`GREEN´ HOUSE or GREENHOUSE?

Climate change and the building stock of Hong Kong and Macau

Report by
***Civic Exchange** – Peter Gorer, Andrew Lawson and Christine Loh*
***Architects Association of Macau** – Ana Mafalda Vilaça Botelho and Rui Leão*

Executive Summary

Good buildings are vital for quality of life

Buildings play a crucial role in determining the quality of life for residents of Hong Kong and Macau, and climate change poses risks to that quality of life by creating a hotter, wetter climate throughout this century, with heavier rainfall, interspersed by longer dry periods. Sea levels are also expected to rise. The role of buildings in the climate change discussion is complex as they are both a defence against the impacts of climate change and a contributor to greenhouse gas emissions.

Energy efficiency is crucial, however you look at it

Energy efficiency in buildings encompasses the most diverse, largest and most cost-effective opportunities to tackle climate change. Energy is the biggest component of greenhouse gas emissions and, in Hong Kong and Macau, the building sector is the biggest user of energy. Most of the energy consumed by buildings is used after construction is completed. Electricity is the major source of greenhouse gas emissions for both territories and air conditioning is a hefty user of electricity. Attention should focus on the operational phase of commercial and residential buildings, particularly in the use of electricity.

Efficiency gains need the right regulatory and incentive framework

There are existing technologies that can result in much greater energy efficiency in buildings at no or a limited cost, which would have substantial benefits to society as a whole in lowering long term energy requirements, improving local air quality, and reducing emissions of greenhouse gases. However, for the most part, the costs and benefits of these issues are external to the important players in the building sector (e.g., developers,

builders, property owners, renters and governments looking to maximise near term government revenues).

Government must lead

The Macau and Hong Kong Governments must establish a firm foundation of well-developed policies that provide an appropriate mix of regulations to provide attractive financial incentives to energy suppliers and users to become much more energy efficient, including the building sector. With the right regulatory environment and incentives, the power utilities, building management, and individual consumers of electricity will be motivated to explore efficiency and conservation gains, as well as use available products, services and technologies.

Four vital policy components

There are four necessary policy components: a climate change adaptation and mitigation strategy; an integrated energy policy; optimal building standards; and integrated urban design and planning. Though this paper makes a case for energy efficiency as a priority, it is not the only concern that will confront both Special Administrative Regions as they respond to climate change. The built environment of Hong Kong and Macau needs to both 'mitigate' climate change (i.e., buildings should be low emitters of greenhouse gases) and adapt to climate change (i.e., buildings should help people to cope with the anticipated changes to the climate) using low carbon means.

By combining strong leadership from government with technical and financial expertise, Hong Kong and Macau have an opportunity to be among Asia's leading centres for energy efficient buildings with a low carbon footprint that provide a buffer against climate change.

Climate change: the case for energy efficiency

Overview

Some of the world's highest urban development densities are in Hong Kong and Macau. The significance of this fact is magnified when one realizes that the average person in these communities spends upwards of 70% of their time inside buildings. In the future, climate change will make it more problematic to create and maintain the healthy, fulfilling and safe indoor conditions that people need and want.

The evidence indicates that we have already embarked upon an era of global climate change and that human activities are fuelling this change through the emissions of greenhouse gases (GHGs). In Hong Kong and Macau, electricity use associated with buildings is the major source of GHG emissions.

One dimension of the problem is that a changing climate will bring new and possibly adverse weather conditions to the Pearl River Delta (PRD), in the form of heavier rains, prolonged periods of drought, and rising sea levels. Another dimension is that the pattern of urban development, once confined to the cities of Hong Kong and Macau, is now being repeated in many other cities throughout the PRD. Readers wishing to follow up on global issues related to climate change now have a vast array of resources to turn to, including the United Nations' Intergovernmental Panel on Climate Change (IPCC) Assessment Reports (2007).

The Energy-Climate-Air Quality 'treadmill' – People in Hong Kong and Macau are more aware of the problems with air quality than they are of the problems associated with energy consumption in buildings and the role energy consumption plays in determining air quality and emissions. This leads to the conclusion that something must be done to reduce the burning of fossil fuels that generate electricity, in order for Hong Kong to break the Air Pollution-Climate Change cycle.

