WWF

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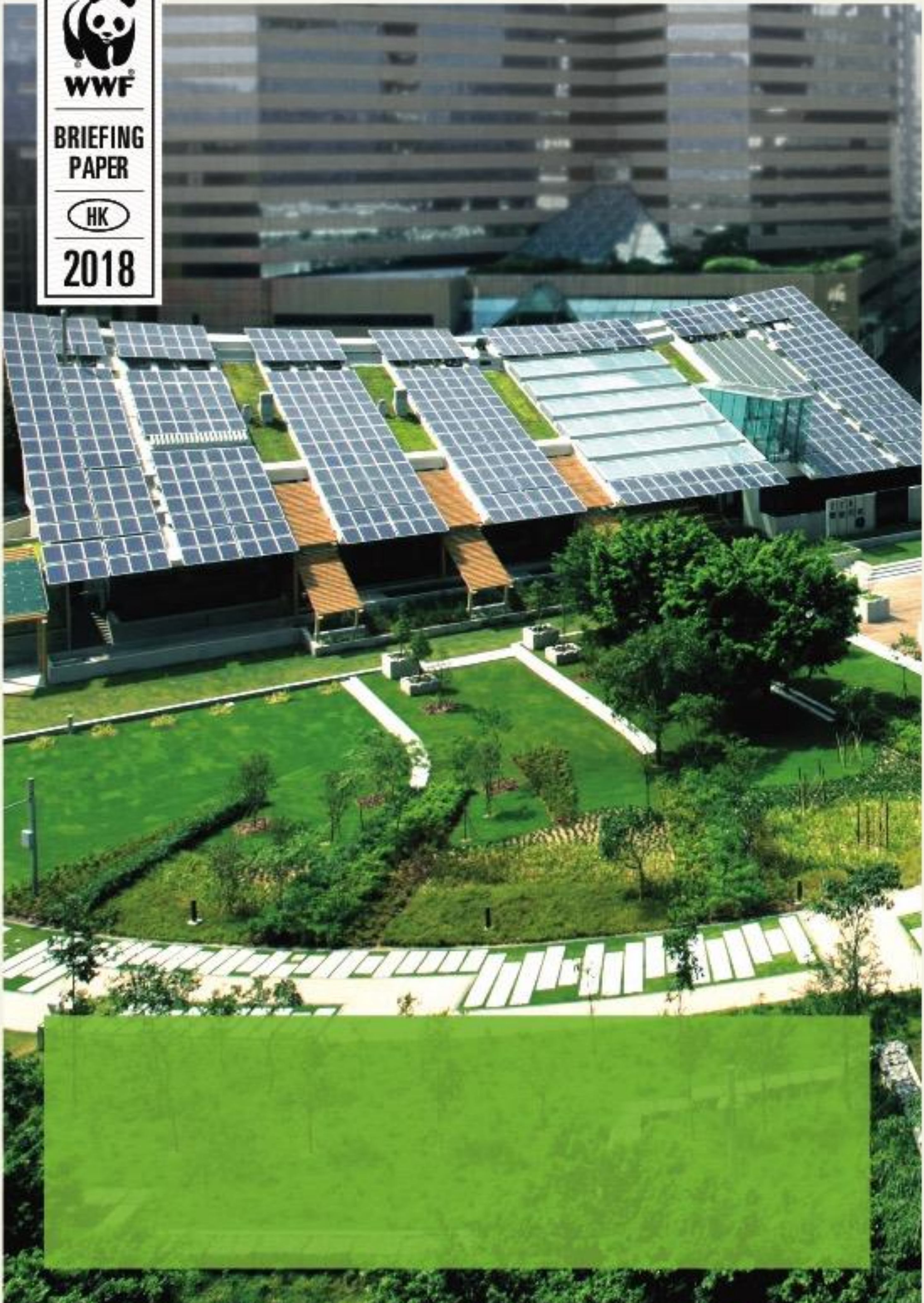

EXECUTIVE SUMMARY

Hong Kong has ambitions to becoming one of the world's leading smart cities. This means its buildings have to be adapted to current environmental challenges: including mitigating and responding to climate change. Buildings use around 90 percent of Hong Kong's electricity; lighting and air-conditioning are responsible for 30 percent of the city's greenhouse gas emissions. To make a step-change reduction, buildings need to use smart technologies to monitor internal conditions, data-science driven software to manage buildings AC and lighting. If Hong Kong is to achieve its 2050 carbon targets of reducing absolute emissions by 26 to 36 percent, maximising energy efficiency and developing smart buildings are of key importance.

Green building certification schemes (GBCSs), like Hong Kong's BEAM Plus[1] have an important role to play in remedying this. Since 2011, government has provided developers a generous gross floor area (GFA) concession of up to 10 percent extra gross floor area, for undertaking BEAM Plus assessments and supplying the Buildings Department (BD) with information on buildings' projected energy use[2].

RECOMMENDATIONS

We make the following suggestions to government to better align its incentives and regulations, and to the organisations responsible for developing BEAM Plus to improve the scheme's focus and increase the rates of participation and completion:

Gross Floor Adjustment Incentive for building and commissioning green buildings

- We recommend that the government vary the GFA concession it awards according to the ambition of the design (e.g. 2 per cent for minimum performance improvement – 10 per cent concession for ultra-low carbon, and up to 15 per cent for zero carbon).
- We recommend the performance standards for the GFA award be limited to a small subset of key BEAM Plus indicators which have a strong 'public good' element.
- We recommend that the Hong Kong government asks developers to post a bond worth half the value of the GFA concession granted. This money is returned after the BEAM Plus final assessment demonstrates the sought after performance was attained.

Enhancing building energy efficiency & renewable electricity

- We recommend the building envelope be given its own indicator in BEAM Plus linked to significantly outperforming the OTTV standards.
- BEAM Plus's level of ambition for platinum should be benchmarked to near-zero carbon buildings in terms of operational energy use. Ambitious targets should also be set for reducing embodied carbon emissions in building materials and construction.
- We think Government should set an objective that all new buildings should be near-zero carbon in a decade, and set a trajectory for tightening to OTTV and RTTV standards. We would expect this

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[1] Taken to mean Building Environmental Assessment Model v.1 2 New Buildings

[2] Buildings Department (2011) "Building Design to Foster a Quality and Sustainable Built Environment" Practice Note for Authorized Persons APP-151

to increase the rewards for building integrated PV, recognising the gains this provides in generating electricity and providing internal shade.

Rewarding Green operation of the building

- We recommend BEAM Plus consider offering credits for:
    - using Building Information Management (BIM) software to optimise design and reduce construction waste, installing smart meters to capture major building service data from the tenant and shared services, physical environment sensors and Building Energy Management Systems;
    - using leases to commit tenants, owners and building management companies to share real-time data to control and optimise building energy use. This could be written into the tenancy contracts;
    - suitably anonymised data to be made publicly available on an annual basis enabling interested parties, like prospective tenants, to understand and compare the building's actual energy performance,; and
    - use of data science/machine learning to drive automatic control of building energy management services: lifts, lighting circuits and coolant flows.
- We recommend government offer a discount in the Government rates that landlord or tenant has to pay every quarter (say reducing it from 5 per cent of the rental value of the property to 4 per cent) to encourage owners or tenant to invest in ongoing investment in building energy efficiency, data sharing and encouraging good tenant behaviour as set out above.

Improving the effectiveness of Government regulation

- We recommend Government review the departmental responsibility around building envelope regulation, and consider carefully whether BD should continue to play its current role given issues about its enforcement of its existing responsibilities.

OUR KEY FINDINGS

With this report WWF hopes to inspire the construction of *smart buildings*. These should:

- be highly energy efficient using near zero energy per square meter
- be constructed with local, low impact construction materials,
- sense internal and external environmental conditions,
- apply learning algorithms to manage and report performance to minimise energy usage; and
- maintain a healthy internal environment.

In short, smart buildings are efficient, intelligent and have a small ecological footprint. This report's focus is on new buildings, this is not because existing buildings are less important, but because the actors that need to be influenced and the impediments to change are different.

Hong Kong buildings are far from this ideal. Government should continue to intervene in the property market and provide incentives for certain, but not all, green building characteristics. We welcome the review of incentives for green buildings re-announced alongside the Chief Executive's 2017 autumn Policy Address. We hope WWF's report will provide evidence and views for this review and spark debate within the professional community and wider society.

GBCSs are typically defined by building design professionals. They assess performance on themes like energy and water use, and indoor environmental quality. Often they use local building codes as a reference point (Hong Kong's Building Energy Code 2015) and then award points for going beyond these standards. We believe GBCSs need to have an eye to the future, signalling the direction of travel architects and developers need to journey to reach smart building goals.

Our analysis looked at the BEAM Plus and compared it to schemes found in other advanced economies with similar climates to Hong Kong's. We reviewed the guidance documents and websites of eight GBCSs in these countries, interviewed around 50 building design professionals and their clients as well as organised an expert Panel to comment on our emerging findings and provide their insights into the commercial practicalities of making buildings more energy efficient.

We found that relatively few BEAM Plus final assessments were undertaken over the last seven years: barely 100, despite 989 buildings registered for BEAM Plus New Building scheme by April 2018. According to government data some 481 proposals received a gross floor area GFA incentive between April 2011 and December 2016. Upon detailed examination of approved project with GFA concession based on green features in 2016, we found majority of the approved projects are either: "Registered" (XX%); at "Provisional Assessment" stage (XX%); attained "Final Assessment (Unclassified)" (XX%); or attained "Final Assessment (Bronze)" (XX%). We can only conclude that Buildings Department had failed in fulfilling their duty set out by the relevant policy, and the threshold for granting GFA concessions for 'green building' is too lax.

To have an impact, a GBCS needs to be completed and its results carefully considered by the developer and their design team. A simple registration or design with no/little positive environmental impact achieves nothing. We found that in other countries, GBCSs are more widely used by developers either because there is a more effective "contract" between the developer and the building authority, or because the property market sees intrinsic value in the assessment's results. There are several reasons for the low level of completed BEAM Plus Final Assessments in Hong Kong:

- lack of enforcement by government,
- BEAM Plus's onerous and bureaucratic reporting requirements necessitate substantial spending on consultants,
- the excessive number of indicators, some of which make no sense to the building's specific circumstances, and
- high registration and assessment fees paid to the two organisations that administer BEAM Plus. These costs are an order of magnitude higher than other GBCSs despite the close similarities.

Not all of BEAM Plus's 'green' themes, are of equal public policy interest. Some, like energy use, provide benefits to the wider society and are not wholly captured through higher rents or property prices. These are true positive externalities. Others, like indoor environmental quality or tenant amenities, provide direct benefit to occupants and ought to be captured in higher rents and should not be rewarded with Government incentives. We think Government should only incentivise positive externalities.

Building design can influence a building's energy use in two principal ways: (i) energy used by building services (defined as centralised energy efficiency, lighting circuits, lifts and escalator) and (ii) the energy used during the construction phase. BEAM Plus gives a high weight to the building's overall energy efficiency, as defined by the extent efficiency improves beyond mandatory building codes. Hong Kong's building codes are specified by the BD: the building envelope regulation (OTTV) covers heat gain from sunlight through windows, or through the building's external walls and roof; and by the Electrical and Mechanical Services Department (EMSD) through its Building Energy Code which covers the efficiency of cooling, lighting and lifts/escalators systems.

Several architects operating in Hong Kong who we spoke to were unaware of the OTTV regulation. People familiar with it told us it was regarded as very unchallenging. BD are in the middle of a review (there have already been three since 1996, one of which weakened the standard!). We spoke to two technical committee members who advised on its review, and got the impression BD is putting few resources into the process despite its potential importance in Government's overall climate action plan. In other countries, equivalent regulations on the building envelope have systematically been tightened. The EU, for instance, aims for all new buildings to be "nearly zero-energy" by the end of 2020; for new public buildings, this "nearly zero-energy" goal should be attained by 2018[i]. By contrast with BD, EMSD regulations are broadly as stringent as those in other advanced countries.

Concerning envelope regulations, many locally trained architects believe that insulation concerns are irrelevant in Hong Kong's mild climate; a view that is not shared by foreign-trained building design professionals, nor by WWF. There was however consensus that smaller window-to-wall ratios reduce the need for air-conditioning since it reduces the penetration of radiant heat through windows. But green-minded building design professionals did not feel empowered to challenge the orthodox "glass-box" design ubiquitous in modern Hong Kong buildings. Instead developers and architects continue to propose designs badly suited to Hong Kong's climate and implementing AC systems to rectify their ill-conceived building concepts. Encouragingly, the government's architectural service sets tougher envelope standards for public buildings, but clearly the strategy of leading through example does not appear to work. WWF finds that energy usage per square meter in Hong Kong offices to have been near constant over the last eight years. Government buildings became 40 percent less energy efficient between 1985 and 2015 in terms of how much heat the windows, walls and ceilings allowed in. In the decades since air conditioning became common place we have forgotten how to make buildings that stay cool naturally.

BEAM Plus masks these deficiencies by setting thirteen different indicators to score "energy use", more indicators than other GBCS. There is only one non-scoring "pre-requisite" and this simply asks the building to meet the mandatory standard i.e. not be illegal. In short: not a terribly high bar to pass. Furthermore, these indicators reward behaviours or characteristics that are frighteningly unambitious, either because they:

- should be undertaken anyway (like documenting building services, ensuring equipment is commissioned),
- are old-fashioned and do not reflect advances in information technology (e.g. leaving the operator documentation about the building's electrical services), or
- reward characteristics that provide trivial energy savings (installing marginally more efficient ventilation and lighting in the car-parks).

As a consequence of the gerrymandering of the points system, it is possible to obtain a respectable BEAM Plus grade by making cheap 'improvements' that save little energy. To varying extents, this is also true of the other design-based GBCSs though UK's BREEAM sets specific energy-efficiency goals to attain the higher grades, preventing the dilution effect from the "easy" indictors. All the design-based GBCSs award a high proportion of the "energy use" marks to an overall "energy efficiency" indicator. BEAM Plus is the least demanding: whilst the full 15 marks are awarded if energy efficiency exceeds building codes by 20 percent (residential) or 45 percent (office), BREEAM requires "zero carbon", and LEED a 50 percent exceedance of code. Comparing the underlying codes themselves is a major project in its own right and we recommend Government undertake this work. As previously stated, WWF believes OTTV to be lax.

The current GFA concession is very generous. Based on the Rating and Valuation Department's statistics about the price of new residential and office space by grade and region this report estimates that the extra space received by developers having submitted the 481 proposals granted the GFA concession since 2011 is worth $42 billion. The true figure is difficult to estimate because the Building Department's website reports only the name of the developments that have been awarded the concession but no further information to aid investigators. Yet, the Buildings Department seemingly makes little effort to enforce the requirement that developers *undertake a BEAM Plus* assessment as a prerequisite for having been granted the GFA concession. We see this requirement as wholly inadequate. In other countries developers are required to attain minimum levels of performance to obtain any incentive.

WWF believes there is great scope to improve energy efficiency regulations and the design of BEAM Plus to enhance new building's energy efficiency.

Making Hong Kong's Buildings Smart

Introduction

Imagine the skyline of a sustainable Hong Kong in 2050 – perhaps you see offices and housing blocks with a skin of translucent solar panels which generate electricity and provide shade for the people inside. In the building's basement, autonomous vehicles ferry recyclable waste away while the MTR conveys people in and out. Sensors and controls open and close windows, vary the levels of ventilation, light and cooling depending on internal and external conditions. Sounds like science fiction? Look out of the window at the cranes outside, the buildings being built now will make-up the skyline of 2050; our future city is being constructed as we speak.

