastal and North Coastal in Europe. The result shows that the uses of energy efficient lighting systems to the office buildings, will have an energy savings of 40% ∼ 60% in the north climatic zones. The general energy savings are drawn up in Table 3.1.

3.4.2. Residential buildings

Five Belgian residential buildings (Verbeeck, 2005)

Five reference existing buildings based on a statistical analysis were chosen to represent the average residential types in Belgium. The choice of good insulation to roof, glazing and heating system will account an energy savings ranging from 36% to 60%. The energy savings are drawn up in Table 3.2.

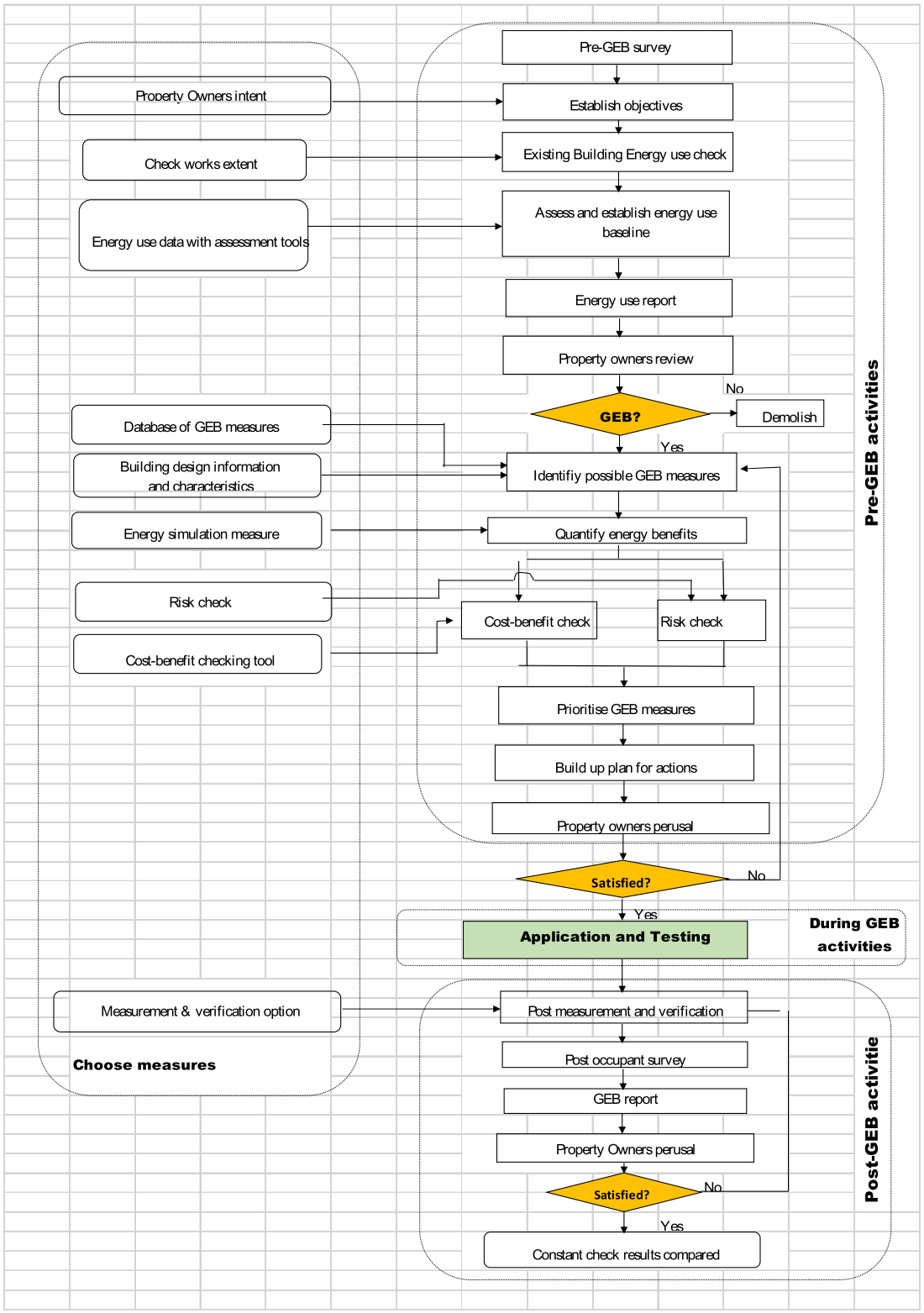


Fig. 3.2. The GEB Strategies—The systematic approach (Ma et al., 2012).

3.4.3. Other types of buildings

The campus of Melbourne University, Australia (Stefano, 2000)

It was found that the lighting fixtures at Melbourne University of Australia attributed almost 30% of the electricity being used. Thus amendment of the existing fluorescent fixtures to four different energy efficient lighting fixtures has significantly reduced the electricity bill. The following replacement of four alternatives lighting fixtures has resulted in energy savings of

1. 13.9% for using electronic ballasts;
2. 20.5% for T8 magnetic ballasts;
3. 24.4% for T8 electronic ballasts; and
4. 64.9% for T5 electronic ballasts.

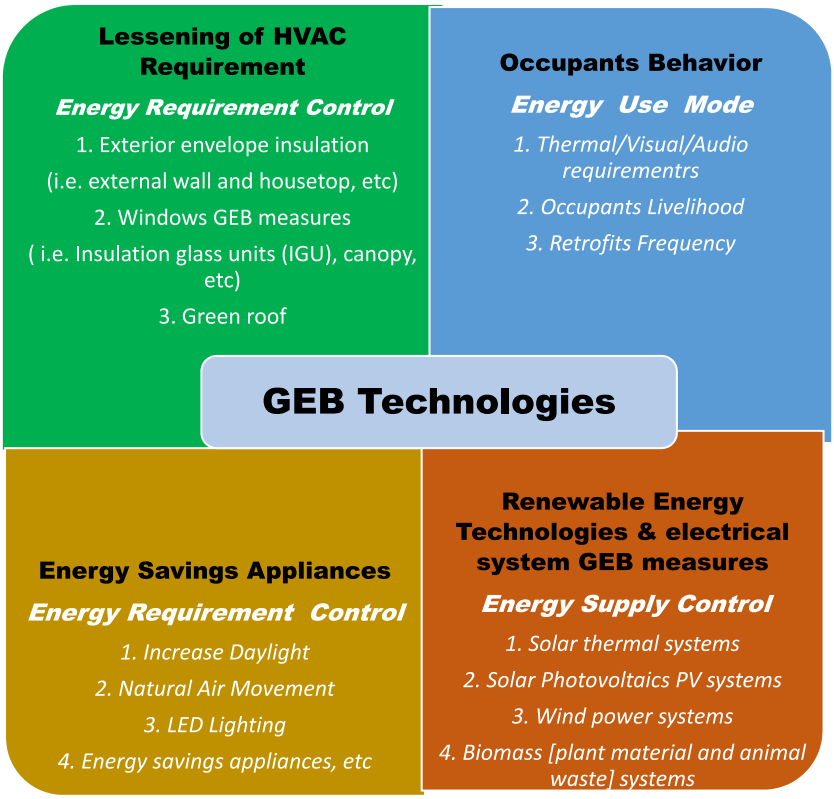


Fig. 3.3. Main Categories of GB Technologies (Ma et al., 2012).

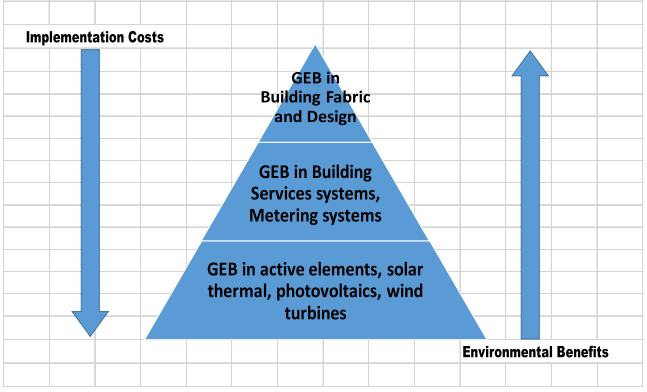


Fig. 3.4. Cost application versus its Implementation Benefits of the energy stratum (Fusion, 2010).

The energy savings comparison is drawn up below in Table 3.3.

3.5. The identification of the top five GEB technologies

The above GEB studies indicated a significant improvement of energy savings of the buildings in existence if the GEB technologies are carefully selected and implemented properly.

Based on the above GEB case studies of different types of existing buildings, *the top five most acceptable GEB technologies* in terms of potential cost benefits can be identified as follows (Burton, 2012):

1. Energy savings equipment selection
2. Low/energy savings lamps (T5 fluorescent)
3. Time control trigger
4. Motion control and
5. Light-emitting diode (LED) as a source for lighting.

This correlates with the study by Thomas Ng et al. (2014) identified by a questionnaire survey carried out in most of different districts in Hong Kong from June to July 2013. However, more GEB case studies on different types of buildings is required to confide the existing building owners/end users to adopt the above greening strategies for the improvement of their existing buildings' sustainable performance.

4. Green rating systems for existing buildings-green audit award [GAA]

Green rating systems adopted so far with common global coverage are:

I. **LEED** (Leadership in Energy and Environmental Design) mainly used in USA and Canada,
II. **BREEAM** (Building Research Establishment Environmental Assessment Methods) in UK and
III. **GREEN STAR** in Australia and New Zealand.

LEED is a globally recognized symbol of excellence in green buildings. Commencing from 2007, the United States Green Building Council has developed a LEED Green Building Rating Systems for Existing Buildings: Operations and Maintenance or LEED-EBOM/LEED-EB for short. LEED-EB has laid down those green standards that the existing buildings should be addressed to for retrofit before the buildings can be certified as a green building. LEED-EB applies to all existing residential, offices and civic buildings of all sizes. Its goal is to maximize a building's energy efficiency and the indoor air quality if those green standards as laid down in LEED-EB are complied with thus enhancing the health and comfort of its occupants while minimizing the building's adverse environmental

Table 3.1
General energy savings of GEB actions for the mentioned office buildings.

Major GEB Technologies used	➢ Improve the exterior building envelope; ➢ Use energy saving lighting and daylight; ➢ Enhance the HVAC systems.
Method to record the Savings	Use Imitation model
Major Results	A **reduction of total energy** use ranging from ***40% ~ 60% in the North climatic zones***

Table 3.2
The energy savings of GEB technologies inputs for the five Belgian residential buildings.

Major GEB Technologies used	➢ Insulate on roof and floor; ➢ Use thermally better performing glazing ; ➢ Input renewable energy using photovoltaic cells.
Method to record the Savings	Building imitation and use of NPV technique
Major Results	Using exterior envelope insulation with insulated glass unit and effective HVAC system, the **energy savings** ranging from ***36% to 60%*** for thermally better performing glazing renewal.

Table 3.3
The energy savings using four different energy efficient lighting fixture for the mentioned Australian University.

Major GEB Technologies used	Replace 1200mm fluorescent lighting appliances with the following four different energy savings appliances : **1.** Electronic ballasts, **2.** T8 magnetic ballasts, **3.** T8 electronic ballasts, and **4.** T5 electronic ballasts.
Method to record the Savings	Energy computation
Major Results	The replacement of four energy savings lighting appliances has resulted in energy savings of **1.** 13.9% for using electronic ballasts; **2.** 20.5% for T8 magnetic ballasts; **3.** 24.4% for T8 electronic ballasts; and **4.** 64.9% for T5 electronic ballasts

impacts. It gives building owners and operators a verification system and an effective benchmark in a ***design perspective to guard*** the green improvement/retrofits and maintenance over the life cycle of an existing building. However, up to this moment, there is ***no green rating system that has been designed for assessment of the existing buildings*** at their status quo.

Based on the LEED-EB version 4 released in November 2013, with some modification to suit the climate and type of existing building stock in Hong Kong, a green audit award (GAA) plan will be established to assess the green standards of the existing buildings aiming to reveal which area and what green strategies/technologies should be adopted to upgrade the existing building to maximize operational/energy efficiency while minimizing environmental adverse impacts. Unlike LEED-EB, GAA does not put forward any green standards, instead, the subject existing building will be assessed/certified under a GAA plan. After the GAA assessment, a ***unique*** green improvement plan will be derived based on the green deficiencies identified in the assessment if the subject existing building is not certified as green. This will enable the existing building can be sustainably improved in a cost

effective and energy efficiency manner pursuant to the characteristics/constrains/peculiarities of the subject existing building.

Thus, GAA gives the owners of the building with a distinctive green mark that elaborates its whole energy savings performance/deficiencies. It seeks to

- Dig up the green deficiencies/potentials of the existing buildings with the aim of setting a set of green improvements so as to make the existing buildings more green with the least costs and time;
- Stimulate the users/owners to perform the most cost effective green measures that are affordable and within the constraints of the subject existing building;
- Enhance the quality and green performance of existing buildings

Based on the LEED-EB protocol, and the international consensus building assessment on performance, the Green Audit Award (GAA) plan will take a complete view of the sustainable performance of the buildings in existence on their operation/maintenance within their whole building life cycle.

GAA incorporates many key performance data of the existing buildings, inclusive of:

- Local transportation in relation to the use of public transport;
- Recycled materials usage, and refuse disposal arrangement;
- Water usage and its cleanliness; and
- Energy conservation and distribution;
- Internal air quality, thermal, visual and audio comfort.

GAA assessment scheme for all buildings in existence will include all buildings types like those residential, office and civic. GAA not only evaluates the actual sustainable performance of an existing building, but also it will postulate its green potentials so that the building can be turned green with ease and low cost effectively. The various aspects of sustainable performance in GAA are grouped within the following 10 classifications.