Energy efficiency

Arguments favouring an energy efficient future – Both Hong Kong and Macau are completely dependent on imported energy to fuel their economies. Even the relative wealth of our communities cannot hide the fact that the vulnerabilities associated with a total dependence on world energy markets are heightened in an era of rising commodity prices, regional conflict and terrorism. Embedded within the energy security topic is the question of energy reliability – energy efficiency can help reliability. At the September 2007 APEC Leaders' Conference in Sydney, Hong Kong's Chief Executive recognised that efforts are needed to build a more sustainable future and agreed to try to reduce energy intensity by at least 25% by the year 2030 (with 2005 as the base year). However, much more could be done. Firstly, the target is not binding. Secondly, since energy intensity is a measurement of energy per unit of GDP, this target can be achieved even if overall energy use continues to grow.

Air pollution is another major motivating factor for achieving energy efficiency in Hong Kong, Macau and other cities of China. The discussion continues between those who advocate the need for unrestrained economic development, and those who recognize that the community is no longer able to bear the costs associated with deteriorating public health and environmental degradation.

An energy efficient future does not necessarily mean a reduction in energy consumption – in some cases there are opportunities for clean development, particularly in regards to activities that result in reduced or even zero carbon emissions. To help achieve this aim, the APEC Leaders resolved to establish the Asia-Pacific Network for Energy Technology (APNet) to strengthen collaboration on energy research, particularly in areas such as clean fossil fuel energy and renewable energy.

Role of buildings

About half of all energy consumed in Hong Kong is in the form of electricity and buildings account for over 80% of that demand. Energy usage in Macau follows a similar pattern. Fossil fuels used to generate energy for buildings in Hong Kong, Macau and the PRD emit large amounts of CO2 and other GHGs, as well as chemicals and particulates that cause smog. A policy that improves energy efficiency in buildings in Hong Kong and Macau could make a substantial contribution towards reducing both communities' overall greenhouse gas emissions.

Energy efficiency know-how is available

There are many ways to improve energy efficiency in buildings. Higher thermal performance of the building envelope is feasible for new construction and a lot can be done to improve the energy efficiency of air-conditioning, lighting, and vertical transportation systems in both new and existing buildings.

There is also a growing inventory of energy efficient consumer electronics, office equipment, and household appliances on the market, together with independent labelling schemes to guide buyers on their product selections. Building energy management systems, including continuous monitoring technologies, are also widely available and can both ensure energy efficiency over time and provide an early warning of a system malfunction. Hong Kong designers can also consider renewable technologies that rely on solar, geothermal, and wind energy.

The Asia Business Council's 2007 publication "Building Energy Efficiency – Why Green Buildings are Key to Asia's Future", points out that four out of the five most cost-effective measures that can be taken to reduce greenhouse gas emissions involve building efficiency, namely: improving building insulation quality, lighting, air-conditioning, and water heating systems.

Building case studies provide a

valuable resource for demonstrating the technical feasibility of installing energy efficient technologies. In Hong Kong, the primary private sector resource for case studies is the HK-BEAM web site. As well, EMSD has a benchmarking tool that can assist practitioners to further understand what is possible and how planned designs measure up.

Why isn't more being done?

"Where's the return on investment?" – The most common argument against improved building energy efficiency is based around the question of implementation cost and returns on investment. More specifically, the contention is that since energy efficient buildings do not command a premium in sales or rental prices, there is no financial incentive for uplifting current construction standards. It is true that some developers see advantages in green marketing, but most improvements they offer tend to be superficial, which do not obviously translate into improved energy efficient building

Fire Station with Ambulance Depot and Police

Post at Penny's Bay, Lantau Some of the passive design features incorporated in the complex:

Functional orientation suits the use of photovoltaic panels on the roofs to provide renewable energy; Use of pergolas in key areas to shade walls; Maximise the use of daylight and natural ventilation; Extensive roof overhangs and sun shading devices to minimise solar heat gain; and Use of long life and low maintenance prefabricated materials. (Source: ASD).

performance or reduce environmental impacts.

Not a factor in buying or renting a place – The apparent lack of concern among the bulk of commercial and residential end-users about energy efficiency in buildings is another reason for slow adoption. Although changed circumstances or policies could alter this perception quickly, it is likely that end-users have not voiced their desire for improved energy performance for two reasons: they feel that other location-related priorities trump a building's energy-savings potential; or they are indifferent so long as their electricity and gas bills only represent a small proportion of their total expenditures.

