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# Sustainability Metrics - A Public Housing Empirical Experience

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***Abstract*:** *The Hong Kong Housing Authority (HKHA) manages a housing stock of 740,000 public rental housing (PRH) units of different block type designs and ages. In driving sustainability of the existing PRH, HKHA adopts a set of sustainability-focused maintenance strategy. Sustainability performance of different housing block types is gauged by using the Hong Kong Quality Assurance Agency Sustainable Building Index (SBI), which is a green building rating system, to facilitate the identification of areas for improvement and setting of priorities in the formulation of long-term maintenance and improvement (M&I) programmes. To maximize cost effectiveness, HKHA applies SBI metrics strategically to a selective number of PRH estates which represent the majority of the block type designs to obtain an overview of sustainability performance of the existing housing stock and makes use of the Building Environmental Assessment Method (BEAM) Plus for planning of specific estate-based improvement project.*

***Sustainability Metrics, Sustainable Building Index, greenhouse gas emission, BEAM Plus***

## 1. Introduction

In Hong Kong, over two million people (about 30% of the population) live in public rental housing (PRH) estates. The Hong Kong Housing Authority (HKHA) is a statutory body that develops and implements the public housing programme for low income families. Currently, the HKHA is managing some 740,000 PRH units in about 1,200 multi-storey buildings of different block type designs, ages and building conditions located in more than 200 estates. To sustain the PRH stock while coping with the changing needs of the community over time, the HKHA establishes its sustainability-focused maintenance strategy in the economic, social and environmental dimensions which sets the blue print for the implementation of maintenance and improvement (M&I) programmes (Figure 1).

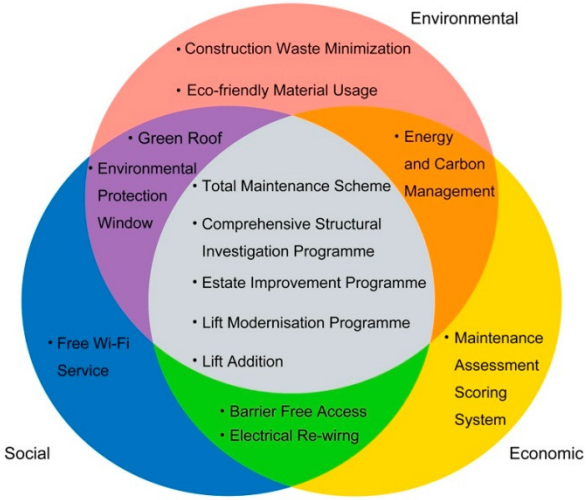


*Figure 1 : Three Dimensions of Sustainability-focused Maintenance Strategy*

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To effectively formulate the long-term maintenance and improvement (M&I) programmes for the PRH stock in such scale, it is prudent to gauge the sustainability performance of the portfolio, which mainly consists of over 20 standard block type designs developed over the decades, by a building sustainability performance verification system so that the necessary improvement schemes can be formulated to upkeep and raise their sustainability. This paper describes how the HKHA drives building sustainability through a sustainability-focused maintenance strategy with an aid of a set of sustainability metrics verification system.

## 2. Sustainability Metrics

Over the past decade, different green building assessment systems or certification schemes were published with the aim of enhancing buildings' sustainability performance. Globally, there are various green building rating systems or certification schemes. For example, the Building Research Establishment Environmental Assessment Method (BREEAM) from the United Kingdom, the Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) from Japan and the Leadership in Energy and Environmental Design (LEED) from the United States of America. In Hong Kong, there is a growing use of the Building Environmental Assessment Method (BEAM) Plus for new building projects since it forms one of the pre-requisites for granting gross floor area concessions from the Building Authority. In late 2012, the Hong Kong Quality Assurance Agency (HKQAA) launched a building assessment scheme named HKQAA Sustainable Building Index (SBI), which is a territory-wide benchmarking tool for the environmental, social and economic performance measurement for existing buildings.

### *2.1 Sustainability Challenges in Hong Kong*

Hong Kong is one of the most densely populated cities in the world. Being a service focused economy without major energy-intensive industries, electricity generation is the major source of greenhouse gas (GHG) emissions in Hong Kong, which accounts for over 60% of the total local emissions. Among various end uses of electricity, buildings are the most consumptive, which accounts for some 89% in Hong Kong [1].

