THE HONG KONG INSTITUTION OF ENGINEERS
香港工程師學會

Environmental Division
環境分部

The HKIE Environmental Division Annual Forum

Hong Kong's Role in **Low Carbon Development:** Challenges and Way Forward

PROCEEDINGS

Monday, 18 April 2016
Hong Kong Convention & Exhibition Centre

The HKIE Environmental Division Annual Forum

Hong Kong's Role in Low Carbon Development: Challenges and Way Forward

18 April 2016

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HKIE THE HONG KONG INSTITUTION OF ENGINEERS 香港工程師學會

Environmental Division
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The Hong Kong Institution of Engineers (HKIE), founded in 1947, is a professional body of engineers in Hong Kong. Now that the interest from HKIE members on environmental related issues has been quickly increasing in the past two decades, Environmental Division is one of the largest Divisions of HKIE with over 5,000 divisional members from a wide range of disciplines such as civil, electrical, mechanical, building services and among others. The aims of the Divisions are to advance the objectives of the HKIE in facilitating the exchange of knowledge and ideas, nurturing young generation and training the members in new technology and practices, raising the standing and visibility of engineers, and also to foster a spirit of friendly collaboration amongst its members and with members of similar institutions or other professional bodies.

There is an important need to address all kinds of environmental issues, the nature of which varies with time. Whatever environmental problem we face today could be a challenge for all economies globally. The commitment to awareness, understanding knowledge and developing expertise are recognized as critical steps along the path to sustainability. Fully understanding this and respecting for our natural resources, the Environmental Division plays an active role in organizing high quality seminars and technical visits by providing updated information about the environmental related fields for members. We have also been proactive in providing professional views during government consultations and contributing technical articles to promote environmental professionalism in Hong Kong.

This year the Environmental Division works closely with HKIE Headquarters to promote and echo the theme "Celebrating 40 Years of success. Your Dreams Our Goal". The highlights in this session revolve around the following topics: green building, energy efficiency, solid waste management, water quality, wastewater treatment technology, air quality and climate change. We have organized Annual Reception and Annual Forum, job shadowing program, training workshops in collaboration with universities and industrial partners, technical visits as a platform for networking and experience sharing with our stakeholders. Your unfailing support by joining our activities is much appreciated and we are looking forward to seeing you at our upcoming events. For more details about the Environmental Division of HKIE, please visit our website at http://ev.hkie.org.hk/.

Organising Committee

Chairman	Ir TANG, Kelvin
Members	Ir Professor LO, Irene Ir LO, P C Ir AU, Elvis Ir CHENG, Norman Ir CHOI, C M Ir Dr GBAGUIDI, Alex Ir IP, T Y Ir KWAN, Anthony Ir LAM, C S Ir LEE, Stephen Ir LEE, Vincent Ir LUK, Ken Ir WONG, Kenny Ir YUEN, Andrew Ir Dr ZHOU, Shelley Ms CHAN, Jacqueline Mr CHAN, Kevin Mr LAM, Benjamin

Supporting Organisations

Academic

City University of Hong Kong, School of Energy and Environment

Hong Kong Baptist University, Asian Energy Studies Centre

Technological and Higher Education Institute of Hong Kong

The Chinese University of Hong Kong, School of Life Sciences

The Hong Kong Institute of Education, Centre for Education in Environmental Sustainability

The Hong Kong Polytechnic University, Department of Civil and Environmental Engineering

The Hong Kong University of Science and Technology, Department of Civil & Environmental Engineering

The Open University of Hong Kong, School of Science and Technology

The University of Hong Kong, Department of Civil Engineering

Non-academic

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Netherlands Consulate General in Hong Kong SAR and Macao SAR China

ASHRAE Hong Kong Chapter

Business Environment Council

Chartered Institution of Water and Environmental Management – Hong Kong Branch

Construction Industry Council

Environment Bureau, The Government of the HKSAR

Engineers Australia Hong Kong Chapter

Federation of Hong Kong Industries

Friends of the Earth (HK)