Despite the efforts of the HK-BEAM Society (Hong Kong Building Environment Assessment Method) and others, there is still little tangible evidence that Hong Kong and Macau property markets recognise a link between the development's green characteristics and increased asset value.

Governmental indifference – The lack of government leadership in championing energy efficiency in buildings is probably the strongest barrier against making buildings more energy efficient. Political leaders have the responsibility to ensure a sustainable economy for their citizens, yet some have been aggravatingly slow to recognise that factors such as global energy prices and the threats associated with climate change mean that the inefficient use of energy in buildings is no longer a viable option.

The professionals aren't pushing it – Major opportunities for energy efficiency are lost during a project's design phase. Few planners, architects and engineers have been trained specifically to address energy and environmental design matters, and thus there is a widespread lack of understanding about issues such as the building assemblies, products, and technologies that can achieve the best results in environmental terms. This perception is supported by a 2006/7 international building industry survey that found that professionals commonly

overestimated the costs (sometimes by three times) and underestimated the benefits of green building designs.

Perception that "green always costs more" – The conventional wisdom that "green buildings cost more" is difficult to overcome. The discussion above about developers highlights the cost-to-construct versus benefits-in-use dilemma, but it is also true that few have any idea whether in the long term a green component really costs more than a conventional equivalent when all life cycle cost criteria are factored in. An increasing number of researchers have shown that greener building does not necessarily cost more.

Of particular interest to anyone pursuing a green building assessment, a respected cost consultancy in the USA found that that the capital costs associated with university projects earning a LEED certification (Leadership in Energy & Environmental Design) had much more to do with programmatic requirements than with their green features.

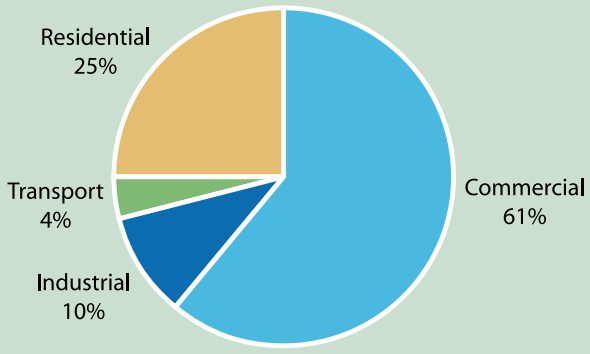
Energy and emissions in Hong Kong

Greenhouse gas emissions

Energy sector is the major emitter of greenhouse gases – Globally, energy supply is the biggest component of global greenhouse gas emissions, accounting for about a quarter of all emissions

In Hong Kong, with minimal agriculture and forestry, declining heavy industry, and much of the transport electrified, energy industries account for over 60% of the territory's anthropogenic greenhouse gas emissions.

Buildings – In Hong Kong, buildings account for over 80% of electricity use, and electricity use in buildings comprises at least a third of greenhouse gas emissions. Hong Kong's total energy use for the year 2005 from all fuels and sectors was 79,515 million kWh. According to the EPD, Hong Kong's total greenhouse gas emissions in the same year from all sources and sectors were about 45 million tonnes CO2e. It is



Electricity consumption by Sector in Hong Kong in 2005 (Source: EMSD 2007)

possible to estimate the carbon intensity of energy produced by the electricity and gas utilities and by applying these carbon intensities to EMSD's energy end-use data, it is also possible to estimate the greenhouse gas emissions of various building-related activities (e.g., air conditioning, lighting etc).

Energy use in buildings – Where does it occur?

The commercial sector's functional diversity obscures statistical analysis of how energy is consumed, but EMSD data shows that the consumption of energy for space conditioning and lighting are major considerations in the design of offices and retail spaces. In the residential sector, too, there are differences between public and private housing, and between tower blocks and luxury housing. The general picture makes an interesting contrast to that of the commercial sector.

