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INDUSTRY COUNCIL
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COST-BENEFIT-ANALYSIS FOR IMPLEMENTING GREEN BUILDINGS PROMOTION INCENTIVES WITH TRANSACTION COSTS CONSIDERATIONS

RESEARCH SUMMARY

Construction Industry Council Cost-benefit-analysis for implementing green buildings promotion incentives with Transaction Costs Considerations Research Summary

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FOREWORD

The GFA (gross floor area) Concession incentive scheme has been implemented several years after its first launch in 2011 aiming at promoting the development of green buildings in Hong Kong. It is time to review the scheme comprehensively and figure out the way to go forward. One of the function of the Construction Industry Council (CIC) is to convey the industry's needs, thus we were pleased to support the research project proposed by the Hong Kong Polytechnic University, and hoped the project could tell us the effectiveness of the scheme and how we can improve it.

The project is quite challenging; however, the researcher has done a good job. The framework of costs and benefits analysis was first established. Then the actual costs, hidden costs, actual benefits and hidden benefits were investigated. Based on thorough investigations, it is recommended to keep the incentive scheme, and adjust the scheme to promote a higher level of green buildings.

I would like to give thanks the research team led by Prof. Edwin Chan, and all the professionals engaged in the project to share their valuable opinions. The project cannot succeed without their participation and contribution.

Ir Albert CHENG
Executive Director
Construction Industry Council

PREFACE

As an academic department closely related to the Hong Kong construction industry, the Department of Building and Real Estate takes pride that our research in general has not only provided theoretical influence through international publication but also left significant societal impact, particularly contributing toward the industry. This research project aims to improve our construction industry by applying Cost-benefit-analysis (CBA) to study the hurdles in implementing green building (GB) promotion incentives with the consideration of Transaction Costs (TCs). It was funded by the R&D Fund of the Construction Industry Council (CIC) of HKSAR. The research team led by Prof. Edwin H. W. CHAN, included contributing members from the Department of Building and Real Estate, and Department of Building Services Engineering, The Hong Kong Polytechnic University, supported by overseas co-investigators of OTB, Faculty of Architecture and Built Environment of Delft University of Technology, and of Universiti Teknologi Malaysia.

On behalf of the Department and the research team, I would like to thank all those involved in the completion of this research study, particularly the key collaborator, the Professional Green Building Council, who called upon experienced practitioners and experts of its membership to participate. Over 50 professionals shared their valuable opinions with us on implementing GB promotion incentives. They contributed their case experience and views on TCs involved in delivering green building projects in Hong Kong. Without their patience and full support, the research project could not be completed smoothly and successfully. I would like to record our sincere thanks to all contributors, whether in interviews, general discussions or in validation focus group meetings. We also wish to recognize our research assistants for their efforts and time in organizing the data collection exercises.

I endorse the results of this project to deliver the impacts to industry as intended, and strongly believe this valuable study will lead to further collaboration between academia and the construction industry.

Prof. Albert PC CHAN
Head of Department of Building and Real Estate
The Hong Kong Polytechnic University

RESEARCH HIGHLIGHTS

The HKSAR government has introduced in April 2011 an incentive scheme linking the bonus floor area of a development project to promote GB where a developer has to meet certain green building requirements to gain the extra bonus building floor area (known as "granting GFA concessions"). This GFA (gross floor area) Concession incentive scheme has been implemented to promote GB development and address the issue of large building energy consumption. Since its implementation, this scheme has succeeded in improving market share of GB. There is a need to evaluate the GFA concession scheme to make it more effective and efficient. This study aims to answer the questions that what costs and benefits (including the hidden ones) are added to the stakeholders by the "granting GFA concessions" GB incentive, how these costs and benefits affect, and how the incentives schemes to be modified if necessary, i.e., to whom, when, how and what to offer, in order to smooth out the overall hidden costs (transaction costs) in the society and thereby attract more market penetration for GB.

The research results show that Hong Kong has relatively lower threshold to apply for the GFA concession, compared with Arlington of US and Singapore where the GFA Concession scheme is more mature. In Singapore, the calculation restricts the GFA bonus in high land-value areas that usually have high density, in order to reduce negative impacts of increased density on the surroundings. However, in Hong Kong, the GFA concession does not consider land value. Since the land is owned by government, and developers have to bid for the land, the benefits of GFA concession go back to land cost in the end.

The framework of costs and benefits of implementing the GFA Concession scheme comprises actual costs, hidden costs, actual benefits and hidden benefits. The extra actual costs include construction costs, consultancy fee, certification and assessment cost. The hidden costs (transaction costs) include information searching cost, research/learning cost, approval cost, negotiation/coordination cost, monitoring cost, and verification cost. The actual benefits include enhanced value of green building, energy saving and water saving. The hidden benefits include reputation/branding of private sector, competitiveness of private sector, job opportunities for the society, health/productivity (indoor), and environmental benefits (outdoor). The results of analytical hierarchy process (AHP) analysis show that construction cost is still private sectors' major concern and that actual costs are more important than hidden costs. Energy savings and enhanced value of GB are valued by participants of the GFA Concession scheme most. Regarding the environmental benefits resulted from the Sustainable Building Design Guidelines (SBDG), it turns out that building separation and setback are effective in removing air pollutants and reducing pedestrians' health risks. The amount of benefits gains vary with the building configurations. Building setback could provide monetary benefit gains twice as much as building separations. It is recommended to keep the incentive scheme because it is proved to be effective and government incentive is still needed at this stage. However, the incentive scheme needs to take transaction costs into consideration to make it fairer to stakeholders, especially consultants who absorb unpaid transaction costs. Also, it is time to adjust the scheme to promote higher level of GB, and the detailed methods of adjusting the incentive scheme need more in-depth study with wider consultation of the industry.

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1 INTRODUCTION

1.1 Background

In Hong Kong, buildings consume almost half of all energy and about 89% of electricity, which contribute 17% of all Hong Kong's greenhouse gas emissions. Acknowledging the importance of creating a 'Quality City, Quality Life' for the people of Hong Kong, the HKSAR Government recognizes the necessity to holistically understand the life-cycle:- from planning, construction, commissioning, operation, refurbishment, and renewal to decommissioning of buildings. In the past few years, the HKSAR Government has been actively taking part in driving GB initiatives. For example, the HK-BEAM and other green-label programmes are already accepted assessment tools promulgated by voluntary bodies. In 2012, the HKSAR promulgated the Buildings Energy Efficiency Ordinance to regulate energy-saving engineering solutions for newly-constructed buildings. With both land and building floor area in Hong Kong known to be extremely scarce, in April 2011 the government introduced an incentive scheme linking the inclusion of GB features to a bonus increase in permissible floor area, to promote energy-saving. Developers have to meet certain GB requirements to gain the extra bonus building floor area (known as “granting GFA concessions”). The scheme itself has gained in popularity among developers. However, there are still public concerns on how much it has benefited the public and how far it will go. The benefits, and particularly the cost implications, are yet to be fully assessed. The challenging questions are to ensure that the incentives are designed, to be financially fair and effective to all affected parties, the tax-payers and the policy-makers, and also to be environmentally and socially fair to the public.

The barrier to the GB market is higher than its conventional counterpart. For green buildings, many actual costs such as extra design / construction costs and new material expenditure etc. can easily be appraised. The problems come from the hidden costs (transaction costs) involved and the particular kinds of "unintended consequences", as by-products, or repercussions after embarking on a course of action. If the asymmetric information about quality standards or requirements exists, the opportunistic behaviour of market players may lead to the production of conventional buildings (Akerlof, 1970). The benefits from GB at a household level are over-shadowed by the huge extra costs, misunderstood by the public and stakeholders in the building industry. It makes sense to study how the incentives should be designed in a way to maximize the interests of various stakeholders in the GB market.

Cost-benefit analysis (CBA), is an analytic procedure, to evaluate the desirability of the scheme/project, by weighing the resulting benefits against the corresponding costs, in order to see whether the benefits outweigh the costs. CBA quantifies the potential returns and expenses of a policy/regulation and balances the pros and cons to arrive at a decision. The major CBA indicators include present value, net present value and benefit cost ratio (Thomas, 2007a), all of which are applied in this research. One of the aspects to be evaluated by CBA in this research is hidden costs and benefits, which have not yet been reflected in most cost-benefit analysis. When hidden costs, in terms of transaction costs (TCs), are too large, they inhibit exchange, production, and economic growth. The functioning of TCs under alternative institutional rules is also crucial to the workings of markets (Cheung, 1998; Coase, 1998; North, 1991). Therefore, a better understanding of the nature and structure of TCs helps to evaluate an incentive scheme, which is implemented under a set of rules and institutional environment for the market.

In this project, we need to understand the following research questions with reference to the existing GB incentive scheme "granting GFA concessions" for GB:

- What are the costs and benefits (including the hidden ones) added to the stakeholders by the "granting GFA concessions" GB incentive?
- How these costs and benefits are affected?
- How the incentives schemes may be modified if necessary, i.e., to whom, when, how and what to offer, in order to smooth out the overall TCs in the society and thereby attract more market penetration for GB?

1.2 Aims and Objectives

This research contributes to tackling the sustainability issues in the construction industry. It establishes a framework using the CBA technique to evaluate the identified green building promotion incentive scheme, "granting GFA concessions" in Hong Kong, by taking TCs into account. The objectives are:

- To compare the international best-practice incentive schemes for promoting green buildings;
- To review the benefits and costs, including those hidden costs caused by TCs and unrevealed benefits, to the all stakeholders upon implementation of the "granting GFA concessions" incentive;
- To establish measurements for the costs and benefits, including the TCs, that would be brought to all stakeholders by implementing the "granting GFA concessions" incentive in Hong Kong;
- Develop a CBA framework to evaluate the key benefit creators and cost drivers of the "granting GFA concessions" incentive scheme; and
- Recommend key issues for modifying the existing incentive scheme to smooth out the overall TCs in the society, and to attract more equitable market penetration for GB

1.3 Scope

This research project was funded by the CIC R&D Fund. A review of the relevant literature has been conducted to review international best practice of incentive schemes for GB promotion. It helps to establish an analytical framework for understanding the concerns and expectations of stakeholders to the GB investment. Studies have been carried out by some of the research team members on the incentive schemes and the role of government for promoting building energy efficiency. These form the foundation for further investigation for this research study (Chan & Yung, 2002; Qian and Chan, 2008d, 2009, Chan *et. al.*, 2009, Qian and Chan, 2010, Chan and Qian, 2011). Based on the literature review, an analytical framework of costs and benefits as well as a list of stakeholders were formulated. With the lists of benefits and costs criteria, a series of interviews with experts were conducted. These were intended to validate the framework and evaluate the incentive schemes using the AHP, a method that helps to prioritize the benefits and costs of incentive schemes according to the value of priority vectors. A hypothetical case was constructed, which was based on one of the sample models shown in APP 152: Sustainable Building Design Guidelines (SBDG), to estimate the costs and benefits. We have also included in our CBA considerations of some of the key parameters of sustainable building design, comprising:

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1 Building setback;

2 Permeability of buildings;

3 Building façade length; and

4 Aspect ratio (ratio of the proposed building height and street width)

Relating to these key parameters, we have focused on evaluating the health benefits due to improved air quality versus the development costs relating to the above parameters. This part of the technical study was exploratory in nature which intended to provide indicative trends after conducting a set of parametric studies on the individual parameters. The above research exercises provided us a set of preliminary results, which were presented to industry to get feedback and validation. Two rounds of focus group meetings were conducted with industry experts to validate the preliminary findings.

This study applies the CBA to evaluate the existing incentive scheme, "granting GFA concessions" for GB by taking TCs incurred into consideration. The CBA was applied to evaluate the GB incentive scheme by including both the tangible and intangible parts of the costs and benefits in the equations. The approach focuses on the safeguarding of investment specific to an incentive to GB and its balance with incentive intensity for controlling the collective cost of the policy and the cost to stakeholders (Finon and Perez, 2007). By understanding the all-round costs and benefits of GB, both actual and hidden, it sought to connect the benefits and costs fairly among the stakeholders in order to optimize the total societal costs when designing or modifying an incentive. The CBA framework was adopted to highlight the significance of key elements that affect decision-making. This study is an extension and application of research results of related projects carried out by the Principal Investigator (PI). The research team worked with the industry via the Professional Green Building Council, to establish a framework for evaluating the current incentive schemes and to propose improvement. The research results help to inform end-users and developers of the actual benefit and costs that affect them in the GB incentives, specifically in the “granting of GFA concessions” scheme. The study not only provides better understanding of the theories of costs and benefits involved but also identifies the significant criteria for assessing an individual incentive scheme.