Green Council

Hong Kong Association of Energy Engineers

Hong Kong Construction Association

Hong Kong Environmental Industry Association

Hong Kong General Chamber of Commerce

Hong Kong Green Building Council

Hong Kong Green Strategy Alliance

Hong Kong Science and Technology Parks Corporation

Hong Kong Waste Management Association

Institution of Mechanical Engineers - Hong Kong Branch

New Zealand Chamber of Commerce in Hong Kong

The Chinese General Chamber of Commerce

The French Chamber of Commerce and Industry in Hong Kong

The Hong Kong Air Conditioning and Refrigeration Association

The Society of Operations Engineers, Hong Kong Region

Sponsors

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Programme

8:45-9:05am	Registration
9:05-9:10am	**Welcome Remarks** Ir Kelvin TANG, Chairman of the Organising Committee
9:10-9:15am	**Opening Address** Ir Chi-chiu CHAN, President, The Hong Kong Institution of Engineers
9:15-9:40am	**Keynote Address** Mr Kam-sing WONG, JP, Secretary for the Environment, Environment Bureau, The Government of the HKSAR
9:40-10:05am	**Keynote Address – Shaping a Better World with Green Living** Ir Dr the Hon Wai-kwok LO, SBS, MH, JP Legislative Councillor (Engineering Functional Constituency), HKSAR
10:05-10:30am	**Keynote Address** Professor Dadi ZHOU, Director General Emeritus and Senior Researcher of the Energy Research Institute of the National Development and Reform Commission of China 中國氣候變化專家委員會委員、國家發改委能源研究所原所長 周大地教授
10:30-11:00am	Coffee Break
Session I – Climate Resilience and Challenges Chaired by Ir Professor Irene LO, Immediate Past Chairlady, The HKIE Environmental Division	
11:00-11:20am	**Adapting Climate Risks – CLP's Experience** Mr Simeon CHENG, Senior Manager – Group Environment, CLP Holdings Ltd Ir Alex WONG, Deputy Director – Safety, Health, Environment & Quality (Generation), CLP Power Hong Kong Ltd
11:20-11:40am	**Damage Assessments of Coastal Flooding for Hong Kong and the Pearl River Delta due to Climate Change-Related Sea-Level Rise** Professor Alexis LAU Director, Atmospheric Research Center, The Hong Kong University of Science and Technology
11:40-12:00 noon	Discussion
12:00-1:30pm	Lunch Break
Session II – Development of Low-Carbon Infrastructure Chaired by Ir Elvis AU, Deputy Chairman, The HKIE Environmental Division	
1:30-1:50pm	**Towards Low-Carbon Hong Kong: HK Electric's Experience on Renewable Energy Development** Ir C K LAU, General Manager (Projects), The Hongkong Electric Co Ltd
1:50-2:10pm	**Accelerating Carbon Reductions through Multi-stakeholder Engagement at Hong Kong International Airport** Ir Sophia LAU, Manager, Environment, Airport Authority Hong Kong
2:10-2:30pm	Discussion
2:30-2:50pm	Coffee Break
Session III – Urban Mobility Decarbonizing Chaired by Ir Kenny WONG, Past Chairman, The HKIE Environmental Division	
2:50-3:10pm	**The Promotion of Electric Vehicles in Hong Kong – Policy and Measures** Mr Wai-chuen MOK, JP, Assistant Director (Air Policy), Environmental Protection Department, HKSARG
3:10-3:30pm	**Development of Electric Vehicles and Batteries** Ir Professor Eric CHENG Department of Electrical Engineering, The Hong Kong Polytechnic University
3:30-3:50pm	**Policies for Promoting Local Use of Green and Low Carbon Footprint Fuel in Hong Kong** Ir Roberto VAZQUEZ, Acting CEO, ASB Biodiesel (HK) Ltd
3:50-4:10pm	Discussion

Session IV – Carbon Pricing and Market Chaired by Ir Dr Shelley ZHOU, Committee Member, The HKIE Environmental Division	
4:10-4:30pm	**Global Experience in Carbon Pricing: Potential Implications for Mainland China and Hong Kong** Mr Joshua HODGE, Deputy Executive Director for Resource Development, Joint Program and Center for Energy and Environmental Policy Research (CEEPR), Massachusetts Institute of Technology (MIT)
4:30-4:50pm	**Minimising the Cost of Hong Kong Making an Appropriate Contribution to Global GHG Mitigation** Mr Robert GIBSON, Fellow of Civil Exchange
4:50-5:10pm	Discussion
5:10-5:15pm	**Closing Remarks** Ir P C LO, Chairman, The HKIE Environmental Division

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Welcome Message

Ir Kelvin S K Tang
Chairman of the Organizing Committee
The HKIE Environmental Division Annual Forum 2016

On behalf of the Organising Committee, I would like to extend our warmest welcome to all of you for joining the annual forum on "Hong Kong's Role in Low Carbon Development: Challenges and Way forward", which is Organised by the Environmental Division of the Hong Kong Institution of Engineers. As you may know, we are facing the climate change and the shortage of resources, in terms of energy, clean water and clean air. We, definitely, need to overcome many challenges through innovative construction solutions, green materials and excellence in technologies to build a sustainable development of Hong Kong.