Hong Kong is facing building aging problems and the HKHA is of no exception. At present, about 30% of the PRH is aged 30 years or above. While the government has implemented the Mandatory Building Inspection Scheme (MBIS) and Mandatory Window Inspection Scheme (MWIS) to address public concern on the safety and quality of aged buildings, the HKHA has also proactively formulated a series of improvement schemes to address the needs of the aging population of its tenants as well as the new generation in the following decade.

### *2.2 Sustainability Research and the HKQAA SBI*

To promulgate sustainable building to building owners and property management companies, the HKQAA has developed a quantitative Sustainable Building Index (SBI) for assessment of the existing buildings in the environmental, social and economic aspects, which is tailored to the unique circumstances of Hong Kong [2]. Local contexts are included by taking into account the Hong Kong legislations, carbon reduction in buildings and rateable value in economic term. The HKQAA's sustainability metrics was developed based on the United

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Nations Environment Programme – Sustainable Buildings and Construction Initiative's (UNEP-FI/ SBCI's) Financial and Sustainability Metrics Report 2009 [3] and a few key ISO standards on building sustainability with the salient view to identifying significant Performance Indicators (PIs) to stakeholders; allowing opportunities for improvement; standardizing PIs for benchmarking with established norm performance; and addressing key sustainability issues in Hong Kong. The assessment system is practical and inexpensive.

The metrics encompass 20 PIs addressing key local sustainability issues and facilitating the stakeholders, the building owners and the property managers to benchmark their building performance in the social, economic and environmental aspects (Table 1).

| Aspects | Issues | Performance Indicators | Measuring Approach |
|---|---|---|---|
| Environmental | Climate Change | Greenhouse gas (GHG) Emissions | GHG per unit internal occupied floor area (IOFA) |
| | Ozone Destruction | Release of ozone-depleting substances into the atmosphere | Ozone-depleting substances emissions per unit IOFA |
| | Biodiversity | Ecology in building | Adoption of recommended practices |
| | Use of Resources | Use of fresh water | Water consumption per unit IOFA |
| | | Use biodegradable/organic materials | Adoption of recommended practices |
| | | Waste recycling | Waste recycled per unit IOFA |
| Social | Building Security and Safety | Building strength and quality | Level of regulatory compliance and beyond |
| | | Fire prevention | Level of regulatory compliance and beyond |
| | | Safety of lifts and escalators | Level of regulatory compliance and beyond |
| | | Emergency planning | Adoption of recommended practices |
| | | Designing out crime | Crime rate |
| | Health and Comfort of Users | User comfort - Lighting comfort | Building user satisfaction survey |
| | | User comfort - Thermal comfort | Building user satisfaction survey |
| | | User comfort - Noise control | Building user satisfaction survey |
| | | Indoor air quality | Building user satisfaction survey |
| | | Quality of fresh water | Adoption of recommended practices |
| | Social Infrastructure | Accessibility to transportation, public facilities and barrier free facilities | Building user satisfaction survey |
| | Harmonized Neighbourhood | Neighbours' satisfaction | Neighbours satisfaction survey |
| Economic | Asset Value | Rateable value of building | Percentage change in rateable value |
| | Building Maintenance | Expenses on maintaining building's operational continuity | Maintenance expenses per unit IOFA |

*Table 1 : Overview of the HKQAA SBI Metrics*

## 3. A Public Housing Empirical Experience

### *3.1 Pilot Study*

To effectively formulate the long-term maintenance and improvement (M&I) programmes for the PRH stock of such magnitude, it is prudent to gauge the sustainability performance of the respective block types of the portfolio so that the necessary improvement schemes can be implemented to upkeep and raise their sustainability. After studying the application of SBI and its potential benefits, the HKHA enrolled a selective number of estates which represent the majority of the standard block type designs of PRH as pilot scheme of SBI in 2012. The scope of the pilot scheme not only covers the enrolment, upkeep and improvement of the building sustainability of the selected PRH blocks, it also requires training for management and frontline staff; compilation of template automation to facilitate data input and analysis, collection of building information for the 20 performance indicators; report on performance;

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verification of the report and review for continual improvement. In the following paragraphs, the HKHA shares its experience in overcoming the technical rigours and highlights the means for improving the sustainability performance of the PRH estates.