The imagined skyline will not arise by itself. Market forces alone are insufficient to propel imaginings into hard concrete. Cities are built out of paper: development documents, zoning rules, building codes. Green Building Certification Schemes (GBCSs), like Hong Kong's BEAM Plus[3], should be the codification of our aspirations. They bear a heavy responsibility: providing developers a marketing tool, tenants an indicator of excellence, and governments a marker with which to associate green incentives. GBCSs have to make visible, to the market, characteristics of the building that are not easily seen. This involves setting measurable performance standards, developing a system of verification, then marketing the scheme to professionals and clients.

Energy efficiency policy is not generating change at the rate needed. We would argue buildings energy efficiency is not changing. Energy use by Hong Kong offices[ii] rose from 2,700 TJ in 1985, to 13,900 TJ in 2000, fell during the 2008-09 financial crises, and was 12,900 TJ in 2015. More ominously, energy use has risen continuously every

[3] Unless mentioned otherwise, "BEAM Plus" refers to BEAM Plus New Buildings version 1.2

year since 2009 – growing 9.6 per cent in six years, slightly faster than the 8.7 per cent growth in office space[iii]. Taking a long term perspective, over the 30 years between 1985 and 2015 offices became 40 per cent less energy efficient in terms of energy use per unit floor area. An even longer term survey of public sector office buildings, found a 58 per cent increase in the heat that the buildings walls and ceilings leaked, from 21.6 W/m^2 to 34.2 W/m^2, from the 1950s to the 1990s[iv].

Government understands the present incentive for constructing green buildings is not working. In a document[v] released at the time of her first policy address, Chief Executive Carrie Lam announced a consultancy study "…to review the current arrangement under which a developed project is only required to register for BEAM Plus as a pre-requisite for application for a gross floor area…", repeating a similar promise made by the previous Chief Executive.

Ironically, two months after the policy address, the Chief Executive had the opportunity to see a genuinely energy efficient structure when she officiated at the opening of the revamped Murray Hotel. Originally built in 1969, the Murray, like other green buildings, had small, recessed windows, large thermal mass to trap night-time cool and cross-ventilation to let in the breeze. Before air conditioning became ubiquitous in Hong Kong, buildings incorporated energy efficiency as an integral part of their envelope's design, not a post construction bolt-on. Today green buildings are sealed boxes of glass with high performing AC systems and building automation to moderate tenants' thirst for electricity. Have we taken a wrong turn?

This report poses three questions:

1. What do we mean by *green* buildings?
2. Which characteristics of a building's design best anticipate its future energy performance?
3. What can Hong Kong's BEAM Plus learn from other systems?

WWF Research approach

The report compares Hong Kong's BEAM Plus with seven other GBCSs, selected because they are commonly used in subtropical countries. Our methodology was to read the different schemes' guidance documents, annual reports and commentary written by academics and professional bodies; and we interviewed architects and engineers based in Hong Kong who have had experience applying the different schemes.

We corresponded and met with government (EMSD and Buildings Department) and the two Hong Kong bodies responsible for managing BEAM Plus: BEAM Society Limited (BSL) and Hong Kong Green Building Council (HKGBC).

In February, WWF organised a workshop (the "Panel") with property developers or clients, building materials suppliers and professional architects and engineers who use BEAM Plus and other GBCSs day to day. During the course of the meeting we polled them on a number of GBCS design issues. The purpose of the exercise was to generate ideas and assess their strength of opinion on how new building's energy efficiency might be improved. We were more interested in the spread of views than in consensus, though where views were unanimous we made note. Many members of the Panel did not agree with each other, and doubtless won't agree with this report either. We are grateful to the assistance of around [50] people that have shared studies and data (sometimes unpublished) with the project team. The reports' conclusions are ours alone.

GREEN BUILDING CERTIFICATION SCHEMES – BRIEF HISTORY AND OVERVIEW

The growing use of GBCSs reflects the desire of developers and government to help customers identify and recognise buildings that embody good environmental design and go beyond mandatory minimum standards. Government often provides some form of incentives for n buildings, or may require its own buildings to achieve above statutory minimum standards of performance.

The focus of this report is on new buildings, which account for the bulk of BEAM Plus assessments in Hong Kong, but that is not to say existing buildings are less important. GBCSs have, to varying degrees, sought to extend their brands creating certification systems for existing buildings, building fit-outs and buildings' impacts on their neighbourhoods. GBCSs have also tried to internationalise their franchises: LEED and BREEAM have been particularly successful in this endeavour.

The different parties engaged in developing GBCSs have different capacities to engage in the discussion, and different objectives for the schemes. Developers are interested in using GBCSs to promote their products and differentiate their buildings from their competitors'. Building design professionals are major players in the process. They dominate the committees defining GBCS standards, conferring the awards, and earn fee income from consultancy services designing and shepherding green building through the assessment. Producers of green electrical equipment and construction materials can see a boost in sales if their product appears on an approved supplier list. Most consumers have little awareness of green buildings, the exception being larger, international companies with CSR reporting requirements that oblige them to rent green buildings, and report their carbon emissions.

Government is often conflicted: environment ministries want to see buildings make their contribution to carbon reduction targets, other parts of government are keen to see the property sector prosper and are cautious about unhelpful green bureaucracy. With this lineage GBCSs are tugged from many directions.

This report reviews GBCSs from Hong Kong (BEAM Plus), USA (LEED and ENERGY STAR), UK (BREEAM), Singapore (Green Mark), China (Green Building Label) and Australia (Green Star and NABERS). Many more GBCSs are listed as members of the World Green Building Council. Usually GBCSs are created by industry led organisations, some by government (Green Building Label and NABERS). We have deliberately chosen Australia and USA because they each have two popular schemes one led by government and the other by the private sector.

The UK's Building Research Establishment and USA's Green Building Council pioneered GBCS in the 1990s creating BREEAM and LEED respectively. Most other GBCS have followed the lead of BREEAM and LEED and adopt a holistic, definition of *green buildings*. To obtain certification projects have to earn credits across 50 to 70 indicators organised in 5 to 10 environmental themes: Indoor environment, Energy, Water use, Site characteristics to name a few.

A quite different approach to GBCS is adopted by ENERGY STAR and NABERS. These were established by public sector authorities seeking to create a simple and accessible benchmarking tool to judge a building's energy use compared to its peers.

Table 1 provides an overview of the above schemes. A couple of points about BEAM Plus are worth making at the outset. Compared to its peers only a small number of buildings have been assessed by BEAM Plus, but the average size of buildings is larger than those in most countries. The fees for registration and assessment are significantly greater than those of other GBCS, even when looking at the figures for large office buildings. As well as the fees paid for registration and certification there are also fees for professional advice needed to evidence the application for certification, and then the costs of implementing the measures themselves.

For GBCSs to have an impact on energy efficiency, they need to be used. Perhaps BEAM Plus greatest weakness compared to other schemes is the low rate of participation. There are over 40,000 buildings in Hong Kong[vi] but only 1061 (2.5 per cent) Hong Kong's buildings had registered for BEAM Plus by February 2018), 566 had undertaken a partial assessment based on the building designs and just 107 (0.2 per cent of buildings) have undertaken the post-completion final assessment [vii]. Some of this drop can be accounted for the time-lag between registration and final assessment, but one building design professional admitted around 30 per cent of his clients register for the incentive but have no intention of undertaking an assessment. One "environmentally progressive" developer confided they undertook a partial assessment as they found the process informative, but did not undertake the final assessment because of the volume of paperwork. Hong Kong's modest number of completed certifications is dwarfed by Singapore's where 3,000 buildings had received certification by 2013 and the current rate of certification is around 300 a year.

The best performer in terms of extent of use, UK's BREEAM, is a genuinely mass participation system with 425,000 certified buildings from a stock of around 20 million UK buildings as a result of the very modest cost of certification. Also planning requirements used to oblige developers to use BREEAM in some local government areas. In the US LEED and ENERGY STAR have 39,000 and 30,000 certified buildings respectively. But just as importantly, 500,000 buildings have used ENERGY STAR'S free tool to benchmark their energy use, but not pursued the certification. Thus, they have used the tool purely out of interest in its results, and not for any external plaudits or recognition. This is a testament of the scheme's usefulness.

BEAM Plus New Build version 1.2

Hong Kong's Building Energy Assessment Model (BEAM) was developed in 1996 and was modelled closely on UK's BREEAM. It was updated to BEAM Plus New Buildings in 2012. It only became popular after government incentivised its use by offering developers a 10 per cent gross floor adjustment[viii]. Its sponsors, Hong Kong Green Building Council (HKGBC) and BEAM Society Limited (BSL), claim the BEAM Plus is uniquely tailored for Hong Kong needs. Its choice of environmental themes and indicators conform closely to LEED's and BREEAM's except they reference local building standards, and certain Hong Kong specific concerns like legionnaire's disease. Fees are paid both at registration stage to HKGBC and at assessment stage to BSL. The BEAM Plus energy use assessment uses Building Energy Code 2015 as its basis of comparison. Energy savings exceed this standard either by enhanced performance of the building envelope (itself regulated by the OTTV/RTTV regulation) or using efficient electrical services (BEC 2015). A new 2.0 version is currently being piloted but HKGBC suggested we use the old version, while the new version is still being reviewed.

TABLE 1: OVERVIEW OF THE EIGHT DIFFERENT GREEN BUILDING CERTIFICATION SCHEMES

Scheme	Country	Year established	Current version	Responsible Agency	Environmental coverage[1]	Certified Area of floor space (m^2)	Projects / buildings registered	Projects / buildings certified	Fees for registration HK$	Fees for certification HK$
BEAM Plus	Hong Kong	1996	2012	BEAM Society Limited / HK Green Building Council	EU, WU, SC, IEQ, MU, In		1,000	97	66,000 - 654,000	154,000 - 3,000,000
Green Mark*	Singapore + others	2005	2015	Building and Construction Authority	EU, WU, SC, IEQ, MU	49 million (2013)	N/A	3,000	Included in certification	91,000 - 214,000
LEED	USA + others	2000	2014	US Green Building Council	LT, SC, WU, EU, MU, IEQ	576 million	92,000	39,000	Included in certification	26,000 - 352,000
ENERGY STAR	USA + others	1995		US Environment Protection Agency	EU		500,000	30,000	0	0
BREEAM	UK + others	1990	2011	Building Research Establishment	EU, WU, SC, IEQ, MU		1,900,000	425,000	2,600	10,100 - 41,300
Green Building Label	China	2006	2015	MOHURD and others	EU, WU, SC, IEQ, MU, In	523 million		4,515		12,069 (design) 60,702 (operation)
Green Star	Australia	2003	2017	Green Building Council of Australia	EU, WU, IEQ, MU, Man, TP, LU, EM	26 million	2,320	1,730		109,675 - 250,685
NABERS*	Australia	1998	2013	Office of Environment and Heritage	EU, WU, WM, IEQ	18 million		2,903 (ever) 1,464	N/A	N/A

Footnote: EU - energy use; WU - water use; IEQ - indoor environment; SC - site; MU - materials; In – Innovation; LT - Location and Transportation, Man - Management, TP - Transport, LU - Land Use and Ecology, EM - Emissions, WM - Waste Management

*Green Mark needs to be recertified after five years. Costs of recertification are typically 25 per cent of the initial assessment costs. NABERS need to be recertified every year. Figure of 1,464 were the number of properties certified in most recent year.

The cost of certification varies widely between different schemes. In each case the extremes of the range are given. Hong Kong buildings are much taller and larger than average buildings elsewhere. To allow a better like-for-like comparison the fees paid to the body sponsoring the scheme for similarly sized buildings are set out in Table 2. The Hong Kong BEAM plus is double the price of the Singapore system (the next most expensive) for small projects, and the differential in costs gets even greater for large construction projects.

TABLE 2: FEES PAID FOR REGISTRATION AND CERTIFICATION TO CERTIFYING BODY IN HK$ (EXCLUDES CONSULTANCY AND COMPLIANCE COSTS)

Construction floor area (m^2)	2,499	10,000	80,000	300,000	600,000
BEAM Plus	223,400	457,200	1,162,700	2,316,400	3,731,300
LEED	26,676	26,676	135,118	negotiated	negotiated
Green Mark	90,258	90,258	125,916	209,899	negotiated
BREEAM	22,458	41,261	41,261	41,261	41,261

BREEAM New Construction 2011

UK's Building Research Establishment Energy Assessment Method (BREEAM) was developed in 1990 and was developed by the eponymous government agency. It has a similar set of environmental themes as BEAM Plus. Over two million properties have been registered for BREEAM reflecting its dominance in the UK market, and importance in other European markets. In UK BREEAM compares energy consumption with Building Regulations Part L standard. Unusually, BREEAM gives specific targets for reducing specifically energy use beyond Part L (indicator EU1) to gain the two highest levels "Excellent" and "Outstanding" so the building designer is obliged to target high levels of energy saving, and not simply amass points on more easily achieved energy related indicators. The assessment is made at both the design and post-construction phase. The international version of BREEAM uses the project's national building codes instead where they are deemed sufficiently stringent.

There have been studies to find out why BREEAM is so popular[ix]. The commonest reason given by developers is that it is a planning requirement. Around a half of local authorities quoted the standard in their planning framework, some insisted on a "Very good" or higher level of attainment. Amongst clients the most common reason for choosing BREEAM certified buildings was for CSR purposes. The 425,000 buildings in UK with BREEAM certification represents 24,000 projects as a developer may build multiple buildings from one certificate.

ENERGY STAR for Existing Buildings

ENERGY STAR is the US Government's energy label conferred on appliances, electronic equipment and, since 1995[4], buildings for their energy efficiency. Unlike most of the GBCS's featured in this report the ENERGY STAR focuses exclusively on *measured* energy use. It is assigned to only the top

[4] https://www.energystar.gov/buildings/about-us/facts-and-stats
https://www.energystar.gov/about/history/major-milestones

quartile of buildings as judged by their normalised *in-use* energy consumption compared to the US Government's Commercial Building Energy Consumption Survey (CBECS). By the end of 2016, 29,700 buildings had been independently certified but nearly 500,000 properties – representing about 50 of the nation's commercial building floor space – had used EPA's free ENERGY STAR Portfolio Manager® tool to measure, track, assess, and report on their energy and water consumption. EPA data suggests certified buildings use 35 per cent less energy than average; studies find that ENERGY STAR certified buildings receive a premium of up to 16 per cent in sales prices and rental rates[1].

The normalisation procedure uses actual energy use by the building, correcting for size, location, number of occupants, number of PCs, etc., the score's algorithm estimates how much energy the building would use if it were the best performing, the worst performing, and every level in between. It then compares the actual energy data you entered to the estimate to determine where your building ranks relative to its peers.

GREEN MARK NON-RESIDENTIAL BUILDINGS 2015

The Singapore government's Building and Construction Authority (BCA), rather than the industry's Green Building Council established the standard. The fees for Green Mark range from HKD 91,000 to HKD 214,000, depending on size. Like in Hong Kong, the government offers a GFA concession to buildings using Green Mark but the concession is linked to attainment rather than registration, specifically 1 per cent for Green Mark GoldPlus and up to 2 per cent for Green Mark Platinum, subject to a cap of 2,500m^2 for GoldPlus and 5,000m^2 for Platinum[x]. The Green Mark only lasts for five years and buildings are obliged to submit operational data every five years to ensure the operational performance is in line with the designed performance.

Green Mark has already been widely adopted by the industry because of the GFA concession (modest compared to Hong Kong's) is applied in a more intelligent manner: developers have to post a bond, worth half the value of the land concession which is redeemed only when the building is built, certified and performs as the proposal set out. Also grants are available to help finance innovative new energy saving technologies[xi]. In an interesting regression analysis of transaction prices of properties with and without the Green Mark, one analyst found average prices of certified residential buildings rose by 2.7 per cent[xii]. The BCA is active in promoting in publicly awarding green building excellence and in 2017 issued 350 Green Mark awards.