This annual forum has been serving as a significant event each year in providing an excellent platform for us to exchange of knowledge, research findings and experience with fellow engineers in different disciplines and the stakeholders in the industry including local and overseas professionals. I believe the papers and the presentations in this annual forum will be informative and serve as a good reference for us. I sincerely hope that you all find this forum enjoyable and look forward to have a fruitful discussion among all the key players and delegates today.

I would like to express my sincere gratitude to Mr. Wong Kam-sing, JP, Secretary for the Environment, Ir Dr the Hon Lo Wai-kwok, BBS, MH, JP, Legislative Councillor (Engineering Functional Constituency) and Professor Zhou Da-di, Director General Emeritus and Senior Researcher of the Energy Research Institute of the National Development and Reform Commission of China, to deliver their insightful keynote addresses and Ir Chan Chi-chiu, the President of the Hong Kong Institution of Engineers for the opening address at this forum.

I would also like to extend my heartfelt thanks to the distinguished speakers, sponsors, supporting Organisations, participants especially for those who are traveling aboard to attend this forum and the Organising committee members, particularly to Ir P C Lo, the Division Chairman, for their time and effort in the past several months in arranging such an excellent and meaningful event. I look forward to your continuous support and active participation in future activities of the HKIE Environmental division.

Finally, I am pleased to let you know that we have followed international best practices in making this Forum as a green and carbon-neutral event from planning to execution.

Ir Kelvin S K Tang
Chairman of the Organizing Committee
The HKIE Environmental Division Annual Forum 2016

Message

Ir P C LO
Chairman of the HKIE Environmental Division

On behalf of the Environmental Division of the Hong Kong Institution of Engineers (HKIE), I would like to thank you again for joining the Annual Forum 2016 on "Hong Kong's Role in Low Carbon Development : Challenges and Way Forward ".

The needs and expectations for a low carbon development are ever increasing in recent years. Nowadays we are facing with more extreme weathers and associated climate risks, and increasing challenges on shortage of resources such as clean water and air. To build a sustainable and low carbon future, we need to overcome these challenges and plan ahead through climate resilience and adaptation, development of low-carbon infrastructure, exploring further on mobility decarbonizing, and finally understanding more on carbon pricing and market.

This forum provides a good platform for both the speakers and audiences to discuss and share their views. I am very grateful to Ir Chan Chi-chiu, the HKIE President for his opening address; Mr Wong Kam-shing, JP Secretary for the Environment, Ir Dr the Hon Lo Wai-kwok, BBS, MH, JP, Legislative Councillor (Engineering Functional Constituency) and Professor Zhou Dadi, Director General Emeritus and Senior Researcher of the Energy Research Institute of the National Development and Reform Commission of China, for their inspiring keynote addresses, and all distinguished local and overseas speakers for their presentations. I trust the insights, knowledge and experience shared by our speakers will help us to develop a low carbon environment for Hong Kong.

I am deeply impressed to see the overwhelming response to this Annual Forum. I would like to express my sincere gratitude to all the members of the Organising Committee (OC) for their unfailing support over the months in planning and Organising this seminar, especially to the OC Chairman Ir Kelvin Tang on his deep devotion and great leadership. Last but not the least, I have to express my heartfelt thanks to our guests, speakers, sponsors and participants for their enthusiastic support and contribution in making this forum a great success and your continuous support to our activities.

Ir P C Lo
Chairman
The HKIE Environmental Division (Session 2015/2016)

Biography of Guests of Honour

Mr Kam-sing WONG, JP
Secretary for the Environment, The Government of the HKSAR

Mr KS Wong was born in 1963 and is an architect by profession. He has been promoting green building and building energy efficiency over the past years. He had served as the Vice Chairman of the Hong Kong Green Building Council and the Chairman of the Professional Green Building Council. He has contributed to the development of local green building standards and taken part in a number of green building projects.