(1) Location & Transportation [LT]

Using of public transports is highly recommended so as to reduce air pollution. It is highly favored for the internal estate transportation given that enough parking facilities are available. A bicycle-sharing system, or bike-share scheme is encouraged to operate within the large estate now dominates one-third of existing buildings in Hong Kong. Bicycles can be made available for shared use to individual on a very short term fee basis. This bike share scheme can allow people within the estate to borrow a bike from point A and return it to point B, for instance, from home to the MTR station. A credit will be awarded if this service is available in the subject existing building under assessment.

(2) Sustainable Sites [SS]

This includes the assessment of the buildings in existence of their:

- location/orientation;
- odor releases like harmful gases from the building site; and
- site administration.

(3) Water Efficiency [WE]

The assessment under this category includes:

- water usage and cleanliness
- waste water discharges

(4) Energy & Atmosphere [EA]

This includes:

- annual energy usage/distribution; and
- renewable energy supply mechanism used.

(5) Material & Resources [MR]

Material & Resources features include the materials in their:

- assortment and usage; and
- disposal and reuse

(6) Indoor Environmental Quality [IEQ]

This covers:

- internal quality of air;
- health and safety;
- air movement and its convection; and
- thermal, visual and audio comfort of the indoor condition;

It should be pointed out that a significant improvement can normally be done to upgrade the IEQ with least cost and effort for existing building. As it can be seen in the pilot test in terms of a case study in this paper, IEQ can be greatly improved for existing building with ease.

(7) Economic Value [EV]

The assessment will be based on those performance that can achieve significant, measurable added value with reduced energy and raw materials performance. The economic value will include:

- achieve targeted energy cost reduction; and
- optimize waste reduction/energy efficiency performance with added value

(8) Human Impacts [HI]

Encourage for tenants involvement/social participation should be made if the performance of buildings can be improved significantly. This includes impacts:

- on the inferior groups like the disabled and the aged group with age above 60 years; and
- lifestyle and convenience of the tenants e.g. ease in marketing with good hygiene and covered facilities

(9) Innovation [IN]

Credits will be given to those performance with significant, measurable environmental performance using an innovative strategy/technology. Innovation includes:

- Added value to the environment;
- New method to renew energy and reuse of water discharge;
- Alternative internal transportation with ease and under cover; and
- Substantial reduction of noise and air pollution to the living community.

(10) Regional Priority [RP]

Credits will be awarded to each performance feature specific and unique to the region of the buildings in existence under study.

The GAA credits allocation

The GAA weighting and allocation of credits and its individual assessment were expressed under a global trend as dawn up in Fig. 4.1.

The figure identifies **ten** broad categories to audit the energy savings/green performance of the buildings in existence. These are: **[LT]**- Location &Transportation absorbing 15 credits [LT-15]; **[SS]**-Sustainable Site for SS-10 marks; **[WE]-** Water Efficiency for WE-12; **[EA]**- Energy & Atmosphere for EA-30; **[MR]**- Material

Table 4.1
GAA 4-rating bandwidth.

Points achieved	Award rating
40 to ≤50	Certified
≤60	Silver
≤80	Gold
80+	Platinum

& Resources for MR-8; **[IEQ]**-Indoor Environmental Quality for IEQ-17; **[EV]**- Economic Value for EV-5; **[HI]**- Human Impacts for HI-3; **[IN]**- Innovation for IN-6; **[RP]**- Regional Priority for RP-4. Each aspect has been assigned several criteria which evaluate the environmental performance. Points allocated to each aspect relies on their importance respect to national concerns. As a result, [EA]-Energy & Atmosphere was allocated the maximum points of 30 marks. GAA can be classified as a performance based green audit for buildings in existence. GAA is a 4- awarded rating system. In order to be GAA certified, an existing building must achieve a minimum tally of 40 to ≤50 points, silver with higher points tally of ≤60, gold with higher points tally of ≤80 and a highest rate of platinum with points tally of 80+ as denoted in Table 4.1. The Table 4.2 summarizes the various criteria that make up the marks under each performance category.

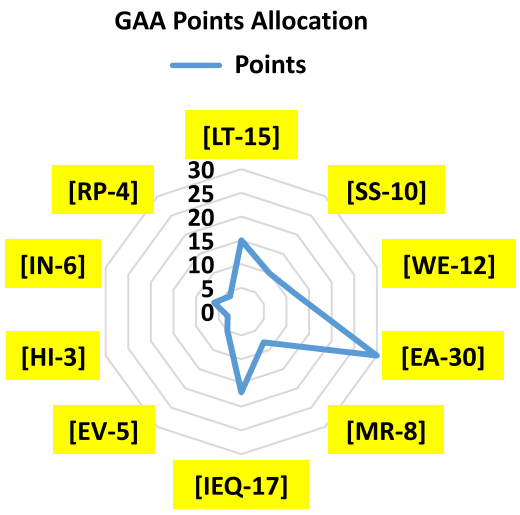


Fig. 4.1. GAA Points Allocation.

Table 4.2
GAA assessment criteria.

No.	Green building aspects	Assessment criteria	Credits
1	LOCATION & TRANSPORTATION [LT-15]	Alternative transportation	15
2	SUSTAINABLE SITE [SS-10]	Site set up — reserve existing natural state	2
		Rainwater control	3
		Heat localized lessening	2
		Light contamination lessening	1
		Site control	1
		Site enhancement	1
3	WATER EFFICIENCY [WE-12]	Exterior water use lessening	2
		In-house water use lessening	5
		Cooling tower water lessening	3
		Water use record appliances	2
4	ENERGY & ATMOSPHERE [EA-30]	Building services testing	2
		Building services testing — performance	2
		Ongoing testing	3
		Energy use	12
		Enhanced energy recording	2
		Energy Demand control	3
		Energy renewal supply	5
		Refrigerant control	1
5	MATERIAL & RESOURCES [MR-8]	Acquisition — in progress	1
		Acquisition — lightings	1
		Acquisition retrofit	2
		Solid waste control — in progress	2
		Solid waste control — retrofit	2
6	INDOOR ENVIRONMENTAL QUALITY [IEQ-17]	IEQ control scheme	2
		Improved IEQ measures	2
		Heat relief	1
		Internal lamps	2
		Sunshine	4
		Green enhancement scheme	1
		Green enhancement — goods	1
		Green enhancement — appliance	1
		Insects pest control	2
		Comfort Inquiry	1
7	ECONOMIC VALUE [EV-5]	Economic benefits acquired	3
		Added value	2
8	HUMAN IMPACTS [HI-3]	Impacts on local comforts	2
		Value to aged/inferior groups	1
9	INNOVATION [IN-6]	New measures	5
		Green-Pro qualified assessor	1
10	REGIONAL PRIORITY [RP-4]	Local peculiarity	4

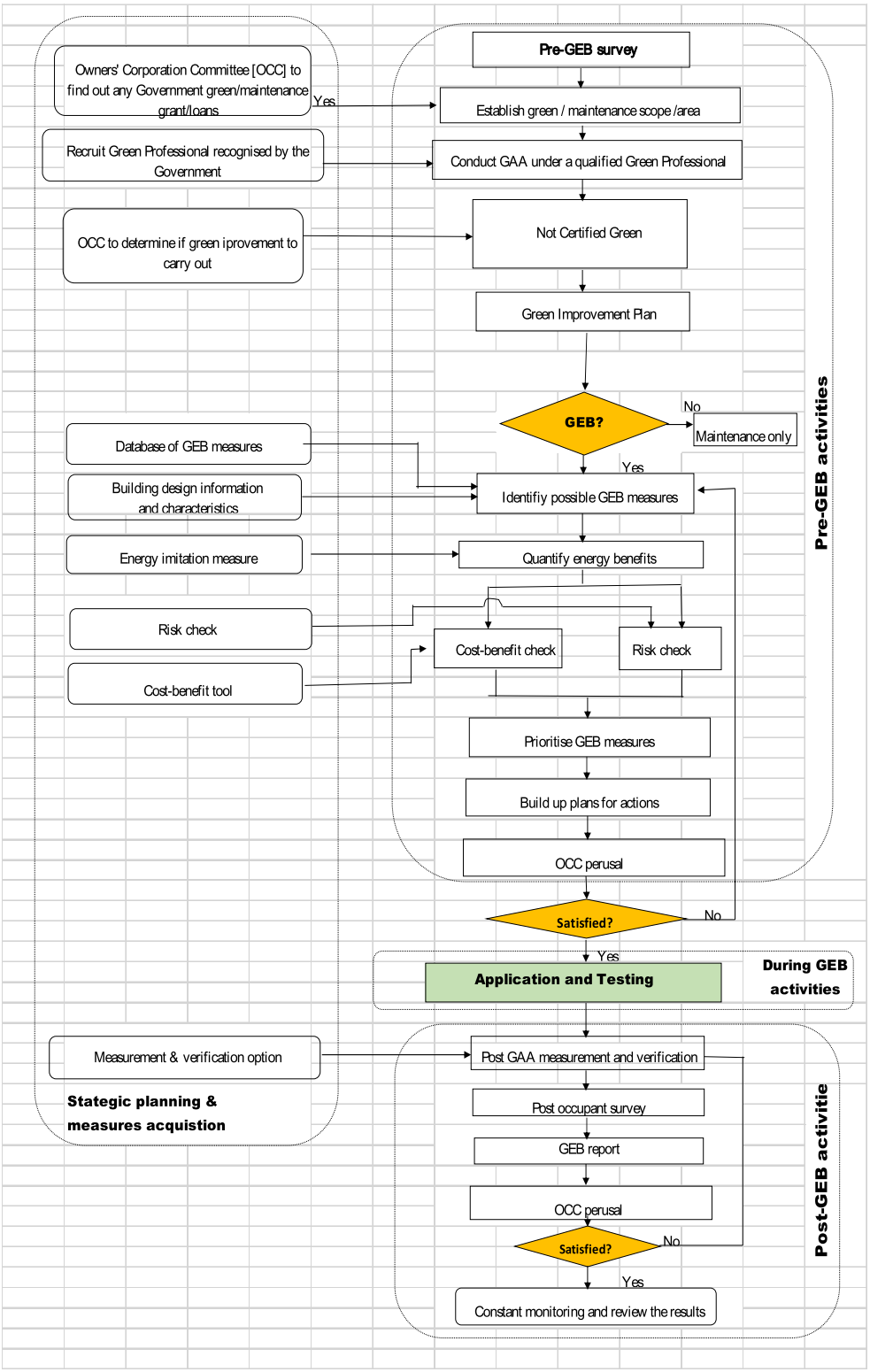


Fig. 5.1. Flow Chart for the GEB strategies to greening the existing buildings.

5. The GEB strategies developed

Based on the above literature findings and the new Green Audit Award [GAA] put forward as a green rating tool for all the buildings in existence, the GEB strategies can now be identified in the flow chart Fig. 5.1.

To facilitate the implementation of the GEB strategies for a subject existing building, it is advised that the following conditions should be satisfied:

I. The existing building should be of age approaching 40 years of age and maintenance is observed to be carried out, like water seepage/plastering works are fading out.

Fig. 6.1. Location plan of Wan Chui Estate (WTE) in Chai Wan, Hong Kong.

II. The building is recommended to form an Owners' Corporation Committee (OCC) under Section 3.3A of the Building Management Ordinance (Cap 344) of HK Government. It would help to made decision much easier as the power and obligations of this OCC are recognized by the HK Government.
III. Maintenance and green improvement should be carried out in one go as HK Government has grant and loans provided for maintenance under the Building and Maintenance Scheme (BMMS) in January 2005.

The GEB Strategies involves the following procedure as outlined in the Fig. 5.1.

I. **Pre GEB Survey**
Once it is ascertained that the subject existing building need major renovation/maintenance, the OCC should carry out a study to:

a Establish the scope and area of the maintenance and green to be carried out.
b Identify if Government loan and grant is available or eligible for this type of maintenance/green area.

If all goes positive, a green professional, Green Pro (like Beam Pro) recognized by HK Government can be recruited to carry out the Green Audit Award assessment.

II. **GAA assessment**
The green rating assessment can be carried out under the above proposed GAA.
Once it is certified in the negative. A green improvement plan can then be developed.

III. **Green Improvement Plan**
The green deficiencies/potentials identified under the GAA can be grouped under each performance category and a green improvement plan can be established to carry out the green improvement together with the maintenance works.

IV. **Green measures implementation**
Once the green improvement plan is decided to carry out, the OCC should go through the cost benefit and risk checkup considering the Government grant/loan to be granted together with the green technologies to be adopted.
Reference can be made to the most cost effective and efficient green technologies that have been identified under this study.

V. **Post GAA assessment**
A post green assessment should be carried out after the green/maintenance improvement to see if the green standard can be achieved. Further green improvement works should be done until the green award is ascertained/verified.

VI. **Regular monitor and review**
It is important that a constant/frequent monitoring of the existing building energy savings performance data should be carried out after the post GEB period to see if energy savings/the occupants health and comfort are continuously maintained. A maintenance/management policy should be incorporated with all the green measures adopted for continued monitoring of the effectiveness of the green implementation.