2 RESEARCH METHODOLOGY

The procedures and methods adopted for this study include:

Literature review

Literature review has been conducted to review international best practice of incentive schemes for GB promotion. It helps to establish an analytical framework for understanding the concerns and expectations of stakeholders to the GB investment. Studies have been carried out by the PI on the incentive schemes and the role of government for promoting building energy efficiency. These form the foundation for the investigation of this research (Chan & Yung, 2002; Qian and Chan, 2008d, 2009, Chan *et. al.*, 2009, Qian and Chan, 2010, Chan and Qian, 2011).

Establish an analytical framework

The study established an analytical framework for analyzing the cost and benefits of the identified incentive scheme, "granting of GFA concessions" for GB, with consideration of the TCs during the implementation process of the schemes. It aimed to identify a list of benefits and costs of the incentive schemes, and a list of stakeholders. With the long list compiled, a critical review was carried out through brainstorming among research team members and interview/discussion with a few experts, to develop a short list of the criteria.

Expert interviews

With the lists of benefits and costs criteria, interviews with 30 experts were conducted with invited practitioners from industry through the Professional Green Building Council (PGBC) and professional institutes. Through these, more insights into a particular topic could be understood thoroughly. For the "granting of GFA concessions incentive", the participants were asked to pick the important relevant benefits and costs from the lists of identified benefits and costs.

Analytical hierarchy process (AHP)

Upon identifying the important benefits and costs, the next step was to evaluate the incentive schemes using the AHP method. The AHP is an analytical tool using a deductive approach (Wong and Wu 2002), which uses criteria, sub-criteria and alternatives by a series of pairwise comparisons to describe a decision problem, in order to derive prioritized scales. The interviewed experts were asked to give their estimates of value that was ascribed to each benefit and cost. The AHP helps to prioritize the benefits and costs of incentive schemes according to the value of priority vectors.

Extract cost data from a hypothetical model case

With the support of quantity surveyors, the baseline model in APP 152 was selected as a hypothetical model case. Extracts of the relevant cost data for each benefit and cost items were prioritized as important by the AHP exercise.

Computational fluid dynamics (CFD) simulation models

To evaluate the outdoor environmental benefits arising from different building and road configurations, CFD models were constructed to simulate the airflow patterns and to predict air pollutant concentrations. Air pollutant concentrations were subsequently used to estimate personal exposures. In turn, personal exposures were used to estimate the number of different types of avoided health outcomes. The economic benefits of avoided health outcomes and losses in development floor areas as well as the dynamic investment payback period were evaluated by comparing the modified building configurations with the baseline ones.

Validation by a panel of experts' discussion forum

The findings were validated through a structured discussion forum (Focus Group Meeting) with an independent panel of 10-15 experts from industry, government and academia. Critiques and comments were reviewed, and the recommendations were refined as necessary following the validation process.

3 RESEARCH FINDINGS AND DISCUSSION

3.1 Review of International Best Practice for Promoting Green Building

Among all of the incentive schemes, the GFA concession incentive scheme is one of the most popular. The GFA incentive scheme rewards developers with additional GFA, for providing public amenities. It has been widely applied to government programmes, such as the affordable housing programmes in the USA, Australia and the UK (Fox & Davis, 1975; Gurran *et al.*, 2008), and the renewable energy of buildings in New Zealand, Japan, France and the US (Paetz & Pinto-Delas, 2007). This incentive scheme is about using leverage on private investment for providing public amenities (Tang & Tang, 1999). After long-term practice, it has proven to be an effective tool. In recent years, the idea has been applied to GB promotion in several countries and regions. For example, the Singapore and Hong Kong governments issued the Green Mark Gross Floor Area Incentive Scheme in 2009, and GFA concession incentive scheme in 2011, respectively. Even though the application of the GFA bonus to green building is very new, it has achieved success to some extent (Fan, Qian, & Chan, 2015).

A variation in terminologies exists in different regions, which share a similar meaning and intent, e.g. GFA concession, GFA Incentive Scheme, DB (density bonus), and FAR (floor area ratio) bonus. In Hong Kong, the GFA concession means the floor area of certain building features are allowed to be discounted from the total GFA of the development with a cap of 10%, with the prerequisite of BEAM Plus certification and fulfilling SBDG (Council for Sustainable Development, 2009). In Singapore, the Green Mark (GM) GFA incentive Scheme is to reward developers with additional GFA for constructing GM Platinum and Gold plus buildings. DB and FAR bonus are applied in North American practice. In the USA, any developments guaranteeing LEED could increase allowable density by increasing permitted building height or floor area ratio. Overall, all these concepts serve the purpose of promoting GB by rewarding extra GFA in a site. The international best-practice incentive schemes are compared. All the incentive schemes turned out to be effective, but in different degrees.

The USA

The Arlington County was the first one to implement the GFA bonus in the USA (see Table 1). The table illustrates the development history of the GFA bonus incentive scheme in Arlington County. The adjustment of the GFA bonus incentive is based on the market transformation that buildings achieved lower levels of LEED more frequently.

Table 1: The GFA bonus scheme in the US

	Objective	Assessment Criteria	Calculation of GFA concession
1999	To guide the building design and construction	LEED Silver only (commercial office only)	Up to 0.25FAR (floor area ratio)
2003	To include all LEED levels and all the projects	LEED Certified, Silver, Gold or Platinum	0.15FAR (Certified); 0.25FAR (Silver); 0.35FAR (Gold); 0.35FAR (Platinum)
2009	To adjust the bonus to reflect market transformation	LEED Certified, Silver, Silver, Gold or Platinum	**For office buildings** 0.05FAR (Certified); 0.15FAR (Silver); **For residential buildings** 0.10FAR (Certified); 0.20FAR (Silver); 0.40FAR (Gold); 0.50FAR (Platinum)
2012	To focus on energy efficiency to align with the Community Plan goals minor bonus adjustment	LEED 2009 Silver, Gold or Platinum Energy efficiency for commercial office buildings	**For office buildings** 0.20FAR (Silver+20% energy efficiency); 0.35FAR (Gold+20% energy efficiency); 0.45FAR (Platinum+20% energy efficiency) **For residential buildings** 0.25FAR (Silver); 0.40FAR (Gold); 0.50FAR (Platinum) **Multifamily residential buildings** Additional 0.05FAR(LEED+18% energy efficiency)
2015	To encourage developers focusing on the incorporation of energy efficiency into the site plan and on the ongoing energy consumption	LEED version 4 Energy Star Building certification within four years of occupancy (commercial office building) Community Priority credits (optional)	**For office buildings** <u>Silver</u> • 0.25 FAR (Energy Star score of 75) • 0.275 FAR (Energy Star score of 75+ one Community Priority credit) • 0.30 FAR (Energy Star score of 75+ two Community Priority credits) <u>Gold</u> • 0.35 FAR (Energy Star score of 75) • 0.375 FAR (Energy Star score of 75+ one Community Priority credit) • 0.40 FAR (Energy Star score of 75+ two Community Priority credits) <u>Platinum</u> • 0.50 FAR (Energy Star score of 75) • 0.525 FAR (Energy Star score of 75+ one Community Priority credit) • 0.55 FAR (Energy Star score of 75+ two Community Priority credits)

Table 1: The GFA bonus scheme in the US

	Objective	Assessment Criteria	Calculation of GFA concession
2015	To encourage developers focusing on the incorporation of energy efficiency into the site plan and on the ongoing energy consumption	LEED version 4 Energy Star Building certification within four years of occupancy (commercial office building) Community Priority credits (optional)	**For office buildings** Silver ● 0.25 FAR ● 0.275 FAR (one Community Priority credit) ● 0.30 FAR (two Community Priority credits) Gold ● 0.35 FAR ● 0.375 FAR (one Community Priority credit) ● 0.40 FAR (two Community Priority credits) Platinum ● 0.50 FAR ● 0.525 FAR (one Community Priority credit) ● 0.55 FAR (two Community Priority credits) LEED Gold plus Two Community Priority credits plus Net Zero Energy certification may earn extra density bonus above 0.55 FAR

Source: Arlington County Government (2016), Chris Cheatham (2009), Arlington County Government (2014), Office of Sustainability and Environmental Management (2013)

Table 1 indicates that to reflect the market transformation, the adjustment of GFA bonus could start from four aspects: 1) to expand the range of GFA bonus; 2) to reduce the level of GFA bonus; 3) to improve the criteria to acquire GFA bonus by upgrading the green building assessment methods, and adding additional conditions (like energy efficiency); and 4) to increase GFA bonus for meeting higher rating of GB or additional conditions, and decrease bonus for lower ratings. From 2009, the incentive for office buildings was separated from and less than that for residential buildings on the rationale that office buildings have more market demand. Government incentives were given more to the residential sector. From 2012, the energy efficiency requirement was added in the incentive scheme to further promote sustainability. In 2015, Energy Star certification became mandatory to apply for the GFA bonus for the office buildings. Every time, to adjust the incentive, developers' costs and benefits were considered.

Comparison of Hong Kong and Singapore

Hong Kong and Singapore have both integrated GFA concession incentive scheme into the development control system, but each in their own way (Table 2). Key differences between the Singapore and Hong Kong GFA concession schemes are that Hong Kong aims to promote sustainable building design and green features that were formulated according to its unique built environment. GFA concession would be granted only if the green feature required under the SBDG could be complied with, together with achieving the minimum level of BEAM Plus certification. In contrast, Singapore's GM Incentive Scheme promotes the attainment of higher tiers of GM building. Only projects certified with GM Goldplus or above could acquire GFA bonus. Also, the methods to calculate GFA concession are different. In Singapore, the GM GFA is sensitive to land value with the total GFA regulated in the Master Plan and green premium. If the project is located in the city centre, that has high land value, then the GM GFA would be less than that of the same project located in suburban areas. This restricts the GFA bonus in high land-value areas that usually have high density, in order to reduce negative impacts of increased density on the surroundings.

Hong Kong has three types of GFA concession: exempted GFA, disregarded GFA and GFA bonus, subject to the building features. Some building features, e.g. those beneficial to the community, are not set with a cap of GFA concession. This, in turn, encourages developers to provide as much as possible. However, green features and amenity features (e.g. balcony and utility platform) are subject to the cap of 10% GFA concession.

Table 2: Comparison of the GFA Concession Scheme in Hong Kong and Singapore

	Hong Kong Gross Floor Area concession (since 2011)	Singapore Green Mark Gross Floor Area incentive scheme(since 2009)
Objective	To attract developers to construct BEAM Plus building and integrate sustainable building design ratings guidelines (SBDG)	To encourage the private sector to develop buildings that attain higher tier Green Mark (i.e. Green Mark Platinum or Green Mark Gold PLUS)
Assessment criteria	• BEAM Plus Registration (Prerequisite) • Sustainable building design guideline (Prerequisite) • Building features illustrated in the Joint Practice Notes (e.g. green features.)	• Green Mark Platinum could be awarded 2% GFA bonus at most (subject to a cap of 5,000 sq.m). • Green Mark Gold plus could be awarded 1% GFA bonus at most (subject to a cap of 25,000 sq.m)
Calculation of GFA concession	GFA Concession = Exempted GFA + Disregarded GFA + GFA bonus (with a cap of 10% GFA concession)	$\text{GM GFA} = \frac{\left(\begin{array}{c}\text{Proposed GFA (sqm)}\\ \text{(subject to Mp allowable intensity)}\end{array}\right) \times \left(\begin{array}{c}\text{Prescribed Green}\\ \text{Premium(\$/sqm)}\end{array}\right)}{\text{Land Value (\$/sqm) (determined by proxy using DC rates)}}$
Mandatory / Voluntary basis	• Voluntary to participate in GFA concession incentive scheme; • Mandatory to acquire BEAM Plus certification and fulfil SBDG if developers want all the building features granted GFA concession	• Voluntary for new private development (non-public sector), redevelopments and reconstruction developments to join the scheme; • For the sites where the GM Platinum or Goldplus standards are mandated as part of land sales condition, it's mandatory to reach GM Platinum or Goldplus without GFA bonus. • For the sites where the Goldplus standard is mandated, it's voluntary for developers to attain the higher GM Platinum standard and acquire an incremental GFA incentive (the difference between GFA incentives for GM Platinum and GM Goldplus).
Enforcement	NA	• Security deposit to guarantee that developers achieve the GB grading they committed
Minimum standard to grant GFA concession	• BEAM Plus registration • Provision of prescribed green features • Fulfilling the SBDGs	• GM Gold Plus

On the other hand, the threshold (minimum standard to grant GFA concession) to participate in the GFA Concession Scheme in Hong Kong is lower than that in Singapore (Table 2). Developers only need to register for the BEAM Plus, that costs them much less than reaching the higher ratings of GB. This little extra cost can help them acquire the GFA concession and make profits from it. That is why, after implementing the GFA Concession Scheme, the number of registered BEAM Plus projects have increased almost one third within one year. Moreover, unlike Singapore, developers in Hong Kong do not have to provide a security deposit to guarantee that they would achieve the certain rating of BEAM Plus they committed to, to apply for the GFA concession. This largely decreases the investment risks for developers. However, with the increase in GB knowledge and market demand, it is the time to review and adjust if necessary the incentives to reflect the market transformation. Other differences between the two cities are:

- Singapore implements incentive schemes to promote higher-tier GB ratings. A higher bonus is given to higher-tier GB ratings in Singapore. In Hong Kong, the GFA Concession scheme does not distinguish the rating levels of BEAM Plus, as long as the project meets the minimum rating level;
- Singapore's GM GFA Incentive Schemes has a strong emphasis on energy efficiency in order to achieve the reward. This entails professionals spending additional time working on energy efficiency;
- Singapore has special financial incentives for architects and engineers to pay for their additional efforts and time spent on GB. This explicitly recognizes the importance of the design stage. In contrast, the reward from Hong Kong's GFA concession scheme is only targeted at the developers.