### *3.1.1. Environmental Aspects*

From the pilot study, the HKHA has identified that the key issues affecting the sustainability performance of the PRH in regard to the environmental aspect are the GHG emissions and waste recycling.

*Reduction of GHG Emissions*

In fact, the HKHA has started establishing the baseline for GHG Emissions for the major housing block types since 2008 and developed a systematic methodology for collection of data for measuring GHG emissions of all major block type designs. The results indicated that electric lighting and lift system are the two major items attributable to GHG emissions of the communal facilities in PRH estates.

Targeting at reducing energy consumption for electric lighting, a series of energy saving measures are put in place, including the optimized use of daylight through employment of photo sensors and time switches, use of T-5 fluorescent tubes and in 2012, a 42-month programme of replacing electromagnetic ballast with energy-saving electronic ballast for the light fittings in all existing estates was launched.

As more data were gathered and analysed under the SBI pilot study, opportunity for refinement of the energy saving programmes was revealed after the first verification exercise of SBI for the enrolled estates. It was noted from the PIs that some estates having a higher intensity of GHG emissions of the common areas per unit of useable floor area of the housing block should be given a higher priority in programming for the energy saving initiatives. As such, the replacement programme for electronic ballasts was refined by re-shuffling some of the estates according to the results of the PIs of the SBI.

With respect to the lift services, the HKHA has implemented the Lift Modernization Programme since 1989. The programme includes replacement of the aged lift cars, machinery and control system with a view to improve efficiency, riding comfort and to enhance accessibility to every floor of the housing block in older estates with additional lift landings. All the new lift systems are now equipped with enhanced comfort ride, greater passenger capacity, higher speed, more landings and landing announcement system, etc. On the energy saving front, these new lifts are more energy efficient by trimming down energy consumption of over 30% when compared with the old ones.

*Waste Recycling*

To facilitate effective waste recycling, allocation of sufficient space for recycling operations at designated points is found useful. To boost tenants' participation in waste recycling, tenants are encouraged to deliver their recyclable household waste to the collection counters

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in all PRH estates for exchange of small incentives. The HKHA has been actively implementing the Source Separation of Domestic Waste Programme. 31,660 tonnes of used paper, plastic bottles, aluminium cans and used clothes were collected in 2012/13.

To minimize food waste, a pilot scheme on food waste recycling using on-site composters was launched in December 2011. The scheme now expands to 14 estates using off-site food waste recycling for conversion into fish feed as well as on-site recycling for compost by micro-organisms. Over 3,000 households have registered to the scheme and the average weight of food waste collected per month is about 24,590kg. To further engage tenants in food waste reduction, a series of estate-wide campaigns are held, such as the food waste green recipe competition and broadcast of educational videos on the Housing Channel.

*Other Findings*

The SBI has also provided a useful means for comparison of the communal fresh water consumption per unit of internal occupied floor area of the standard block types. Some examples are demonstrated in Table 2.

| Block Type | Fresh water consumption ($m^3$ per 1,000$m^2$ per year) |
|---|---|
| A | 130 |
| B | 63 |
| C | 46 |

*Table 2: Fresh water consumption of three block type designs*

It is observed that water consumption of Block Type A is on a higher side than the other standard block types. After further investigation, it is found that the higher water consumption is attributable to a higher greening of 40% site coverage. As such, water saving measures, including the review of planting and irrigation modes, the choice of plant and the use of rainwater harvesting system, would be further studied.

### *3.1.2 Social Aspects*

Findings of the pilot study reinforce the effectiveness of the people-oriented and sustainability-focused maintenance strategy adopted by the HKHA as it well meets the PIs under the social aspects of the SBI.