6. Pilot test of GAA—A case study

A Hong Kong public housing estate of 11 blocks, **Wan Tsui Estate (WTE)** in Chai Wan, Hong Kong was chosen for the illustration of application of the GEB strategies/technologies and the green building rating under the Green Audit Award (GAA) plan adopted. The reasons behind why the public housing were selected for the pilot test were of twofold:

I. About 2.3 million out of 7million people are residing in public rental housing built by Hong Kong Housing Authority (HA). HA has an existing public rental flats amounting to 0.7 million stocks (Liu et al., 2013). There are 205 Estates with 58 Estates that are over 30 years.
II. GEB is one of the key maintenance strategies promoted by the Housing Authority of HK for the public housing. To upkeep the provisions and facilities of an old estate so that it can continue to provide tenants with a quality living environment meeting their up-to-date needs, an Estate Improvement Program (EIP) has been formulated for estate of about 40 years old after detailed structural appraisal under the Comprehensive Structural Investigation Program (CSIP)

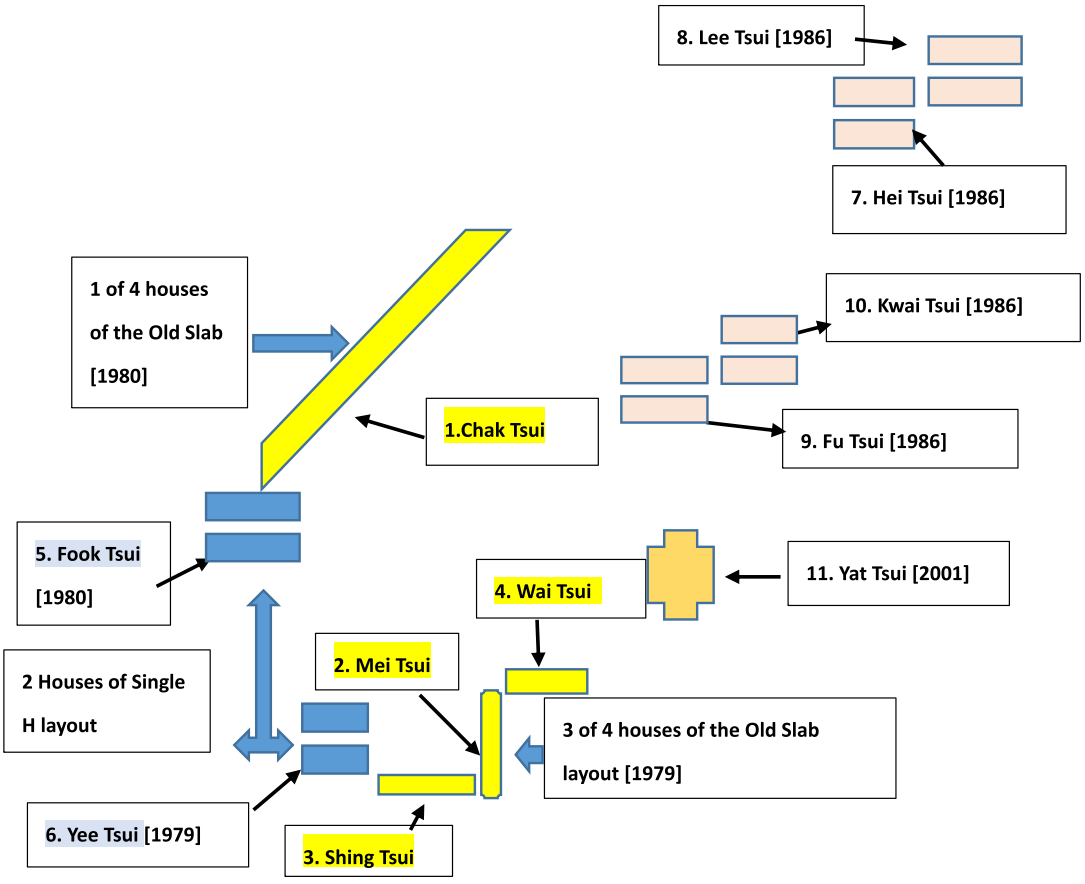


Fig. 6.2. Wan Tsui Estate layout plan showing the six houses with age about 40 years under this case study.

Table 6.1
Key indicators of Wan Tsui Estate (WTE) *(From Wikipedia, the free encyclopedia).*

District :	**Wan Tsui Estate**
Completion Year :	1979-2001 (only six houses reach 40 years old and are under this pilot test)
Estate Area :	55,000 m2
Domestic Flats :	3,600
Population :	● 10,600 ● Elderly: 3,200 (30%) ● 60% Households have elderly members aged 60 or above ● 60 Flats are occupied with members of physically disabilities
Ancillary Facilities :	● Shopping mall & Market (1) ● Single storey Car Parks (2) ● Community Hall (1) ● Primary Schools (2) & Kindergarten (1)
Type of Domestic Blocks :	4 Old Slab Blocks , 2 Single H blocks, 4 Double H blocks and 1 Small Household block (17 to 18 storeys)

Table 6.2
The GAA plan assessment with credits awarded.

No.	Green building aspects	Assessment criteria	Credits	Earned
1	LOCATION & TRANSPORTATION [LT-15]	Alternative transportation	15	13
2	SUSTAINABLE SITE [SS-10]	Site set up — reserve existing natural state	2	2
		Rainwater control	3	0
		Heat localized lessening	2	0
		Light contamination lessening	1	1
		Site control	1	0
		Site enhancement	1	0
3	WATER EFFICIENCY [WE-12]	Exterior water use lessening	2	0
		In-house water use lessening	5	3
		Cooling tower water lessening	3	0
		Water use record appliances	2	0
4	ENERGY & ATMOSPHERE [EA-30]	Building services testing	2	0
		Building services testing — performance	2	1
		Ongoing testing	3	0
		Energy use	12	5
		Enhanced energy recording	2	0
		Energy Demand control	3	0
		Energy renewal supply	5	0
		Refrigerant control	1	0
5	MATERIAL & RESOURCES [MR-8]	Acquisition — in progress	1	1
		Acquisition — lightings	1	1
		Acquisition retrofit	2	0
		Solid waste control — in progress	2	1
		Solid waste control — retrofit	2	0
6	INDOOR ENVIRONMENTAL QUALITY [IEQ-17]	IEQ control scheme	2	0
		Improved IEQ measures	2	0
		Heat relief	1	1
		Internal lamps	2	1
		Sunshine	4	1
		Green enhancement scheme	1	0
		Green enhancement — goods	1	0
		Green enhancement — appliance	1	0
		Insects pest control	2	0
		Comfort Inquiry	1	0
7	ECONOMIC VALUE [EV-5]	Economic benefits acquired	3	1
		Added value	2	0
8	HUMAN IMPACTS [HI-3]	Impacts on local comforts	2	0
		Value to aged/inferior groups	1	0
9	INNOVATION [IN-6]	New measures	5	0
		Green-Pro qualified assessor	1	0
10	REGIONAL PRIORITY [RP-4]	Local peculiarity	4	0

and confirmed as structurally sound and economically viable for maintenance.

Fig. 6.1 shows for the location plan of Wan Tsui Estate (WTE) a public estate of Chai Wan Estate adjacent to Chai Wan MTR Station.

6.1. Building description

As illustrated in Table 6.1, WTE was completed in 1979–2001 with a site area of 55,000 m^2 at Chai Wan District. With its unique characteristics built in adjacent to the Cape Collinson Crematorium in Chai Wan, it consists of four slab block buildings of 17 to 18-storey high, two car park of one storey and a shopping center. It is a mature estate with a total number of 3600 flats. Amongst the population of 10,600, 30% (3200 persons) are elderly tenants, 60% of the households have elderly member aged 60 or above and about 60 flats are occupied with members of physically disabilities. The six houses about 40 years under this study is laid

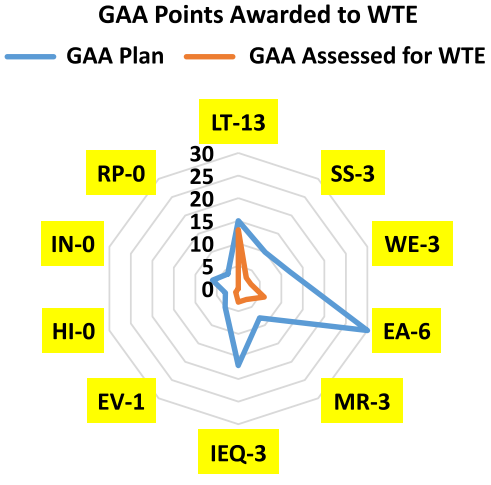


Fig. 6.3. The GAA points awarded to WTE: LT-13; SS-3; WE-3; EA-6; MR-3; IEQ-3; EV-1; HI-0; IN-0; RP-0 [$\sum$**32**].

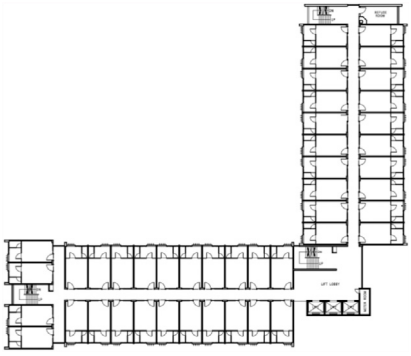
down in the following Fig. 6.2 *Wan Tsui Estate (WTE) with layout plan showing the six houses with age about 40 years under this case study*.

The Six houses are:

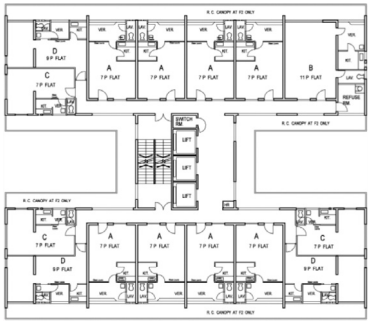
1. Chak Tsui
2. Mei Tsui
3. Shing Tsui
4. Wai Tsui
5. Fook Tsui
6. Yee Tsui

The layouts plan

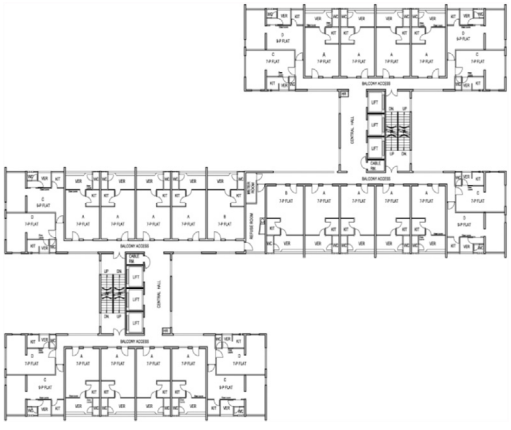
I. The Old Slab



II. The Single H



III. Double H



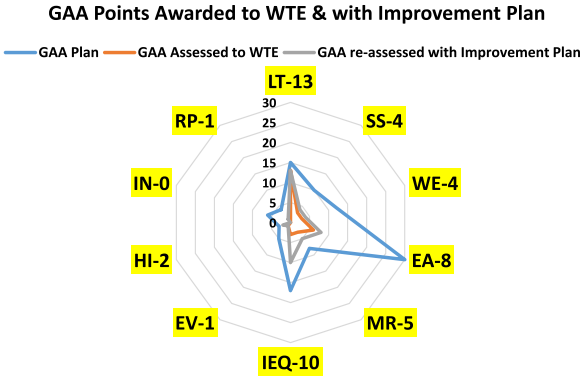
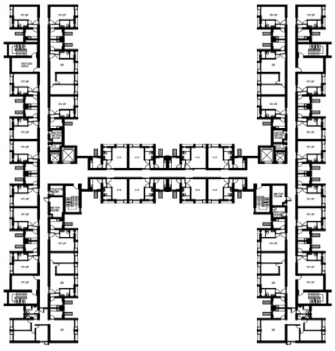


Fig. 6.4. The GAA re-assessment points awarded to WTE: LT-13; SS-4; WE-4; EA-8;MR-5; IEQ-10; EV-1; HI-2; IN-0; RP-1 [∑48].

	LOCATION & TRANSPORTATION [LT]			13 → 13
	SUSTAINABLE SITE [SS]			3 → 4
	WATER EFFICIENCY [WE]			3 → 4
	ENERGY & ATMOSPHERE [EA]			6 → 8
	MATERIAL & RESOURCES [MR]			3 → 5
	INDOOR ENVIRONMENTAL QUALITY [EQ]			3 → 10
	ECONOMIC VALUE [EV]			1 → 1
	HUMAN IMPACTS [HI]			0 → 2
	INNOVATION [IN]			0 → 0
	REGIONAL PRIORITY [RP]			0 → 1
	PROJECT TOTALS			32 → 48
AWARD	40 to ≤50 Points CERTIFIED	≤ 60 Points SILVER	≤80 Points GOLD	80+ Points PLATINUM

Fig. 6.5. The Graphical map showing the GAA assessed to WTP [∑32] and GAA re-assessed with improvement plan [∑48].

IV. Small Household Block



6.2. The GAA assessment

The GAA assessment for the six houses of the WTE are identified in the Fig. 6.3.

The award under the GAA plan assessment is summarized in Table 6.2 as follows:

The total points awarded to WTE was 32 not falling within the minimum tally of 40 to ≤50 point and the WTE under test was ***not certified*** under GAA assessment.

Table 6.3
The proposed green improvement plan for WTE.