3.2 Establishment of an Analytical Framework Through Expert Interview and Analytical Hierarchy Process

Based on the literature review, Appendix 1 summarizes the actual costs and benefits of committing to the GFA concession scheme among the different stakeholders. Through the literature review, the hidden benefits of stakeholders due to GFA concession scheme are encapsulated in Appendix 2. Also, a list of possible TCs that will be verified in the interviews is presented in Appendix 3. These review results contributed to developing the interview questions.

In order to support the case study, interviews with experts were conducted to understand the GFA concession practice in Hong Kong. The structured interviews were designed to discuss the extra costs and benefits due to participating the GFA concession scheme. The interview questions were divided into three parts: the actual costs and benefits (refer to Appendix 1); the TCs (refer to Appendix 3); the hidden benefits (refer to Appendix 2).

The interviewees were encouraged to share their views beyond this framework, which is believed to be essential to capture any novel factors. The discussion also included the relevant background knowledge that is not shown in the website or publications, and the future perspectives of GFA concession schemes in their views. The comprehensive views of the interviewees help to verify and complement the theoretical framework of this paper from practical perspectives.

3.3 Validated Framework

Based on the interview results, the following is a summary of the findings with the key issues discussed:

(1) Actual costs

Increased construction costs and land cost

The extra construction cost to acquire BEAM Plus certification from the Bronze to Platinum is around 1%-5%, depending on the project's original provision. Specifically, if the original provision of the project has no any green features, the extra construction cost could reach to 8% at most. The uncertainties caused by GFA concession due to the complex design to be approved by the government, directly affects the estimation of the developers' profits, especially at the land bidding stage. Developers in Hong Kong have to estimate the possible GFA concession granted and decide the maximum land cost they could afford. Therefore, the GFA concession scheme causes land prices in Hong Kong to increase, which in turn decreases developers' expected profits.

Consultancy fee

Because of the extra work, the consultancy fee of GB is 5%-10% more than that of non-GB. For the whole project, the consultancy fee depends on the size of the project. However, with the development of GB market in Hong Kong, there are more and more GB consultants available in the market, which lowers the human asset specificity and leads to the further decrease of consultancy fees.

Certification fee

To apply for GFA concession, BEAM Plus registration and assessment are required. The certification fee has to be paid by developers according to the published scale of fees. In some cities and counties of America, the certification fee and building permit fee are reduced as incentives to promote GB (Work, 2007).

(2) Hidden cost

Searching cost

Searching Cost refers to the cost of collecting information. In this study, consultants collect specialized information of GB such as the performance of green equipment and green building design information. Developers usually seek experienced architects and GB consultants, and pay more because consultants' experience largely affects the amount of GFA concession granting to developers and the assessment results of BEAM Plus. According to the interview, there is 20%-25% risk of obtaining unexpected results, depending on the experience of consultants. Searching cost accounts for the additional time and money spent in the implementation process. However, two interviewees mentioned that there is a shortage of experienced consultants, which indicates that GB market still has much room for further development.

Research / Learning cost

Research/learning cost means the time and resources spent on processing information and decision-making, such as analysing the property market. In this study, at the time of land bidding, developers will make a rough building plan according to the land features to calculate how many GFA concessions could be guaranteed. As there are uncertainties of GFA concession application, developers usually tend to be conservative to estimate the possible GFA concession achieved. With the estimated GFA concession, developers would calculate the maximum land cost to make the decision of land bidding. In this process, research cost is inevitable and will not disappear with the development of the GB market. After developers bid for the land and determine the building design scheme, a lot of considerations have to be taken into account. It's tug-of-war between GFA concession and market price. This indicates that the uncertainty of the GFA concession and property market give rise to more research costs.

Negotiation / Communication cost

Negotiation/communication cost refers to the cost of bargaining or communication to achieve the agreement or delivery information between parties. Four interviewees mentioned that as the BEAM Plus assessment process is not transparent nor consistent, BEAM Plus assessment is largely depending on assessors, whose measurements vary, so leading to unexpected or inconsistent results. Generally, there is 20%-25% risk of the application being rejected. This will cause developers to negotiate or resubmit, which, in turn, increases the risk and time concerned and leads to 20%-30% extra work. Similarly, uncertainties also exist in the process of GFA concession application. Negotiation and resubmission of application also cost 20%-30% extra work. If there are some special designs, Buildings Department will hold a conference meeting to discuss the decision of GFA concession of special design. Architects have to negotiate and convince government to accept their design with strong evidence of the environmental benefits. Negotiation/communication between design teams and developers or contractors can also generate transaction costs due to the complex requirements for building design in Hong Kong. This reflects that stakeholders have not developed a standard procedure of cooperation and tacit agreement, which usually takes much time to build.

Approval cost

Approval cost arises when the transactions must be approval by government. It may result in the delay of transaction completion and impose modifications. In this study, consultants need to prepare supporting documents for BEAM Plus registration/certification and GFA concession application. Additional information may be required to supplement, and inadequate information may cause the delay of processing. In granting modification of or exemption from the provision of the Building Ordinance, conditions may be imposed by the Building Authority. If there are special designs, architects have to prepare relevant documents in detail to support the application of GFA concession.

Monitoring cost

Monitoring cost is the cost of monitoring policy compliance, contract implementation, and the outcome. Site monitoring and reporting on the execution of the instructions have to be conducted to provide evidence for BEAM Plus certification. Two interviewees mentioned that contractors have to monitor and work longer time, and the cost would be reflected in the total construction cost. Before the GFA concession scheme, few developers constructed GB because of high monitoring costs.

Verification cost

Verification cost refers to the cost to verify the effectiveness of green materials or equipment. Three interviewees pointed out that the information of effectiveness of green materials or equipment provided by suppliers may not be complete, hence they have to do some research or test to verify the effectiveness. Replacing the material and equipment is common if there is lack of information before procurement. Thus the green specification could be specified in the contract. In this sense, the verification costs could be reduced.

(3) Actual benefits and hidden benefits

Reputation / branding of private sector

Developing GB could gain a good reputation for developers, but this is not the main reason for GB development. For the developers who only achieve the BEAM Plus registration, participating the GFA concession scheme is perceived as not enhancing their reputation or may even negatively influence their reputation. Some residents do not acknowledge the utility of concession features and regard them merely as developers' instruments to acquire extra GFA and make more money.

Competitiveness of private sector

Competitiveness of the private sector means the increased business competitiveness with more and more project experience accumulated, simply referring to profit margin. For the private sector, stakeholders, such as architects, contractors, suppliers and developers, the earlier they learn new knowledge relevant to the GFA concession incentive scheme and entry the green building market, the more competitive they are. For those who hesitate to enter the market, they will fade out gradually.

Environmental benefits (outdoor) and health/productivity (indoor)

To fulfil the requirements of the SBDGs is one of the prerequisites of obtaining GFA concession. The SBDGs are tailored for the unique built environment of Hong Kong. In a place like Hong Kong which is featured by a high density of development and a rapid pace of life, open space is very rare and precious. The amount of time that people spend in open space is associated with the risk reduction of stress-related illness development (Grahn & Stigsdotter, 2003). Besides, GB has good indoor air quality that benefits people's health and improves productivity.

Job opportunities

Over half of the interviewees mentioned that the GFA concession scheme created more job opportunities. One of the interviewees specifically stated that his/her architect firm has employed an extra 20% of employees to do BEAM Plus projects. There are new job positions created by the GFA concession scheme, including green professionals, environmental consultants, green material/equipment suppliers, BEAM Plus assessors, and energy simulation consultants. However, some interviewees stated that, in terms of the whole society, the GFA concession scheme did not create too many job opportunities.

Energy & water efficiency benefits

Some interviewees claimed that the new technologies were not cost-effective because of high upfront costs and low energy and water savings. Opposing views endorsed the energy and water efficiency benefits because government could save the cost of energy and water infrastructure expansion. In short, it seems that GBs do generate energy and water efficiency benefits for the public, but developers have to bear the upfront costs that may be even more than the lifecycle savings. That is why some countries and regions have provided subsidies to compensate developers.

Incremental property price of GB

According to the interview, there is an apparent inconsistency about the perceptions of market value of GB. Some interviewees state that GB does not have any higher value than its counterpart, so developers construct GB mainly for GFA concession, while other interviewees believe GB has enhanced value, but the amount of enhanced value depends. In Hong Kong, the actual benefit of GB has not been reflected by the market price of BEAM Plus building, comparing to the traditional ones. Green features and energy efficiency are not the main considerations of residents. For office buildings, some international firms may prefer GB labelled offices, which may make GB have some comparative advantages to the traditional buildings for rent or sale. Besides, there is little price difference between the levels (Bronze Silver, Gold, and Platinum) of BEAM Plus ratings. Some interviewees stated that the GFA concession scheme did not help improve building quality too much, which is the main reason that general public are not willing to pay for it.

3.4 Costs and Benefits Measurement

(1) AHP Method

This section presents the results of measuring what benefits and costs motivate and concern stakeholders, respectively. Based on the above review and interview with experts, the validated framework depicting the overall structure of costs and benefits analysis is shown in Figure 1.

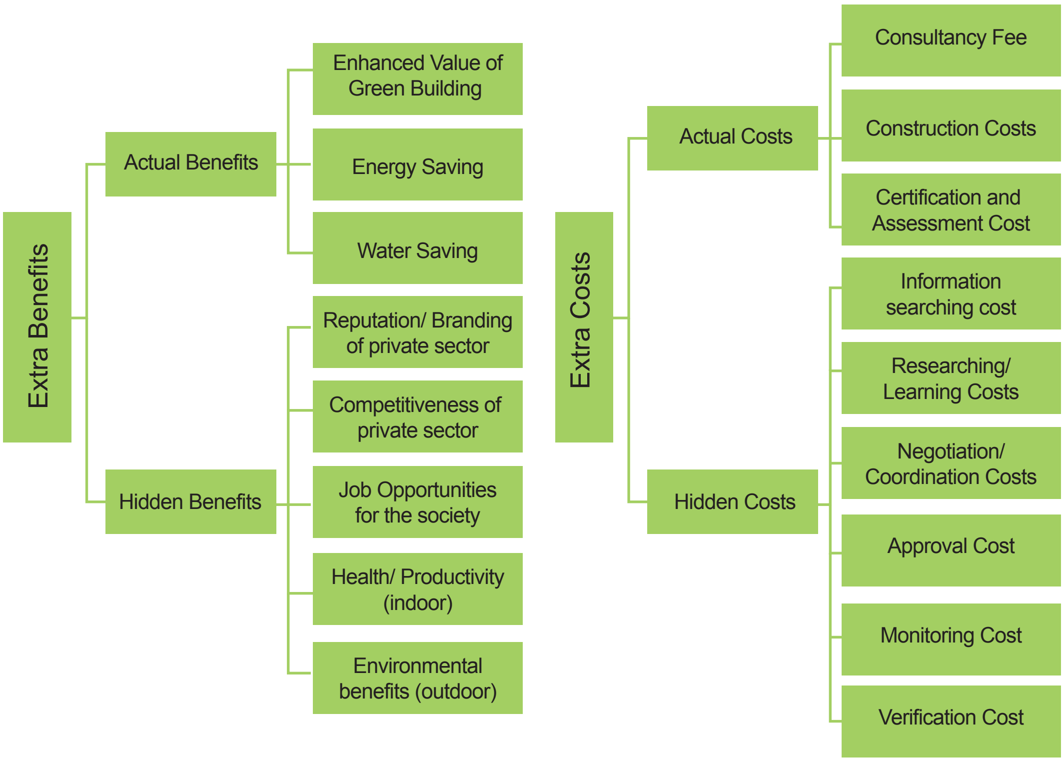


Figure 1 Framework of costs and benefits analysis

The AHP method has been employed to compare the importance of each cost and benefit item using data obtained from questionnaire survey/interviews with 30 experts. One benefit item, GFA concession, and one cost item, increased land cost, are eliminated because this research focuses on the extra costs and benefits. The GFA concession and extra land cost are the items that already exist when stakeholders participate in the scheme. The results are shown in Figure 2 and Figure 3.