Before joining the Government, he has contributed to the work of a number of Government advisory bodies. In particular, he had active involvement in the public engagement processes of the Council for Sustainable Development. He was the convener of the Support Group on Combating Climate Change: Energy Saving and Carbon Emission Reduction in Buildings. He was also a member of the Support Group on Building Design to Foster a Quality and Sustainable Built Environment.

Mr Wong graduated from the Department of Architecture of the University of Hong Kong. He received further education on green building from the University of British Columbia in Canada. He has been appointed as the Secretary for the Environment of the HKSAR Government and assumed the post on 1 July 2012.

Ir Chi-chiu CHAN
President, The Hong Kong Institution of Engineers

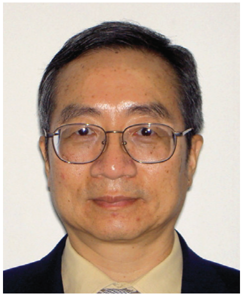
Ir CHAN Chi Chiu is a professional civil engineer. He has worked in several engineering departments of the Government of the Hong Kong Special Administrative Region. He has been the Director of Drainage Services, overseeing all aspects of wastewater and stormwater drainage services, covering capital projects for new infrastructure, improvement works to existing assets, operation and maintenance of existing systems and facilities, and collection of sewage services charges.

Ir CHAN is very active in professional and community services. He is currently a member of the Construction Industry Council, an Honorary Fellow of the Chartered Institution of Water and Environmental Management and an Adjunct Professor of the Department of Civil and Environmental Engineering, The Hong Kong University of Science and Technology.

Biography of Keynote Speakers

Ir Dr the Hon Wai-kwok LO, SBS, MH, JP
BSc(Eng) MSc(Eng) MBA EngD CEng FHKIE FIET FIMechE FHKEng RPE
Legislative Councillor (Engineering Functional Constituency), HKSAR

Ir Dr the Hon LO Wai Kwok, SBS, MH, JP, is Member of the Legislative Council of the Hong Kong Special Administrative Region, representing the Engineering Functional Constituency. He is the current Chairman of the Public Works Subcommittee, Chairman of the Hong Kong Quality Assurance Agency, member of the Hong Kong Science & Technology Park Board of Directors, the Housing Authority, the Hospital Authority and the West Kowloon Cultural District Authority, Vice Chairman of the Business and Professionals for Hong Kong, Founding Chairman of the Hong Kong Green Strategy Alliance, and Committee Member of the China Association for Science and Technology.



Professor Dadi ZHOU
Director General Emeritus and Senior Researcher of the Energy Research Institute of the National Development and Reform Commission of China

Professor Zhou Dadi is the Director General Emeritus and Senior Researcher of the Energy Research Institute of the National Development and Reform Commission of China. He has devoted for long time on energy policy and energy system analysis, focusing on sustainable energy strategy, energy conservation, and climate change policy. He was the founder and first executive director of the Beijing Energy Efficiency Center, member of STAP of GEF, chief investigator of many important policy and energy system analysis projects. He has contributed for long as one of the most influential advisors in the development of energy conservation plans, energy strategy, and climate change policy of China. He was the LA and CLA of IPCC WGIII for the IPCC second, third, fourth and Fifth Assessment Reports. His current professional positions include: the Vice Chairman of the State Energy Expert Advisory Committee of China, Member of the National Climate Change Expert Committee of China, Member of the Advisory Committee of National 13th Five Year's Plan, Vice Team leader of the Expert Committee of the National Energy Bureau for the 13th Five Year's Plan, the Executive Vice President of the Chinese Society of Energy Research, Vice President of China Institute of Geo-politics and Energy Strategy, Vice Chairman of the National Innovation and Development Strategy Society, etc. and advisors to Chinese Ministries, provincial governments, national companies, EDF, ADB, and many NGOs.

Biography of Speakers

Ir Professor Eric CHENG
Department of Electrical Engineering, The Hong Kong Polytechnic University

Professor Eric Cheng graduated from the University of Bath in 1987 and obtained his PhD from the same university in 1990. He has been working in Lucas Advanced Vehicle System Development in Birmingham UK as the project leader. His research interest ate all aspect of power electronic and electric mobility.