No.	Performance Category	Proposed Improvement Area	Re-award
1	LT	● **Add lift tower** to relieve the aged group connected to adjacent shopping malls	13
2	SS	● **Add green roof** at the shopping center located at the estate center. Not only can it provide aesthetics enhancement to the neighborhood, the surface housetop temperature can be reduced by about 4℃, and increases the overall green ratio to 28% of the total estate floor area. ● Provides **vertical greening** for low rise structures, such as the walls at refuse/pump rooms. ● Using soft landscaping to upgrade the existing landscape of WTE ● Develop community gardens thus promoting **community participation** in greening of WTE ● **Rain Water Harvesting** to WTE shopping center. Both rain water and condensate from the shopping center's A/C system is harvested for irrigation. 65% annual reduction in water consumption is expected for irrigation.	4
3	WE	● **Using the reclaimed water** from the air conditioning condensate for the irrigation of all planter areas to reduce the water consumption and waste water. ● **Monitor the water consumption if it is used effectively by installing four or more water systems** with meters for cooling towers, reclaimed water and other process water like humidifiers, dishwashers, clothes washers and pools.	4
4	EA	● To arouse the tenants' awareness of energy conservation and environmental sustainability, a LCD panel called **Environmental Protection Window (EPW)** can be installed at G/F lift lobby of all the blocks of WTE to show the periodic consumption of : ➢ Electricity (both tenants and communal) ➢ Gas (tenants only) ➢ Water (communal only) ➢ Periodic comparisons on various consumption performances of the blocks within the same period in previous year. ● Convert the **exterior lighting** to renewal energy lighting	8
5	MR	● Use of **timber from sustainable source** from Forest Stewardship Council (FSC) certified	5

(*continued on next page*)

Table 6.3 (*continued*)

		● Change the **refuse storage** to **material recovery room** ● Provide **mail box type disposal system** for recycling materials. This will encourages source separation of domestic waste and provide protection and avoid nuisance. ● Provide plan to constant monitor the waste volume to encourage tenants' involvement in the recycling programs presently available.	
6	**IEQ**	● Install **De-odorizes** at the covered refuse area incorporated with bio-chemical technology to contain the odor as serves as a pest control management. ● Conduct periodically **on-site measurement** to verify the effectiveness of air ventilation technology and generate data for benchmarking improvement opportunities ● Adhere to the nontoxic cleaning agent ● Constant monitor the thermal comfort at all major air refreshing equipments	**10**
7	**EV**	● Use **energy saving lighting installation/motion sensors** that can save 10% energy consumption ● Hold **"Earth Hour" campaign** by switching off the non-essential external lightings in public rental housing estates to show support for energy saving.	**1**
8	**HI**	● Periodic comparisons on various consumption performances of the blocks can be assessed within the same period in previous year to arouse green awareness in the public. ● Increase the rate of domestic refuse recovery and reduce refuse for disposal. ● Introduce **daylight and views** into the space ● Add **lift tower** to shopping centres for those disadvantaged groups	**2**
9	**IN**	● Use **Twin Tank System** to provide uninterrupted water supply to tenants, even during cleansing of water tank. The pipe works of the existing two water tanks located on the same roof can be modified for the twin tank function. Such arrangement is more cost-effective as it retains the existing structure to avoid demolition and construction waste, but at the same time improve the quality of living and sustainability of the estate. Twin Tank can be provided to Old Slab –Shing Tsui, Mei Tsui, Wai Tsui and Chak Tsui and Double H blocks-Fook Tsui and Yee Tsui with modification of pipe works connecting the two tanks together.	**0**

(*continued on next page*)

Table 6.3 (*continued*)

		• Incorporate **Sound Barrier Balcony** using sloped glass panes as sound barrier and sound absorption materials at the two sides and top level. This innovative sound barrier balcony could achieve a noise reduction to almost 8 dB(A) • **Install Acoustic Window** which functions as a window with double glazing and openings offset to allow natural flow of air. Upon testing for different flat and window scenarios, the acoustic window could achieve noise attenuation up to 8 dB(A)	
10	**RP**	• Add **incentives that allow local feature and social peculiarity**. As 30% of the population belongs to the aged group, wherein 60% households have elderly members aged 60 or above and 60 flats are occupied with members of physically disabilities, more provisions like disable toilets, travelling ramps, tower lifts and leisure/ recreation area for elderly persons with fitness equipment for senior adults should be provided. • Improve **Barrier free access** [BFA] and connectivity: WTE is a mature estate with a total number of 3,600 flats. Amongst the population of 10,600, 30% (3,200 persons) are elderly tenants, 60% of the households have elderly member aged 60 or above and about 60 flats are occupied with members of physically disabilities. Addition of lift towers will made significant improvement of BFA as well as the connectivity of the estate, and should be welcomed by the tenants. • Add **other BFA improvement works**, such as the tactile guide-paths, railings at staircases, ramps, accessible parking space, unisex toilets, etc. at communal areas can also be considered and provided. • Provide **more weather-protected pedestrian walkway network** by extending the existing covers along the elevated walkways between each block. This weather-protected walkway network enhances the connectivity amongst building blocks and major facilities of the estate. • **Set up local gardens** at WTE to promote occupants' involvement in greening activities. This should be most welcome for the estate with high % of aged group. Planting Day and greening activities can also be organized • Set up **waste reduction campaign** to engender the waste reduction concept and habits in the Estate.	**1**
			∑ **48**

Credit by credit analysis

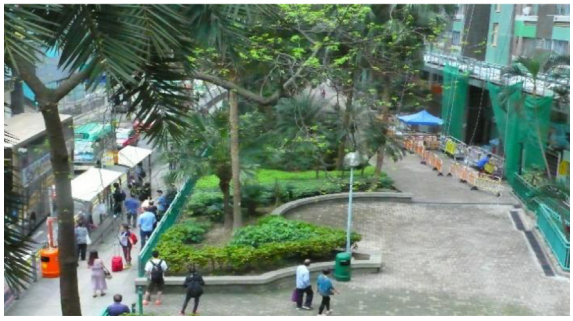
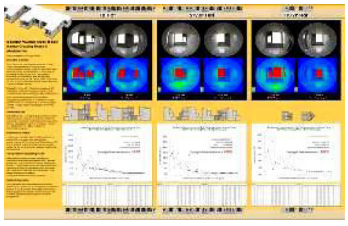
The credit awarded can be further analyzed as follows with rationales under the GAA plan.

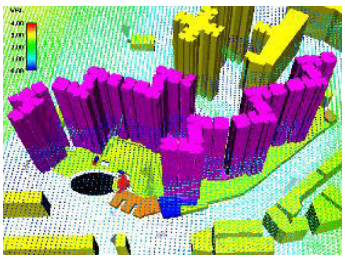
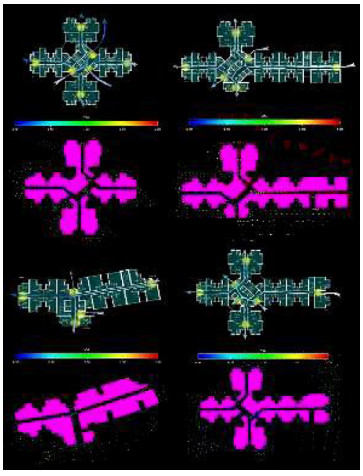
1. LOCATION AND TRANSPORTATION [LT]

<table>
<tr><th colspan="2">ASSESSMENT GUIDELINES</th><th>Credit</th><th>Earned</th></tr>
<tr><td>LT Credit</td><td>ALTERNATIVE TRANSPORTATION</td><td>15</td><td>13</td></tr>
<tr><td>MEASURES SUPPORTING ACHIEVEMENTS</td><td>WEATHER-PROTECTED PEDESTRIAN WALKWAYS TO ENHANCE THE CONNECTIVITY AMONGST BUILDING BLOCKS. See Fig LT1 and Fig LT2.
Fig LT1 Weathered protected pedestrian walkways

Fig LT2 Covered walkways
 </td><td></td><td>13</td></tr>
<tr><td></td><td>Carpark facility provided for the tenants. From survey, only 40% of the tenants have private cars as 60% of the tenants are using the public transit as both the MTR[Chai Wan MTR station] and the public vehicles are next to the estate within a few minutes’ walk. See Fig LT3
Fig LT3 Carpark facility
 </td><td></td><td></td></tr>
</table>

2. SUSTAINABLE SITES [SS]

ASSESSMENT	GUIDELINES	Credit	Earned
SS Credit	**SITE SET UP-RESERVE EXISTING NATURAL STATE**	2	2
MEASURES SUPPORTING ACHIEVEMENTS	**Landscaping** The existing landscape of WTE dominates about 10% of the site area. See Fig SS1. **Fig SS1 The existing landscape in two different areas** 		
SS Credit	**RAINWATER CONTROL**	3	0
MEASURES SUPPORTING ACHIEVEMENTS	Rain Water Harvesting [NIL] Pipe works for collection of rain water [NIL]		
SS Credit	**HEAT LOCALISED LESSENING**	2	0
MEASURES SUPPORTING ACHIEVEMENTS	Since 2004, Hong Kong Housing Authority has employed computational fluid dynamics technology to evaluate environmental performance and to enhance location of the housing blocks in all newly-designed estates. **But not for this project. See Fig SS2.** **Fig SS2 The Computational fluid dynamics analysis for newly designed housing blocks sample graphs** 		

	  On site measurement at post occupation stage is conducted to verify the effectiveness of the above methodology and to generate data for wind environment, natural ventilation, daylight and indoor thermal condition, etc for benchmarking improvement opportunities. See Fig SS3. **Fig SS3 Site measurements to check the wind environment, natural ventilation, daylight and indoor thermal conditions, etc** 		
SS Credit	**LIGHT CONTAMINATION LESSENING**	1	1
MEASURES SUPPORTING ACHIEVEMENTS	Use energy saving light bulbs at public area of estate management office, ground floor lobby of domestic blocks, as well as other indoor and outdoor areas of WTE to reduce glaring effect and to improve nighttime visibility. Shielding is provided to avoid direct emitting down glare. **See Fig SS4.** **Fig SS4 Energy saving light bulbs at public area**		

SS Credit	**SITE CONTROL**	1	0
MEASURES SUPPORTING ACHIEVEMENTS	Green surrounding barrier and green top at the site containers ● Reuse of surrounding barriers. ● Green top to allay the air pollutants. [NIL for this estate]		
SS Credit	**SITE ENHANCEMENT**	1	0

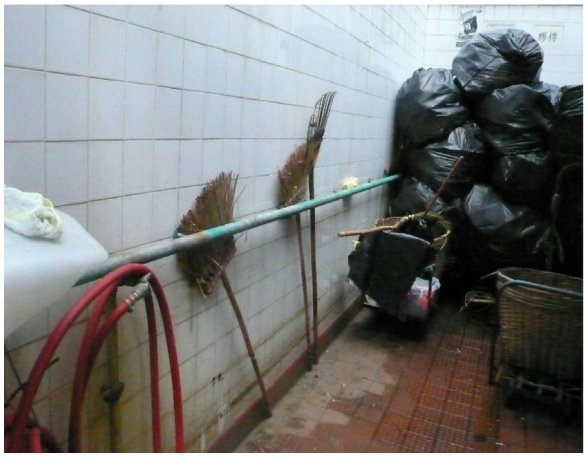
3. WATER EFFICIENCY [WE]

ASSESSMENT	GUIDELINES	Credit	Earned
WE Credit	**EXTERIOR WATER USE LESSENING**	2	0
MEASURES SUPPORTING ACHIEVEMENTS	● WTE shopping centre. Both rain water and condensate from the shopping centre's A/C system is not harvested for irrigation.		
WE Credit	**IN-HOUSE WATER USE LESSENING**	5	3
MEASURES SUPPORTING ACHIEVEMENTS	Install water saving devices—add air into the potable water, meeting with the functional requirement for cleansing water with less water. Water saving device installed at basin of bathroom. See Fig WE1~3 **Fig WE1-Before water saving devices Fig WE2-After water saving devices** 		2
	Fig WE3 The water saving devices 		
	Dual flush toilet **Flush water consumption and waste water can be reduced using the dual flush toilet. See Fig WE4.** **Fig WE4 The dual flush toilet device** 		1

WE Credit	**COOLING TOWER WATER LESSENING**	3	0
MEASURES SUPPORTING ACHIEVEMENTS	Reclaimed water for irrigation of soft landscape area [NIL]		
WE Credit	**WATER USE RECORD APPLIANCES**	2	0
MEASURES SUPPORTING ACHIEVEMENTS	No tracking of water consumption to identify opportunities for additional water savings.		

4. ENERGY AND ATMOSPHERE [EA]

ASSESSMENT	GUIDELINES	Credit	Earned
EA Credit	**BUILDING SERVICES TESTING**	2	0
MEASURES SUPPORTING ACHIEVEMENTS	WTE has not adopted the following building testing measures: ● Data and records gathering like environmental purchasing records, waste records, etc. ● Procedures/manuals/guidelines development like tenant guidelines/handbooks ● Site measurement like water quality survey ● Technical studies like waste audit, energy audit, carbon audit, water audit		
EA Credit	**BUILDING SERVICES TESTING-PERFORMANCE**	2	1
MEASURES SUPPORTING ACHIEVEMENTS	No independent mechanical air filtration system for existing refuse storage areas. See Fig EA1. **Fig EA1 The Existing Refuse storage area without filtering system** 		

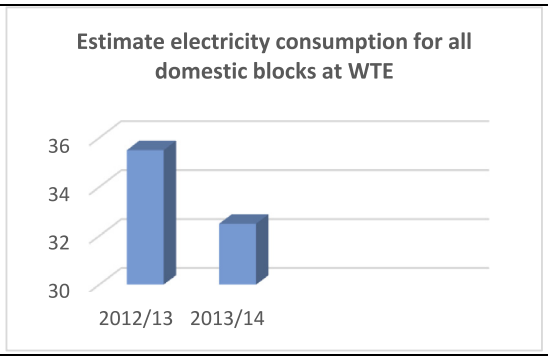


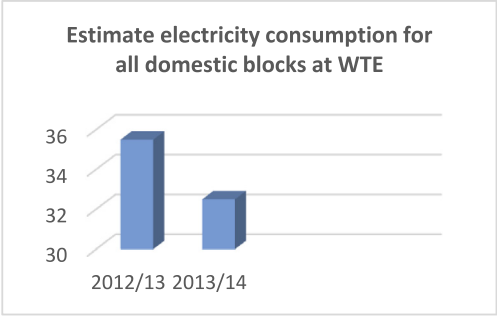
Public lighting replacement using energy efficient product-electrical ballast with registration under EMSD's energy efficiency labelling scheme. See Fig EA2.