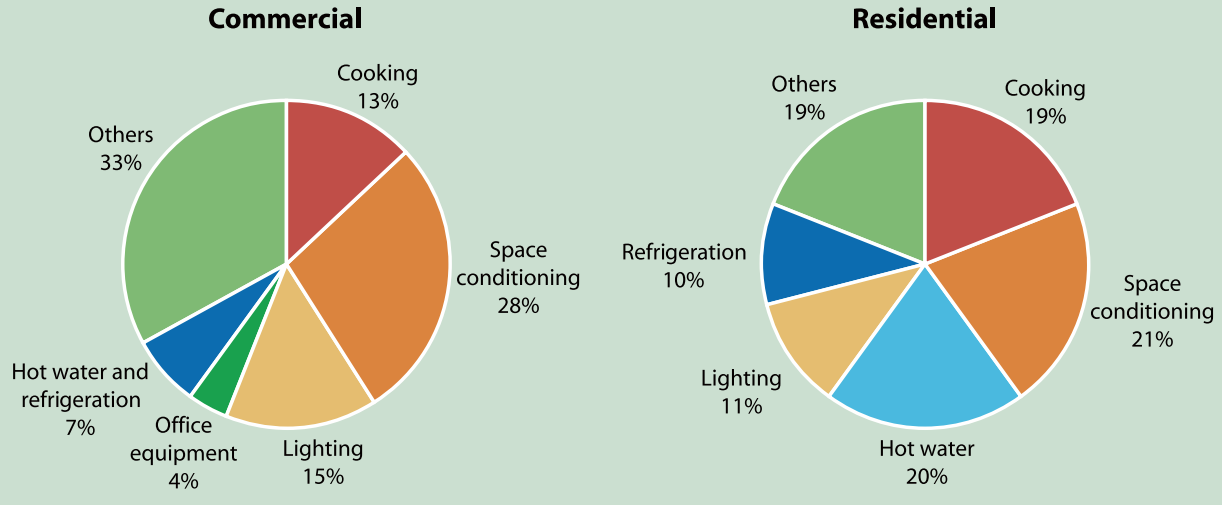
Life Cycle Costs and Assessments

Although it is possible for an engineer to calculate system consumption and estimate life expectancy, designers are not accustomed to making evaluations using Life Cycle Costing (LCC) and Life Cycle Assessment (LCA) techniques. Such exercises will gain in importance as greater emphasis is placed on mitigating recurring costs.

A 2004 Hong Kong University study into a Housing Authority block and a similarly sized private sector residential building provides a rare example of the application of LCC and LCA techniques in Hong Kong. While it is dangerous to draw general conclusions from this one example, it is hoped that by applying these techniques to other projects, decision-makers will be better placed to choose between alternative design solutions and identify opportunities for improvement.

How does Hong Kong compare with others?

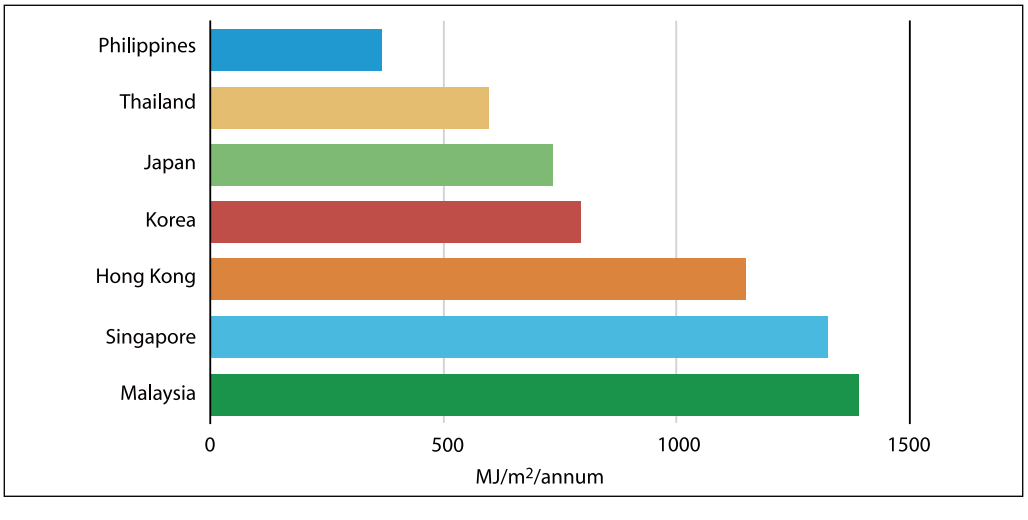
To compare energy consumption per square metre in a typical Hong Kong office building



Hong Kong's commercial and residential sector energy use in 2005 (Source: EMSD 2007)

against other APEC countries, it provides an opportunity to consider what measures might be needed to bring Hong Kong office energy consumption into line with Thailand or Japan.