Mr Simeon CHENG
Senior Manager – Group Environment, CLP Holdings Ltd

Simeon is the team leader of Group Environment of CLP Holdings Ltd. A chartered Chemical Engineer by training, he also hold qualifications in business and law. Apart from CLP's core work, he is also widely engaged externally with local and international organisations as CLP's representative.

Mr J Robert GIBSON
Fellow of Civil Exchange

J Robert Gibson is a Fellow of Civic Exchange, an Adjunct Professor in the Division of Environment at Hong Kong University of Science and Technology and a member of the Hong Kong Institute of CPA's working group on Sustainability and Integrated Reporting. He focuses on mechanisms for making capitalism more sustainable and facilitating action by business to mitigate greenhouse gas emissions and adapt to climate change. Robert studied Engineering Science and Economics from Oxford University and worked as an Engineering Apprentice before qualifying as a Chartered Accountant in the UK. He has lived in Hong Kong since 1980. He worked for the Swire Group up to 2010 including being the Director Sustainable Development for John Swire & Sons (HK) Ltd from 2007 to 2010.

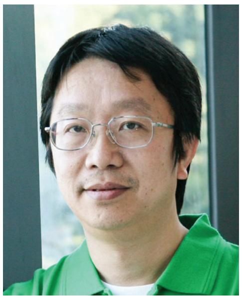
Mr Joshua HODGE
Deputy Executive Director for Resource Development, Joint Program and Center for Energy and Environmental Policy Research (CEEPR)

Massachusetts Institute of Technology (MIT)

Prior to joining MIT, Hodge ran the Commodities Research and Forecasts business, Americas, at Thomson Reuters where he managed the launch of the firm's North American carbon, power and gas forecast modeling services. Previous to Thomson Reuters, Mr. Hodge was Managing Director, North America, at Point Carbon. Joshua holds an MBA from the University of Virginia.

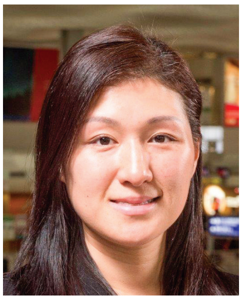
Ir C K LAU
General Manager (Projects), The Hongkong Electric Co Ltd

Ir Lau received his Associateship in Electrical Engineering from Hong Kong Polytechnic in 1977. He has been working in the power industry for over 30 years. He joined The Hongkong Electric Co. Ltd. in 1977 and is now the General Manager of Projects Division overseeing the design, construction and project development for generation, transmission system and renewable energy projects. He is a member of the Hong Kong Institution of Engineers and the Institution of Engineering and Technology in the United Kingdom.



Professor Alexis LAU
Director, Atmospheric Research Center, The Hong Kong University of Science and Technology

Alexis Lau PhD (Princeton Uni.), JP: Director of the Atmospheric Research Center, and Co-Director of Institute for the Environment at HKUST. His research specializes in Air Quality (AQ), Weather and Climate. He has served on many local and international panels and also as a part-time member of the government's Central Policy Unit.



Ir Sophia LAU
Manager, Environment, Airport Authority Hong Kong

Ir Sophia Lau is a Chartered Environmental Engineer whom has over 15 working experience in environmental field. She joined the aviation industry in 2007 as an Assistant Environmental Manager in Cathay Pacific where she developed the carbon offset programme – the fly greener programme for CX. Sophia joined the Airport Authority Hong Kong in 2009 and was the project manager for the HKIA carbon reduction programme. She is currently the Manager, Environment of AA, responsible for developing and implementing environmental strategies to reduce environmental footprint of Hong Kong International Airport.

Mr Wai-chuen MOK, JP
Assistant Director (Air Policy), Environmental Protection Department, HKSARG

After graduation, Mr Mok started his career with the power industry and then joined the Government in 1987 as an Environmental Protection Officer. Before taking up the post of Assistant Director of Environmental Protection (Air Policy), he worked in different air quality areas including air dispersion modelling, air planning, vehicle emission control, and others. He is now responsible for the formulation and implementation of air quality management policy.