GREEN BUILDING EVALUATION STANDARD 2015

The China "Green Building Evaluation Standard" label (henceforth called Green Building Label) is the newest label surveyed and was established on a voluntary basis in 2006 and then became mandatory in large scale cities such as Shenzhen, Guangzhou, Shanghai and Beijing in 2012. It is created at the national level by MoHURD (Ministry of housing) and implemented by local government. Only 1092 buildings had received certification by 2014[xiii]. There are separate design and operation stages undertaken when the design is submitted, and a year after the building is completed and put into service. It has since been updated and the design stage label made mandatory in January 2015[xiv], around 10 per cent of buildings undergo the operation phase at the moment. There is an interview at the design stage, and a field visit at the operational stage. Since MoHURD's five-year plan on green buildings in 2013 there has been much greater emphasis and explicit targets for green buildings to contribute to sustainable development goals. China's MoHURD has committed that 30 per cent of all new construction projects will be achieving the GBLS certification by 2020. A subsidy of 13 US$/m^2 and 7US$/m^2 will be awarded to building that achieving highest and second highest rank certified buildings[xv].

LEED

The LEED green building rating system was first introduced in 2000 for the USA, and it was last updated in 2014 when LEED version 4 was introduced. As of October 2017, LEED has registered more than 92,000 total commercial projects in 162 countries, and more than 39,000 projects have been certified, covering more than 0.6 million m^2 certified[xvi]. The certification fees for LEED can range from HKD26,600-352,000, depending on size of the project. Five countries, outside USA, that regularly use LEED for building certification are Canada (4814 total projects), China (2022 total projects), India (1883 total projects), Brazil (991 total projects), and South Korea (279 total projects)[xvii]. The LEED energy use assessment uses ASHRAE 90.1-2010 as its basis of comparison, which has minimum requirements for building envelope, HVAC, domestic hot water, power, lighting, and other equipment. After the building is registered, the review process begins. Project teams have the option of a combined design and construction review or a split design and construction review. A split review allows project teams to submit some part of the project documentation during the design phase for GBCI to review. This allows project team to know what credits they can anticipate for certification. It is also important to know that projects must recertify every five years and are eligible to recertify as often as every 12 months. LEED certification sometimes provided some minor incentives depending on the local municipality. These range from expediting the local certification process, density and height bonuses and tax breaks and grants.

GREEN STAR

Green Star was launched in 2003. There are currently 1715 Green Star-rated projects, covering 37 per cent of office space in Australia[xviii]. The onetime fee ranges from HKD 110,000 HKD 250,000 depending on the project size. They offer two separate and independent certifications for design and for on-going performance. The design certification, is separate from the performance certification. Due to the maturity of Green Buildings, many federal schemes that promised tax breaks and subsidies have expired five years ago. Common incentives now seem to be relying mostly on the environmental benefits and the marketability of the certification, such as Green Star buildings produce 62 per cent fewer greenhouse gas emissions than average, use 66 per cent less electricity than average, consume 51 per cent less potable water than minimum standards, and recycle 96 per cent of their construction and demolition waste[xix]. There are five pathways to get credits for the energy use assessment that measures greenhouse gas emissions reduction by comparing the proposed building relative to benchmark building. In the pathway that offers the most credits and available to the largest variety of buildings, the benchmark is based on "NCC Section J Verification Method JV3, with specific modifications to the methodology and the reference definitions to suit better the objectives of Green Star."

NABERS

Like ENERGY STAR, NABERS was established by a public authority and is focussed on comparing measured normalised energy use by existing buildings. Energy efficiency standards were centralised in Australia in 2000[xx], the Australian Building Codes Board set minimum energy efficiency standards for building fabric, choice of glazing in 2003. Energy use by buildings, as determined by NABERS has to be disclosed at the point of sale through a new Act in 2010.

WHAT IS AN ENERGY EFFICIENT BUILDING?

GBCSs' scoring criteria encompass a great many virtues, not all of which are concerned with the environment. The following headings are included in some, but not all, schemes:

- **Site aspects**: characteristics of the location like its neighbourhood amenities, level of contamination and also the management of the construction process
- **Material aspects**: materials selection, efficient use of materials, recycling

- **Energy**: annual CO_2 emissions, energy management, building energy efficiency
- **Transport**: proximity to public transport, provisions for cycling and walking
- **Water**: water efficiency
- **Wellbeing/Healthy indoor environment**: hygiene, acoustics, building amenities
- Innovation

The 71 indicators assessed by BEAM Plus currently include: "Access for person with disability", "Cultural heritage", "BEAM professional *(being employed on the project team)*" – the first two very worthy, but unrelated to environmental sustainability. Some of the other indicators offer marks for short term benefits, which are already subject to statutory controls: "Reduced indoor vibration", "Noise during construction", "Water pollution during construction". Several of the indicators are for features that are selling points of the building and the property market already rewards: "Amenity features", "Natural lighting", "Local transport". Altogether 20 of the BEAM Plus's 71 indicators involve meeting existing planning or professional guidelines. This plethora of indicators means there can be inconsistent requirements. A BEAM Plus client who was constructing a building far from the sewage network complained that in order to obtain points for the Water Use criteria, the building was forced to install oversized sewage treatment far larger than necessary, that would greatly increase the building's energy consumption. (That said, there are indicators not-listed under energy use that provide energy benefits such as microclimate around buildings.) Contractors have told us that clients complain the assessment criteria force them to install apparatus that they will not use, and which they sometimes even disable once the assessment is done. They felt the assessment could focus on the sought-after *environmental ends* like saving energy or water, rather than being overly prescriptive about the *means*.

This issue of a profusion of "nice-to-haves" being rewarded is not peculiar to BEAM Plus. GBCSs which are developed by committees of building design professionals, which have a commercial interest in creating demand for their services, are likely to produce similar long lists. The two certification schemes established by government, ENERGY STAR and NABERS, are starkly different in their philosophy and aim for mass participation and keep the number of indicators to an absolute minimum.

How should the number of indicators be reduced? Our Panel generally supported the idea that a "green" building includes environment and non-environment attributes: sustainability is after all about the social and economic spheres as well as the environmental. We undertook an exercise in which we carried out a mock weighting across the BEAM Plus themes (Energy use, Indoor environment, Materials use etc.). The Panel's weightings closely mirrored those in BEAM Plus. In the subsequent discussions, we tried to tease out why all these themes should be included in the GBCS, and also asked whether alternate certification schemes that better targeted social and economic issues. An architect and a client (representing the luxury end of the hospitality industry), said they were advocates of the WELL standard.

TABLE 3: WEIGHTING USED IN BEAM PLUS AND SUGGESTED BY PANEL

	Panel weight	BEAM Plus weight
Energy use: in-use energy efficiency	34	35
Indoor environmental quality: ventilation, lighting, noise, hygiene	19	20
Water use: water efficiency	15	12
Site aspects: nearby amenities, greenspace, nuisance caused during construction	12	25
Materials: sustainable timber, low-carbon construction materials, reuse of construction materials	12	8
Transport: proximity of public transport, bike / walking facilities	8	NA

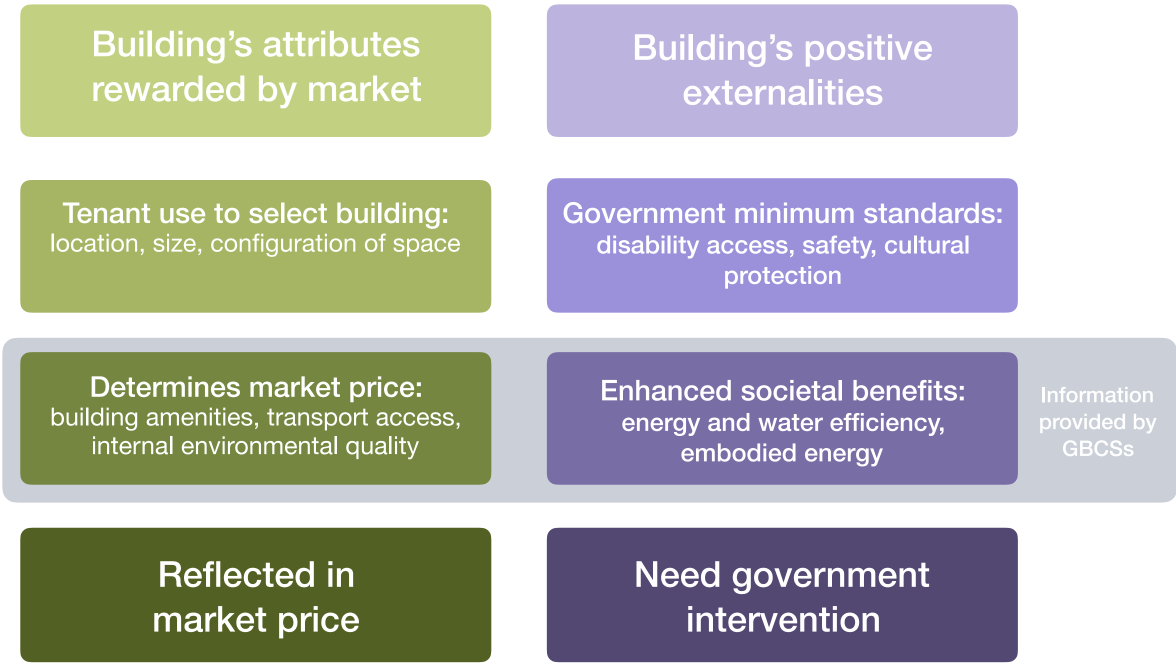
Another Panel member felt issues like employee comfort and cultural heritage, though important, should be assessed separately from environmental sustainability, and not conflated into a single certification system. They argued that if a developer is interested in marketing the comfort or historical authenticity of a building, they are free to find other schemes tailored for this purpose. Another interviewee, a major property developer and operator, said that from their perspective buildings needed firstly to be the right size and location. After this they were interested in their life-cycle energy use, materials use and how well the building fitted in the local landscape. Worker comfort was also extremely important but this could often be addressed at the fit-out stage rather than the design and construction. One of our Panel thought the assessment should include climate resilience. There was also a feeling that emissions arising from the construction and construction material production should be given more weight.

The BEAM Plus *Existing Building 2.0's* certification scheme adopts a menu based approach and the owner of building can be assessed on any or all of the following: Management, Site aspects, Materials and Waste, Energy Use, Water Use and Indoor Environment Quality.

Even if the GBCS sponsors might wish to include a wide number of indicators, government could zoom in on a small subset of indicators it is interested in. The public interest is distinct from the interests of developers that use BEAM Plus to certify characteristics that will attract clients. For determining government incentives, assessment should be based on aspects of the building's performance that are important for society, but which tenants would not be prepared to pay the full price, in other words the building's "positive externalities".

Figure 1 shows our model for deciding which of the many hundreds of characteristics of a building might be encouraged by market forces (rent levels) and public policy (regulation/incentives). The upper two white boxes are mandatory – tenants will choose a building on the basis of its location and size, and the building has to comply with basic regulatory standards. The lower two ringed white boxes are the scope of GBCSs – characteristics of a building where it is helpful to have an agreed set of definitions, scores and verification procedures to make visible to the market and government characteristics that are otherwise hard to observe. Some of these are already rewarded by the market through higher rents. Others provide society-wide benefits – government incentives should be targeted on these characteristics otherwise they will be underprovided.

Figure 1: Building characteristics and Green Building Certification Schemes



So, what are these characteristics government incentives should focus on? The box below states the Building Department's mission – only *excessive building bulk* and *carbon emissions reductions* are separately identified as its public policy priorities.

> ***Buildings Departments Mission***
>
> To set and enforce safety, health and environmental standards for private buildings.
>
> Promoting Green and Sustainable Building Developments Since 2001, we have introduced, jointly with the Planning Department and the Lands Department, incentives for developers to provide green features in new building developments for promoting green and innovative buildings and quality living space. To respond to the global agenda on carbon emission reductions and address local concerns about the negative impact of excessive building bulk on the environment and premised on the recommendations of the Council for Sustainable Development based on its public engagement exercise, we have implemented a policy to foster a quality and sustainable built environment through building design since April 2011.

For Hong Kong we would single out life-cycle carbon emission reduction as the most important attribute government should reward, perhaps supplemented with water efficiency. If the Hong Kong government is to succeed in its goal of reducing greenhouse gas emissions intensity between 2005 and 2030 by 65-70 per cent, buildings have to deliver a big part, which we will discuss in more detail shortly. In its 2015 document on energy saving, government signalled its intention to review the GFA concession saying: "tightening GFA concessions with prerequisites such as project registration for BEAM Plus.[xxi] In the introduction we described the 2017 Policy Address restatement of this intent.

At what stage of the development process should the assessment be made?

Assessments serve two quite distinct purposes: informing the building's design and construction, and triggering the award of an incentive. The point in time decisions are taken that will influence the building's sustainability might not be the best point in the process for government to provide its incentive.

GBCSs differ at the point in the development process the assessment takes place. A design-phase assessment influences the architect and engineers decision-making about lay-out, facades and choice of materials and electrical services. An assessment when the building is complete could further assure satisfactory build quality and commissioning of electrical services. Or the assessment could be made once the building's operational data is available which would additionally be based on results of occupants' behaviour.

The Hong Kong situation shows the dilemma faced by policy makers in designing the "contract" in which government incentives are paid to industry for achieving public goals. In most contracts the public good would have to be delivered before payment of the incentive. In Hong Kong, the GFA concession is given before construction commences. Even if it were linked to performance (which the current APP-151 is not), how can it be clawed back if the building does not perform as it was supposed to?

The greenness of the building is ultimately evidenced in its operations. By the time the building is complete, likely as not, it will have changed hands. Tenants or management companies, not the original developer, will be operating the building. The current GFA concession provides *no incentive at all* for sustainable operation of the building, or co-operative behaviour between the tenants and the building management company. But as countless studies have shown user behaviour is a major factor in overall energy use[xxii].

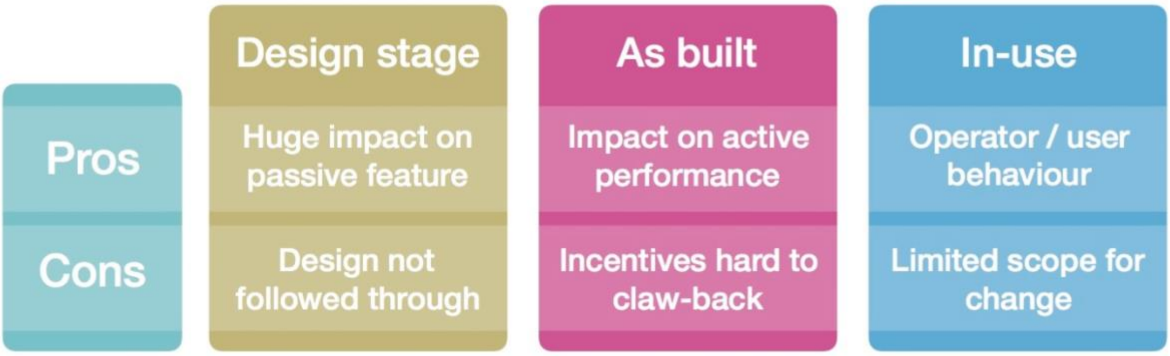
Assessments of existing buildings, in their operational phase, typically use different performance indicators exploiting real-life measurement data, rather than the building simulations of the design projecting future performance.