The United Nations Environment Programme (UNEP) has compiled a series of simulations comparing conventional practices with low energy alternatives in other parts of Asia that provide indications of what might be worth exploring further in Hong Kong. For instance, a Malaysian example compared simulated energy consumption of a new 'low-energy' building against a hypothetical building constructed in accordance with the minimum standards set in the Malaysian codes of practice. The new building achieved 64% savings in energy. In this case, the upfront extra cost of energy efficiency measures was 10% above conventional costs, with a payback period of ten years.



Office building energy consumption in some APEC countries in 2000 (Source: Cheung & Kam 2007)

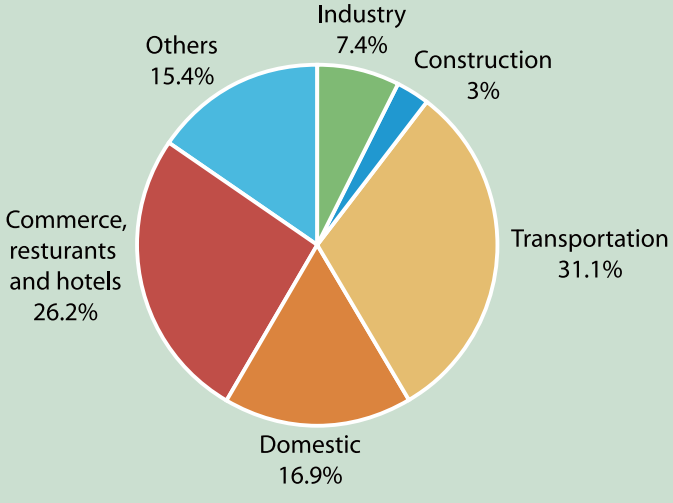
A Perspective on Macau

As neighbours and influential members of the wider Pearl River Delta community, Macau and Hong Kong are well placed to share expertise and provide mutual encouragement for sustainable building practices.

Macau faces particular challenges in relation to the role of buildings in combating climate change and other environmental issues. Firstly, Macau is a small territory with a land area of only 29 sq km. This confinement means that the creation of new lands by reclamation has been the preferred option for new developments. Secondly, Macau is the second most densely populated administrative unit on earth (the first being Monaco). Thirdly, Macau has no fossil fuel resources and imports all of the fuel needed to meet its energy requirements. Lastly, the casino and tourism boom of recent years has wrought enormous changes for Macau, resulting in tremendous opportunities for employment and development, with hotels, resorts, places of entertainment, jobs, more inhabitants, more apartments, more commerce and industry, more construction works, and more vehicles. At the same time, these factors put unprecedented strain on the environment.

Greenhouse gas emissions and energy usage in Macau

The phenomenal development in Macau has seen the territory's greenhouse gas emissions increase by 76% in less than 20 years. In 2005, almost half of emissions come from local electricity generation.



Final energy consumption by sector in Macau in 2004 (Source: Environment Council 2005)

Domestic and commercial buildings accounted for about 43% of final energy consumption in 2004.

Electricity usage in Macau - Macau's per capita electricity use grew by about 20% from 2004 to 2006. The commercial sector dominates, accounting for more than half of Macau's electricity consumption, followed by the residential sector, which accounts for over a quarter of consumption.

Role of hotels

Tourism and leisure are integral to the economy of Macau, with its historic centre listed as a World Heritage site and its extensive promotion as the entertainment and leisure hotspot of China. Therefore,

it is appropriate to focus on hotels in the discussion on energy efficiency in buildings. According to the Macau Government, electricity accounts for 60 to 70% of the utility costs of a typical hotel. As with Hong Kong, air conditioning accounts for a large proportion of all electricity consumed, potentially over 50% of total electricity used in a typical Macau hotel. Lighting is the next biggest item, typically accounting for 25 to 35% of total electricity. In a survey of Macau's hotels in 2003, respondents revealed that many establishments have instituted some energy conservation measures cost effectively without sacrificing guest comfort and energy efficient lighting was the most commonly adopted measure.