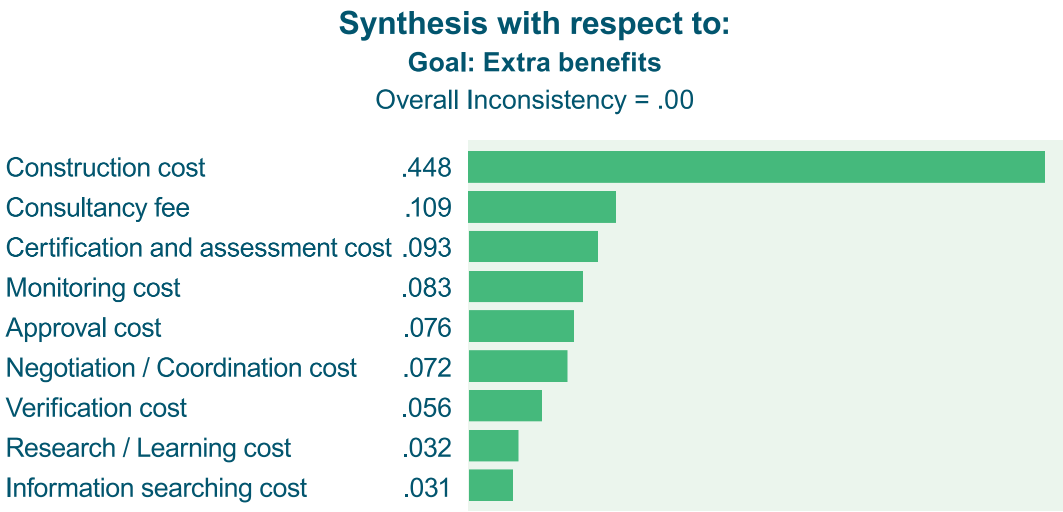


Figure 2 The importance of each cost item

Figure 2 shows that construction cost is, by far, more important than other cost criteria, and actual costs are more significant than hidden costs. This finding indicates that, among all the costs, the high upfront cost of GB should be mainly considered by the private sectors. However, such case is not always true. In the interview, a few large developers claimed that hidden costs highly concerned them because they had sufficient financial budget to deal with actual costs but could not anticipate all the uncertainties in the development process, especially when they wanted to construct something special and innovative for sustainability. Moreover, interviewees mentioned that the certification and assessment costs change with GB assessment methods. For BEAM Plus, this cost is one-off payment and does not concern developers significantly. However, other schemes, such as WELL, that require regular assessments of building performance usually cost much money. In terms of TCs, monitoring cost ranks first because BEAM Plus requires much monitoring work in the construction process. Developers, contractors, and professionals must conduct on-site monitoring to apply for BEAM Plus. Monitoring cost is nearly fixed in that many works can be done owing to BEAM Plus. Approval and negotiation costs rank second and third, respectively. Unlike monitoring cost, the two cost items vary with the project experience and capability of participants. Experienced and capable individuals fully understand the SBDGs and BEAM Plus and can reduce uncertainties in the approval process and suffer less negotiation cost. Unlike monitoring cost, verification cost is nearly fixed as well because documents and green equipment performance can be easily verified. Research/learning and information searching costs are the least significant, which indicate that industry people are becoming familiar with the GFA concession scheme and spend less time on research/learning and searching information.

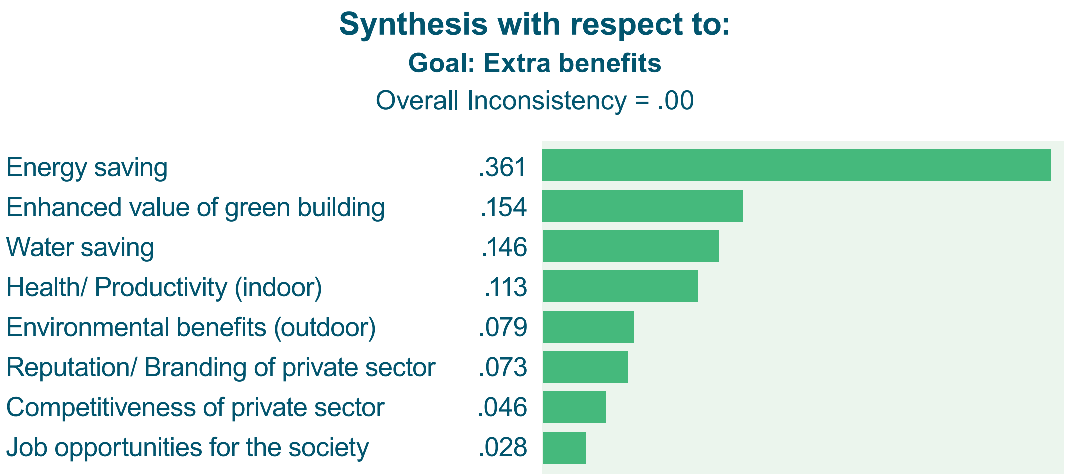


Figure 3 The importance of each benefit item

Figure 3 shows that energy saving is the most important factor and is much more important than other benefit items. The reason is that energy use is the most vital assessment aspects in BEAM Plus with more credits (42 credits) and higher weighting (35%) than those of the five other assessment aspects. The enhanced value of GB ranks the second, which suggests that participants expect that GB can enjoy a price premium in the property market. Interviewees also mentioned that office buildings could easily obtain a price premium because GB benefits the reputation of tenants. On the contrary, residential buildings present difficulty in obtaining a high selling price because the general public does not value green features, and tariffs of energy and water are costly. Unlike energy use, water use possesses only nine credits in BEAM Plus. This credit value is less than that of the five other assessment aspects. This factor also presents 12% weighting, which is less than that of the four other assessment aspects. Health/productivity (indoor) and environmental benefits (outdoor) are more significant than the reputation/branding of the private sector and competitiveness, suggesting that participants highly value sustainability. With regard to job opportunities, nearly all interviewees claimed that the GFA concession scheme did not create too many jobs for the society.

(2) CFD simulation Modelling

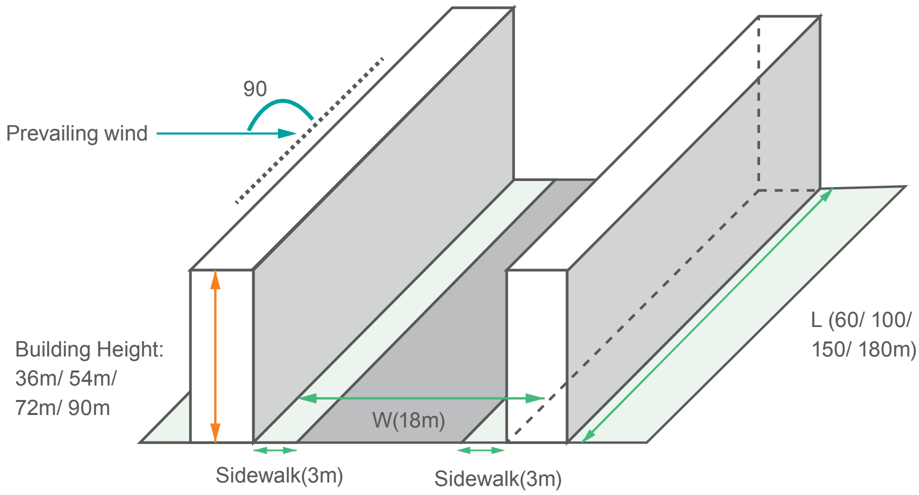
Configurations of CFD simulations

CFD simulation models were constructed to study the effect of street and building configurations on the air quality inside an isolated street canyon. Figure 4 shows the baseline model of the street and building configuration employed for this study. Two stages were defined for this part of the study.

Stage I aimed to study the effect of two important parameters, i.e. aspect ratio (i.e. ratio of building height to street width) and building façade length, on the air quality inside street canyons, and the scenarios investigated were constructed by:

(a) varying aspect ratios from 2, 3, 4, 5, to 6;

(b) varying façade length from 60m, 100m, 120m, 150m to 180m.



Note: L is the façade length and the total canyon length is assumed to be 180m,
W is the street width

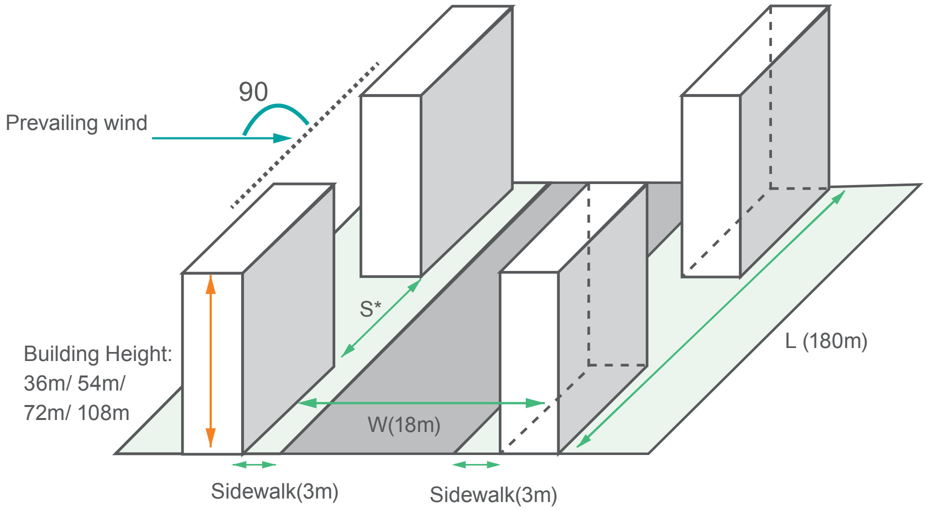
Figure 4 The baseline model showing the street and building configuration

Stage II embraces simulation of a practical case in Kwun Tong with a site area of 300m x 200m. Within this site configuration, the effects of (i) building separation, and (ii) building setback on the air quality inside street canyons having a façade length of 180m and aspect ratios of 2, 4 and 6 were investigated.

Stage I

For building separation, three different permeability values, i.e. 10%, 25% and 35% (which correspond to a building spacing of 18, 45 and 63m, respectively), were investigated. Figure 5 shows a typical configuration of a canyon with building separation.

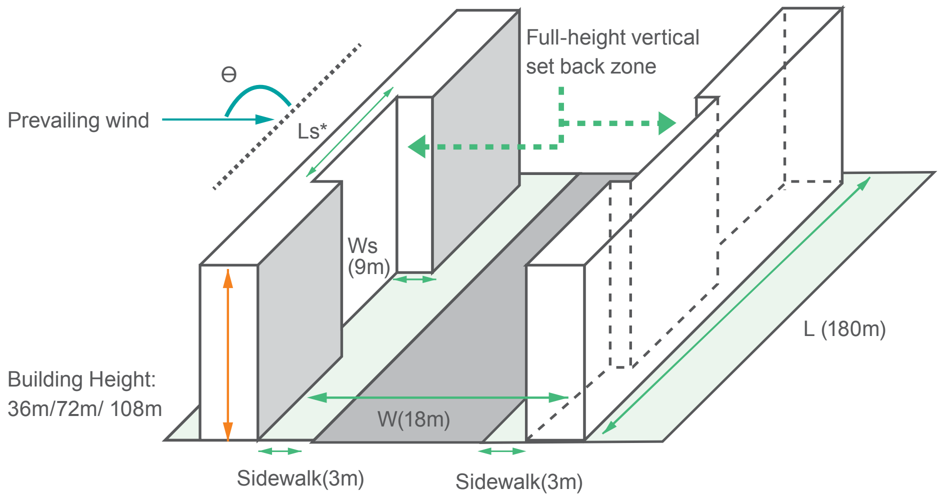
For building setback, both full-height vertical setback and full-length horizontal setback were investigated (see Figure 6). Figure 6(a) shows a typical configuration of a canyon with a full-height vertical setback. Part of the long building wall was recessed by 9m (0.5W) from the street. The length of the setback zone (i.e. 18m, 45m and 63m, which are equal to 10%, 25% and 35% of the total façade lengths, respectively) was varied. Figure 6(b) shows the typical configuration of a full-length horizontal setback. A full-length horizontal setback differs from a vertical setback by having only the lower part of buildings recessed from the street.