Our Panel was asked about the merits of the assessment at the different stages. It gave its strongest support for assessment at the design phase; since this was when the main decisions impacting on final building's performance are made. Delaying the first assessment to a later stage would reduce the pressure on the architect and the engineer to introduce energy efficiency into the design. Support for assessment at "completion" was slightly higher than at the "operational" phase. The Panel gave some support for the operational assessment being integrated with existing building schemes like BEAM Plus Existing Buildings. One person felt strongly that assessment of operational energy use was crucial, as it integrates the real-life performance of the design, quality of build and commissioning as well as the operational management. Singapore's Green Mark requires the testing of every five years and buildings have to perform to the standard set out in the design to retain their certificate. Green Building Label similarly requires a year's operational information for the final label to be awarded, though we understand few building developers undertake the Operational stage certification.

Developers told us they wanted to ensure there is a definitive award given when the building is being marketed. One developer declined to meet with us face-to-face saying their company was happy with the situation as it was and did not see any need to change. They were concerned about having to take on responsibility for measurement of tenants' energy use, or the operational performance of the building which they had no control over. Commercially, they admitted, they had no interest in the building's "as-built" performance.

On the other hand, tenants are only interested in the building's actual performance since this reflects their first-hand energy costs. There is also the worry that designs that look impressive on paper do not deliver in real life. No Hong Kong specific data was available on how BEAM Plus buildings perform in real life. Independent assessments have been made in USA and UK showing the gap between real and designed energy performance. One study reviewed 62 buildings and that on average actual buildings were 34 per cent more energy demanding than the modelled buildings[xxiii].

FIGURE 2: STAGES OF THE BUILDING CYCLE IN WHICH ASSESSMENT IS MADE



ENERGY USE IN BUILDINGS

In Hong Kong's plan, Climate Change 2030+, the government set a target to reduce total greenhouse gas emissions (GHG) by 26 to 36 per cent from 2005 to 2030[xxiv]. The current emphasis is to increase the share of gas fired electricity and reduce the share of coal fired generation but there is a limit to the reduction in CO_2 this approach can ultimately achieve. There is no specific commitment to increase energy efficiency, but WWF's recommendation is to achieve an annual 1-2 per cent improvement in energy efficiency so that the remaining demand can be met solely by renewables[xxv]. Progress to date has not been in line with a 1-2 per cent improvement in energy efficiency. Instead, we have only seen a marginal reduction in per capita emissions from 6.0 tonnes in 2005 to 5.7 tonnes in 2015, which is clearly not enough[xxvi].

Figure 3 shows electricity generation accounts for around 70 per cent of greenhouse gas emissions in Hong Kong, and buildings consume 92 per cent of Hong Kong's electricity generation[xxvii]. We calculate air conditioning contributes 22 per cent and lighting 8.4 per cent of the cities GHG emissions. Previous WWF analysis shows Hong Kong's total electricity consumption could rise, with existing energy efficiency policy, from 43.9 TWh to 54.6 TWh between 2014 and 2030. An aggressive energy efficiency policy similar to that enacted in other countries could cut demand to 38.3 TWh[xxviii].

FIGURE 3:SHARE OF HONG KONG'S GREENHOUSE GAS EMISSIONS ARISING FROM BUILDINGS

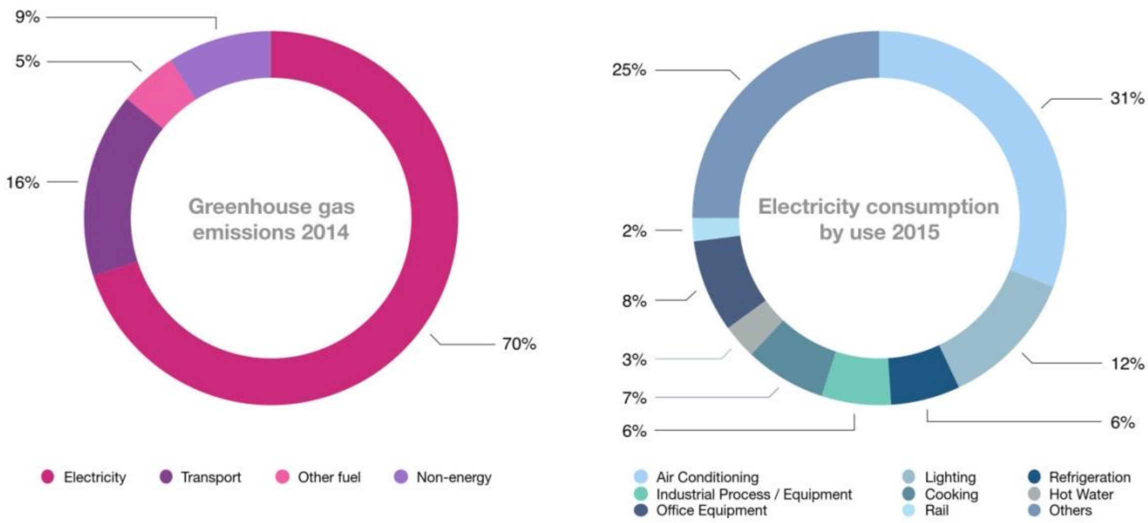
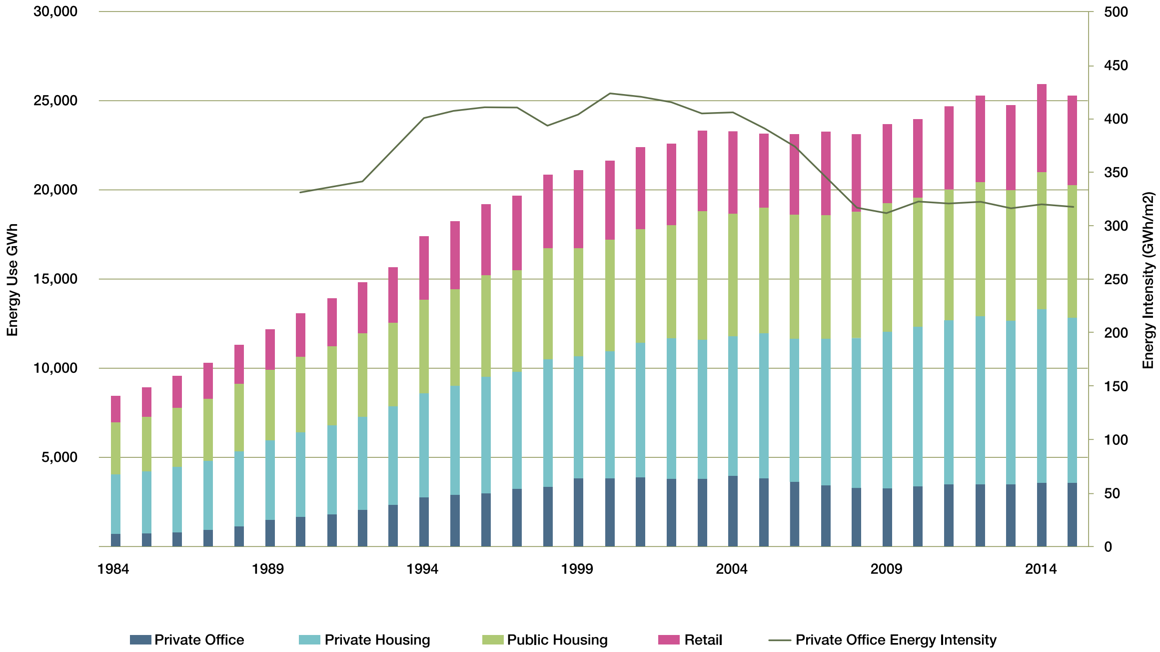


Figure 4 shows how total energy use in private office, retail, private and public housing (the chart excludes energy used in other types of commercial buildings like hotels and restaurants) has changed from 1984 to 2015, along with the energy intensity of private offices (total energy use divided by million square meter of private offices)[xxix] from 1990 to 2015. Building energy use has been on an upward trajectory throughout this time. Energy intensity of the average office space in 2015 was 317 kWh/ m^2/yr. It is noticeable that office energy intensity decreased from 2000 to 2009, but since 2010 (when BEAM Plus's GFA concession was introduced) the energy intensity has changed little. Understandably the proportion of buildings built with GFA concessions after 2010 is small in relation to the total stock of buildings, but Hong Kong has initiated several energy efficiency policies apart from GFA concessions, and the data indicates that recent policy has not led to any reduction in energy use.

FIGURE 4: BUILDING ENERGY USE AND OFFICE ENERGY INTENSITY



Other countries have implemented policies to dramatically reduce their energy use. An example of an ambitious and major step forward was Tokyo's cap and trade program launched in 2010 (notably, it predated 2011 Fukushima crisis). The goal for the first phase of the project, between 2010 and 2014, was an 8 per cent reduction in energy use. In the second phase, between 2015 and 2019, Tokyo's large commercial buildings must achieve 17 per cent reduction. By December 2014, the scheme had successfully reduced emissions by 23 per cent. By 2015, 90 per cent of buildings had met their first phase target, and 69 per cent of buildings had already met their second phase target. This is a huge achievement and a major factor for this reduction was improved energy efficiency[xxx].

New York City, like Hong Kong and Tokyo, has numerous large buildings, which account for 73 per cent of carbon emissions. New York City has committed to reducing its greenhouse gas emissions by 80 per cent between 2005 and 2050. One of the many initiatives being taken is the NYC Carbon Challenge. This is a ten-year roadmap to improve the city's building energy efficiency and reduce total greenhouse gas emissions by 30 per cent by 2025. The plan includes partnering with more than 100 private companies that account for about 9 per cent of the citywide building floor area. Public buildings pledge to lead by example and have a target of 35 per cent reduction by 2025. This plan works by high level commitment by both the private and the public buildings to raise awareness within their communities and take systematic steps to reduce their emissions. For example, Google set an internal target of 50 per cent by 2025. It achieved its 30 per cent target by replacing old steam chillers to new electric chillers, replacing windows to upgrade the building envelope, installing new lighting control systems to maximize efficiency, and retrofitting all office space for LEED silver certification or above. Ten other companies have already achieved their 2025 target and have set themselves more ambitious targets[xxxi].

These examples show that government needs to lead not just by example as Hong Kong government does already, but by either calling on or obliging major energy users, and developers to invest in and implement proven energy saving strategies.

PHYSICS BEHIND KEEPING BUILDING'S COOL

Reducing the energy use by buildings is not rocket science, but it is science, meaning there is a well understood body of theory behind designing buildings to minimise heat entry from the outside and the generation of heat inside. This section was included because during the course of our interviews we heard conflicting views about which measures are relevant to Hong Kong.

HOW BUILDINGS HEAT UP

Outside heat is transferred into buildings either through conduction (heat transfer through the solid walls and windows), convection (warm air draughts) and irradiance from the sun.

HEATING THROUGH IRRADIANCE

In Hong Kong, heat gain from irradiance is the most important source. Horizontal open space in Hong Kong is exposed to around 1300 kWh/m^2/yr of energy as solar radiation. Sunlight is stronger in summer than winter with the flow around 70 per cent higher in July than in February[xxxii]. Because of the way the sun is angled, vertical faces of the building are exposed to less sunlight, between 470 kWh/m^2/yr (north face) and 682 kWh/m^2/yr (west face).

Glazing varies in the proportion of the sun's heat it lets through. When sunlight strikes a transparent window, some of the radiation is transmitted through the glass to the insides heating the room; some is absorbed by the glass warming the glass's molecules, which in turn transmits heat inside and out; and some of the light is reflected back to the outside, particularly if the glazing has a reflective coating. The proportion of the sunlight's energy that penetrates the window and causes internal heating is called its solar heat gain coefficient (SHGC). If the SHGC of a window is 0.5 then it will allow in around 341 kWh/m^2/yr of energy as light through a west facing window.

HEATING THROUGH CONDUCTION

If the outside air and soil is warmer than the desired internal temperature then heat will flow through the buildings' envelope. The rate of flow depends on the thickness of the window/wall, its area and the temperature differential between the inside and outside. The tendency for a material to allow heat to be conducted through is called its U value. Glass is a poor insulator and has a U value of 5W/m^2/°C. A well-insulated roof with 10 cm of insulation can have a U value of as little as 0.2 W/m^2/°C. If on average the temperature difference between inside and outside is 2.9°C (the absolute average monthly difference for Hong Kong) a standard square-meter of clear single glazing will allow in 125 kWh/m^2/yr of heat every year, and the well-insulated roof just 6.5 kWh/m^2/yr if the desired internal temperature is 23°C.

This above results suggests that a single pane glazed window will allow in a quarter of heat through conduction, and three quarters through irradiance. If the desired internal temperature of the room is 25.5°C, as the government recommends, rather than 23°C then conduction is much less important.

INTERNALLY GENERATED HEAT

Appliances like air conditioners, fans, computers and lighting all consume electricity which ends up warming the internal environment. About a quarter of electricity is used by chillers or external units of air conditioners which are not situated in the main buildings and therefore do not heat up the inside of the building. A typical Hong Kong household uses: 1,614 kWh/person/yr of electricity at home. Energy use by workers in commercial buildings is on average 7,280 kWh/worker/yr. If each office worker is assumed to have 5m^2 of floor space than this suggests equipment accounts for 1,500 kWh/m^2/yr. Incidentally, human beings also produce heat from their metabolism, some 750 kWh/person/yr.

Operation of Air conditioners

Air conditioners use electricity to compress a refrigerant to expel heat from the inside of the building to the outside. The efficiency with which air conditioners convert electricity into "cool" is determined by their coefficients of performance (COP). This usually varies between 3 and 5 depending on the difference between the inside and outside temperature and whether water or air is used as the medium for accepting the rejected heat. The warmer the outside the harder the air conditioner has to work and the COP drops.

How to reduce heat entry?

Buildings' envelopes can be designed to greatly reduce the entry of heat. The most effective option is replacing transparent glass with an opaque wall to reduce transmission. This is referred to as reducing the window-to-wall ratio (WWR). New floor-to-ceiling glass office buildings have WWR of 60 per cent, residential buildings is typically lower. Shading that overhangs the south facing windows, and vertical fins that shade the east and west windows can also make a significant difference. Buildings like ZCB or Murray House use all these extensively. A less effective option is to use internal blinds which occupants operate themselves. Internal shades are more effective at preventing glare, than screening heat since the heat has already entered the building and some of it is trapped inside.

Changing the glazing material can greatly reduce heat entry. A standard pane of glass of 5.7 mm thickness glass has a specific heat gain coefficient (SHGC) is 0.777 (i.e. it lets in 77.7 per cent of the sunlight's energy). Tinted glass's SHGC is 0.524, that of a reflective surface, like a metal coating, is 0.348, and a laminate of glass and PV panels is 0.280[xxxiii]. The use of reflective surfaces is now restricted by building regulations to avoid nuisance to neighbours and road users. The other option is to use double glazed windows with low-e glass on one of the panes and tinted/reflective glass on the other pane. This can reduce the SHGC to as little as 0.12 – a massive reduction in heating compared to standard clear glass. Buildings can massively reduce the amount of cooling they need in summer by reducing the proportion of glazed surface, and failing this to use high performing windows.

Conduction and convection can be a source of heat gain when there is a difference between the desired internal temperature and the external air temperature. When the outside air is hot (or cold) this heat (or cool) is transferred through poor insulators like single pane glass. Leaky building envelopes or open doors allow cold internal air to escape outside, losing the energy used to cool the air.

Beliefs and myths about energy saving

During the course of this study many building professionals repeatedly gave reasons why building envelope efficiency was less important in Hong Kong than in Europe or North America. Senior professionals who trained or operated only locally were surprised at our focus on the thermal envelope regulation OTTV. However, building professionals trained in other countries who we interviewed, felt differently. The three claims we heard most often were:

1. Hong Kong's buildings are large, so most of the heat load is internally generated, rather than heat flowing from the outside;
2. Hong Kong has a mild climate and so insulation doesn't help much;

3. If windows are made smaller, or darker the extra energy needed to provide artificial lighting will counteract the energy saving from less air conditioning; and
4. Occupants in Hong Kong like large windows and the panoramic views.