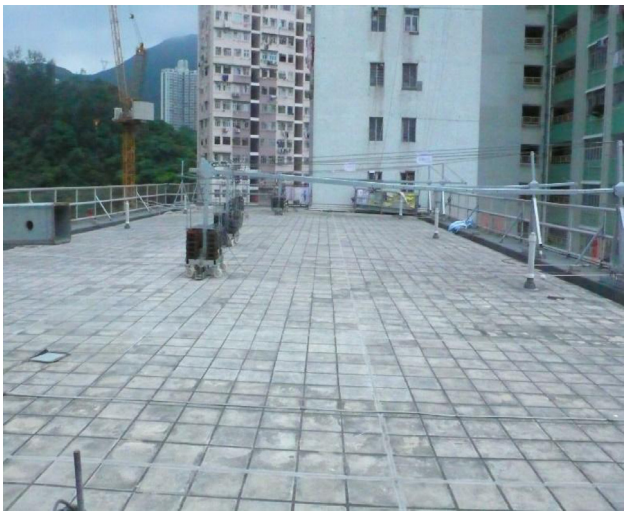
Fig EA2 Bulkhead light fittings c/w electronic ballast

Significant energy reduction of at least 15% for all buildings of WTE from 35.4 kWh/m2 dropped to 32.5kWh/m2. See Fig EA3.

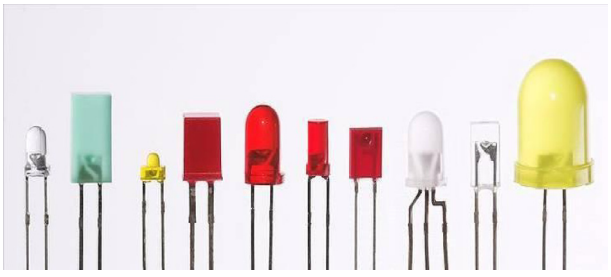
Fig EA3 The Electricity consumption for all domestic blocks at WTE



EA Credit	**ONGOING TESTING**	3	0
MEASURES SUPPORTING ACHIEVEMENTS	No use of Environmental protection window to ongoing arouse the tenants' awareness of energy conservation and green strategy.		
EA Credit	**ENERGY USE**	12	5
MEASURES SUPPORTING ACHIEVEMENTS	WTE has attained a drop of electrical consumption from 35.4 kWh/m2 in 202/13 to 32.5kWh/m2 in 2013/14 approximately of 8%. See Fig EA4. **Fig EA4 The Electricity consumption for all domestic blocks at WTE**		
			
EA Credit	**ENHANCED ENERGY RECORDING**	2	0
MEASURES SUPPORTING ACHIEVEMENTS	No installation of electricity check meters system to monitor electrical energy usage of major electrical loading.		
EA Credit	**ENERGY DEMAND CONTROL**	3	0
MEASURES SUPPORTING ACHIEVEMENTS	No measures are taken to energy demand control to efficiently generate and distribute the energy use i.e. periodic comparisons on various consumption performances of the blocks within the same period in previous year, and periodic comparisons of various energy use indexes of individual block with the average figures of all Public rental Housing blocks in Hong Kong		
EA Credit	**ENERGY RENEWABLE SUPPLY** No Photovoltaic (PV) panel system and no timber from sustainable source are used. See Fig EA5 and Fig EA6	5	0

MEASURES SUPPORTING ACHIEVEMENTS	**Fig EA5 No Grid connected PV panel system to the rooftop.**		
			
	Fig EA6 No use of timber from sustainable source from Forest Stewardship Council (FSC) certified.		
EA Credit	**REFRIGERANT CONTROL**	1	0
MEASURES SUPPORTING ACHIEVEMENTS	To safeguard the ozone layer of the earth, non-Chlorofluorocarbon (non-CFC) has been adopted by Housing Authority since 1996. However, WTE has not adopted this measure yet.		

5. MATERIAL AND RESOURCES [MR]

ASSESSMENT	GUIDELINES	Credit	Earned
MR Credit	**ACQUISITION – IN PROGRESS**	1	**1**
MEASURES SUPPORTING ACHIEVEMENTS	Join hands with charitable organizations to arrange various waste recovery activities such as collection of used clothes, rechargeable batteries, compact fluorescent lamps and fluorescent tubes, waste electrical appliances/computers and moon cake tin boxes. See Fig MR1. **Fig MR1 Waste recovery activities** 		
MR Credit	**ACQUISITION - LIGHTINGS**	1	**1**
MEASURES SUPPORTING ACHIEVEMENTS	● Special disposal of all environmental hazardous materials like mercury containing lamps. ● To use non mercury lamps such as Light Emitting Diode (LED) : Use Light-emitting Diode (LED) Lighting at reception area of estate management office, ground floor lobby of domestic blocks, as well as other indoor and outdoor areas of WTE. See Fig MR2 **Fig MR2 Light-emitting Diode (LED)** 		
MR Credit	**ACQUISITION RETROFIT**	2	**0**
MEASURES SUPPORTING ACHIEVEMENTS	No use of timber from sustainable source from Forest Stewardship Council (FSC) certified.		
MR Credit	**SOLID WASTE CONTROL – IN PROGRESS**	2	**1**
MEASURES	Enhanced “Trip Ticket System”		

SUPPORTING ACHIEVEMENTS	● Enhance the monitoring on the transportation records of the construction & demolition materials disposal. ● Incorporate performance monitoring system on the contractor. Sorting facilities at the Public Fill Reception at Tuen Mun Area 38		
MR Credit	**SOLID WASTE CONTROL – RETROFIT** No refuse storage and material recovery room are provided. See Fig MR3.	2	**0**
MEASURES SUPPORTING ACHIEVEMENTS	**Fig MR3 No refuse Storage and Material Recovery Rooms** No mail box type disposal system for recycling materials. See Fig MR4. ● Encourage source separation of domestic waste. ● Provide protection and avoids nuisance **Fig MR4 Mail box type disposal system** 		

6. INDOOR ENVIRONMENTAL QUALITY [IEQ]

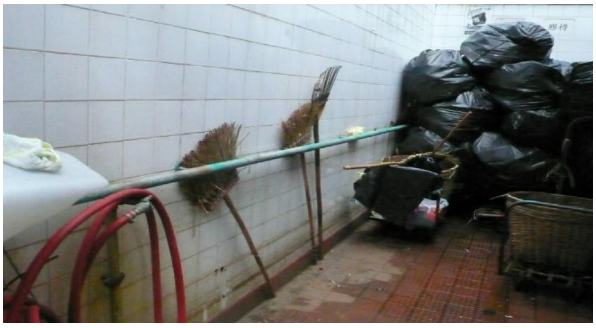
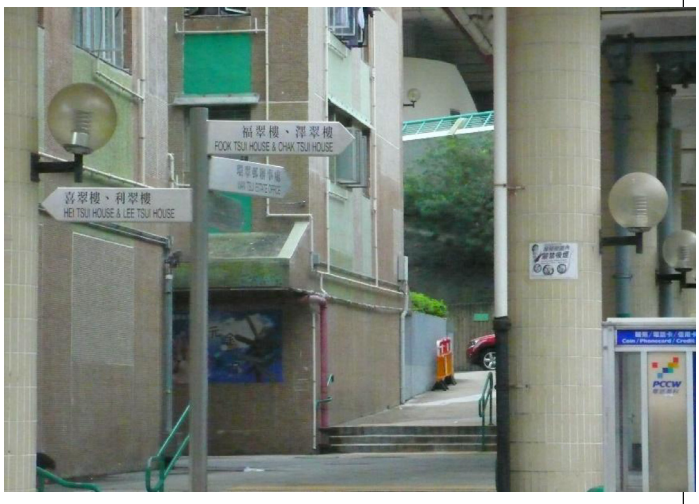
IEQ Credit	**IEQ CONTROL SCHEME**	2	**0**
MEASURES SUPPORTING ACHIEVEMENTS	No Odor Control at Refuse Collection Points. Only water tap for cleaning is provided. See Fog IEQ1.		
	Fig IEQ1 No Odor Control at Refuse Collection Points 		
IEQ Credit	**IMPROVED IEQ MEASURES**	2	**0**
MEASURES SUPPORTING ACHIEVEMENTS	Hong Kong Housing Authority has intended to use new applications to enhance air quality. WTE has not used bio chemical to filter the contaminants from vehicles in the public / carparks. See Fig IEQ2. **Fig IEQ 2 Bio chemical filter panels in other estate of Housing Authority** 		
IEQ Credit	**HEAT RELEIF**	1	**1**
MEASURES SUPPORTING ACHIEVEMENTS	The long corridor /louvre in the corridor design allow max lighting and natural ventilation at the human comfort level thus allaying the energy consumes in the HVAC and lighting system. See Fig IEQ3 and Fig IEQ4. **Fig IEQ 3 The long corridor allows max lighting and ventilation to each tenant.**		

	 Fig IEQ 4 The louvre in the corridor allow cross ventilation to each flat		
IEQ Credit	**INTERNAL LAMPS**	2	**1**
MEASURES SUPPORTING ACHIEVEMENTS	WTE provides high quality lighting to promote occupants' working tempo using: **Light-emitting Diode (LED) Lighting Installation** Use Light-emitting Diode (LED) Lighting at reception area of estate management office, ground floor lobby of domestic blocks, as well as other indoor and outdoor areas of WTE. See Fig IEQ5. **Fig IEQ 5 Light-emitting Diode (LED) Lighting Installation in public area**		
			
IEQ Credit	**SUNSHINE**	4	**1**
MEASURES	To promote the occupants to outdoor activities thus using less lighting,		

SUPPORTING ACHIEVEMENTS	WTE introduces open view with long and open corridor. See Fig IEQ6. **Fig IEQ 6 WTE introduces open view with long and open corridor.** 		
IEQ Credit	**GREEN ENHANCEMENT SCHEME**	1	**0**
MEASURES SUPPORTING ACHIEVEMENTS	No green cleaning procedures adopted in WTE to promote the risk of contamination as well as the measures to allay its health implication.		
EQ Credit	**GREEN ENHANCEMENT- GOODS**	1	**0**
MEASURES SUPPORTING ACHIEVEMENTS	No Refuse Storage and Material Recovery yard are provided. See Fig IEQ7. **Fig IEQ 7 No provision of storage and recovery space for refuse at each floor to promote source separation.** 		

IEQ Credit	**GREEN ENHANCEMENT- APPLIANCE**	1	**0**
MEASURES SUPPORTING ACHIEVEMENTS	**Refuse Handling System** WTE does not adopt a designated area to collect refuse for each building. See Fig IEQ8. **Fig IEQ 8 Refuse handling system** 		
IEQ Credit	**INSECTS PEST CONTROL**	2	**0**
MEASURES SUPPORTING ACHIEVEMENTS	No installation of De-odorizes at the Covered Refuse Collection Points Since 2003, new de-odorizers are installed at designated cover area for the refuse, where bio-chemical technology is employed to contain the odor as serves as a pest control management. See Fig IEQ9. **Fig IEQ 9 De-odorizes at the Covered Refuse area** 		
IEQ Credit	**COMFORT INQUIRY**	1	**0**
MEASURES SUPPORTING ACHIEVEMENTS	Unlike other estates, WTE did not conduct periodically on-site measurement to verify the effectiveness of air ventilation technology and generate data for benchmarking improvement opportunities. See Fig IEQ10. **Fig IEQ 10 The on- site measurement device for air ventilation** 		

7. ECONOMIC VALUE [EV]

EV Credit	**ECONOMIC BENEFITS ACQUIRED**	3	**1**
MEASURES SUPPORTING ACHIEVEMENTS	WTE has attained a drop of electrical consumption from 35.4 kWh/m2 in 202/13 to 32.5kWh/m2 in 2013/14 approximately of 8%. A slight cost reduction.		
EV Credit	**ADDED VALUE**	2	**0**
MEASURES SUPPORTING ACHIEVEMENTS	No measure has been implemented to add value to the estate.		

8. HUMAN IMPACTS [HI]

HI Credit	**IMPACTS ON LOCAL COMFORTS**	2	**0**
MEASURES SUPPORTING ACHIEVEMENTS	No measure has been done to increase the tenants comfort nor improve their quality of life.		
HI Credit	**VALUE TO AGED/INFERIOR GROUPS**	1	**0**
MEASURES SUPPORTING ACHIEVEMENTS	No particular measures have been adopted to give benefits to the disadvantaged groups		

9. INNOVATION [IN]

IN Credit	**NEW MEASURES**	5	**0**
MEASURES SUPPORTING ACHIEVEMENTS	No new measures		
IN Credit	**GREEN PRO QUALIFIED ASSESSOR**	1	**0**
MEASURES SUPPORTING ACHIEVEMENTS	No GREEN PRO qualified assessor was employed.		