Ir Roberto VAZQUEZ
Acting CEO, ASB Biodiesel (HK) Ltd

In June 2012, Ir Vazquez joined ASB Biodiesel (Hong Kong) Ltd, an investment of Al Salam Bahrain Bank. From September 2014, he is acting CEO. He holds an MS degree in Industrial Engineering, an Executive MBA from IE Business School and a BS degree in Physics.

Ir Alex WONG
Deputy Director – Safety, Health, Environment & Quality (Generation)
CLP Power Hong Kong Ltd

Ir Alex Wong is the Deputy Director – Safety, Health, Environment & Quality (Generation) of CLP Power HK Ltd. He is responsible for managing safety and environment performance of Generation Business Group. Before his current position, he held a number of engineering and managerial positions in network planning, operations, maintenance, asset management and metering services.

"Shaping a Better World with Green Living "

HKIE Environmental Division Annual Forum

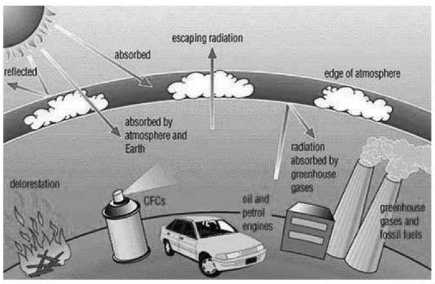
Ir Dr the Hon LO Wai Kwok, SBS, MH, JP
BSc(Eng) MSc(Eng) MBA EngD CEng FHKIE FIET FIMechE FHKEng RPE
盧偉國 議員 博士 工程師

18 April 2016

1

Hong Kong experienced very cold days this winter

Photo source: Internet



While Industrialization has brought to us modernization, it has also caused depletion of fossil fuels, global climate change, deforestation, degradation of our soils, depletion of the ozone layer, pollution of air and water, etc.

3

Urgent tasks ahead for the world

- Reverse global warming
- Reduce CO2 emission
- Optimize fossil fuel consumption
- Develop alternative energy source
- Transition to 100% sustainable Green power
- Maintain balanced economic growth
- Devise economic tools & political will power to make the above happen

Questions : Is there a solution at all?

Too little & too late?
Mission impossible???

Solution:

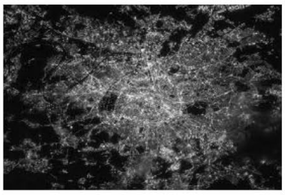
low carbon living

smart use of energy
green building

waste management

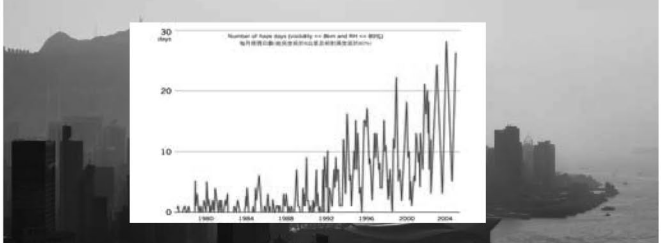
Hong Kong Situation

Electricity generation accounted for about 67% of our total emissions in 2008. Close to 90% of our city's electricity is consumed in buildings. In other words, electricity consumed by buildings contributes to about 60% of Hong Kong's GHG emissions.

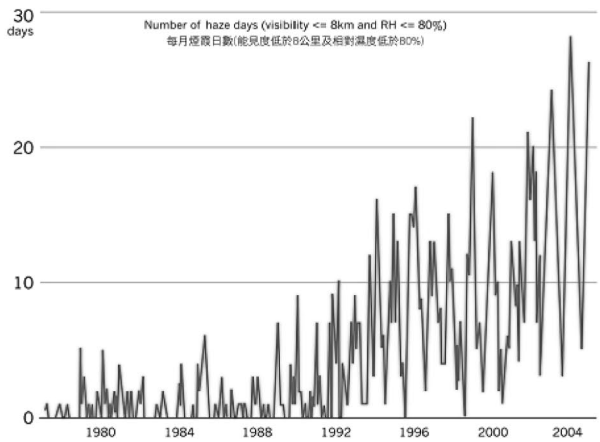


Hong Kong Air Pollution Problem

- Smog
- Poor visibility
- Hazy days increased over the past 20 years

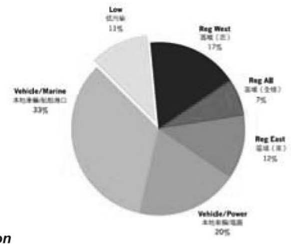


Source: Relative Significance of Local vs.Regional Sources: Hong Kong's Air Pollution