Myth 1: Heat Entry through the Building Envelope doesn't matter for large structures

Buildings vary in the proportion of how the heat load is generated internally (from internal electricity and gas use), and how much flows from the environment. We calculated how these may vary for different size buildings. Table 1 shows that in large buildings constructed to today's OTTV standards, around 40 per cent of the overall heat might be internally generated. In a small townhouse with a large surface area and just three people living inside only around 10-15 per cent of the heat load is internally generated, the rest is gained from outside. A couple of points are worth making. The figures below are averages over the year. In the summer a far greater proportion of the heat load is gained through the envelope. Secondly, we used the current regulated OTTVs to calculate flows through the envelope. Older buildings might be built to less stringent or no standards and allow a greater share of heat gain through their envelope.

Table 4: Internal and external heat gain in different sized Hong Kong buildings

Building type	Dimensions	Surface area m2	Heat through envelope kWh/yr	Internally generated kWh/yr	Total heat gain	External heat%
Townhouse	20m x 5m x 5m	350	19,929	3,632	23,561	85
20 storey office	40m x 10 x 50m	5400	838,858	1,996,005	2,834,863	30
	Office: 30m x 20m x 60m	7500	1,226,400	2,425,973	3,652,373	34
Complex building	Mall: 120m x 80m x 14m	5600	2,289,280	2,360,820	4,650,100	49
	Hotel: 40m x 15m x 80m	8800	1,888,656	2,596,902	4,485,558	42
	Overall	21900	5,404,336	7,383,695	12,788,031	42

* Assumes that 25 of energy used is directly emitted to the external environment and does not contribute to heat gain and that office is used for 14 hrs a day, and the town house is air conditioned for 7 months a year

The above results suggest there is significant scope for reducing the overall cooling load (30 - 42 per cent for larger buildings) by more stringent envelope standards. It is worth just making the obvious point that even if a building's principal source of heat gain is internal energy use, it still makes sense to reduce the amount of heat gain through the building envelope from outside. Why pour oil onto an already burning fire?

High envelope standards are found in other jurisdictions. China specifies maximum window-to-wall ratios and minimum U-values for roofs. Singapore specifies minimum U values for roofing material. Similar rules are found in Europe and North America in the building codes rather than the GBCS.

Myth 2: Mild climate means insulation is unnecessary

The amount of heat that enters through conduction and convection depends on the difference in the inside and outside temperatures. The table below shows the average *daytime* temperatures in south UK and Hong Kong.

TABLE 5: OBSERVED LONG TERM OUTSIDE TEMPERATURE AND HEATING/COOLING NEEDS IN UK AND HONG KONG*

	Mean daytime temp °C		Cooling / Heating need °C	
	Hong Kong	UK	Hong Kong	UK
January	18.6	7.5	0	10
February	18.9	7.7	0	9.9
March	21.4	10.5	0	7.4
April	25	13.2	0	5
May	28.4	16.7	1.7	1.7
June	30.2	19.6	3.6	0
July	31.4	22	4.6	0
August	31.1	21.8	4.4	0
September	30.1	18.9	3.4	0
October	27.8	14.8	1.2	3.1
November	24.1	10.7	0	6.9
December	20.2	7.9	0	9.6
Average	25.6	14.3	1.6	4.5

* Daytime temperature was calculated by taking a weighted average of the Min/Max series for UK from the UK Meteorological Office. Long term averages for both 1981-2010 Hong Kong and UK. The desired minimum temperature is assumed to be 16°C in UK and the maximum 25.5°C in Hong Kong

The table indicates the average difference between internal and external temperatures in UK is 4.5°C on average. For Hong Kong the OTTV guidance provides assumptions about the temperature difference between the insides and outside walls. As summers become warmer through climate change cooling need will rise further. For a medium density walls this varies from 2.7°C (North face) to 5.0°C (South face)[xxxiv], another paper puts it much lower at 1.8°C for the six-month cooling period[xxxv]. These findings indicate the *air conditioning-need* figure for Hong Kong is lower, perhaps half, the heating need for the UK. An expert in the German Passivhaus standard told us that the movement's research indicated that because temperatures were less extreme in Hong Kong insulation should be around half the level for continental Europe.

The current trend to making structures with low levels of insulation and light mass is a break with the past, and does not take advantage of the properties of building materials to moderate swings in daytime temperatures and prevent the entry of external heat. Previous generations, when designing prestigious buildings and temples built with thick walls to ensure the insides were cool. They acted wisely. Techniques that reduce heat gain through conduction, like lowering window-to-wall ratio and adding double glazing with low-E glass, also reduce heat gain through irradiance providing a double benefit.

MYTH 3: IF WINDOWS ARE MADE SMALLER, OR DARKER THE EXTRA ENERGY NEEDED TO PROVIDE ARTIFICIAL LIGHTING WILL COUNTERACT THE ENERGY SAVING FROM LESS AIR CONDITIONING

Official documents support natural lighting: guidance on RTTV says: “efforts should be made to provide as much natural lighting into the building as possible”. BEAM Plus credits day-lighting under two different headings. The Australian GBCS Green Star recommends 2.5 per cent of illumination be provided by daylight.

But there is an energy penalty from large windows because they allow sunlight to enter. In the RTTV guidance note, there is a useful formula developed by regression analysis of building energy model to calculate how the building envelopes RTTV changes as we change key parameters[xxxvi]. We investigated the impact of changing the window-to-wall ratio from 0.6 to 0.5 (i.e. a 17 per cent drop in the proportion of glazed area) with all other parameters held at the same level. The result was that the RTTV dropped from 14.5 W/m^2 to 12.2 W/m^2. For a building the same size as the Swire building described earlier, this would result in a 5 per cent reduction in electricity use by the chiller and air-handling units. Several professionals told us a lower window-to-wall ratio was the most effective design change to reduce energy needs. One New Zealand architect writes: "Modern architecture should be innovative in a way to mitigate the growing climate change challenge and not compound it."[xxxvii] His paper goes on to argue that to achieve a 2.5 daylight factor in New Zealand in a room of depth 7 meters would need the window aperture to be 80 per cent of the wall. This is a huge price to pay for a small amount of light.

We were interested in evidence on how much daylight can help replace artificial lighting and reduce electricity consumption. We looked at two articles on this topic[xxxviii] written by a proponent of day-lighting. These argue that if lights 6 m from the window dimmed automatically (the technique known as daylighting) in perfect response to external daylight, it could save 13 per cent of the hypothetical building's power use from lighting and cooling. This finding is based on computer simulations using the US DOE-2 model from 2003 (presumably before the use of modern LED lights). This provides an idealised upper bound estimate from the saving that be achieved from use of daylight in 2003. The paper makes an interesting point that as the window-to-wall ratio increases beyond 20 per cent the saving achieved from daylighting falls sharply – i.e. most of the energy saving is achieved from replacing a wall with a small window, savings afterwards tail off. This means that as the glazed area increases beyond 20 per cent the savings in electricity from reduced use of lights start to diminish as the light does not penetrate far into the building, <u>but the gains in heat from the sunlight continue to rise</u>.

Savings from large windows substituting for artificial light are also being eroded by technological improvement - highly efficient bulbs, motion sensors, and task lighting – reduce the benefit from natural light because the building is being lit less, but more productively. EMSD recommend lighting levels of 300 lux for computer work and 500 lux for paper work[xxxix]. In the pamphlet, they calculate in an office with low density of desks task lighting can reduce the lighting load to 10.4W/m^2 to 11.7W/m^2 reducing energy use by 22 per cent. Technologies like individual switches, motion sensors can reduce energy use further. Energy analytics firms are able use sensors, controls and learning algorithms to tailor lighting to actual need, and not the vagaries of occupant motivation. Tomorrow's smart building should use far less lighting than today's dumb buildings through better design.

Myth 4: Occupants like large windows

Architects like glass. We heard one story about a foreign "brand-name" architect who insisted on a large clear glass atrium on the ground floor. The idea was only over-turned when local staff told him the tenant's valuable paintings would soon be bleached by the fierce Hong Kong sun. We also heard how clients shopping for a new office to relocate to viewing the empty office space wowed by the floor-to-ceiling windows with long panoramic vistas, failing to consider how the space will look when it is occupied and the open vistas is replaced by desks, screens and stacks of paper.

A couple of interviewees off the record admitted that there were strong commercial reasons for perpetuating the idea that large clear glass windows are a good thing. Single pane glass is relatively cheap and quick to build in comparison with materials like brick and concrete. Sheets of glass are brought onsite and are swiftly slotted into place reducing construction and financing costs. One senior architect working for an international firm was disparaging about the lack of imagination of many of his colleagues: “Big glass windows are the go-to option for many architects and their international clients. But a building designed for Hong Kong should not look like a building designing for New York because their climates are so different.”

Do large clear windows even supply uniform and comfortable levels of light that the occupants want? It is worth observing how occupants in offices with large windows behave. The position of the sun in the sky changes over the course of the day and rarely penetrates far into a building. Large windows also cause glare and excessive brightness for people near the window. As a result, workers sitting next to large windows and who control the blinds draw them down. This means the office relies on normal ceiling lights instead. We wonder if floor-to-ceiling windows in reality reduce the use of artificial light at all, they most certainly increase the need to use air conditioning.

There are well known techniques for harvesting sunlight aside from large windows: sun-pipes, sun shelves, skylights – but these are not the same thing as large floor-to-ceiling windows. From an energy saving perspective Hong Kong buildings’ windows are simply too large.

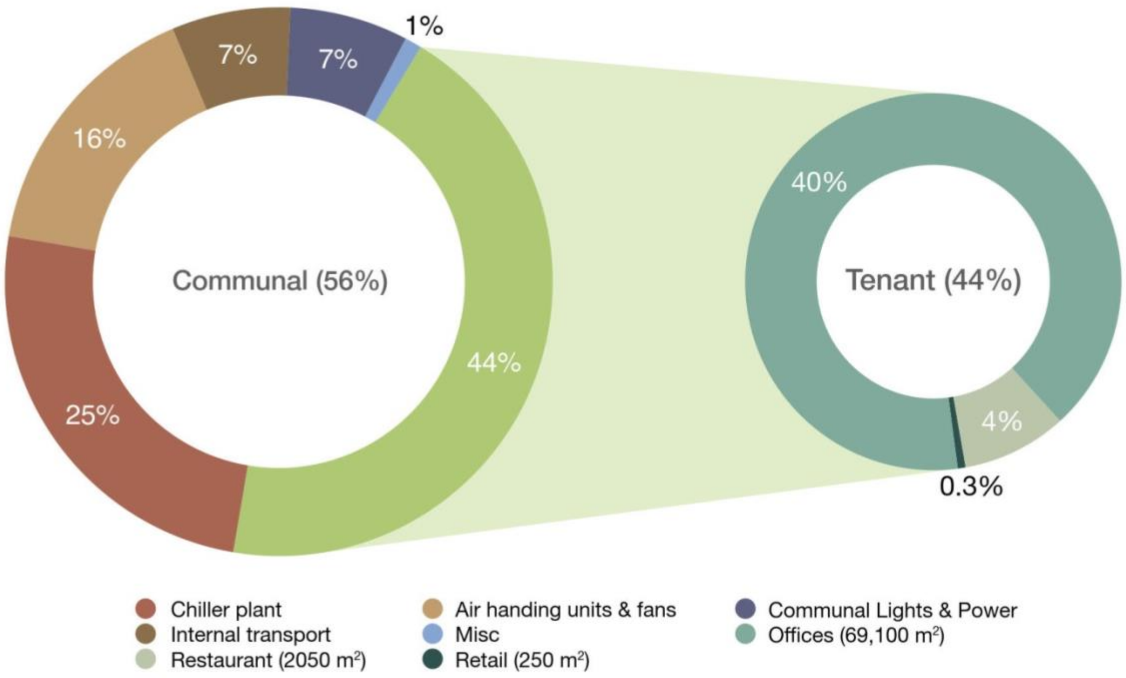
WHERE MIGHT WE SAVE ENERGY?

A multi-storey office building uses electricity for heating, ventilation, AC and lighting, and also a myriad of other appliances scattered through-out the building. Some of these devices are under the operational control of the building manager and others are controlled by the tenants. Electricity is used for other common services like lifts and escalators. Individual tenants use electricity for their computers, audio-visual and kitchen appliances. Who is responsible for what depends on the layout of the building and the details of the tenancy contract.

Understanding where buildings use energy for cooling and lighting is important if the green building labelling scheme is to give a fair weight to the many different enhancements to the design and operations owners could feasibly make. Not much data is publicly available in Hong Kong mapping the detailed energy use within a building *based on real metered data*. Results from one[xl] informative, albeit old, study undertaken for a Swire building are given in Figure 5. The building uses 314 kWh/m^2 floor area/yr electricity or 728 kWh/m^2 external surface area/yr.

The above figure shows just over half (56 per cent) is used for communal services and the balance (44 per cent) for tenant areas. The tenant areas usage includes lighting, electronic equipment and fridges and cooking equipment. The air conditioning system consumed 41 per cent of the buildings total energy needs, and the communal lighting a further 7 per cent. Therefore, building design directly impacted over half of the building’s overall electrical use.

FIGURE 5: DETAILED SUB-METERED DATA ON ENERGY CONSUMPTION IN TENANTED AND SHARED AREAS OF A LARGE HONG KONG BUILDING



The energy analytics firm En-trak[xli] which helps businesses manage their energy use, supplied WWF with buildings level sub-metered data from two of its clients' buildings. This is shown in Table 6 which suggests that Heating, Ventilation and AC consumes around 27 per cent of energy. The main change from the older data set is the spiralling of power consumption by centralised ICT equipment. In Building 1, half of one floor was given over to a data centre and yet this equipment accounted for 30 per cent of the total electricity consumed by the building. Building 2 is a more standard office, but the servers still consume 12 per cent of the electricity usage.

TABLE 6: METERED BUILDING LEVEL ENERGY DATA DISAGGREGATED BY MAIN USES (% OF BUILDING ENERGY USE)

	Building 1 9 storey	Building 2 10 storey
Tenant Areas (Lights & Sockets)	38.2	39.5
HVAC (all - centralized)	27.7	26.9
Servers / Data Centre	30.0	12.0
Essential Power (incl. lifts)	0.6	3.8
Public Areas (lobby carpark signboards storage etc.)	3.5	17.8

Building energy use can be greatly reduced by combining more energy efficient building envelope (as described above) and more efficient electrical equipment – which is being enhanced by tightening of regulations by EMSD. The third approach is through greater use of information technology. Buildings should be using temperature and humidity sensors, and automated and occupant controls in real-time to trigger cooling. Use of daylighting, and detection of people's presence could make substantial reductions in the buildings' lighting needs. Action needs to be also taken on lifts/escalators, fridges, electronic equipment and servers/data centres if the overall demand is to be cut. Computer servers are quickly becoming major energy users, in terms of direct use for the computers, and also the indirect use by their cooling needs. So technologies like replacing desktops with laptops, use of cloud computing where server farms powered by renewables and appliance label need to encouraged.

GOVERNMENT POLICIES TO IMPROVE ENERGY EFFICIENCY

GBCSs do not exist in isolation. The government has a statutory framework that sets floor standards for energy efficiency with all buildings have to adhere to, Figure 6 below shows Hong Kong's statutory framework for improving energy efficiency. Two government departments have responsibility for building energy efficiency: Electrical and Mechanical Services Department (EMSD) which sets standards for the electrical energy efficiency of electrical services and Buildings Department (BD) which handles the building envelope of commercial buildings and hotels on a statutory basis (OTTV), and on a non-statutory basis (RTTV). Buildings Department requires developers to demonstrate adherence to the OTTV standards before they issue an occupational permit (Practice Notes for Authorized Persons APP-67, APP-156) and the data is intended to be available for scrutiny by the public.