In regard to building security and safety, apart from the routine inspections of the common parts of the building, the HKHA takes a higher standard through implementation of the Total Maintenance Scheme (TMS), which is a proactive and customer-oriented maintenance programme to upkeep the conditions of the building elements and installations. Well-trained In-flat Inspection Ambassadors are appointed to conduct flat-to-flat survey to PRH blocks aged over 10 years at a 5-year cycle to ensure prompt repair and education for tenants about flat maintenance to prevent minor repair issues from blowing up into major problems. The second 5-year cycle was launched in 2011 with the in-flat inspection programme successfully rolled out in 97 estates. Among these estates, 62 estates were completed in March 2014. Since the launch of TMS, the tenants' satisfaction rates have been maintained around 80%.

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Emergency planning is always an important item on the job list in the HKHA. Besides the set of emergency procedures laid down in the manual and the regular drills, the HKHA has adopted a systematic approach of ISO 31000 risk management framework for maintenance and improvement works since 2012. External and internal contexts are reviewed in detail at the process of hazard identification and risk assessment. Such framework facilitates the assessment of complex risks.

To sustain the aged estates while meeting the up-to-date needs of the tenants is a challenge to the HKHA. Upgrading of the social infrastructure and communal facilities, provision of barrier free access and enhancement for pedestrian circulation are some of the major considerations in the planning of the estate improvement project under the HKHA's Estate Improvement Programme (EIP). The EIP is tailored for the aged estates, which have been appraised under the Comprehensive Structural Investigation Programme confirming the estate is structurally safe and economically viable to maintain. The key concerns of the tenants in a particular estate are collected through surveys and consultation. The improvement works are people-oriented, which cater for the needs of different age groups, particularly the elderly, rather than facility-based. Lifts towers are built attaching to the housing blocks lacking lift facilities, as well as to estates where there are large level differences between building platforms. The communal facilities and the uses of non-domestic premises are brought up-to-date to suit the latest needs of the tenants as well as the neighbourhood. For example, the innovative conversion of a car parking block with long standing vacancy rate to an education centre. Recreational facilities are enhanced to cater for different age groups and re-shaping public space for better social interaction, including installation of fitness equipment for the elderly and play equipment for the children. Weather-protected passage and barrier-free access are integrated into a master pedestrian network to improve pedestrian circulation bearing the needs of the elderly and disabled tenants in mind.

### *3.1.3 Economic Aspects*

Building maintenance expenses per unit of the internal occupied floor area is a key issue in measuring the economic performance of the building under the SBI. To maximise cost effectiveness, the HKHA has developed a set of M&I cost indicators for budget control and monitoring of M&I expenses. With the customer-oriented preventive maintenance being implemented under the TMS, the rate of breakdown repairs at PRH units are well contained, which reduces the expenses on the more costly responsive maintenance.

With the implementation of various energy saving initiatives, the electricity consumption in estate public area has been progressively reduced. In 2012/13, the electricity consumption in public areas of PRH blocks was 59.3 kWh per flat per month [4]. Such consumption figure represented a reduction of 14.6% in five years (Figure 2). To raise energy consumption efficiency and to support carbon reduction in Hong Kong, the HKHA implemented ISO 50001 for all PRH estates in two phases. Phase One commenced in October 2013 and full certification for all existing estates is scheduled in April 2015.

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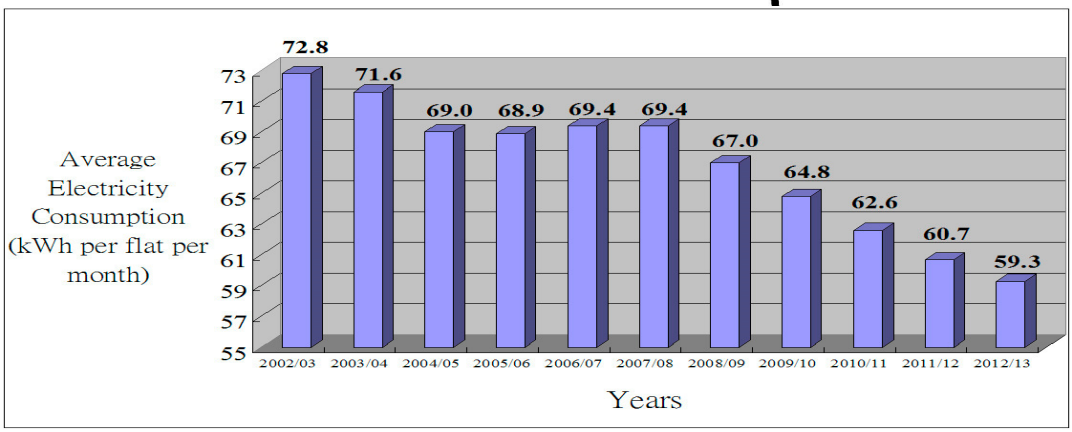