- Based on a study conducted by the Hong Kong University of Science and Technology in 2007
- Regional sources contribute to 36% air pollution
- Local sources contribute to 53% (crucial)

- Reduce local emission
  ---> improve air quality



Source: Relative Significance of Local vs. Regional Sources: Hong Kong's Air Pollution

Local Sources of Air Pollution

- Diesel commercial vehicles account for 88% of vehicular emissions of respirable suspended particles (RSP) and 76% of nitrogen oxide emissions (Paper by Civic Exchange in 2010)
  http://www.civic-exchange.org/wp/wp-content/uploads/2010/08/Non-road-mobile-sources-CE-Submission.pdf
- High-sulfur fuels used by the ships also release high amount of sulfur dioxide

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Main Sources of Air Pollution

The Hong Kong Government has collaborated with Guangdong on reducing emission of four major pollutants – SO2, NOx, RSP and VOC.

At present, Hong Kong's air quality is broadly comparable to some Asian cities such as Seoul and Taipei

Reduce Road Side Emission

TAXIshare
save money and the environment

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- **New target of achieving a 5% saving in electricity consumption for government buildings in the coming five years *(2015 policy address)***

- **Energy Saving Plan for Hong Kong's Built Environment 2015-2025+ *(2016 policy address)***

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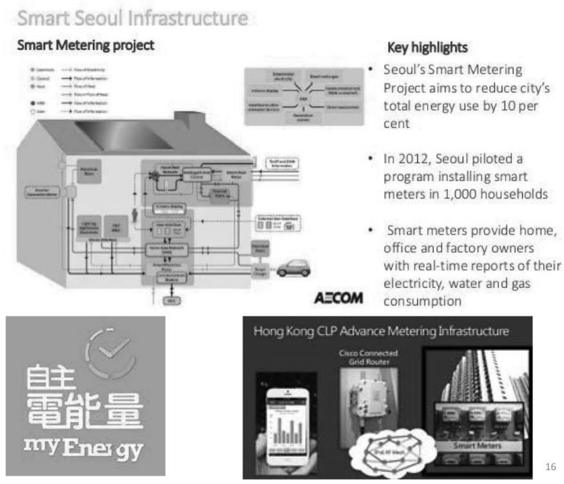

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HK3030

Using the electricity consumption level of 2005 as the yardstick, it seeks to reduce the electricity consumption of buildings territory-wide by 30% by 2030.

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HK3030

25 recommendations have been put forward to develop Hong Kong into a low carbon city so far.

key recommendations:
1.Public Education
2.Citywide Electricity Consumption
3.More Stringent Requirements for GFA Concessions

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Government Initiatives

- **Install energy efficiency facilities in government buildings**
- **Set up Steering Committee on the Promotion of Green Building**

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In light of Hong Kong's unique conditions such as its high developments density and hot and humid weather, we have our locally developed BEAM Plus assessment tool to set a new benchmark of excellence for green buildings.

Source: https://www.hkgbc.org.hk

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Bill on District Cooling Services

- assumed the role of Chairman of the Bills Committee in LegCo
- District Cooling System (DCS) in Kai Tak Development (KTD) is an air-conditioning system with relatively higher energy efficiency
- consumes 35% less electricity as compared with traditional air-cooled air-conditioning systems and 20% less electricity as compared with water-cooled air-conditioning system using cooling towers

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Bill on District Cooling Services

- reduce the total building cost by about 5% to 10%, enabling more flexible building designs, reducing heat island effects
- provide a more adaptable air-conditioning
- help to develop Kowloon East as a green community
- apply to other new development areas

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Government Initiatives

- Buildings Energy Efficiency Ordinance
- Mandatory Energy Efficiency Labeling Scheme (MEELS)
- Bills Committee on Promotion of Recycling and Proper Disposal (Product Container) (Amendment) Bill 2015
- Bills Committee on Promotion of Recycling and Proper Disposal ((Electrical Equipment and Electronic Equipment) (Amendment) Bill 2015

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Regional Circular Economy

- Promotion of the waste recycling industry cannot possibly depend on Hong Kong alone
- Regional co-operation must be promoted
- Urged the Government to assist the industry in the non-local sale of local green products and technologies
- Enhance our co-operation with the Mainland in the areas of waste recovery, handling and recycling, and so on