The project team reviewed the EMSD and BD websites and approached the departments to discuss any plans to tighten or revise the regulations. EMSD maintains a register of energy use that is searchable by building and can be accessed for free. Around 1500 buildings are on this database, and over 6000 major renovations that fall within the regulation can be viewed. Around seven prosecutions have been made of building owners that have failed to comply with energy audit requirements. Several hundred compliance letters have been sent to encourage adherence to the building energy codes. EMSD shared their international benchmarking exercise with us, and demonstrate their desire for Hong Kong standards of electrical services efficiency to progress at similar rates to other jurisdictions.

Unlike EMSD, BD do not maintain a register of compliance with OTTV/RTTV on their website. We understand from their conversing with BD staff this data is held within the department in paper format. We found no evidence of any prosecutions or enforcement actions for failure to comply with the regulations. Their annual environment report (last published in 2015) and sustainability report (2016)[xlii] makes no mention of any activities relating to adherence to the regulations they are supposed to enforce (except for the 60 energy wardens that remind colleagues to save energy within Buildings Department).

The department does give statistics about the amount of properties that applied and were granted GFA concession. From their website we see that in four years to 2015, 371 out of 909 developments which had received occupational permits had been granted the 10 per cent GFA concession. It seems that most of these developments had simply registered for BEAM Plus with Hong Kong GBC; this is the first stipulation under APP 151, but for the most part there is no information about other stipulations such as completing a final assessment or reporting projected energy use data that developers are meant to supply.

We were very surprised to find that during the course of our interviews many professionals including three "green" architects that design buildings in Hong Kong were unaware of the acronym OTTV or of the regulation, though of course were familiar were the concept of building envelope energy efficiency. We think it unimaginable that building design professionals in other countries would be wholly unaware of the statutory frameworks like Part L (UK), ASHREA 90.2 (USA) that operate in UK and USA respectively. OTTV is scheduled to be tightened this year. We understand a working group of experts was convened to advise BD. We interviewed two members of the working group, and did not get the sense it achieved much or met often. We understand no resources were available to undertake research to compare Hong Kong's building envelope codes with those of other countries. The only analysis undertaken by BD was to assess the extent of over-compliance with the existing code and estimate how much it could be raised. This strikes us as a rather tautological exercise that reinforces the status quo rather than examining what is possible. Off the record several professionals involved in building energy assessment across different jurisdictions told us the Hong Kong OTTV regulation is a "bit of a joke" and is not seen as stringent at all.

FIGURE 6:STATUTORY FRAMEWORK FOR IMPROVING ENERGY EFFICIENCY IN HONG KONG

Appliance energy efficiency standards

- Mandatory energy efficiency label standards (MEELS)
- Includes fridges, room air conditioner, CFL, etc
- Phased updates in 2015-2016

Building electrical services

- Building Energy Efficiency Ordinance (BEEO Cap 610 2010)
- Building Energy Code (BEC)
- Air conditioning, lifts/elevators, light circuits
- BEC updated in 2012, then in 2015, new version expected this year

Building envelope

- Building (Energy Efficiency) Regulation (BEER Cap 123M 1995)
- Office (OTTV) standards [& non-statutory Residential (RTTV)]
- Covers the roof / walls of podium & towers
- RTTV introduced in 2014, OTTV last tightened 2011

The GBCS should position itself as pushing the envelope (no pun intended) and encouraging buildings to perform beyond the minimum standards. In its "*Energy Saving Plan for Hong Kong's Built Environment 2015-2025+*" the administration sets out a time-table for updating these floor levels of performance. In one interview a developer remarked the Energy Saving Plan's timetable is welcome, but what he wanted to see was an articulation of future ambition – regardless if it was a 10 per cent or 20 per cent tightening every revision. Because of the time lag – extending as much as a decade - between conceiving a building and its ultimate occupation, the industry needs early signals. An examinee finds the exam timetable useful for preparing logistics, but to pass the exam she needs the syllabus itself. In the UK, government pre-announced BREEAM's higher levels of attainment would be future statutory minimum performance standards. In USA and Europe several jurisdictions have set out their long-term ambition as being net zero-carbon buildings.

How should a building label scheme recognise energy efficient design?

Baseline energy use

GBCSs have to cater for buildings that vary enormously in their size and complexity. A townhouse in the New Territories with several split air-conditioners is a very different proposition to a building like the International Finance Centre with its complex energy management technologies, mixed uses and enormous size. How should the energy efficiency of the two buildings be assessed and compared on a fair basis?

We asked the Panel their views about how a baseline standard of performance should be defined. One approach is to simply use energy consumption on a per square meter basis. A second option is to focus on the key electrical systems: air-conditioning and lighting. A third might be just focus on the building envelope and compare. The fourth might be to develop a theoretical reference building built to mandatory standards and compare the actual design reference. For the latter three the designed building would refer to building standards as the point of comparison.

As seen in Table 7, the Panel's favoured approach was option 1, judging the building by its energy use per square meter like ENERGY STAR or NABERS using other factors like local climate, hours of operation etc. to normalise. These rely on actual measured data being available i.e. data that is only revealed during the operational phase. The use of building energy models (option four) was the next most favoured and would work during the design phase.

Table 7: Defining the buildings baseline energy performance

On a 1 (low) to 5 (high) scale, how should we measure building energy efficiency?	Average score
No reference - simple measured kWh/m²	3.6
BEAM Plus / LEED / BREEAM – designed buildings improvement over building code	3.1
Elemental - thermal efficiency of envelope / HVAC efficiency	2.9
Reference building's improvement for efficiency of just electrical systems	2.8

To cater for the different complexities of buildings GBCSs allow two routes to demonstrate overall energy efficiency: the prescriptive and performance routes. BEAM Plus, in common with LEED and BREEAM, references the designed building's modelled energy use, with a theoretical reference building built to the envelope energy efficiency and electrical systems' mandatory codes. In the prescriptive route the developer simply needs to show the building is out-performing the mandatory standard on an element by element basis – e.g. whether the chiller's coefficient of performance meets or exceeds the expected standard. In the performance-based approach, points are earned for the design as a whole and demonstrated by a building energy model that simulates the design of the building holistically. To do this the consultant engineers create a computer simulation of a theoretical building to be constructed. In the baseline case the parameters are tweaked so it *just* complies with the building envelope and electrical systems codes. The just-compliant building's annual energy use is calculated. Then the building's true design is used including envelope characteristics (shading, window-to-wall) and active features (actual efficient chillers or lighting circuits) and the annual electricity demand calculated. Such building energy models are needed to demonstrate complex designs that manipulate the numerous variables like the glazing's properties and shading.

Such assessments are expensive and impractical for small structures. The EMSD told us most buildings demonstrate compliance with the mandatory Building Energy Codes (covering the electrical systems) by sending in documents about the efficiency of chillers, layout of lighting circuits etc. Developers find this demonstration of compliance more cost effective and intuitive. EMSD told us, even if the developer is applying for BEAM Plus, they still submit information to EMSD using the prescriptive route to save money and to access the large pool of professionals trained in using the Building Energy Code. Most people wishing to lose weight do not pay for a nutritionist and blood tests, simply eating less does the job. Heuristic approaches often suffice.

WWF Opinion

We think it important that the GBCS does not bias developers to one sort of assessment over another by skewing the marks to favour either route. Some GBCS, BEAM Plus included, make it easier to gain high marks through the performance route, forcing developers to spend scarce resources on demonstrating attainment rather than materially improving performance. We believe that a major reason for the low take-up of the BEAM Plus is the high costs, especially consultancy costs of using the scheme, and energy efficient designs should be able to easily access the prescriptive route avoiding the cost of building energy simulation models.

Pre-requisites for a green building

The Panel were asked which of the possible building energy efficiency measures should not attract credits but be pre-requisites, because they were already common practice and were cost-effective. Results are shown in Table 8.

Two-thirds of the Panel thought that commissioning of ACs/lifts/lights post completion and training and leaving contractors leaving behind documentation to aid the building operators should be pre-requisites. Half believed that installed appliances should be MEELS label 1 or 2, and split air conditioners should be installed so the external units were well spaced.

Table 8: Which of the following should be pre-requisites and not attract credits?

	Yes %
Commissioning/checking AC, lights, lifts perform well	67
Operation of electrical equipment (documentation, train operator staff)	67
Air conditioning units external heat rejection units being spaced well-apart	56
MEELS 1 or 2 or Energy Star fitted appliances	56
Metering of AC's energy use and performance	56
Passive design features. e.g. Window to wall ratio, natural ventilation	44

BEAM Plus has just one pre-requisite (compliance with the building energy code, already a legal requirement) and 13 scoring indicators, more than any other scheme except the Green Building Label scheme. The Chinese system is very different in nature rewarding major elements of building for exceeding their targets separately (like efficiency of chiller, lighting power density) rather than evaluating the building as a whole. It also awards points for passive features like low window-to-wall ratios, windows designed for opening. No other scheme does this.

BEAM Plus awards marks for features which other schemes treat as pre-requisites: e.g. Singapore's Green Mark mandates sub-metering, energy system controls. BEAM Plus also awards credits for inconsequential features that save minor amounts of energy such as minor enhancements to the ventilation systems and lighting in the car-park, and provision of outside clothes drying space (a bad habit it inherited from BREEAM). We understand that the new BEAM Plus v2.0 will reduce the number of energy use indicators some, but not all, of these easy wins. In part this was inevitable because EMSD's tightening of mandatory standards in BEC2015, makes some things compulsory things that BEAM Plus v1.2 offered points for.

WWF OPINION:

BEAM Plus should either discard or make pre-requisite some of the good housekeeping type indicators like retaining manuals (or web-sites) for all the electrical systems, training in their use, sub-metering of key systems and ensuring that external units of split air conditioners are spaced apart as per manufacturers' instructions. We understand that developers already require their contractors to ensure equipment is commissioned, operators are trained and manuals are left behind.

HOW MUCH WEIGHT SHOULD WE GIVE DIFFERENT MEASURES TO REDUCE ENERGY USE?

Most of the GBCSs assess building designs to project how much energy the building will use when it is operational. This will depend on its envelope, the efficiency and successful commissioning of its electrical systems, which appliances and IT equipment the tenant selects, and how well the building is operated by the new owners. Several of these cannot be predicted at the design stage and depend on operators' behaviour, despite the best intentions of the developer.

We were particularly interested in how much recognition panelists thought should be given to passive design features, since these are wholly determined at the building design stage. Panel members and other people we interviewed generally agreed the most cost effective ways of improving a buildings energy performance at the design stage is to reduce the window-to-wall ratio, followed by choosing glazing that reflected or reduced transmission. However, panellists said in practice this option was simply off the table as developers and marketing teams believed this would reduce their rents the building could command.

Panelists also told us developers were also unwilling to pay for more expensive glazing like tinted double glazing with low-E that can reduce the amount of energy transmitted indoors by 75 per cent compared to clear glass. Instead they use simple tinted glass which reduces transmitted energy by around 30 per cent. Shading is added if necessary to comply with the OTTV regulation on building envelope. One architect commented that the price difference between the glass used in Hong Kong and high performing glazing is quite modest so the extra costs of building with energy efficient glazing is in reality quite small. His façade engineer told us the use of fins and shading only reduced energy use by 3 per cent.

Interviewees told us most architects and clients were not interested in designs with less glazing, or paying more than necessary for high performance glass to improve the building envelope. WWF mentioned these approaches were common practice in residential homes, and in government offices where building envelope targets are more stringent. The view seemed to be private sector offices are different and have to be more 'luxurious' than public sector buildings. This attitude is regrettable. It has seeped into the design of the GBCS; the purpose of GBCS is surely to push building design towards sustainability, not to placate commercial interests by downplaying the most effective and low cost solutions.

WWF OPINION

BEAM Plus awards credits for 13 different energy use indicators, more than the other GBCSs surveyed. Table 9 paraphrases several of the indicators and gives both the panel's views about their weights, and also BEAM Plus actual weights. Our view is that several of the indicators in BEAM Plus are either second order, or issues that are not determined at the design stage (choice of energy efficient appliances, training in use of equipment) so should be removed. As mentioned before indicators like metering, adequate spacing of split air conditioners outdoor units, should be made mandatory.

We asked the Panel, Table 9 to separately rank energy use into improving building envelope and improving electrical services even though BEAM Plus consolidates them into one indicator (EU1). The Panel thought passive features almost as important as the efficiency of its electrical systems in determining the buildings energy efficiency. BEAM Plus only explicitly gives one credit for a passive design: *energy efficient orientation*. We understand that the new BEAM Plus offers more; however, it continues to neglect to reward window-to-wall ratio, and enhanced glazing instead rewarding less effective technologies like "green roofs" and "daylight penetration".

TABLE 9: IMPACT OF OVERALL ENERGY USE CAPTURED BY DIFFERENT INDICATORS USED IN BEAM PLUS PANEL'S VIEWS AND BEAM PLUS WEIGHTS

	Panel score %	Beam Plus %
Energy efficiency of electrical services (central chillers, lifts)	22.2	36
Passive design features. e.g. window to wall ratio, natural ventilation	20	5
Embodied energy in building materials	10	2.5
Metering of AC's energy use and performance	9.4	2.5
Commissioning/checking AC, lights, lifts perform well	8.9	10
Operation of electrical equipment (documentation, train operator staff)	8.9	7
Energy efficiency of ventilation and lighting in car-park exceeding standards	6.1	10
Air conditioning units external heat rejection units are spaced well-apart	6.1	2.5
On-site renewables provide 5% of demand	5.6	12
MEELS 1 or 2 or Energy Star fitted appliances	2.8	5

The main difference between the Panel's and BEAM Plus's weights is the greater emphasis they gave to embodied emissions through the materials and the construction method; a Panel member explained emissions from the building materials are equivalent to 40 years building energy use. This member was keen to see more modern methods of construction being adopted, particularly precast / prefabricated elements that are manufactured in a factory setting (gaining efficiencies of material use, waste management, energy consumption, safety and ensuring quality e.g. air tightness). These can be lifted into place and installed rather than constructed on site. These elements could either be modular or 'flat pack' to reduce the amount of 'air' inside room modules being transported. In either case they must adopt a DfMA approach (Design for Manufacturing and Assembly). The experts gave low weights for the use of energy efficient appliance, renewables (because of the modest potential for on-site renewables to contribute to a large office blocks energy needs), and car-park related energy measures.

We were curious how much the designed level of *energy saving* contributed to the overall energy use score ("of energy use marks"). This is hard to compare on a like-for-like basis but in BEAM Plus "Reduction of CO_2" plus "Reduction of Peak demand" contribute 43 per cent of the marks, a reasonably high ratio, but lower than the other schemes except Green Mark and Green Building Label which have a profusion of element-by-element indicators rather than one overview indicator. Green Mark philosophy is interesting; it encourages buildings to be "climate responsive" rewarding low thermal bridging, tropical facades. In Table 10 WWF reviewed the different schemes documentation to understand how the design of the GBCS Energy use indicators evaluated the energy efficiency of a building from the designs. (For this exercise NABERS and GREEN STAR are less relevant since they certify already operating buildings). We are not engineers, nor architects and we only used publicly available documents. An excellent review was undertaken by Arup[xliii] which we recommend. Australia's Green Star documentation is entirely behind paywalls and was excluded from the table. BEAM Plus is a model of transparency and all the technical guidelines are visible for free and easy to locate.

HOW ENERGY EFFICIENT SHOULD A BUILDING BE BEFORE IT CAN BE CALLED GREEN?