10. REGIONAL PRIORITY [RP]

RP Credit	**LOCAL PECULIARITY**	4	**0**
MEASURES SUPPORTING ACHIEVEMENTS	**No barrier free access [BFA] and connectivity** Around 30% of the population in WTE aged 60 or above and the percentage is growing. The needs of providing barrier-free access (BFA) and improving connectivity within the estate becomes inevitable particularly lift towers are important for connectivity within the Estate. See Fig RP1 and Fig RP2.		

Fig RP 1 No Vertical access for the pedestrian footbridge

Fig RP2 Only vertical lift is provided in the public area

6.3. The improvement plan and GAA re-assessed award

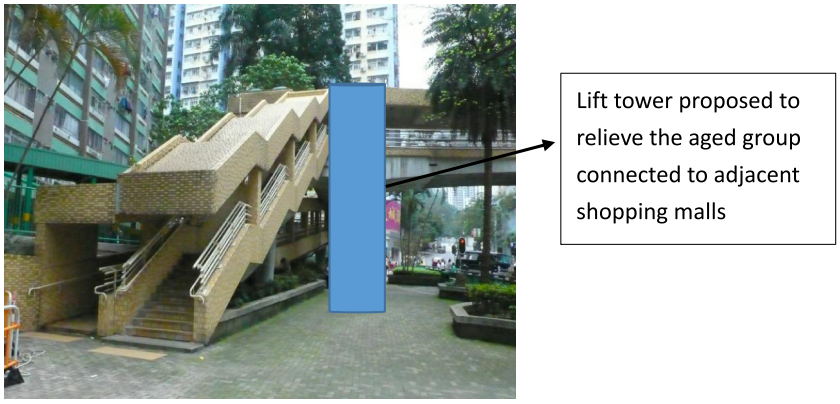
Based on the green deficiencies/potentials identified under the above GAA assessment, the green improvement plan as indicated in Table 6.3 can be put forward pursuant to this particular existing building [WTE]. The GAA reassessment is put forward in Figs. 6.4 and 6.5. The total points awarded to WTE after incorporating the improvement plan will be 48 falling within the minimum tally of 40 to $\leq$ 50 point and the WTE under test after the improvement plan will be **certified** under this GAA re-assessment.

The detailed improvement in awake of the assessment under the GAA plan can be evaluated and put forward under each performance below:

1. LOCATION AND TRANSPORTATION [LT]

1.1 As the estate is located quite near to the public transport, most of the building tenants are using the public transport like buses and MTR.
1.2 The connectivity of each block and the adjacent shopping malls are considered adequate but lift tower should be provided to facilitate the aged group of the estate that is growing. See Fig LTR1.

Fig LTR1 - Lift Tower is proposed to relieve the aged group to access the footbridge connected to the adjacent shopping malls.



2. SUSTAINABLE SITES [SS]

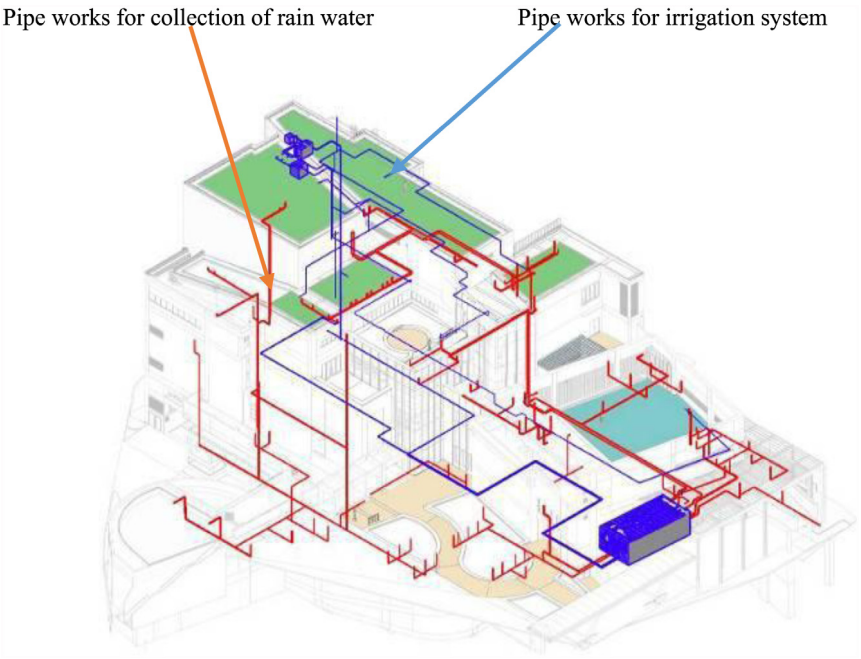
2.1 Ecological integrity can be preserved by providing green roof at the shopping center located at the center of the estate. It not only provides aesthetics enhancement to the neighborhood, it also roof slab temperature by about 4° C, and increases the overall green ratio to 28% of the total Construction Floor Area of the estate. Vertical greening is also provided for low rise structures, such as refuse/pump rooms. See Fig SSR1.
2.2 Landscaping: the existing landscape of WTE can be upgraded by soft landscaping under the Landscape Improvement Program with local gardens. See Fig SSR2.

Fig SSR1-Provision of green roof to the top roof of the shopping center and vertical greening to the refuse/pump room.

Fig SSR2 Set up local gardens to stimulate the occupants' involvement in greening the surrounding environment of WTE.

2.3 Rain Water Harvesting: WTE shopping center. Both rain water and condensate from the shopping center's A/C system is harvested for irrigation. 65% annual reduction in water consumption for irrigation. See Fig SSR3.

Fig SSR3 The rain water harvesting scheme



3. WATER EFFICIENCY [WE]

3.1 Cooling tower water use: reclaimed water for irrigation of soft landscape area Reclaimed water from the air conditioning condensate is sufficient for the irrigation of all planter areas so that the water consumption and waste water can be reduced. See Fig WER1.

Fig WER1 Cooling tower water use: reclaimed water for irrigation of soft landscape area.

3.2 Four or more water systems can be installed with meters for cooling towers, reclaimed water and other process water like humidifiers, dishwashers, clothes washers and pools.

4. ENERGY AND ATMOSPHERE [EA]

4.1 WTE can use an ENVIRONMENTAL PROTECTION WINDOW (EPW) to promote continuity of information to ensure that energy efficient operating strategies are maintained and provide a foundation for training and system analysis. See Fig EAR1. To arouse tenants' awareness of energy conservation and environmental sustainability by Installing a LCD panel at Ground floor lift lobby of all domestic blocks to show the periodic consumption of:

- Electricity (both tenants and communal)
- Gas (tenants only)
- Water (communal only)
- Periodic comparisons on various consumption performances of the blocks within the same period in previous year, and periodic comparisons of various energy use indexes of individual block with the average figures of all Public rental Housing blocks in Hong Kong.

Fig EAR1 Example of Environmental Protection window is shown in Kai Shing West Estate:

<table>
<tr><td> </td><td> </td></tr>
<tr><td>4-month average water consumption of landlord at public area (m3/flat/4-month)</td><td>Bi-monthly electricity saving performance of tenants</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>Monthy gas consumption of tenant (unit/flat/month)</td><td>Average monthly electricity consumption of landlord at public area (in kwh/flat/month)</td></tr>
<tr><td>
</td><td>
</td></tr>
</table>

4.2 Energy Recording Appliances

WTE can install energy recording appliances to support energy management and identify opportunities for additional energy savings by tracking building level energy use and continue to make use of the Housing Channel at the ground floor lift lobbies of public rental housing blocks to disseminate green messages to tenants and encourage them to lead a green life. See Fig EAR2.

Fig EAR2 Installation of electricity check meter system to monitor electrical energy usage of major electrical loading

4.3 Renewable Energy and Carbon Offsets

A Photovoltaic (PV) panel system with grid connected is proposed to add to the roof top. See Fig EAR3 and exterior lighting is proposed to convert to renewal energy lighting. See Fig EAR4.

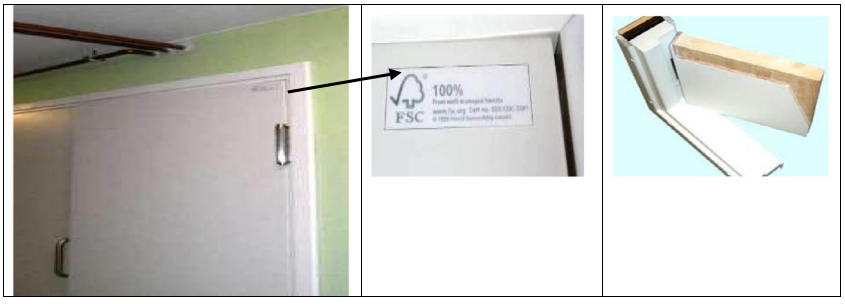
Fig EAR3 Add Grid connected PV panel system to the rooftop with more than 234 m2 of mono crystalline photovoltaic panels, providing an estimated average annual electricity output of 34,300 kWh

Fig EAR4 Convert the exterior lighting to renewal energy lighting

5. MATERIAL AND RESOURCES [MR]

5.1 Use of timber from sustainable source from Forest Stewardship Council (FSC) certified. See Fig MRR1.

Fig MRR1 Timber use from sustainable source from Forest Stewardship Council (FSC)



5.2 Change the refuse storage to material recovery room. See Fig MRR2.

Fig MRR2 Change of the refuse storage to material recovery room

5.3 Provide mail box type disposal system for recycling materials. This will encourages source separation of domestic waste and provide protection and avoid nuisance. See Fig MRR3.

Fig MRR3 Change to mail box type waste disposal system

6. INDOOR ENVIRONMENTAL QUALITY [IEQ]

6.1 **Green cleaning equipment**: Refuse Handling System: WTE can adopt a designated refuse area to facilitate the cleaning and avoidance of pest and odors. See Fig IEQR1.

Fig IEQR1 The refuse handling system

6.2 Integrated pest management:

Installation of De-odorizes at the Covered Refuse Collection Points

Since 2003, new de-odorizers are installed at covered refuse collection points in newly-completed estates, where bio-chemical technology is employed to contain the odor as serves as a pest control management. See Fig IEQR2.

Fig IEQR2 De-odorizes at the Covered Refuse Collection Points

6.3 Occupation comfort survey

WTE can conduct periodically on-site measurement to verify the effectiveness of air ventilation technology and generate data for benchmarking improvement opportunities. See Fig IEQR3.

Fig IEQR3 Checking ventilation device

7. Economic Value [EV]

- WTE can use energy saving lighting installation that can save 10% energy consumption
- WTE can hold "Earth Hour" campaign by switching off the non-essential external lightings in public rental housing estates to show support for energy saving.
- WTE can take measures to demand control to generate and dissipate energy efficiently i.e. periodic comparisons on various consumption performances of the blocks within the same period in previous year, and periodic comparisons of various energy use indexes of individual block with the average figures of all Public rental Housing blocks in Hong Kong. See Fig EVR1

Fig EVR1 The energy consumption data

4-month average water consumption of landlord at public area (m3/flat/4-month)	Bi-monthly electricity saving performance of tenants
Monthy gas consumption of tenant (unit/flat/month)	Average monthly electricity consumption of landlord at public area (in kwh/flat/month)

8. Human Impacts [HI]

8.1 WTE can implements the Source Separation of Domestic Waste Programme so as to enhance recycle of waste. See Fig HIR1.

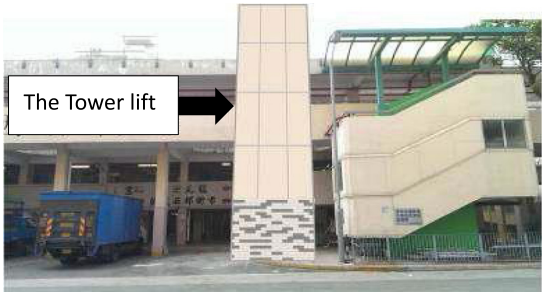
Fig HIR1 Domestic waste separation programme

8.2 To promote outdoor activities so as to use less lighting. WTE can introduce skylight construction, open space design to allow more sunshine and daylight. See Fig HIR2.

Fig HIR2 Provision of daylight into the stalls

And add lift tower to shopping centers for those disadvantaged groups. See fig HIR3.