*Figure 2: Average Electricity Consumption in Public Area of Estates [4]*

### *3.2 Review of Pilot Study*

Other intangible benefits are gained through the enrolment exercise. For example, the awareness of frontline staff about building sustainability has increased. They are motivated by the scheme and more actively participate in the implementation of environmental, social and economic initiatives. The SBI provides a comprehensive and yet very practical benchmarking mechanism for building sustainability. The quantified performance indicators allow participants to examine the building performance in the respective aspects and facilitate self-comparison over time.

According to the enrolment result, the sustainability performance of all the PRH blocks of the pilot scheme are found above the norm and are granted with the HKQAA SBI Verified Mark. In fact, the HKHA is the first organization obtains the HKQAA SBI Verified Mark. As at the first quarter of 2014, there are 40 PRH blocks enrolled to the SBI.

While the SBI encompasses the building performance in the environmental, social and economic aspects with enhanced usability, the system enables an effective broad-brush scanning of the sustainability performance for a large housing portfolio of various block type designs and reveals the areas for improvement with quantifiable reference through PIs.

*Enhanced Management System for Sustainable Building*

From the experience gained in the pilot scheme for SBI, the HKHA has established a structured verification system under its Environmental Management System and strategically selected a number of PRH estates which represent the majority of the block type designs for enrolment to the SBI Scheme. The objective is to facilitate the planning of the long-term maintenance and improvement strategy for enhancing the sustainability performance of the housing stock.

*Application of Other Green Building Rating System*

On the other hand, for the design planning of a specific estate-based improvement project, the adoption of BEAM Plus may be useful. The BEAM Plus methodology is designed with an environmental orientation and engineering approach, which provides detailed environmental rating to facilitate improvement through design, specification and testing [5].

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The HKHA has applied BEAM Plus methodology in the estate improvement project at Kwai Shing West Estate, which is 39 years old and consists of over 5,200 PRH flats in 10 housing blocks. Comprehensive assessments of site aspects, material aspects, water use, indoor environmental quality, innovations and addition under planning, design, construction, operation and management provisions are conducted. Following completion of the feasibility study, Kwai Shing West Estate was registered with the Hong Kong Green Building Council for BEAM Plus certification and achieved 'Platinum' grading in the Provisional Assessment of BEAM Plus in May 2014. It is the first residential estate to be awarded "Platinum" for BEAM Plus Provisional Assessment in the category of existing buildings in Hong Kong. The experience gained in this project would be applied to similar improvement projects of the same block type design.

## 4. Conclusion

In driving sustainability of the existing PRH, the HKHA has adopted a sustainability-focused maintenance strategy incorporating social, environmental and economic initiatives with an effective building performance verification system of SBI. The quantifiable performance indicators provide essential information allowing the HKHA to examine the performance of different housing block types against the norm so that long-term M&I plans for the portfolio can be drawn up holistically with prioritization of various M&I programmes for different block types to rationalize the use of resources.

For specific estate-based improvement project, the HKHA makes use of the BEAM Plus for Existing Buildings, which involves sophisticated design tools, extensive data gathering, recording and detailed technical studies on environmental aspects. The experience gained together with the BEAM Plus ready specification developed for the individual estate improvement project will provide useful reference for similar improvement projects.

With the quality, environmental and energy management system (certified to ISO 9001, 14001 and 50001) in place, complemented with the building sustainability assessment tools, the sustainability performance of the PRH portfolio as well as the maintenance and management practices are closely monitored and reviewed for continual improvement. Through the implementation of the sustainability-focused maintenance strategy and long-term M&I programmes, the HKHA effectively upkeeps and raises the sustainability of the existing PRH estates to achieve the goal of providing a sustainable living environment for the community.

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