Another key question is how the minimum energy efficiency the GBCS demands beyond the mandatory standards. This is not always an easy question to answer. Our best-endeavour answers are shown in Table 10 in columns "Minimum improvement" and "Min to Get Top Grade". In reality, only few of the schemes make such a clear-cut demand on overall the building's energy efficiency, fudging it either by allowing a building to score marks across a range of different energy indicators obscuring its actual overall energy efficiency attainment. BEAM Plus asks a bronze building to attain 40 per cent of its marks from the energy use theme marks and 70 per cent for platinum. But because of the way marks are awarded this does not guarantee any particular level of savings compared to the baseline building – and the developer can fatten up the building's score by installing sub-meters or promising to leave the occupier the equipment's manuals. That said, an analysis by Professor John Ng[xliv] in 2013 of the 12 BEAM platinum *provisional assessments* suggest they were around 25 more energy efficient than the baseline requirement.

LEED demands buildings have to exceed the baseline energy model by 5 to even be accredited. Singapore's Green Mark requires building envelopes to exceed the mandatory standards by at least 10 per cent. ENERGY STAR demands all buildings perform in the top quartile of the average national performance. Unusually, BREEAM requires gold and platinum buildings to be 25 per cent and 40 per cent more energy efficient than the baseline requirement.

Table 10's last column shows how other GBCS treat passive features which recognise aspects of the building's design that reduce the amount of heat entry. As mentioned earlier reducing the window-to-wall ratio is a highly effective passive measure, so too high thermal mass, and shading or tinted glass to reduce sunlight entry. The Green Building Label explicitly sets a maximum window-to-wall ratio, and explicitly rewards energy efficient building envelopes. Green Mark also give explicit recognition of passive energy saving features: the reference building used to compare performance has a window to wall ratio of 0.4, overall U-value for walls and windows of 1.6 $W/m^2/°C$ and maximum air leakage rates, unusually Hong Kong has no standard at all for air-tightness. BREEAM uses a complex composite indicator of energy saving which gives a 41 per cent weight to "reduction in energy consumption" in the energy use indicator.

The linked issue is *by how much do buildings have to exceed the local building codes to get full marks for overall energy performance* which is set out in the column labelled "improvement over baseline needed for full points".

Here the toughest GBCS is BREEAM where full marks are only attained by a zero carbon building. LEED v4 awards full marks for a 50 improvement over code. BEAM Plus is the least demanding requiring residential buildings to exceed baseline by just 20 per cent and offices by just 45 per cent.

Figure 7 is reproduced from a publication shows how the number of marks awarded for energy enhancement above the baseline. Green Star (like BREEAM) only awards full marks for a 100 per cent reduction. It is important that the new BEAM Plus upwardly revise its targets so both residential and office buildings are set much higher targets (we suggest 100 per cent) to gain full marks.

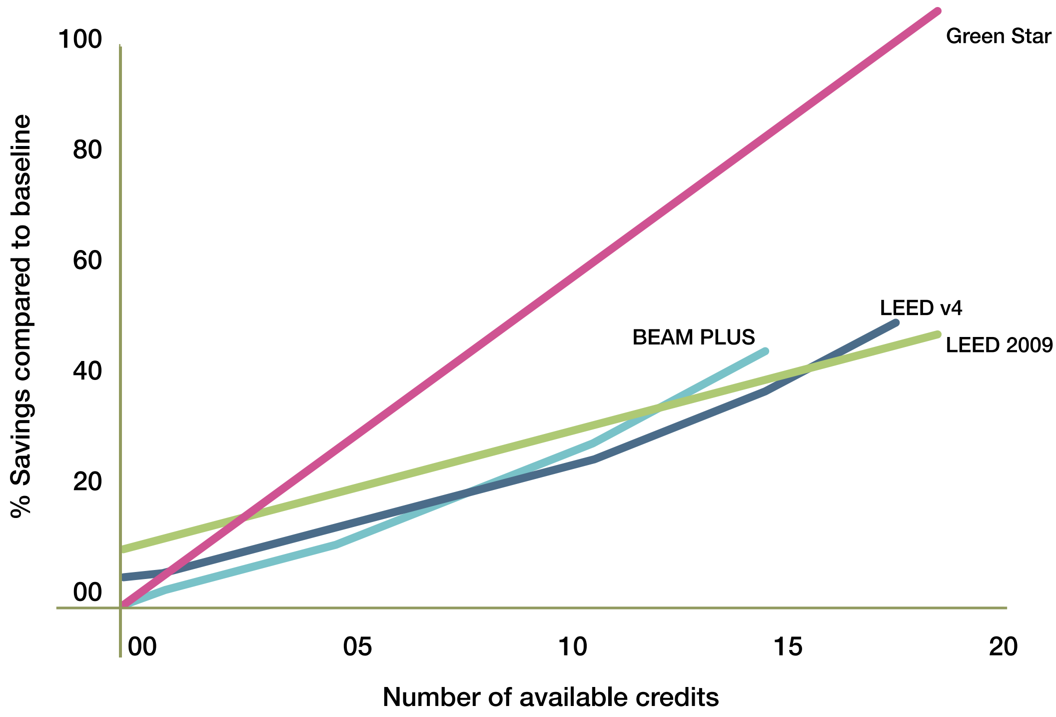
The elephant in the room is the different mandatory requirements vary in their stringency. There is no easy answer to this. A number of the experts who had used BREEAM, BEAM Plus, LEED and Green Building Label said that LEED and BREEAM are the hardest, especially the most recent updates like LEED 4 – described as "impossible" because it is based on the ASHRAE 90.1-2010 baseline. Few of our interviewees had first-hand experience of using Green Building Label. Those that used it had mixed views. Some regarded it as rapidly progressing, but still badly documented making it hard to predict whether the proposed design would be accepted by the scheme's accessors. The Design stage label has been commonly used since 2014, but the Operational label was scarcely being used. This latter group expected it to play a major role in driving forward China's attempts to make its economy more energy efficient.

Table 10: Comparison of the Energy Use assessment by the different GBCSs

Scheme	Energy use	Min. improvement	Min to get top grade	No. of scoring EU indicators	Dominant energy use indicator	Energy efficiency % of energy marks	Basis for defining baseline for typical new build office tower	Means of assessing baseline performance	improvement over baseline needed for full points	% marks for passive & comments
BEAM Plus	35	40	70	13	Energy performance	43	Building Energy Code	Projected	20 (residential) - 45 (commercial	1.7 for building layout
Green Mark	32	45W/m²	38W /m²	8	Building energy & Advanced Green efforts	29	ETTV of 50W/m²	Actual and Projected*	50	7.1 for tropical design
LEED	26	5% exceedance	47-50	6	Energy performance	55	ASHRAE 90.1 (2010)	Projected		
ENERGY STAR	100			1	Energy use intensity	100	Distribution of EUI of buildings in DOE database	Actual		
BREEAM	36	30	85, reduction	9	Weighted average energy/CO_2	42	Building Codes Part L 2.A (2010)	Projected	100	25 of energy use - included in baseline
Green Building Label	24			16	10 marks each: envelope, chiller and renewable			Projected and Actual		Max. window-to-wall ratio 0.7; Openable windows
NABERS	29			1	Energy use intensity	100	Average Australian performer	Actual		

* Singapore's Green Mark provides an Energy Performance Points calculator to project how the elements of the building services (over) comply. The calculator excludes the envelope's performance.

FIGURE 7: INCREMENTAL PERFORMANCE OVER BASELINE



Source: Arup International Sustainability Systems Comparison

OPERATIONAL PERFORMANCE

Our Panel and most experts we spoke to all agreed that how the building is operated is the major determinant of whether design intentions finally materialise. Except for NABERS and ENERGY STAR, all the other GBCSs reviewed focus on the design and construction phase. There are two ways a design and construction label influence operational decisions. The first is to over credits for handing over technical manuals and fitting sub-meters to measure major circuits. The second is to delay the final assessment till sometime into the operational phase to ensure at least the initial tenants and building managers are equipped and trained to use the building as intended.

The different schemes all award points to the design for features intended to influence user behaviour. In BEAM Plus credits are given for sub-metering (1 credit), clothes drying facilities (1 credit, residential buildings only), maintenance staff are supplied with equipment manuals and training (3 credits). Of course, the developer is not in a position to provide assurance that tenants and operational staff will retain or use these features so we think this a second-best solution. Also BEAM Plus's final assessment occurs at end of construction so even the small proportion of buildings that undertake the final assessment do not directly touch operator behaviour. One developer we spoke to, but who declined to have a formal interview, was clear this was the way the company preferred it.

Most of the other GBCSs, even those primarily intended as design and construction labels, are more explicit in tying the award of the final label to actual operational attainment. BREEAM's New Construction methodology is intended to engage with the assessor at the pre-design phase, and extend into the initial occupation period. In China Building Label the final label is only supplied a year after the building is occupied ensuring at least a year's worth of behaviour change, though like BEAM Plus most buildings only have the mandatory design label. Singapore's Green Mark requires the building to be assessed every five years and retro-commissioning performed to ensure the major systems are operating as designed.

Several of the scheme, BEAM Plus included, also sell green building operational certificates. Our Panel believed that such operational labels should be closely aligned with the design and construction label so the building is expected to deliver its design intentions. Only the Green Mark is explicit in such linkages between design and construction, and operations.

WWF OPINION

It is important that operators and tenants have an incentive to use the buildings in the manner intended by the designer. However, the indicators being offered credits under BEAM Plus are unlikely to be effective. The Singapore system of requiring on-going retro-commissioning seems a good model. It is also important that prospective tenants and owners have information at the point of renting / purchasing the property so they know how the building's major electrical systems (centralised air conditioning, common lighting, vertical transport) was supposed to perform, and how it actually performs every year. We think it desirable that such information is available as of right which would necessitate the sub-metering and collation of data for reporting purposes, and also incentivise the operator to maintain, operate, retro-commission and update major energy using apparatus.

INCENTIVES FOR GREEN BUILDING

Most countries offer some form of encouragement to developers to promote the uptake of green buildings. In Hong Kong APP-151 makes the extremely valuable 10 per cent GFA concession conditional on BEAM Plus participation. Examining the Ratings and valuation Department statistics it seems that since 2011 the value of the new residential buildings was HK$620 billion, and office buildings a further HK$220 billion. Even if just half of these were in receipt of a GFA concession of 10 per cent the combined value of the incentive is $42 billion from 2011 to 2017.

There is a second taxation incentive linked to attainment available for buildings that achieve at least a Final bronze rating under BEAM's Existing, New, or Interiors. This incentive permits capital spending to qualify for accelerated depreciation reducing liability to profits tax. Alternate schemes like LEED's international label, which is also commonly used in Hong Kong, do not allow the developer to access these incentives providing HKGBC / BSL a monopoly gateway to valuable incentives. It was this feature that resulted in HKGBC and BSL being converted into public bodies a couple of years ago, though it is unclear in what way this has changed their policies.

Government procurement rules are also an important incentive. The Hong Kong Government announced in the "Energy Saving Plan 2015+" government buildings attain BEAM Plus gold for new large offices (>5000 m^2) and new housing estates. The Housing Authority and Arch SD have championed green building long before the publication of the Energy Saving Plan. In particular, it sets much tougher building envelope standards than OTTV. The OTTV standard is currently 56W/m^2 for the podium and 24W/m^2 for the tower, but since 2000, 80 per cent of the government designed buildings have been built with 18W/m^2 building envelops overall. Also, the Housing Authority designs homes with natural ventilation in mind. Government has long laboured under the belief that where it leads the private sector will follow but our discussions with architects suggest nothing of the sort is happening. The private sector is uninterested and unknowing of what government buildings have accomplished in terms of energy efficiency.

In other countries the incentives are either more modest, or different in nature. Singapore also offers a GFA concession of 1 per cent, capped at an extra 2500m^2, for buildings that attain a GoldPlus in Green Mark, or 2 per cent, capped at an extra 5000m^2, for buildings that attain a Platinum rating[xlv]. Developers have to deposit money equivalent to half the value of the GFA concession with the government to ensure the building meets the intended Green Mark standard. This administrative technique is well worth examining to see if it could be applied here in Hong Kong.

In UK planning rules are devolved to local government. Local planning guidance can go beyond mandatory national standards and takes into account the health of the local property market when determining if any extra planning restrictions should apply. Recent government have reduced the powers of local government to set discretionary extra standards and have tightened national standards. Some local governments apply additional criteria based on BREEAM. For instance, Camden Council in London[xlvi] has issued the following guidance for new homes: "Developments will be expected to achieve 60 per cent of the un-weighted credits in the Energy category of their BREEAM assessment". This highly targeted intervention ensures means that the developer is spared the cost of complying with aspects of the BREEAM assessment which local government has no policy interest in. The develop is of course free to undertake the full BREEAM if there is demand from clients.

In USA states determine if they want to encourage green building. A few cities give minor incentives for green buildings like expediting applications, or reducing building application fees[xlvii]. One example of a city that specifically names LEED is Arlington, VA[xlviii]. The city allows an extra 5 per cent floor area ratio (GFA concession) if the building achieves LEED version 4 silver or higher, and earn ENERGY STAR building certification within four years i.e. the building needs to be amongst the top quartile in terms of measured energy use.

In China province and sub-province governments are mandating Green Building Label certification as a pre-requisite. For instance, Shenzhen requires all private buildings to be "planned, built and operated" for the one-star level of attainment, and public buildings two-stars level of attainment of the Green Building Label[xlix].

WWF Opinion

Hong Kong's system of incentives for green buildings are by far the most generous in the world, and simultaneously the least demanding. This is not a good place to be in terms of public policy. Even more worryingly we believe BD does try and enforce the weak agreements it asks developers to sign under APP 151.

Criticisms of BEAM Plus and Green Building Schemes

GBCSs attract a fair degree of criticism. Because LEED and BREEAM are older and more prevalent they have attracted most hostile views. Many of these criticisms are true to a greater or lesser extent of other GBCSs. The criticisms take many forms but here are three broad headings.

Bureaucracy and excessive paperwork associated with certification

All design based GBCS will require a degree of paperwork to check the characteristics it is planned to have, are built and operate as intended. But excessive or overly conservative reporting requirements are expensive and time consuming to comply with, and do not necessarily result in a better building. At least one developer told us they were put off applying for the BEAM Plus Final Assessment because of the effort and time taken to obtain the documents off the supply chain. At the Final Assessment stage BEAM consultants are required to produce receipts, photographs of FSC labels and detailed diagrams which show the precise locations of the installed fixtures. One interviewee commented "It's as though they don't have confidence in their own assessor's abilities." Everyone we spoke to that had experienced BEAM Plus and other certification systems criticised BEAM Plus for its excessive and overly prescriptive paper work. One person quipped: “the paperwork is needed to justify the high costs of certification”. We understand the piloting of the version 2.0 of BEAM Plus might offer opportunities to streamline the processes.

One developer provided us a cost breakdown of securing a BEAM Plus for an extra-small (<2,499 m^2) structure they were constructing; this included fees and consultancy services. The structure was targeting a Gold rating. The costs of BEAM registration, certification and credit interpretation came to $200k, but the sustainability consultant costs were $2,000k and they estimated it would take 10 months to model and prepare the reports. The consultancy costs is around 25 per cent of the incremental capital expenditure of the project’s green features, some of which the developer deemed impractical, but installed anyway to rack up sufficient credits. The developer in question was obliged to do this as a matter of internal policy. Few other small buildings would be prepared to spend this sort of sum on a green building scheme. Another developer told us they chose not to go target a high BEAM Plus Final rating as they weren’t interested in gaming the system.

LEED was singled out the simplicity and pragmatism of its criterion and documentation requirements. Much of the reporting can be uploaded online.