Note: L is the total canyon length, W is the street width, S is building separation,
Ɵ is the angle between the prevailing wind and canyon axis

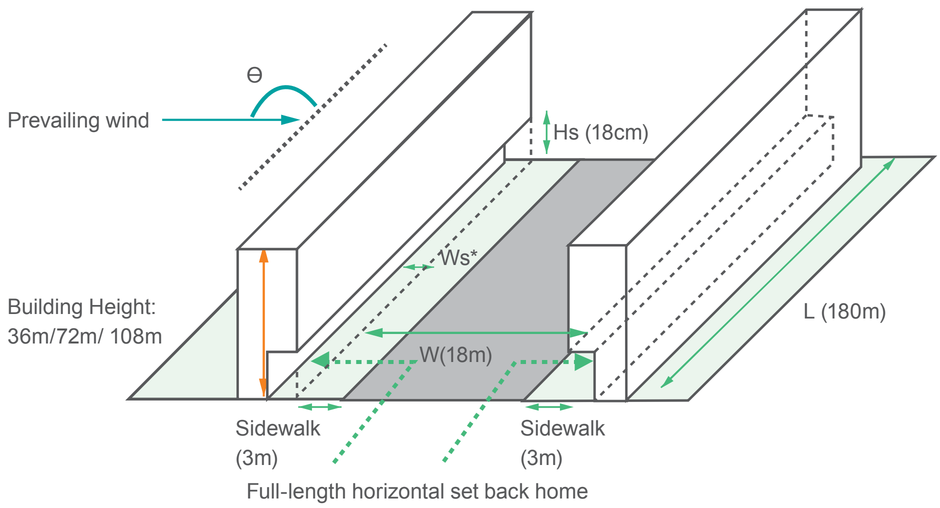
Figure 5 A sketch of the configuration with building separation

*represents a variant of this configuration



Note: L is the total canyon length, W is the street width, Ls is the length of the setback zone, Ws is the width of the setback zone, ϴ is the angle between the prevailing wind and canyon axis

(a) A full-height vertical setback



Note: L is the total canyon length, W is the street width, Hs is the length of the setback zone, Ws is the width of the setback zone, ϴ is the angle between the prevailing wind and canyon axis

(b) A full-length horizontal setback

Figure 6 Sketches showing the configurations with:
(a) a vertical set-back; and (b) a horizontal set-back

*represents a variant of this configuration

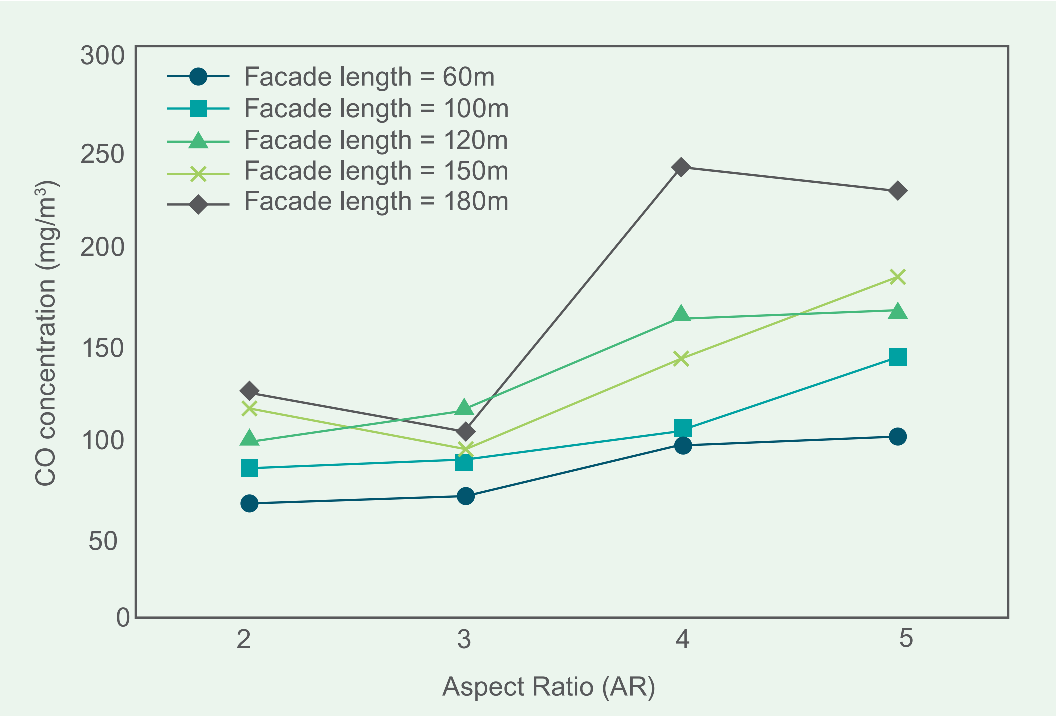


Figure 7 The mean CO concentrations for different façade lengths at different aspect ratios

Pollutant concentrations of CFD simulations

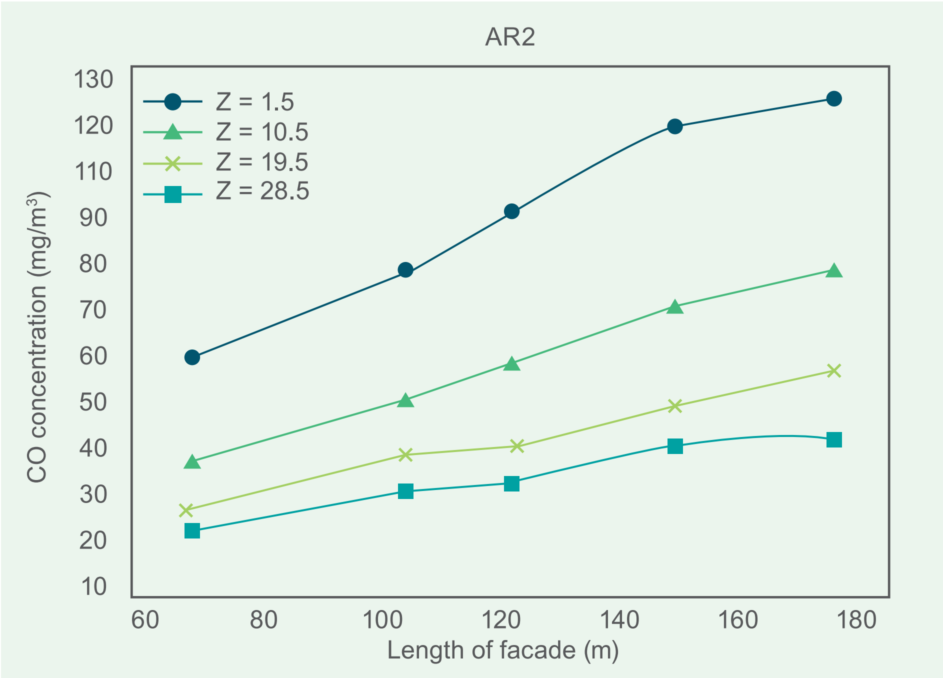
In this study, carbon monoxide (CO) was chosen as a tracer gas to represent the pollutants emitted form vehicle sources within street canyons.

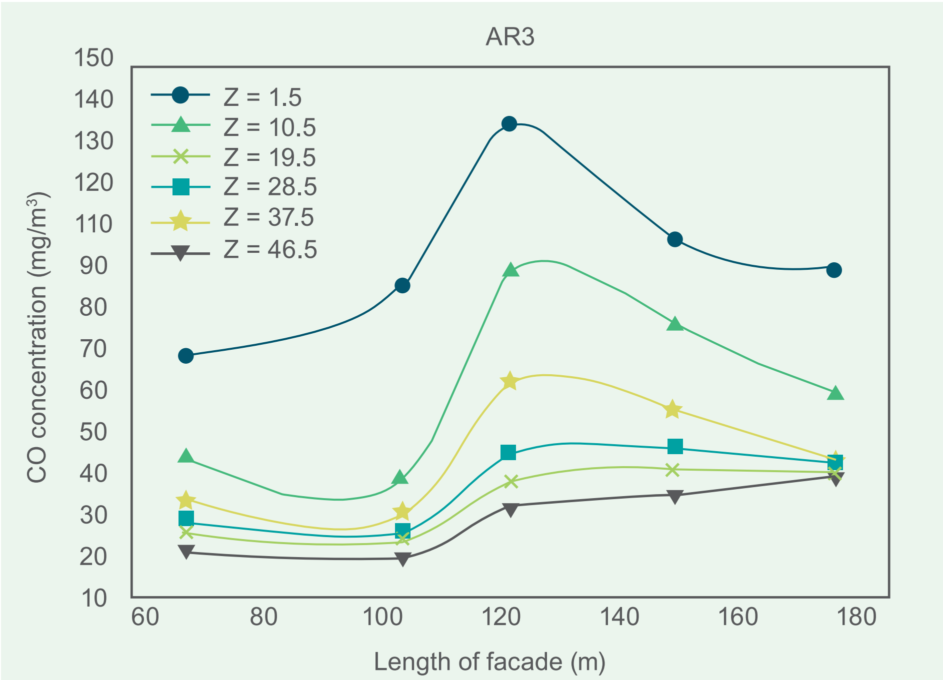
(a) Effect of aspect ratios on the CO concentration level

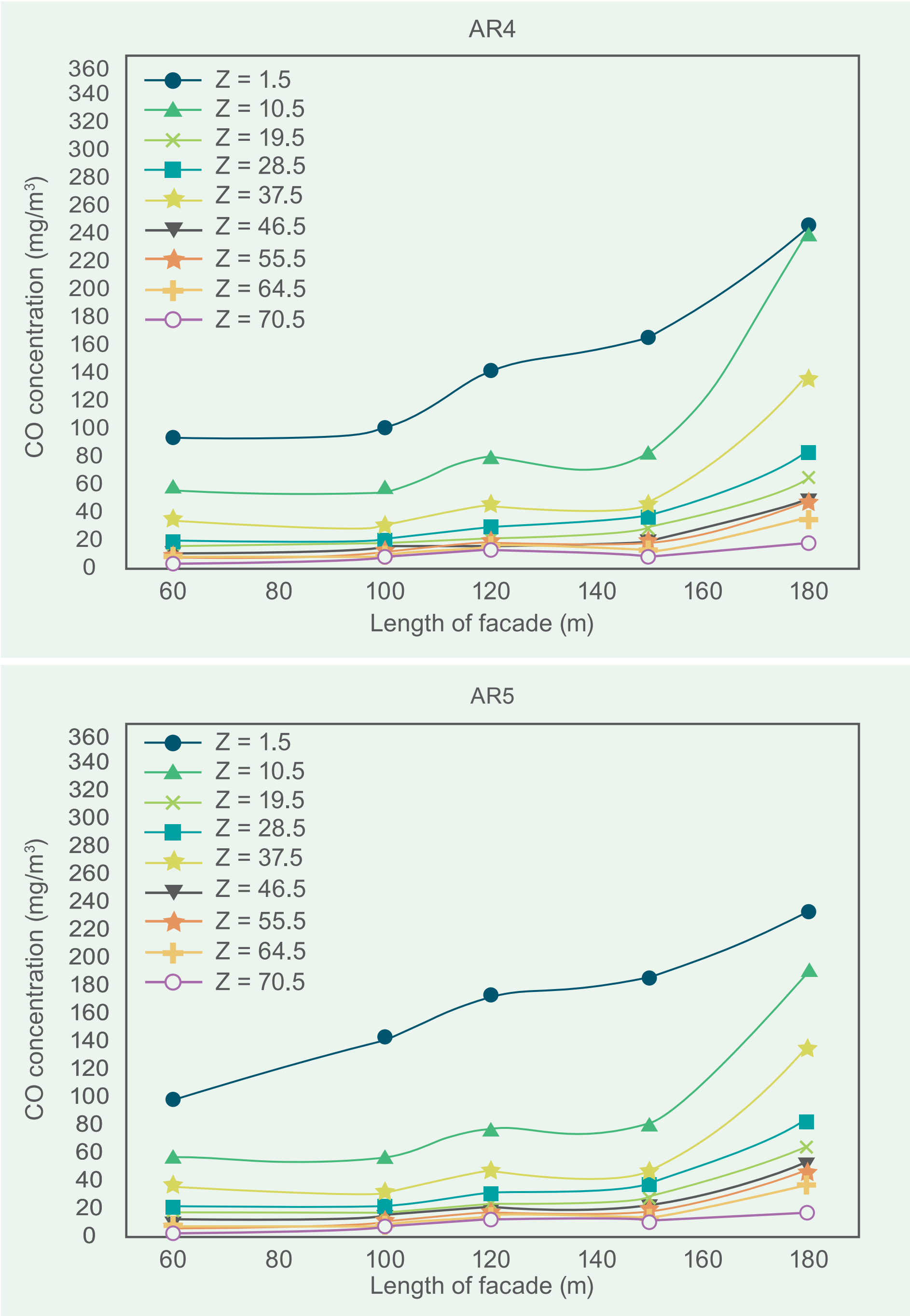
- Figure 7 shows the mean CO concentration increased with aspect ratio for all façade lengths