Building the vision

Tie-in to the global challenge

Many have begun only lately to realise that global climate change is underway and that the causes are largely anthropogenic. Some are beginning to develop an understanding of the implications for nations, populations, and customary ways of life.

Hong Kong and Macau are fortunate in having the financial means to build a vision for a way of life that can mitigate environmental impacts, adapt to new

climate conditions, and begin the regenerative processes that will lead towards a more viable future. As a C40 Climate Change Leadership Group member, Hong Kong has expressed a willingness to begin addressing climate change, which was reiterated through the Hong Kong Government's support of the climate change declaration of the 2007 APEC leaders' meeting.

Within the context of the built environment, many different groups need to become involved in the discussion, including government, real estate stakeholders, planning and design professionals, and the people who ultimately live in, work in, and otherwise use the buildings of Hong Kong and Macau.

Leadership from the front

Role for government - Almost all branches of government have some influence on the creation of energy efficient and low carbon communities in Hong Kong and Macau, and inter-departmental collaboration is vital for the development of policy.

In contemplating the future of the two SARs' building stock, it is hoped that both Governments will be able to address multiple concerns, including:

i) Adaptation of revenue policies related to land leases;

ii) Tax policies that encourage environmental responsibility, including the introduction of a carbon tax;

iii) Instigating public works programmes that both mitigate climate change and adapt to new realities (such as rising sea levels) using low carbon methods;

iv) Promoting 'passive survivability' policies for new and existing buildings;

v) Adopting better energy policies;

vi) Reducing carbon intensity through land use policies that include re-evaluating the carbon costs associated with land reclamation;

Photo by Raymond Wong Wai Man

vii) Mitigating the climate impacts related to transportation and building access; and

viii) Strengthening fresh water conservation and other natural resource policies.

The SAR Governments can carry out a wide range of measures to improve the environmental performance of its own properties, as well as those under the control of public organisations such as hospitals authorities, public housing authorities, Hong Kong's Urban Renewal Authority, schools and universities. Additionally, the two Governments can take advantage of the intellectual resources of their territories' universities by funding research into specific topics related to the city environment, its buildings, and climate change.

Real estate stakeholders' buy-in

Developers - As primary decision-makers, private sector developers have a particular responsibility to create new building stock in ways that minimise environmental impacts and that provide accommodation that is well suited to a low energy, low carbon future.

It is essential that developers make use of a growing range of available green building 'roadmaps' to guide development decisions, whether or not they seek recognition from organisations such as HK-BEAM, GreenGlobes, USGBC or others.

Making development decisions earlier in the project planning, design, and construction processes will make it easier to achieve the desired result with the least amount of practical and financial effort. There is every incentive for developers to test the technical feasibility and life cycle cost implications of low-energy, long-life, low-carbon options as early in the process as possible.

As climate change impacts start to hit home, real estate stakeholders will seek

Photo by Raymond Wong Wai Man

compensation from their insurance brokers. Thus, it is not too early for Hong Kong and Macau developers to commence a dialogue with lenders and insurance companies both to see mitigation measures reflected in insurance premiums, and increase the likelihood of equitable compensation in the event of weather-induced damage.

Building managers - Building managers are tasked with ensuring that facilities actually achieve performance targets. This is a daunting task, as virtually none of the existing building stock of Macau or Hong Kong has been adapted to provide healthy, comfortable indoor environments and function at reduced energy levels.

Matters that management companies may consider to ensure that the two SARs' buildings will be in the best position possible to address climate change challenges include:

i) Supporting whole building commissioning principles for new and existing buildings;

ii) Increasing staff awareness of energy management and housekeeping best practice standards through education programs;

iii) Understanding the pros and cons of performance contracting agreements;

iv) Understanding the benefits of energy auditing, and taking advantage of monitoring and verification protocol principles and building automation systems;

v) Integrating 'passive survivability' into emergency action plans; and

vi) Creating effective feedback loops with developers and design consultants to ensure that future projects will benefit from the 'lessons learnt' based on operational experience.

Planners and Landscape Architects

There is a growing realisation internationally that urban planners and landscape architects can contribute a great deal in advancing cities' climate change plans.