The Green Building Label unusually requires the design team to attend an interview with the assessors to justify their designs in person. There is also provision for site visits. One of the professionals with experience of the label said the interview added a high degree of subjectivity to the assessment and made the outcome hard to predict, as he couldn’t be confident his design would be approved. In Hong Kong the BEAM Plus is entirely paper based both at the Partial and Final stage and the outcomes fairly predictable.

GBCSs scoring systems can be exploited amassing many points for mere good practice, some points are awarded for changes delivering low energy savings

Most of the professionals we spoke to agreed that BEAM Plus included several easy to achieve indicators which all well run buildings should do as a matter of course. Of the 450 BEAM partial assessments by end 2016, over two-thirds aimed to secure credits for “Metering”, “O&M Manuals”, “Commissioning” which are together worth six points out of thirty-five. “Energy efficient appliances: *MEELS label 1 &2*” & “Drying facilities” are also low hanging fruit which cost very little and might not result in much operational savings. Points were also available for using marginally more energy efficient lighting in car-parks, or marginally more energy efficient ventilation systems (3 points available).

We heard of several examples of schemes like UK’s BREEAM and BEAM Plus encouraging installations of equipment that no-one ever expected to be used e.g. bat boxes where no bats were observed (UK) and oversized bicycle shelters to comply with pre-determined ratios (both)[l] and oversized water treatment plant in a location off the sewage network (BEAM Plus).

Several interviewees said a consequence of the profusion of “easy to gain” indicators, was the system was easy to game so it was easy to obtain a low grade of pass for BEAM Plus, though obtaining a BEAM Plus platinum meant having to engage with harder indicators. But some indicators are largely ignored. In John Ng’s analysis, BEAM platinum buildings only targeted 17 per cent of the available credits for Renewable systems and Life cycle assessment of materials. Overall the average energy use (EU1) of the platinum designs was 33 per cent more efficient than the baseline models in 2013, but had deteriorated slightly to 27 per cent more efficient than the baseline by 2017.

Performance gap between energy modelled energy use and objective reality

Because the *design based* GBCs make use of projected energy efficiency, completed buildings' actual energy use may be different to designed building. This can occur either because the modelling was based on over-simplified or inaccurate assumptions, or the design engineer gamed the software by exploiting known loopholes, or because the equipment or occupiers didn't behave as expected[li] for instance setting the AC temperature lower than guidelines, or adding supplementary lighting, or failing to use the energy controls as envisaged. We were even stories about performance being sabotaged by the occupier, for instance deliberately disabling motion sensors controlling lighting, and ventilation in car parks. Occupier behaviour often causes poor or deteriorating energy efficiency performance. For instance, to save a small amount of money tenants or landlords might fail to regularly service, or recalibrate their air conditioning and other electrical equipment.

Another criticism was that the energy models and the staff operating them have become so divorced from reality they don't understand what they are doing. In one study[lii] researchers found that 108 energy modellers were asked if changes to certain parameters in the building design would cause performance to improve or deteriorate, and then their responses were compared to reality. The modellers' intuition for what effect a change in the variable would have on the real-world performance was worse than a random guess. Modellers seldom visited the buildings they were simulating, nor spoke to anyone onsite – they had little on the ground understanding of what they were doing. In the course of undertaking the research we read research papers based entirely on Building Energy Models (BEMs) outputs to recommend policy change, with no measurement data to verify if models (often developed in the US) apply to local conditions, and with little or no explanation about the simplifying assumptions made by the model.

We well understand the difficulties and inconvenience in accessing real life data with which to calibrate and improve design models and there is an urgent need to remedy this. We hope the new BEAM Plus will create incentives for sharing of data on actual energy use between tenants, buildings managers and the professional community.

Conflicts of interests between sponsors of GBCSs and professions evaluating buildings

The GBCSs are responsible for designing a certification scheme that attract significant levels of implicit subsidy through the incentive programs. Some sub-national tiers of government in UK and USA oblige new buildings to attain a desired level of performance. As we have observed before Hong Kong and Singapore governments offer GFA concessions for using their local GBCSs.

In the Hong Kong context this causes two sorts of conflict of interest. Firstly, a high proportion of the BEAM Plus indicators (some 23 out of 71) require the developers to commission a report (e.g. "Contaminated land survey", "Noise from building equipment") but do not oblige any action to be taken. This greatly increases the spending on consultancy services without any benefit to sustainability. Many of the people on the working groups devising these standards are the building design professionals whose firms will be commissioned to write all these reports. Secondly, several points are awarded under BEAM Plus for using *BEAM professionals* i.e. staff that pay HKGBC certification and CPD attendance fees. BEAM Plus is by no means the only GBCS that uses the scoring system to increase its own income.

End remarks and Recommendations

Last year, on 22 August, The Hong Kong Observatory (HKO) recorded a temperature of 36.6°C across the city, making it the hottest day since records began in 1884. A day later Typhoon Hato struck Hong Kong and Macau with lethal results[liii]. Tropical cyclones will become stronger and more frequent in years to come, especially in western Pacific Ocean, impacting the coastlines of Hong Kong and other Asian nations[liv]. Climate Change is not something we will face 50 years; it is already happening, and it will get worse even after the levels of greenhouse gas in the atmosphere starts to fall.

Our buildings are responsible for around half of our greenhouse gas emissions. The glass box designs, so common these days, in Hong Kong are ill-suited to the city's climate. They use substantial amounts of electricity to keep the internal temperature and humidity at a comfortable level. In the past, buildings minimised the amount of heat they gained from the environment by exploiting characteristics like small windows, shading, natural ventilation and light-coloured walls. Modern architectural practices regrettably ignore such techniques and rely on electrical air conditioning to make the interiors bearable.

We are lucky in Hong Kong to have a pool of skilled building design professionals, well-resourced property developers, and a well-known and respected local GBCS that enjoys the support of the government, and which has deep roots in the professional building design community. We have the necessary policy tools and the administrative and professional apparatus to develop energy efficient buildings. And yet, average building energy efficiency is not improving.

It doesn't have to be like this. On 13 September 2017, three weeks after Typhoon Hato, Cornell Tech opened its new campus in New York City. The site includes *The House at Cornell Tech*, a 26 storey Passive House certified building with 352 student housing units, the biggest building to receive this certification to date[lv]. The building is not just an incremental improvement on other skyscrapers, it is a seismic shift. It shows that zero carbon principles can be modified and applied to large buildings dramatically reducing the amount of energy consumed. The structure has a window-to-wall ratio of 23 per cent, compared to the norm of 60 per cent in Hong Kong; it has triple glazed windows, in Hong Kong tinted single-glazed windows are still the norm, it is designed to be more than 30 times more airtight than traditional buildings, and avoids cold spots on window frames where condensation forms. As a result of this and many other design details it will consume just 120 kWh/m^2/yr, 70 per cent less energy than if it were built to New York local building code; also around 70 per cent less than the average Hong Kong building (317 kWh/ m^2/yr). Of this 120 kWh/m^2, just 32kWh/m^2 is used for heating and cooling compared to 127kWh/m^2 for the Hong Kong building described earlier in this report. If Hong Kong is to rely solely on renewable electricity in the middle of the next century we have to use electricity more efficiently and make more buildings like Cornell Tech.

The current BEAM Plus will not trigger this sort of shift in Hong Kong. Far too many buildings register for BEAM Plus and go no further. And yet they have taken additional floor area incentives worth tens of billions of dollars. The fact that only 10 per cent of BEAM Plus registrations have so far completed a final assessment is a matter of great concern, and contrasts vividly with ENERGY STAR where four times more firms undertake an assessment than register for any award.

BEAM Plus is made by buildings design professionals and developers and serves their interests more than it does the interests of building users or wider society. Our recommendations for improving BEAM Plus are so it can enable the development of the 2050 skyline envisaged at the start of this report. Ultimately we need all buildings to be as energy efficient as *The House at Cornell Tech*. We think the guiding principles for the design of a GBCS should be:

- *most new buildings use it*: it has to be cheap to use, and seen as valuable in its own right, and not something that developers endure because of inducements offered by government;
- *indicators should focus on final outcomes like CO_2 reduction:* too many credits are offered for characteristics that neither society, nor customers care about. At best it reduces the take-up of the GBCS by increasing its costs; at worst it devalues the scheme itself. Every indicator should be there because either because developers see the utility of standardising descriptions of characteristics which their customers find useful, or there is a strong social benefit in buildings having these characteristic; and
- *the bar set for excellence anticipates the buildings we need, and not the buildings we build now*: GBCSs need to set it standards so they have an eye to the future and define the ways buildings need to develop, and don't just reflect current consensus views of what is "realistic" and inoffensive to developers. There is nothing wrong in having aspirational standards that we can't yet attain. They provide a spur for innovation.

GFA Incentive for building and commissioning green buildings

The 10 per cent GFA concession government provides developers is a generous incentive for using BEAM New Buildings. But at present it is given away too cheaply and the weak actions developers agree to undertake are not enforced. In Singapore, a smaller GFA concession (1 and 2 per cent both capped at a maximum level) is tied to tight attainment standards. We need to do the same. Developers are required to pay to deposit money with the government which they can recover if the building achieves the Green Mark standard the developers planned for.

We recommend that the government vary the GFA concession it awards according to the ambition of the design (e.g. 2 per cent for minimum performance improvement – 10 per cent concession for ultra-low carbon, and up to 15 per cent for zero carbon). There needs to be meaningful sanctions (perhaps name-and-shame for a first-time offence, perhaps money retained by the government for repeat offender as surety) to ensure the building performs as it was designed. In Singapore developers are required to post a bond with the authorities equivalent to half the value of the GFA concession. This money can only be redeemed once the building is completed and successfully attains the Green Mark label the developer claimed it would achieve. We recommend that the Hong Kong government asks developers to post a bond worth half the value of the GFA concession. This money is returned after the BEAM Plus final assessment demonstrates the sought after performance was attained.

We think many of the indicators rewarded by BEAM Plus are not of relevance to society-as-a-whole and should not be used for awarding GFA concessions. We recommend the performance standards for the GFA award be limited to a small subset of key BEAM Plus indicators which have a strong 'public good' element. These would certainly include: reduction of CO_2 compared to baseline model, embodied emissions in the building structure, water efficiency and enhancing microclimate around buildings and several new indicators described below.

In Singapore three hundred buildings a year undergo the Green Mark final assessment; in Hong Kong around ten buildings undergo BEAM Plus Final assessment. We would expect the cost of undertaking the BEAM Plus assessment for just these key indicators to be much cheaper than the current BEAM Plus assessment and therefore much more widely adopted.

ENHANCING ENERGY BUILDING ENERGY EFFICIENCY

A naval architect who cares only about a ship's speed or appearance, but is indifferent to whether it leaked would not last long in his profession. But some architects and developers continue to propose building concepts that haemorrhage energy and are fundamentally unsuited to Hong Kong's climate. They then rely on engineers to fix the problem. The system of awarding a combined score for envelope and building electrical services obscures Hong Kong's underperforming building envelopes. In China and Singapore there are somewhat stronger standards for the building envelope, but even these don't go far enough either. We recommend the building envelope be given its own indicator in BEAM Plus linked to significantly outperforming the OTTV standards.

Greater use of modular or flat-pack construction methods can reduce waste, create more uniform and air-tight structures (reducing heat flows) and improve worker safety and should be rewarded.

BEAM Plus's level of ambition for platinum should be benchmarked to near-zero carbon buildings in terms of operational energy use. Ambitious targets should also be set for reducing embodied emissions in building materials and construction.

Other countries have set out a timetable and a trajectory for how building codes should be tightened in the future. Hong Kong's Government is committed to strengthening the OTTV and will undertake two reviews between now and 2025. Government should conduct and publish a benchmarking analysis comparing OTTV with global building envelope standards like ASHRAE 90.1 (2007, 20010, 2013), and Passivhaus.

We think government set an objective that all new buildings should be near-zero carbon in a decade, and set a trajectory for tightening to OTTV and RTTV standards.

REWARDING GREEN OPERATION OF THE BUILDING

A typical smart phone will continually display remaining battery capacity. It'll switch off its screen after a few seconds of non-use, if its camera detects low levels of background light it dims its screen, and in low-power mode it'll further conserve power by switching off power hungry circuits like Bluetooth and WiFi. The power management app on a smart phone allows users to change default settings, and interrogate the phone for electricity by each piece of software. These devices manage power wisely.

GBCSs, including BEAM Plus, have not kept up with improvements in technology. In the original version of BEAM, issued in 1996, credits were awarded for sub-metering of air handling units, chillers and other major circuits, for leaving behind *paper* copies of operational manuals and ensuring that the equipment's commissioning is planned and properly undertaken. Maybe this made sense 20 years ago. Think what has changed since then: Moore's Law has exponentially expanded computational power and storage, Hadoop doing the same for data interrogation, WiFi and Bluetooth permits wireless communications within structures, the invention of micro-sensors and Internet of Things allows feedback between electrical equipment and remote management software. Yet the current BEAM Plus still offers a credit for basic sub-metering and references underlying standards from the 1980s and 1990s! This shocked us.

A mobile phone might use 2.5 kWh of electricity a year, around 0.1 per cent of what a home uses, and yet a home has none of the phone's power saving features. Why is a $5000 phone so smart and a $5 billion building so dumb? Put simply because phone designers realise that power management which extends battery life makes the phone much more attractive to consumers. At the moment the incentive structure does not convey tenants' thirst for economy, or current and future generations' interest in a liveable environment. GBCSs cannot fix these incentives problems by themselves, but they can help.

GBCSs, like BEAM Plus, could embrace the smart city agenda and ensure smarter building design is rewarded. What we mean by smart building design are standards governing systems which collect and transmit real-time physical data, which use real-time data to control key building services, which install diagnostic software to warn if building services are not operating efficiently. BEAM Plus could be an important enabler: setting out agreed minimum standards for data sharing/data privacy and standards for building sensors and controls. This would involve extending the group of people involved in defining the standard to include consumer groups (to handle privacy), the utilities and data analytics firms.

We recommend BEAM Plus consider offering credits for:

- using Building Information Management (BIM) software to optimise design and reduce construction waste, installing smart meters to capture major building service data from the tenant and shared services, physical environment sensors and Building Energy Management Systems;
- using leases to commit tenants, owners and building management companies to share real-time data to control and optimise building energy use. This should be written into the tenancy contracts;
- suitably anonymised data to be made publicly available on an annual basis to enable interested parties to understand the building's actual energy performance on a basis that can be used to compare with other buildings, and by tenants within a building; and
- use of data analytics/machine learning to drive automatic control of building energy services: lifts, lighting circuits and coolant flows.

It is important that operators of buildings are incentivised to recommission their equipment and utilise their smart controls. We recommend government offer a discount in the Government rates that landlord or tenant has to pay every quarter (say reducing it from 5 per cent of the rental value of the property to 4 per cent) to encourage owners to invest in ongoing investment in building energy efficiency, data sharing and encouraging good tenant behaviour as set out above.

IMPROVING THE EFFECTIVENESS OF GOVERNMENT REGULATION

The Buildings Department is not sufficiently engaged with the energy efficiency agenda. Perhaps the department has too many other conflicting or immediate responsibilities. It declined to participate meaningfully in the study, and from the accounts we hear, its regulations do not have much impact. If Hong Kong is to improve building energy efficiency the department's poor performance on energy efficiency needs to be addressed: either by increasing resources and motivation, or stripping if off its responsibilities, perhaps handing them to the Energy Efficiency Office within EMSD. An alternate solution might for some of the indicators of the BEAM Plus assessment be out on a mandatory basis subject to minimum levels of performance. We recommend government review the departmental responsibility around building envelope regulation and explicitly address whether BD should continue play its current role.

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