(b) Effect of building façade length on the concentration level

- Figure 8 shows the effect of façade length on the mean CO concentration at different height levels;
- For all aspect ratios, the highest concentration occurred when the façade length was 180m;
- At the same height level, the mean concentrations increased with the façade length of the building; and the rates of increase in mean concentration with the façade length were higher at the lower height levels than at the higher height levels;
- The effect of façade length on CO concentration was remarkably different in AR3, where the total effect of canyon vortices in the middle part and corner eddies at the ends of the street canyon was weakest than those at other façade lengths. For AR3, the highest mean CO concentrations found at the façade length of 120m.


AR2
CO concentration (mg/m³)
130
120
110
90
80
70
60
50
40
30
20
10
Z = 1.5
Z = 10.5
Z = 19.5
Z = 28.5
60
80
100
120
140
160
180
Length of facade (m)


AR3
CO concentration (mg/m³)
150
140
130
120
110
90
80
70
60
50
40
30
20
10
Z = 1.5
Z = 10.5
Z = 19.5
Z = 28.5
Z = 37.5
Z = 46.5
60
80
100
120
140
160
180
Length of facade (m)



Note: AR denotes ratio of height of buildings to street width

Figure 8 Effect of building façade length on the CO concentration level

(c) Effect of building spacing on the pollutant concentration level

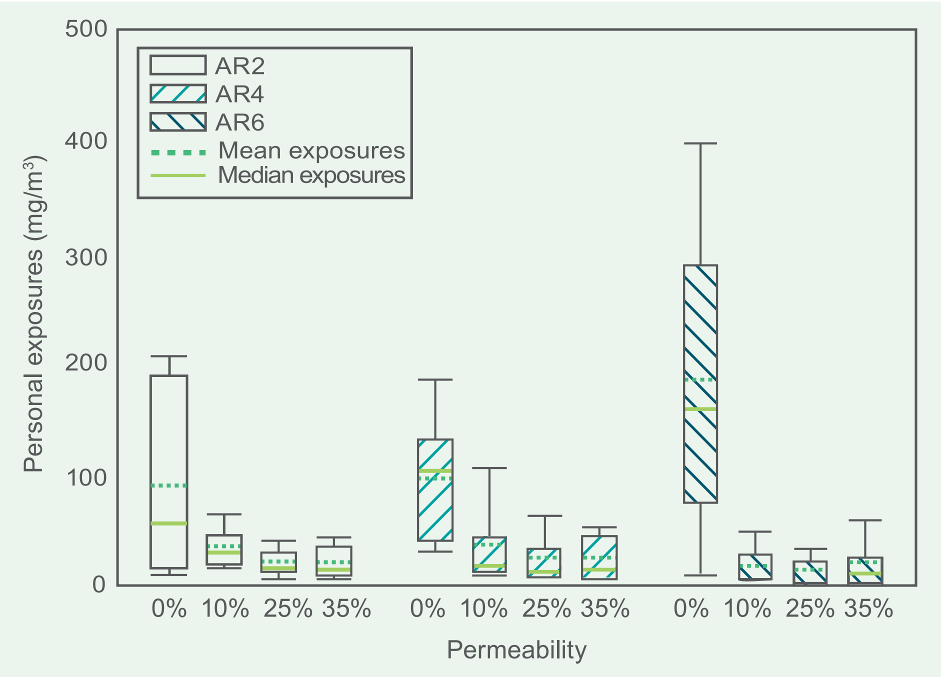
- A significant reduction in CO concentration occurred as building spacing increased from 0% onwards;
- Higher reduction in CO concentration could be achieved in higher AR with equal amount of building spacing;
- Further increase in building spacing from 25% might not be able to remove the pollutants further;
- For higher aspect ratios (i.e. AR4, AR5), building spacing exerted little influence on removing pollutants at upper level of building.

Pollutant personal exposures

Before estimating the CO exposures of different population subgroups, two major assumptions were made: (a) canyons embraced mixed-use buildings with shopfronts at ground level, residential apartment units and work offices above the shopfronts, and (b) the average duration of exposure and CO concentrations in different types of micro-environments for different population subgroups were similar to previous survey findings.

(a) Personal exposures for different permeability values

- Figure 9 shows the ranges of personal exposures experienced in canyons with perpendicular prevailing wind because of introducing different building separations;
- With the permeability value of 10%, the mean exposures reduced by 50% compared with the baseline case for the scenario AR2 and more than 80% for the scenarios AR4 and AR6;
- The mean and highest exposures did not display further significant reductions when the permeability value was further increased beyond 10%.



Note: AR denotes ratio of height of buildings to street width

Figure 9 Ranges of personal exposures for different permeability values

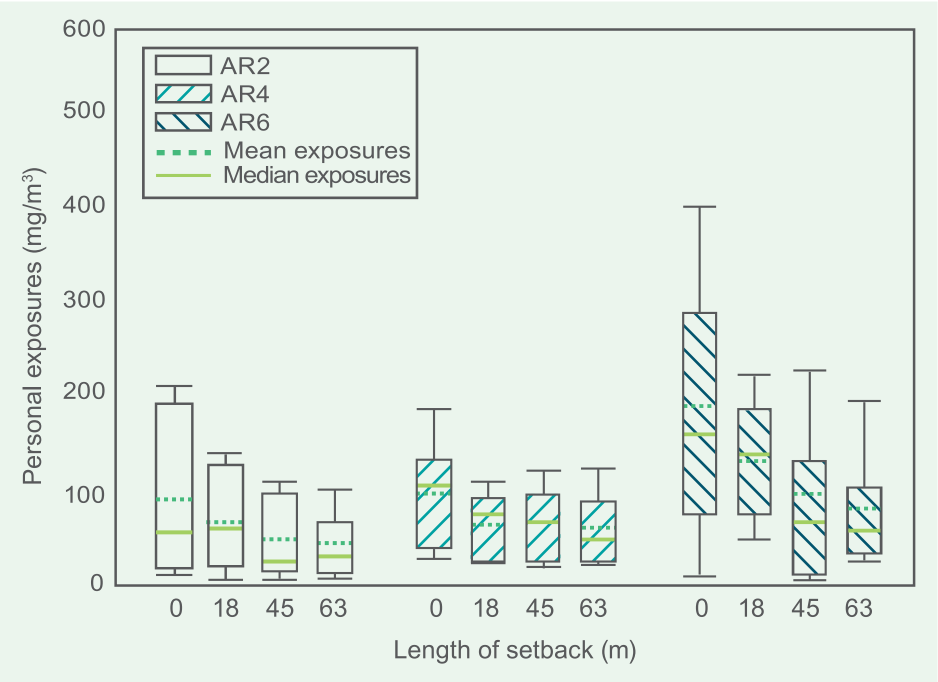


Figure 10 Ranges of personal exposures for different building vertical setback lengths when wind was blowing in perpendicular directions

(b) Personal exposures for different building setback lengths

- Figure 10 shows the ranges of personal exposures experienced in canyons with perpendicular prevailing wind because of introducing different lengths of vertical setback;
- The mean exposure reduced by 27% in the scenario AR2 as a result of introducing a vertical setback of 18 m long, and by 55% if the setback length was further increased to 63 m when compared to the baseline model;
- Vertical setbacks were less effective for the scenario AR4 or AR6 as the magnitudes of the reduction were smaller.

Economic benefits of avoided health outcomes

To estimate the health benefit gains due to improved air quality inside canyons, health outcomes including mortality and morbidity caused by cardiovascular and respiratory diseases, and restricted activity days were expressed in monetary terms. In contrast, additional costs would be incurred by loss in development floor areas as a result of incorporating a particular design scheme. The scheme embracing building separation could lead to a larger floor area reduction than the schemes embracing vertical and horizontal setbacks for all aspect ratios.

Cost-benefit analysis

First, we adopted the dynamic investment payback period method for evaluating the payback periods obtained by introducing different design elements.

- Figure 11 shows the dynamic investment payback periods for three different building design schemes;
- The longest payback period was no more than 15 years;
- For the scenario AR2, vertical setback could yield the largest economic benefit, while for the scenario AR4 and AR6, building separation and horizontal setback could yield the largest economic benefits respectively.

Figure 11 Dynamic investment payback period n for three different building design schemes

Stage II

Costs and benefits measured with the hypothetical model case

Based on the Stage I exercise to understand the costs and benefits of GB in general, in the following, we analysed the appropriateness of the existing incentive level green building incentive scheme. Actual costs and benefits are measured and presented in this section. As costs and benefits change largely with the scale of a project, this study uses a hypothetical case to measure costs and benefits. The hypothetical case is the baseline model of the SBDGs (Figure 12), which is a typical building form in Hong Kong. The model was used as a baseline for soliciting relevant data on monetary costs and benefits in the interviews. These data were used to analyse the effect of the changes in the incentive scheme on the costs and benefits of stakeholders. The changes in outdoor environmental benefits due to variation in key parameter values are considered as the benefits within the CBA framework, which are presented later.