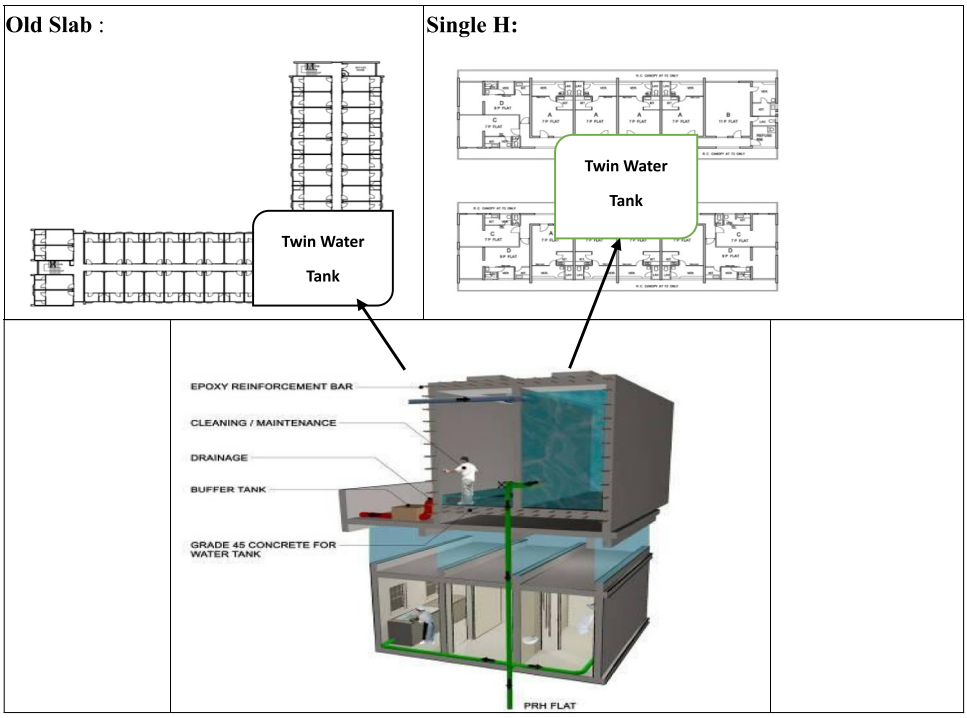
Fig HIR3 The tower lift for the inferior/aged groups



9. INNOVATION [IN]

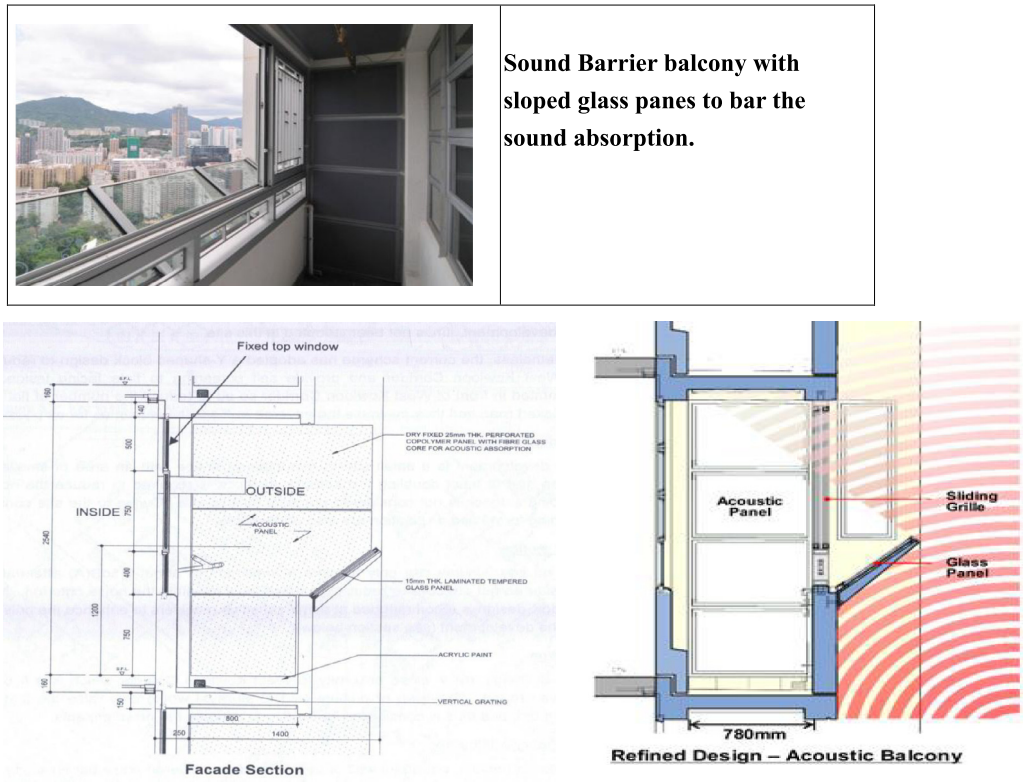
9.1 **Twin Tank System:** The objective of the twin tank system is to provide uninterrupted water supply to tenants, even during cleansing of water tank. While recognizing the social and environmental benefits, the economic implication has also been taken into account. The twin tank system in WTE utilizes the existing two water tanks located on the same roof with modification of pipe-works. Such arrangement is more cost-effective as it retains the existing structure to avoid demolition and construction waste, but at the same time improve the quality of living and sustainability of the estate. Twin Tank can be provided to Old Slab-Shing Tsui, Mei Tsui, Wai Tsui and Chak Tsui and Double H blocks-Fook Tsui and Yee Tsui with modification of pipe works connecting the two tanks together. See Fig INR1

Fig INR1 The twin tank system



9.2 **Sound Barrier Balcony:** Using noise barrier and absorption materials which can lower the sound decibels to almost 8dB (A). See INR2.

Fig INR2 The Sound Barrier Balcony with section drawings



9.3 **Acoustic Window**

HK Housing Authority has designed a type of acoustic window which functions as a window with double glazing with openings offset to allow the natural air flow. Subsequent to conducting laboratory tests on this window design concept which gave very promising results, full scale mock-up flats installed with prototype acoustic window was set up on site for in-situ acoustic measurements. Upon testing for different flat and window scenarios, it was established that the acoustic window could achieve noise attenuation up to 8 dB(A). See Fig INR3.

Fig INR3 The acoustic window with diagrammatic drawings

9.4 **Green Pro qualified assessor**

This qualified assessor will certify and evaluate the environmental and sustainability performance of the buildings, a weighting over different environmental performance categories, including site aspects, material aspects, energy use, water use and indoor environmental quality. Having taken into account of the existing environmental performance as well as the improvement measures to be adopted, WTE can be targeted to achieve 'Gold' or above grading under the BEAM Plus and/or under this Green Audit Award (GAA) plan.

The improvement measures are grouped into five categories: (i) data and records gathering (e.g. environmental purchasing records, waste records, etc.), (ii) procedures/manuals/guidelines development (e.g. tenant guidelines), (iii) site measurements (e.g. water quality survey), (iv) technical studies (e.g. waste audit, energy audit, carbon audit and water audit) and (v) building improvement works (e.g. modification of existing refuse storage areas with independent mechanical air filtration system, replacement of water cistern and urinal flush valve from single flush to dual flush system, sensory water taps for public toilets and implementation of ISO 50001 Energy Management System).

10. REGIONAL PRIORITY [RP]

10.1 WTE should add **incentives** that address regional feature to enhance health and comfort of the occupants. As 30% of the population belongs to the aged group, wherein 60% households have elderly members aged 60 or above and 60 flats are occupied with members of physically disabilities, more provisions like disable toilets, traveling ramps, tower lifts and leisure/recreation area for elderly persons with fitness equipment for senior adults should be provided.

10.2 **Barrier free access [BFA] and connectivity**: WTE was completed in 1979–2001 with a site area of 55,000 m2 at Chai Wan District. With its unique characteristics built in adjacent to the Cape Collinson Crematorium in Chai Wan, it consists of four slab block buildings of 17 to 18-storey high, two car park of one storey and a shopping center. It is a mature estate with a total number of 3600 flats. Amongst the population of 10,600, 30% (3200 persons) are elderly tenants, 60% of the households have elderly member aged 60 or above and about 60 flats are occupied with members of physically disabilities.

To address the aging problem, particular attention should be paid to the special needs of the elderly and disabled tenants, their living pattern and their integration with the younger generation. There is one important consideration in designing the improvement works for an old estate such as WTE, i.e. many tenants have grown up and grown old with the estate and have spent their lifetime in the estate. Around 30% of the population in WTE aged 60 or above and the percentage is growing. The needs of providing barrier-free access (BFA) and improving connectivity within the estate becomes inevitable. Addition of lift towers should be built for pedestrian cross with no lift provision previously. The new lift towers will made significant improvement of BFA as well as the connectivity of the estate, and should be welcomed by the tenants.

Other BFA improvement works, such as the tactile guide-paths, railings at staircases, ramps, accessible parking space, unisex toilets, etc. at communal areas should also be taken due consideration of the valuable feedbacks from Persons with a Disability on BFA facilities. More weather-protected pedestrian walkway network should be provided by extension of the existing covers along the elevated walkways between each block. This weather-protected walkway network enhances the connectivity amongst building blocks and major facilities of the estate. See Fig RPR1, Fig RPR2 and Fig RPR3.

Fig RPR1 Lift tower connected to the pedestrian bridge

Fig RPR2 Barrier Access and handrails to staircase

10.3 **Local Garden Programme**

Local gardens at WTE can be set up to promote occupiers 'involvement in greening activities. This should be most welcome for the estate with high % of aged group. Planting day and greening activities can also be organized. See Fig RPR4.

Fig RPR4 The Local Garden Programme

Community garden

Planting day

Greening activities

Green Carnival

10.4 **Waste reduction campaign** can be set up to engender the waste reduction concept and habits in the Estate. See Fig RPR5 and Fig RPR6.

Fig RPR5 Waste Reduction Campaign

Fig RPR6 Moon cake boxes collected

7. Results and discussion

It is commonly aware scientifically that the Earth has experienced an average rise in temperature of 0.6° C over the past 100 years. This climatic change is related to global warming which primarily is due to the burning of natural resource of fuels, land clearance and renovations, over use of heating, ventilation and air condition and lighting. One of the measures to reduce this warming effect is to reduce the energy use globally. Whilst new building works add a small % annually (Power, 2008), the remaining large % of building blocks in existence consumes about 26% of the total energy (Eurostat, 2009), in fact around 20–40% in modern countries (The Energy Conservation Center, 2008).

As illustrated in the above case study, the Green Audit Award [GAA] methodology is in fact ***not another green rating technique*** but it serves as a means/tool to assess the existing buildings aiming to identify their green deficiencies s/potentials so that a green improvement plan can be set up to improve the energy use of these existing buildings which have consumed about 37% of the accumulated energy use in modern countries like US (U.S. Green Building Council, 2007). The GAA integrates two strategic elements, green and environment. This synergy strengthens the role of the classic green rating audit by providing a method that not only optimize the green performance of existing buildings but also achieve a green retrofit of existing buildings, postulate improvement measures and thus making the existing buildings, and so future cities, more sustainable and green.

The green improvement plan ensues from the GAA assessment defines the green strategies and the actions that result in measures that have taken into account of the human impact/value added strategy/other resources limitation peculiar to the subject existing building as identified in the GAA plan. However, prior to the implementation of the green improvement plan, the assessor should consult with the tenants/users of the subject existing building that the following objectives have been clarified (Giuliano Dali'O' et al., 2012).

I. ***Is the GAA aims to reduce the cost of the energy management?*** If yes, more options can be put forward for the green improvement.
II. ***What is the budget for the green improvement plan and the time for the investment return?*** This will limit the scope and size of the green improvement plan.
III. ***Will the maintenance of the buildings and the green improvement plan be taken concurrently?*** If so, Government grants/loans can be sought under the Building Maintenance Scheme currently run in HKSAR.

Once the subject existing building has improved its green performance, it is important to initiate a management/maintenance policy for its maintenance or continued improvement of such services. All the green measures identified and implemented, will become important elements of a management/maintenance policy to continuously improving the green/sustainability of the subject existing building in times to go. Reference can be made to the standard ISO "Energy management systems—Requirements with guidance for use." to make up the management policy. The standard allows the organization to adopt the systematic approach to continuously maintaining and improving its green/energy efficiency performance. The GAA is thus a useful tool to assess its existing building's green/energy efficiency (or deficiencies) performance so that the building management can identify very easily the pragmatic approach to adopt a green improvement plan that suits the management resources' constraints. With the effort of each existing building in adopting the above GEB strategies, an enormous effect will be anticipated in combating the global warming in return.

7.1. GAA vs the local classic green audit for existing buildings

The paper cannot be completed without a comparison with the local classic green audit system viz: the HK BEAM plus v1.2 for buildings in existence. BEAM plus v1.2 is the green rating system used for the existing buildings in Hong Kong. Up to now, almost 300 projects are recognized by BEAM plus (www.beamsociety.org.hk/). The two systems are compared in the following area:

1. The ranking and scoring system

2. The categories and weightings

Table 7.1A gives each credit rating for the medal assigned. No bronze medal is awarded in GAA. A more detailed weightings are cross compared with GAA vs BEAM plus v1.2 in Table 7.1B. No local transportation, economic value, human impacts and regional priority are found in weightings for BEAM plus v1.2. These differences can be explained as BEAM plus v1.2 is focused on ***design perspective*** whilst GAA is more orientated to each existing building situation. Local transportation, economic value, human impacts and regional priority is crucial particularly in Hong Kong with congested and heavy traffic condition to evaluate the actual thermal, visual and audio comfort together with the internal air quality of the existing building. The two systems quantify differently for each category of sustainable performance but basically the two credits are more or less the same. Both systems place a heavy score on energy use: 39 for BEAM plus v1.2 and 30 for GAA. Thus the total score for the two systems are almost the same, 106 for BEAM plus v1.2 and 110 for GAA. However, as stated before, GAA covers more environmental performance on the actual existing building situation than BEAM plus v1.2.

Table 7.1A
The ranking and scoring systems (www.beamsociety.org.hk).

GAA for existing buildings		BEAM plus v 1.2 for existing buildings	
Award	Credits (Total 110)	Award	Credits (Total 100)
Certified	40 to ≤50	Bronze	40 to ≤54
Silver	≤60	Silver	≤64
Gold	≤80	Gold	≤74
Platinum	80+	Platinum	75+

With more and more buildings certified under GAA for existing buildings, more environmental performance data can be collated to make the GAA more objective and favors by most of the occupiers/owners of the buildings in existence. It should be pointed out that there is no award system for existing buildings and **BEAM Plus v1.2 for existing buildings is normally used as a basis for design renovations** for buildings in existence. However, since April 1 2011, BEAM plus is one of the requirements to have extra Gross Floor Area (GFA) granted in new projects. This GFA extra area incentive is not applicable for green improvement plans in existing buildings. **GAA is put forward as the tool to assess the existing buildings** whereby improvement plans with economic value and human impacts can be assessed on the basis of the award so that the tenants can be optioned to carry out the greening measures.