Since developers in Hong Kong and Macau rarely engage landscape architects except to decorate planting areas, it is

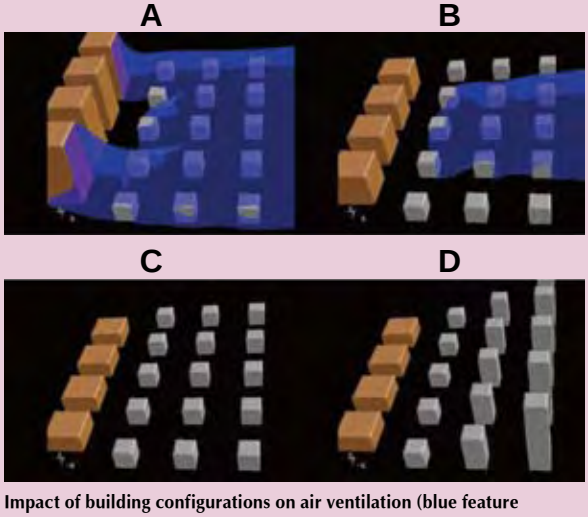
Street Canyon Effect

What is a 'street canyon'?

- Formed between rows of tall buildings
- Can impede airflow and trap pollutants generated at street level from traffic.

What does the effect depend on?

- Direction of prevailing winds.
- Ratio of building height to width.
- Nature of neighbouring buildings (e.g., tall buildings in front of short buildings).
- Size and number of gaps between buildings.



Impact of building configurations on air ventilation (blue feature represents undispersed pollutants) (Source: Fung 2007)

Researchers at the Hong Kong University of Science and Technology are trying to quantify the effect of street canyons on air ventilation.

The figure opposite is a computer simulation of ventilation processes that disperse pollutants in four different building configurations, with the prevailing winds flowing from left to right. The dispersion of heat would follow a similar pattern. 'A' represents a streetscape with tall buildings in front of short; 'B' shows buildings of intermediate height in front of short; 'C' shows buildings of roughly equal height; and 'D' shows short buildings in front of tall. The blue feature represents pollutants generated from street level traffic. The simulation predicts that pollutants linger in A and B, but are dispersed in C and D. The research shows the importance of urban planning to ensure adequate ventilation between buildings. Such ventilation is not only an issue for air pollution but will be important for cooling the city as a result of climate change and urban heat islands.

likely that there is little general knowledge about how landscape architects can help to reduce impacts, promote biodiversity, as well as restore and regenerate ecosystems. Landscape architects are crucial in areas such as:

i) Reducing CO2 levels and improving microclimates by planting shade trees and other vegetation that reduce the urban heat island effect;

ii) Advising on bioremediation techniques using plants to remove contaminants from surface and groundwater systems;

iii) Promoting biodiversity by providing wildlife habitat and food; and

iv) Restoring coastlines to minimise potential damage to populated areas.

Research to support professional knowledge

Several universities in Hong Kong have already done a great deal of applied research that can help further professionals' knowledge of buildings and the environment.

Additionally, the Hong Kong Housing

Authority and others have commissioned consultancy studies that advance understanding on topics such as the microclimate effects of 'street canyons' and 'urban walls' using computational fluid dynamics techniques.

The vision

The vision must be to complete all new buildings in Hong Kong and Macau to much higher energy efficiency and emissions standards, and ongoing research will be needed for some time to advance best practice principles. Additionally, just focusing on new buildings will not be enough and attention is urgently needed to improve the environmental performance of existing building stock. Both research studies into retrofitting existing buildings and demonstration models of Hong Kong/ Macau typologies are immensely important if the energy intensity of existing buildings is going to be improved significantly.

Improving the environmental performance of existing buildings is challenging but immensely important given that most of the two SARs' current stock is going to be in operation for decades to come.

People who use buildings must be on board

Any vision for a real, sustainable policy aimed at reversing anthropogenic climate change must secure the active support of the full spectrum of society.

A well-designed building can operate sub-optimally if people are unaware of how to make best use of its features. Similarly, even in poorly designed premises, the behaviour of occupants can alleviate some of the inherent shortcomings of the building. Whether at home or in the workplace, there are many opportunities to turn off lights and equipment when no longer needed, and replace inefficient light bulbs, plug-in appliances, and air-conditioning systems with energy efficient alternatives. Simple

Photo by Raymond Wong Wai Man

Old Macau streetscape

actions like unplugging devices that have a stand-by mode (such as televisions), and regularly cleaning air conditioner filters can further help reduce energy wastage.