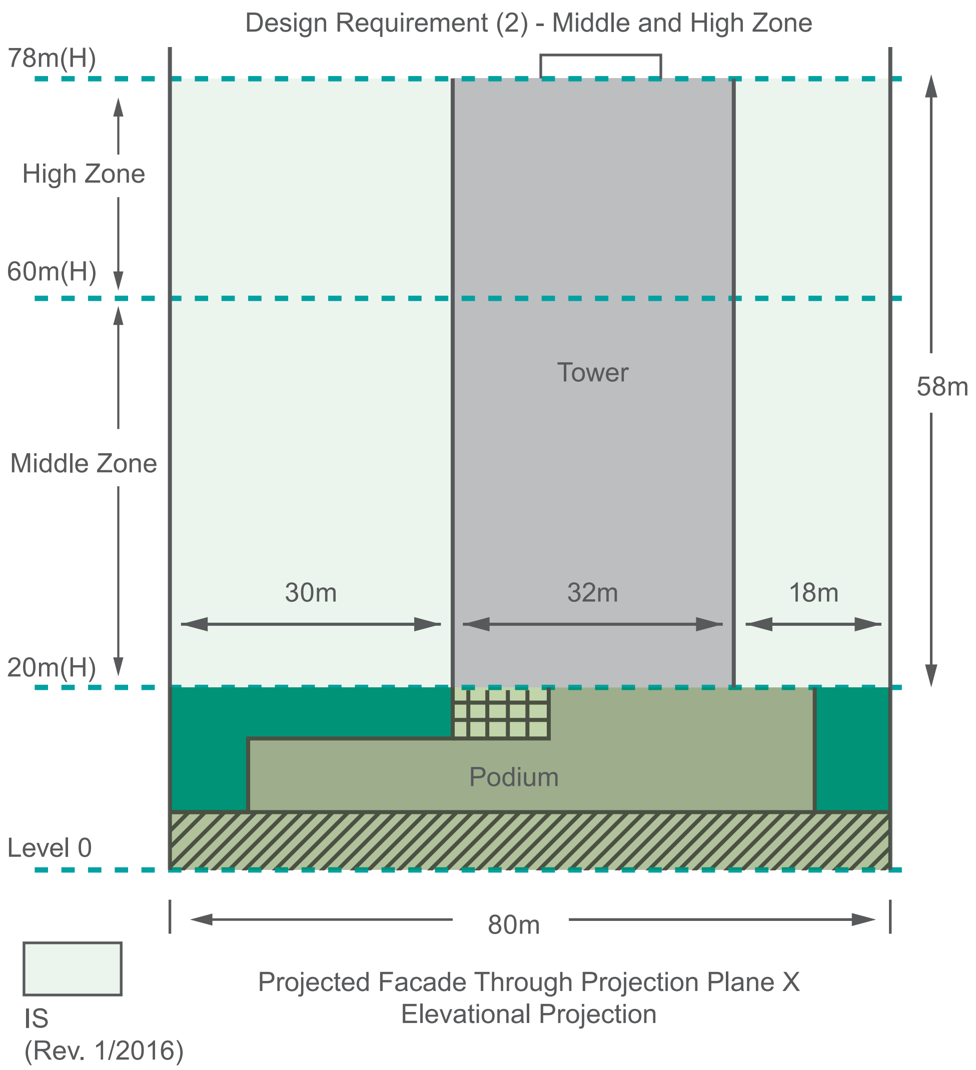
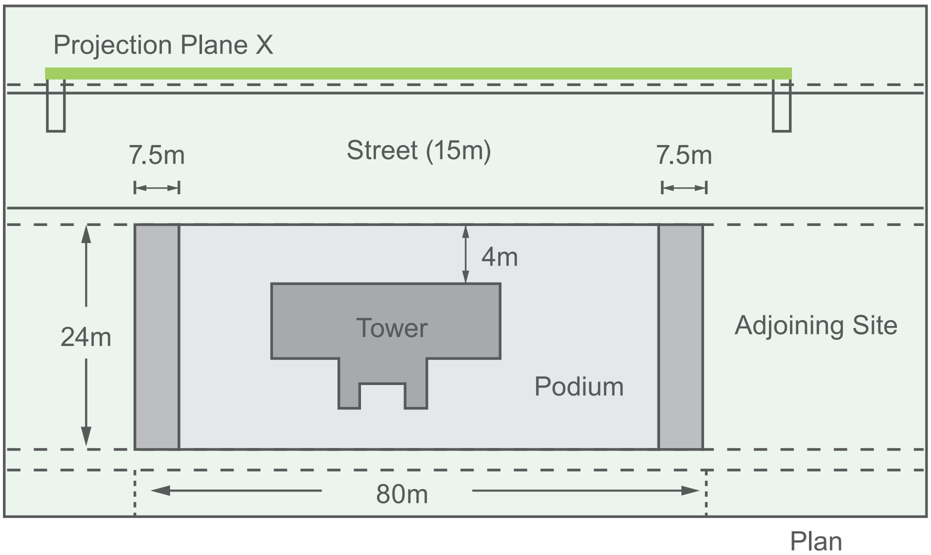


Figure 12(a) Baseline model in the SBDG



IS & S for middle & high zone

- min. 7.5m to common BL
- height ≥ 2/3 of the Assessment Zone or open to above

Middle zone:

Total facade area of the IS

= $(18x40)m^2 + (30x40)m^2 = 1920m^2$

P achieved by IS

= $1920m^2 / (80x40)m^2$ x 100%

= 60% (> 20%, *i.e. OK*)

High zone:

Total facade area of the IS

= $(18x18)m^2 + (30x18)m^2 = 864m^2$

P achieved by IS

= $864m^2 / (80x18)m^2$ x 100%

= 60% (> 20%, *i.e. OK*)

Figure 12(b) Baseline model in the SBDG

Hidden benefits

The main difficulty in securing the GFA concession is to get approval of SBDGs. Therefore, to justify SBDGs, this study employs CFD to measure the environmental benefits incurred by SBDGs. A series of simulations by CFD with parametric variations of the baseline model has been performed. The net-benefits of the key parameters are the outdoor environmental benefits in the CBA framework. CFD models were formulated to predict the air pollutant concentrations and estimate personal exposures to ambient air pollutants. The economic benefits of avoided health outcomes and losses in development floor areas, as well as the dynamic investment payback period, were evaluated by comparing the modified building configurations with the baseline ones. The configuration of the baseline building is a sample case shown in APP 152. Building separation was placed at the podium with a permeability value of 23%. Building setback recessed the lower part of the building located in a street with a width of 5.52 m to maintain the same permeability value with the separation case.

Simulation model results

To estimate realistic health benefits of the proposed building configurations, the meteorological and site characteristics of the constructed models were defined according to a specific street canyon in the heart of Mong Kok, which is an urban district having a high population and road traffic density. The pollutant concentrations in the baseline model were the highest among all configurations. Modified configurations were effective in lowering pollutant concentrations at the pedestrian level and building setback was more effective than building separation. A significant reduction in pollutant concentration was achieved when wind was blowing from the perpendicular direction (90°).

Figure 13 shows the estimated annualized monetary benefits for the proposed building configurations. Generally, building separation and setbacks were effective in removing the pollutants and reducing pedestrians' health risks. The amount of benefits gains varied with the building configurations. Building setbacks could provide monetary benefit gains twice as much as building separation.

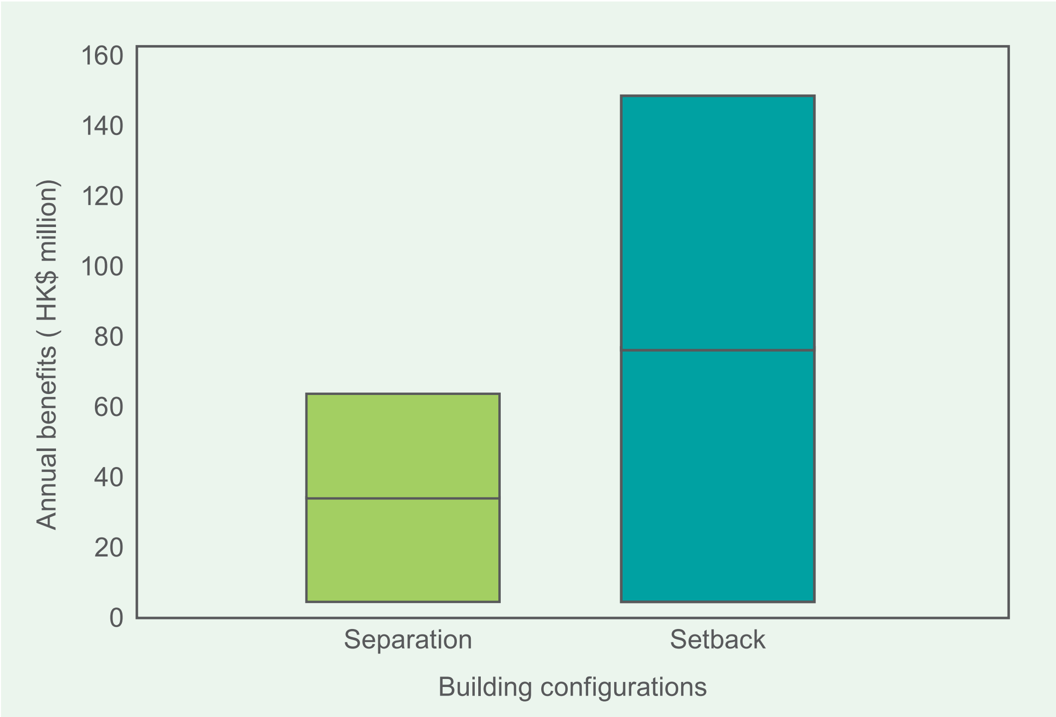


Figure 13 Annual benefit gains for different building configurations

Likewise, similar findings can be observed in terms of total benefit gains per floor area reduction. It is observed in Figure 14 that setback provided higher total benefit gains per floor area reduction, as building setbacks could lead to more reduction in development floor area than building separation. (All the monetary costs and benefits were discounted at 5%).

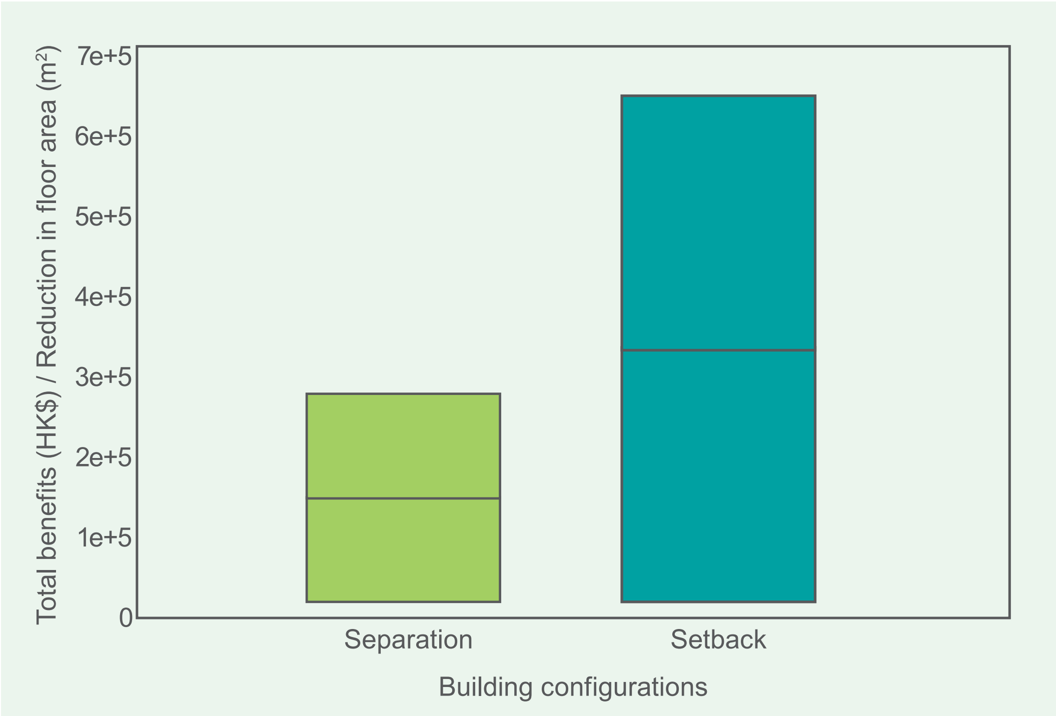


Figure 14 Total benefit gains per floor area reduction

Data from interviews with experts

In the interviews, three firms provided estimated cost data. The data figures presented in the following are the results based on an average of the three data sets. The actual cost data from firms are supported by real figures published by Quantitative Surveying firms. Extra energy savings and water savings are supported by credits of different levels of BEAM Plus. The maximum energy saving of platinum GB in BEAM Plus is 40%. The results are triangulated. In terms of TCs, the TCs of unclassified buildings are mainly incurred in the process of fulfilling SBDGs, but the consultancy fee of unclassified buildings is nil. That is why participants, especially consultants, complained a lot about the SBDGs. Among all the types of TCs, approval cost takes the most time.

The actual costs and benefits, and hidden costs and benefits of the hypothetical case are as follows: (**Note**: The Extra % shown below is the % figure times the fee/cost of a traditional (non-green) project that to be added due to meet any green requirements).

(1) Actual cost

Extra consultancy fee

Unclassified	nil
Bronze / Silver	2%-4%
Gold / Platinum	5%-8%

Extra construction cost (original cost of baseline model: HK$300 million)

Unclassified	1%
Bronze/Silver	1%-3%
Gold/Platinum	5%-10%

(2) Actual benefits

Extra energy savings[1]

Unclassified	0-6%
Bronze	<10%
Silver	10%
Gold	13%-15%
Platinum	15%

Extra water savings

Unclassified	10%
Bronze	10%
Silver	12%
Gold /Platinum	20%

(1) Three firms provide the data figures in the interview. The results are based on an average of the three data sets.
(2) Case study's real figure (published) supports the data from firms.
(3) The maximum energy saving of platinum GB is 40%. The results are triangulated.

(3) Transaction cost

When you participate in the GFA concession scheme and construct green building, how much extra time do you have to spend comparing with doing traditional building?