7.2. Promotions

7.2.1. Support from the government

To make the target of HKSAR reduce to energy power of 40% by 2025 and carbon concentration by 50–60% by 2020 using base year of 2005, the green improvement plan generated by GAA for existing buildings will be a great help and can offer the most cost effective way to achieve the target as the buildings in HK consume the city electricity of almost 90%. As indicated in the findings from the GEB studies for office, residential and other types of buildings (Dascalaki et al., 2002; Verbeeck, 2005; Stefano, 2000), there concludes that using the ***GEB strategies can achieve a total of energy savings in a range of 40–60%***. This high energy savings will definitely be a good contribution to ***carbon intensity reduction in the range of 20–30%***. Like Beam Plus which will grant Gross Floor Area (GFA) concessions capping at 10% of the total GFA of the development projects by HKSAR since 1 April 2011 using Beam plus as a design basis, Government should take a similar lead in promoting GAA for existing buildings assessment. The Building Management and Maintenance Scheme (BMMS) in January 2005 implemented by the Housing Society is a good example offering financial assistance with a funding of HK$1 Billion in its first launch to implement the grant scheme for aged owners.

Since 1 April 2011, the "Integrated Building Maintenance Assistance Scheme" (IBMAS) is another building renovations service managed both by the HK Housing Society (HKHS) and the Urban Renewal Authority (URA). It will help all the qualified property owners of private residential buildings. The same can be provided for those owners/occupiers to launch green improvement plans. Judgement for the grants/financial assistance can be based on the GAA assessment result as postulated in this paper. The energy savings can be evaluated after implementation of the improvement plans ensued from the GAA assessment. This will form the basis for the Government subsidies. Government may have concern in choosing which existing building should be subsidized in priority. A **simple scoring system** is proposed with pointers to measure each of the existing buildings with similar functions prior applying for the subsidy. In additional to the data merited under the GAA plan, three indicators will be measured: (1) Energy Efficiency (2) Indoor Environmental Quality and (3) Water Efficiency.

The measuring instruments are:

1. Power use data report for the **Energy Efficiency**
2. Occupant survey for the **Indoor Environmental Quality** and
3. Water Meter result for the **Water Efficiency**

The above measures have been used in various cases as the acceptable tools for the above measurement (Alajmi, 2012; Building Use Studies, 2011; Frontczak et al., 2012; Oladiran, 2013).

The measurements are listed below:

(1) **Energy Efficiency**

Energy use has to be figured out with the size of the building. Calculating the energy use over size of the building in existence is called building energy pointer (BEP) (Bishop, 2012; Green Tech Malaysia, & SEDA, 2013; Moghimi et al., 2011). BEP can be obtained by dividing the total building energy consumed in a year (kWh/year) over its total floor area (m2).

(2) **Indoor Environmental Quality [IEQ]**

The building occupants' survey on this IEQ will be used to measure the indoor air quality together with the users' thermal/visual/acoustic comfort/satisfaction. Although there are available a number of equipment to measure these set of pointers of humidity/glaring/heat, etc. as in the studies (Baird and Penwell, 2012; Zuo and Zhao, 2014), seeking users' perception using occupants' survey of these pointers are more indicative of the actual feeling of comfort in reality.

(3) **Water Efficiency**

Similar to the power and energy logger, water use is recorded by adapting the number logger to the measured appliance. This allows monitoring of actual water use over the time (say in month) measured as m^3 per month. Illustration of the above scoring system to prioritize the subsidy application for a group of existing buildings is illustrated in Table 7.2.

As indicated, existing building A has better rank position of 7 compared to existing building B of 11. This means that existing building A should be proceeded with the green improvement first before the existing building B since it may need a lot of retrofits to turn this building B to green. Government subsidy should be granted to existing building A in priority. Similar scoring evaluation can be applied to any number of buildings under evaluation.

7.2.2. GREEN Pro

Like the BEAM Professionals (BEAM Pro) recognized by the HK Green Building Council (HKGBC) for the complete building life cycle, particularly in the building planning and design stage, a GREEN Pro can also be recognized by HKGBC in the same manner for the buildings in existence under GAA. This not only will raise/motivate the green awareness of the existing building owners/tenants but will also assure them that the GAA assessment is recognized by the Government. With the support by the Government and HKGBC, the adoption of GAA to promote the green transformation of the existing buildings can be realized. This will help turning the city green ultimately.

7.2.3. Economic incentives

The Hong Kong Department for environmental protection (HKEPD) has appointed the Chinese University (CU) in 1996/97 and the Hong Kong University (HKU) in 1997/98 to study the correlation of the air contamination and morbidity (illness) and mortality (death) of the health of the public using the data available (www.legco.hk). The above studies discovered that high connections between the amount of air contaminants [i.e. nitrogen dioxide (NO2), sulphur dioxide (SO2), respirable suspended particulates (RSP) and ozone (O3)] and those admitted to hospital and death rate for respiratory and cardiovascular diseases. (www.legco.hk). The cost-of-illness (COI) approach has been used to derive the immediate cost of going to hospital and those received medical treatment at the clinic, and implied cost of loss of daily works salaries

Table 7.1B
The categories and weightings.

GAA for existing buildings		BEAM plus v 1.2 for existing buildings	
Categories	Weightings (Points)	Categories	Weightings (Credits) (Bonus :B)
Location & Transportation	15	NIL	
Sustainable Sites	10	Site Aspects	18 + 1B
Water Efficiency	12	Water Use	7 + 2B
Energy & Atmosphere	30	Energy Use	39 + 2B
Materials & Resources	8	Materials Aspects	11 + 2B
Indoor Environmental Quality	17	Indoor Environmental Quality	30 + 3B
Economic Value	5	NIL	NIL
Human Impacts	3	NIL	NIL
Innovation	6	Innovations and Additions	1 + 5B
Regional Priority	4	NIL	
Total	**110**	Total	**106 + 15B**

Table 7.2
Illustration of tallying the score for a group of two existing buildings. (The numbers put in are for illustration only.)

Indicator	Measurements	Unit	Bench mark	Existing Building A	Rank A	Existing Building B	Rank B
Energy Efficiency	Computation of BEP	Annual kWh per floor area	Smaller is better	40	1	80	2
Indoor Environmental quality	Thermal comfort	Score per 100 occupants survey	Higher is better	55	1	40	2
	Visual comfort			63	2	70	1
	Acoustic comfort			45	1	35	2
	In-house air quality			70	1	60	2
Water Efficiency	Water use	m^3/month	Smaller is better	1,200	1	1,480	2
				Total	7		11

Table 7.3A
COI and WTP estimate expressed as % of GDP in 1996.

	By COI estimate	As % GDP
Morbidity and Mortality	HK$3.84 billion	0.35 %
	By WTP estimate:	As % GDP
Morbidity and Mortality	HK$5.64 billion	0.51 %

(www.legco.hk). A selected people survey was used to measure the each person's willingness-to-pay (WTP) to avoid being admitted to hospitals and risk to die (HKEPD, 1998) (www.legco.hk). The economic costs due to air pollution to health were compared to Gross Domestic Product (GDP) (Census and Statistics Department, 1997)(sc.info.gov.hk). In 1996, the HK GDP was 1,108.6 billion. A relatively higher GDP percentage can be resulted as indicated in Table 7.3A:

Using the current GDP in 2016 which was HK$ 2,489,109 million (2,489.1 billion) (Census and Statistics Department, 2017), based on the same % of GDP results, the estimate in 2016 will be indicated in Table 7.3B.

The above study showed that a rather high economic cost will be effected to health due to air pollution. (www.lego.hk) This will enable the government to develop a more cost effective air pollution combating scheme as well as the subsidy scheme to promote internal air quality. As indicated in the pilot test of GAA, there is a significant improvement of internal environmental quality (IEQ) after adopting the green improvement plan postulated by the GAA assessment. The IEQ has improved significantly from 3 points to 10 points as shown in Fig. 6.3. It is proposed that a go-green scheme can be hybridized with the "Integrated Building Maintenance Assistance Scheme" (IBMAS) as the "Integrated Greening Existing Building Maintenance Assistance Scheme (IGEBMAS)". The Government can earmark a Budget of HK$10 billion (say at 0.4% of GDP from the above COI and WTP studies) in the coming year of 2018 to launch the IGEBMAS and the Urban Renewal Authority (URA) can be appointed to administer the IGEBMAS. URA, an independent not-for-profit organization, will provide technical and financial assistance/subsidy/interest free loan to qualified private property owners with GAA certified and green improvement plan certified by the Green Pro together with the maintenance plan. URA, will

Table 7.3B
COI and WTP estimate in 2016 using the same % of GDP in 1996 *GDP in 2016 = 2,489.1 billion.

	% GDP	The COI estimate in 2016
Morbidity and Mortality	0.35%	HK$ 8,711.88 million (HK$ 8.7billion)
	% GDP	**The WTP estimate in 2016**
Morbidity and Mortality	0.51 %	HK$ 12,694.46 million (HK$12.7 billion)

Table 7.3C
Age of buildings by type in 2016 *(Building Department)*.

Age (years)	Commercial	Factory	Residential	Others*	Total
Less than 10	907	420	11,974	904	14,205
10 to 19	2,966	2,427	16,408	1,078	22,879
20 to 29	2,629	3,847	22,660	949	30,085
30 to 39	2,128	3,409	12,669	650	18,856
40 to 49	720	1,556	11,789	685	14,750
More than 50	118	247	6,384	1,381	8,130
Total	9,468	11,905	81,884	5,646	108,904

*Note *: Includes chapel, schools and pre-war buildings, etc.*

Table 7.3D
Estimate of total number of buildings in 2018 with age ≥40 years.

Age (years)	Total	
	2016	2018 (add 10%)
40 to 49	14,750	16,225
More than 50	8,130	8,943
Total (≥ 40 years)	22,880	25,160 (say 26,000)

also facilitate IGEBMAS, and approve applications and release the subsidy to qualified property owners. Priority will be awarded to those existing buildings getting the higher ranking marks using the above proposed Simple Scoring System. The significant improvement in the IEQ using the green improvement plan as illustrated in the above pilot test case study will have a great economic cost reduction based on the COI and WTP estimate in 2016. This again justifies the budget of HK$10 billion to be adopted in the coming year of 2018 to promote IGEBMAS in Hong Kong. Further justification of this budget can be evaluated of the number of existing buildings that will be benefited as result of this GEB strategy. The number of buildings that call for urgent maintenance and green improvement will be proposed for those buildings ≥ 40 years which can be estimated as follows in the Table 7.3C Age of Buildings by Type in 2016 *(Building Department)* and Table 7.3D: the estimate of total number of buildings in 2018 with age ≥ 40 years.

This 26,000 number of existing buildings will share the budget of HK$10 billion subsidy/loan with each building getting around HK$ 400,000. This budget expenditure of HK$10 billion (10B) and its share of HK$ 0.4 million per building ≥ 40 years is considered justifiable in comparison of the high economic costs of COI and WTP (8.7B+12.7B) amounting to 21.4 billion as estimated in 2016.

8. Conclusions/contributions

This paper presents a systematic buildup of GEB strategies to enhance the green/sustainable standard of the buildings in existence, the energy use of which consumes around 30% in average of total energy use in modern countries. In making the GEB strategies feasible, a GAA plan is developed to assess the existing building condition to determine its green deficiencies so that a green improvement plan can be worked out for the retrofit works. An overview of the previous GEB studies have illustrated that green/sustainable performance of the buildings in existence can be improved significantly using the most acceptable green technologies particularly the energy efficient lighting fixtures with energy savings up to as much as 65%.

A management/maintenance policy is proposed to maintain the green improved condition. The green measures once adopted will become the core elements of a management/maintenance policy for the property management company to sustain these green improvement technologies. It should be reiterated that the case study above pointed out that a considerable green improvement in Hong Kong congested environment rested largely in the improvement of the internal environment quality [IEQ] of the building in existence in the context of thermal, visual, acoustic and indoor air quality. This may be one of the major green potential to be adopted in making Hong Kong city green and sustainable. This GAA assessment as one of the key GEB strategies to open up the green potential of an existing building is considered as the most cost effective, if not the best solution to promote green/sustainable performance of the buildings in existence. However, without the Government support and promotion for this GEB strategy using GAA as the assessment tool, the long term continued green awareness and implementation may not be sustainable. To integrate the GEB strategy with the current maintenance scheme administered by the Urban Renewal Authority [URA], both technical and financial assistance from URA can be assured to maintain and sustain these GEB strategies.

The significant improvement of the Interior Environmental Quality as testified in the above case study together with the measurable economic cost savings of air pollution in terms of Cost of Illness and Willing to Pay as identified by a joint study of Chinese University of HK and the HK University from 1996–1998, the substantial expenditure of a budget of HK$10 billion in the coming year of 2018 is highly justifiable for the Government to implement this hybrid of GEB and Maintenance scheme to promote the GEB strategies in Hong Kong. The budget granted can be prioritized under a simple scoring system pursuant to green improvement report postulated by a qualified Green-Pro recognized by the HK Government. Carbon neutral and zero emission buildings are the crux of the GEB's aim and objective, which can be named as the "next generation" green/sustainable building. (Boake, 2008)(ijfm.net). In times to come, GAA compliant existing buildings will become the common practice for all the participants in the property and the construction sector of the industry. It is confident to believe that GEB strategies with its GAA plan will advocate the ***green*** promotion of green cities in the world.

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