In creating the vision of how to address climate change, it is important for experts and decision-makers to recognise that people will still continue to want to have control over their lives. Experts should make every effort to understand human psychology, and present initiatives in the most palatable, least painful way possible. With public education and support, initiatives that otherwise might be extremely costly or doomed to failure, can be implemented easily and cheaply.

Fitting it all together

Though this paper argues for a stronger lead from government in setting the groundwork for a better response to climate change generally and energy efficiency specifically, government policy is only a first step in rallying the various players in the building sector to build a vision of sustainable communities for Hong Kong and Macau. When the government provides strong leadership by implementing effective policy, then the people of Hong Kong and Macau can expect to see the various segments of the building sector working more like the cogs in a well-oiled machine.

Conclusion

By combining strong leadership from government with formidable technical expertise and financial capacity, Hong Kong and Macau have an opportunity to be among Asia's leading cities when it comes to energy efficient buildings with a low carbon footprint that are adapted to the effects of climate change. There are existing technologies that can result in much greater energy efficiency in buildings, which would have substantial benefits to society as a whole in lowering long-term energy requirements, improving local air quality and reducing emissions of greenhouse

gases. However, for the most part, the costs and benefits of these issues are external to the various players in the building sector (e.g., developers, builders, property owners, renters, and governments looking to maximize near term government revenues).

In this case, responsibility ultimately falls on the Governments of Hong Kong and Macau to structure regulations and other incentives in such a way as to internalise the major external costs and benefits into the decision making process, and ensure that buildings are performing to optimal environmental standards. Until the Governments recognise their responsibility, the opportunities of energy saving technologies will continue to be wasted.

As the planet heats up, the people of Hong Kong and Macau will be justified in expecting their Governments to take timely action to mitigate the impacts of climate change and reduce the two regions' carbon footprint. Whether as regulator or as manager of its own real estate, government must demonstrate that it is implementing effective policies that maximise the long-term asset value of the building stock for the sake of future prosperity.

This is an excerpt from the original report with the same title released in April 2008. For full version of the report you may contact Civic Exchange. Website: www.civic-exchange.org

Civic Exchange

Civic Exchange is a Hong Kong-based non-profit public policy think tank that was established in October 2000. It is an independent, well-networked organization that has access to policy makers, officials, businesses, media, and NGOs—reaching across sectors and borders. Civic Exchange's location and expertise in Hong Kong—a key city in Asia for finance, business, and media—makes the organization well-positioned to influence and link with other cities around the world. It has solid experience in energy, environment and climate change research, as well as economics and governance issues. www.civic-exchange.org

Architects Association of Macau (AAM)

AAM is an association of public and private sector architects based in Macau. The organisation was first established in 1980 and undertakes a variety of activities related to architecture in Macau, including holding public lectures, organising architectural tours and representing its members in international architecture associations.
www.macaoarchitects.com

Glossary of Abbreviations

APEC	Asia-Pacific Economic Cooperation
ASD	Architectural Services Department, Hong Kong SAR Government
CEM	Companhia de Eléctricidade de Macau (Electric Company of Macau)
CFD	Computational fluid dynamics
CO_2e	Carbon dioxide equivalent (a means of standardising the effect of different greenhouse gases)
DSMG	Direcção dos Serviços Meteorológicos e Geofisicos (Meteorological and Geophysical Services), Macau SAR Government
EMSD	Electrical & Mechanical Services Department, Hong Kong SAR Government
EPD	Environmental Protection Department, Hong Kong SAR Government
GHG	Greenhouse gas
HK-BEAM	Hong Kong Building Environment Assessment Method
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change, United Nations
LCA	Life Cycle Assessment
LCC	Life Cycle Cost
LEED	Leadership in Energy & Environmental Design (a US-based environmental assessment method for buildings)
OECD	Organisation for Economic Co-operation & Development
PRD	Pearl River Delta Region
SAR	Special Administrative Region of Hong Kong and/or Macau
UNEP	United Nations Environmental Programme
USGBC	United States Green Building Council
WBCSD	World Business Council for Sustainable Development