Unclassified	4%
Bronze	6%
Silver	8%
Gold	12%
Platinum	15%

Note: Consultants get 4% unpaid TC

The general breakdown of the extra time:-

Information searching cost	6%
Research/Learning cost	7%
Negotiation/coordination cost	20%
Approval cost	45%
Monitoring cost	12%
Verification cost	10%

General comments of interviewees

In addition to the above analysis, during the interviews with experts, the general comments from interviewees are summarized:

- The profits from developing GB still depends on the property market, site location, the standard of development, etc. The GFA concession, green features and energy efficiency contribute little to the profits;
- Under the restrictions of the current Building Regulations, the GFA concession scheme does benefit the built environment, but not enough for an advanced city like Hong Kong. The GFA concession scheme is significant for GB promotion, but not outstanding;
- The design of the GFA concession scheme leads to two streams of development. Developers with enough budgets go for higher grading of GB to pursue corporate reputation, and those with insufficient budget go for the minimum grading of GB to maximize the profits;
- The GFA concession provides developers few profit margins to do more for sustainability;
- The GFA concession should promote sustainability, not to attract building designs to meet standards. It should motivate developers to achieve higher grading of GB;
- The GFA concession scheme increased the land cost and Government benefits from the GFA concession scheme through increased land sale price. Developers would suffer losses if this scheme is suddenly tightened or terminated;
- The most critical part that decides the attraction of the GFA concession scheme is the approval process. There are so many uncertainties, and consequently private sectors tend to do less for sustainability to avoid troubles.

3.5 Validation Process

Focus group meetings

The Professional Green Building Council (PGBC) invited members of the Hong Kong Institute of Architects (HKIA), the Hong Kong Institution of Engineers (HKIE), the Hong Kong Institute of Planners (HKIP), the Hong Kong Institute of Landscape Architects (HKILA), and the Hong Kong Institute of Surveyors to attend focus group meetings. In total, 25 experts attended the focus group meetings in two sessions, who are listed in the acknowledgements except those who wished to remain anonymous.

In the two focus group meetings, we presented the findings and preliminary results, and sought their comments. Practitioners agreed that the GFA concession scheme led to the increase of land value and suggested Hong Kong could learn from Singapore to consider land price in the scheme and some other places requiring developers to achieve higher ratings of GB in order to get the GFA concession. They also commented that BEAM Plus was improving continuously, which means both big and small developers have to do more to achieve the current ratings. They agreed that higher level of GB should be promoted, but the way to achieve that will remain to be discussed.

Overall comments from Focus Groups

Overall, practitioners recognized the effectiveness of the GFA concession scheme, and the extra costs and benefits induced by the scheme. Their comments led us to recheck our figures, and we refined some of them accordingly. They also agreed to promote higher level of GB at this stage. However, the way of promotion needs further study because it would affect costs and benefits of many stakeholders in various degrees. With the framework of costs and benefits, our research builds a solid foundation to explore the improvement of the GFA concession scheme.

4 RECOMMENDATIONS

4.1 Consolidated Results

Hong Kong has relatively lower threshold requirements to enjoy the GFA concession. The BEAM Plus to qualify for the GFA concessions is simply to register, which means that buildings do not get certifications and only need to fulfil the prerequisite in each section of the BEAM Plus. This does not cost developers too much. In Hong Kong, the GFA concession is subject to the building features prescribed in APP 151 (Practice Note for Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers), and is subject to a cap of 10%. Since the land is owned by government, and developers have to bid for the land, the benefits that a developer could get from the GFA concession are eventually reflected in land cost under a free market competitive bid in the end.

The framework of costs and benefits of implementing the GFA concession scheme comprises actual costs, hidden costs, actual benefits and hidden benefits. The extra actual costs include construction costs, consultancy fee, certification and assessment cost. The hidden costs (transaction costs) include information searching cost, research/learning cost, approval cost, negotiation/coordination cost, monitoring cost, and verification cost. The actual benefits include enhanced value of green building, energy saving, and water saving. The hidden benefits include reputation/branding of private sector, competitiveness of private sector, job opportunities for the society, health/productivity (indoor), and environmental benefits (outdoor). The results of the AHP analysis show that construction cost is still the private sector's major concern and actual costs are more important than hidden costs. Energy savings and enhanced value of green building are valued by the participants of the GFA concession scheme the most.

4.2 Building Configuration: Separations vs Setbacks

To estimate all the costs and benefits associated with the implementation of an incentive scheme, a baseline model was constructed. Generally, building separations and setbacks were effective in removing the pollutants and reducing pedestrians' health risks. The amount of benefits gains varied with the building configurations. Building setbacks could provide monetary benefit gains twice as much as building separations. However, building setbacks could induce more development floor area reduction than building separations. To identify the type of building configuration that could yield the highest health benefits, the ratio of total benefits (50 years, HK$) divided by floor area reduction (m^2) is used as shown in Figure 14. Building setbacks could still provide better monetary benefit gains than building separations but the effectiveness is about 1.5 times only.

4.3 Costs and Benefits

After expert interviews to collect data and the two focus group meetings to conduct overall validation of our preliminary results, the actual costs and benefits, and hidden costs and benefits of the hypothetical model case are shown section 3. If the current GFA concession incentive is to be improved, these costs and benefits are the baseline for adjusting the current scheme to promote higher level of GBs. They indicate how the costs and benefits would change with the GB ratings. It's worth mentioning that transaction costs are large but are often ignored by policy-makers. Traditional building consultants, such as architects, surveyors and engineers, have to absorb unpaid transaction costs. For new professionals such green building consultants, most of their transaction costs have been priced in when their fee is set up to meet the new phenomenon of GB.

4.4 Potential Areas for Further Research

This research does not take financing issues into consideration due to the limited resources. The risks as to whether getting the GFA concession in building plan approval process may affect the financing cost of developers substantially. Further study is recommended to address this problem.

As to those key parameters used for CFD simulations in this study, we have focused on evaluating the health benefits due to improved air quality versus the development costs relating to the above parameters. This part of the technical study is considered exploratory in nature, which intends to provide indicative trends after running a set of parametric studies on the individual parameters. With our identified indicative trends, we find it worthwhile to pursue further, further in-depth technical study on those areas is suggested. Also, this study concludes that it is worth adjusting the scheme to promote a higher level of GB. The detail methods of adjusting the incentive scheme need more in-depth study with wider consultation of the industry.

4.5 The Way Forward

The GFA concession incentive scheme has been applied to many government programmes in the world, such as affordable housing, green buildings and renewable energy of buildings, which is attractive to developers. The framework of costs and benefits of this scheme provides a holistic picture to see how the incentive scheme works and how it affects stakeholders. The study helps policy-makers use the instrument more effectively and efficiently. Based on the results, we conclude that:

- The GFA concession incentive scheme is useful and can be extended to other sectors, like building conservation, low-carbon city, etc.
- The urgent and necessary issue is to improve air ventilation around buildings, where the SBDGs contribute very well.
- If the market is not willing to pay for green design or green features, developers will not have to provide these design/features. Government policy is needed to provide incentive to both kick-start the market and educate the consumers. When the market is mature enough, it is time to consider removing the incentive or making use of the incentive to push for higher performance requirements.
- The benefit from the 10% GFA concession would finally be capitalized into land value, and such view is supported by the interviewees and the economic theory of Transitional Gains Trap. Therefore, the 10% GFA concession could be kept, as it is attractive to the private sectors and benefits society at large through a better environment and increased land revenue.
- The professionals absorb around 4% unpaid TCs, but what they complain most is the incomplete APP 152 and the imprecise and qualitative approach of the BEAM Plus, which takes them a lot of time to get approval. It is suggested that professional institutes should review the BEAM Plus and APP 152 with government to make it more user-friendly and to reduce their transaction costs.
- After 5 years of implementing the incentive scheme, the information-searching cost and research/learning cost account for relatively little, which indicates that the industry is becoming more and more familiar with the GFA concession incentive scheme. It is the right time to use the incentive to push for higher threshold as a minimum requirement to enjoy the concession.

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6 APPENDICES

Appendix 1: List of actual costs and benefits of committing the GFA Concession (based on literature review)

Stakeholders	Actual Costs	Actual Benefits
Developers	More construction cost due to risk in longer construction time, new construction methods and new GB technologies (Rehm & Ade 2013) • Increased architectural and engineering design time (Kats, 2003)	GFA Concession bonus Higher market selling price (Hebb *et. al.*, 2010)
	Costs of GB certification • Assessment cost • Survey cost Certification cost about HKD75000-150,000 depending on the project scale and complexity (Burnett *et. al.*, 2008)	Costs saving from efficient use of materials • Reduction of material use through modular design (off-site prefabrication, lean construction methods), reuse of building elements • Improved material management and On-site sorting
	Additional or increased Consultant fee (Häkkinen and Belloni, 2011) • Higher cost for green appliance design and energy-saving material at design stage • The design fee rises from around 9%-10.5% of total cost (Larsson & Clark 2000).	
Government	Professional training - Continuous Professional Development (CPD) course	Tax revenues derived from the extra floor area (Kayden, 1978) • Tax from additional housing units' transactions • Tax from extra construction activities
Contractor	More construction cost due to longer construction time Increased architectural and engineering design time (Kats, 2003)	Material saving
End-users	Higher property price	Operational cost saving (quantity depends on building performance) • Energy and water saving (Kats, 2003) Higher property value (resale)

Appendix 2: List of hidden benefits to the stakeholders due to GFA Concession scheme (based on literature review)

Hidden (invisible) benefits to the stakeholders	D	G	P	C	E
Good company reputation/profile , status, market power, job satisfaction, rewards, personal development (Isa *et. al.*, 2013)	X		X	X	X
Future business competitiveness over the long-term	X		X		
Extra GFA bonus to sell more and gain more profits	X				
Energy efficiency and environmental protection can help GB sell quicker (Bartlett & Howard 2000)	X				
Reduction in construction pollution (BEAM Plus) • Reduction of pollution, resource depletion, energy and waste consumption (Addae-Dapaah *et. al.*, 2009)		X			
Reduced demands on infrastructure (Pearce *et. al.*, 2007), public water-treatment, electricity demands, and landfill (Kats, 2003)		X			
(National) Savings of health care (Pivo & McNamara, 2005) • Reduced respiratory infections, allergies, and asthma • Decrease demand for health care facilities • Enhanced occupant productivity and health (Kats, 2003) • Reduced health care cost		X			X
Create more job opportunities		X	X	X	X
Improved working efficiency and social productivity • Increased economic activities, e.g., activity associated with bonus GFA. (Kayden, 1978)		X			X
• Green premium increase construction spending • Stimulate more consumers spend more in the long term, due to the savings from energy bills • Higher interest paid to bank on construction loans(Kats, 2013)		X			
Support from company to take training course (Ahn and Pearce, 2007), i.e., Professional certificate			X		

Note: D for developer, G for government, P for professional, C for contractor, E for end-user

Appendix 2: List of hidden benefits to the stakeholders due to GFA Concession scheme (based on literature review)

Hidden (invisible) benefits to the stakeholders	D	G	P	C	E
Get new professional skills in (Ahn and Pearce, 2007) • Serving new technology • BEAM Pro • Life-cycle cost of GB • GB design process • Familiar with GB standard • Knowledgeable about low environmental impacts materials	X		X	X	X
Better living quality from, e.g.: sky/podium garden, wider corridor, quality indoor environment, natural light and ventilation (Hebb *et. al.*, 2010), better site plan and design, less carbon emissions, etc., (Kats, 2003)					X
New knowledge and skills about green construction (Qian *et. al.*, 2015b) • Basic knowledge and concepts of green construction and management • GB rating system • General knowledge of sustainability in the built environment • GB materials and method	X		X	X	

Note: D for developer, G for government, P for professional, C for contractor, E for end-user

Appendix 3: Transaction costs associated with energy efficiency and green building promotion, and environmental policy implementation

Transaction cost items	Mundaca *et. al.*, 2013	Hein and Blok, 1995	Dudek and Wiener, 1996	Coggan *et. al.*, 2010	McCann *et. al.*, 2005	LBNL, 2007	Michaelowa and Jotzo, 2005	Ofei-Mensah and Bennett, 2013	Singh, 2009	Hagemann *et. al.*, 2015	Joas and Flachsland, 2014
Cost of information searching	X	X	X	X	X	X	X	X	X	X	X
Research cost				X		X		X			
Decision-making cost		X									
Implementation cost			X	X							
Negotiation cost	X		X			X	X	X	X		
Project documentation/ Administration cost				X	X		X	X			X
Approval cost			X			X	X		X		
Validation cost							X		X		
Registration cost							X				
Monitoring and verification cost	X	X	X	X	X	X	X	X	X	X	X
Certification cost							X		X		
Enforcement cost			X	X	X		X	X	X	X	X
Trading cost	X							X			
Transfer cost							X				
Insurance cost			X			X					
Coordination cost										X	

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