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- develop a low-carbon, high-tech and low-pollution city cluster
- promote the development of an environmental protection industry
- foster cross-sector co-operation in recycling and reuse

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Proposals of the Plan

1. setting up a regional co-operation committee on environmental industries
2. driving the development of the eco-conference and exhibition trade
3. setting up a professional website and promoting the establishment of an e-commerce platform for environmental industries
4. exploring a new mode of cross-boundary co-operation in the reuse of recyclable materials through pilot projects
5. jointly promoting the research and application of recycling technologies to upgrade the independent technological research capability of the "regional circular economy"

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email: wklo@engineer.com
Website: www.irdrwklo.hk

ADAPTING CLIMATE RISKS – CLP'S EXPERIENCE

Simeon Cheng
Senior Manager – Group Environment, CLP Holdings Ltd

Alex WK Wong
Deputy Director – SHEQ (Generation), CLP Power Hong Kong Ltd

INTRODUCTION

There can be no doubt that the Earth's climate has been changing. There are ample examples to demonstrate this. Superstorm Sandy hit the eastern coast of US in October 2012, resulting in one of the most expensive extreme weather events in history, causing more than 200 deaths and creating damage as much as $65 billion USD[1], with power outages effecting 8 million residents. Our power stations in Mainland China, Taiwan, and Australia were all affected by the changing climate to various extents. Fangchenggang Power Station in Guangxi and Ho-Ping Power Station in Taiwan were hit by typhoons stronger than ever before, and Australia experienced a period of draught within the last decade. Some may argue that scientifically one cannot, in absolute terms, attribute these to anthropogenic climate change. It is however, indisputable that climate is changing.

CLP has, through its Climate Vision 2050, committed to a range of initiatives to mitigate climate change, including moving towards a much less carbon intensive portfolio, and to reduce emissions over time. On the other hand, we have also started to look into assessing the impact of climate change on our power stations and the associated adaptation options about a decade ago.

Objective of this Paper

This paper provides information on how CLP approached the assessment of climate change impact on its power stations and how adaptation measures were adopted.

What are the Impacts of Climate Change?

In general, common changes in weather patterns include hotter and drier summer, heavy rainfall, more typhoons, heat waves, high winds, warmer autumns and springs, etc. Changes in weather condition could result in business disruption, unexpected maintenance costs and even safety concerns for people. Figure 1 below illustrates how the impacts of changing climate patterns can result for a business. However, it is often more complicated as impacts can lead to other unexpected consequences, e.g. insurance claims by customers, loss of business opportunities, supply chain interruption, increase in raw material prices, etc.

1 National Oceanic and Atmospheric Administration, 2013

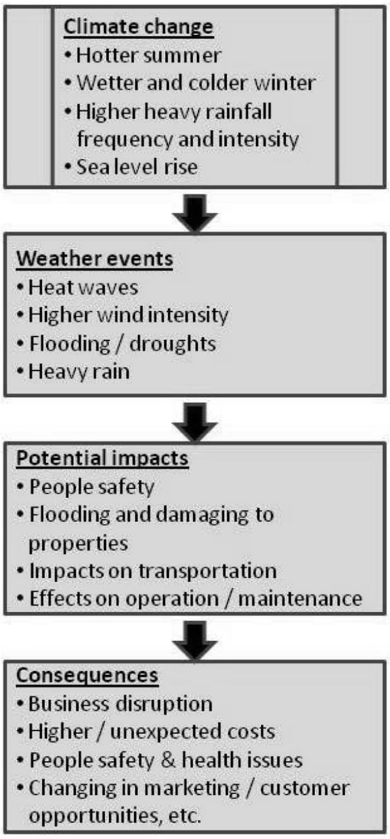


Figure 1: Climate change and business impacts / consequences

Vulnerability and Adapting Capability

In the power sector, the physical assets, infrastructure, day to day operation and maintenance, logistics and supply chain could all be sensitive to climate change, and many of these are site and operational type specific. Conventional energy power stations and renewables, due to their difference in operations and localities, are subject to different impacts from the changing of climate / weather patterns, directly and indirectly affecting business performance and profit.

Figure 2 below demonstrates the relationship between vulnerability and adapting capacity of a business.

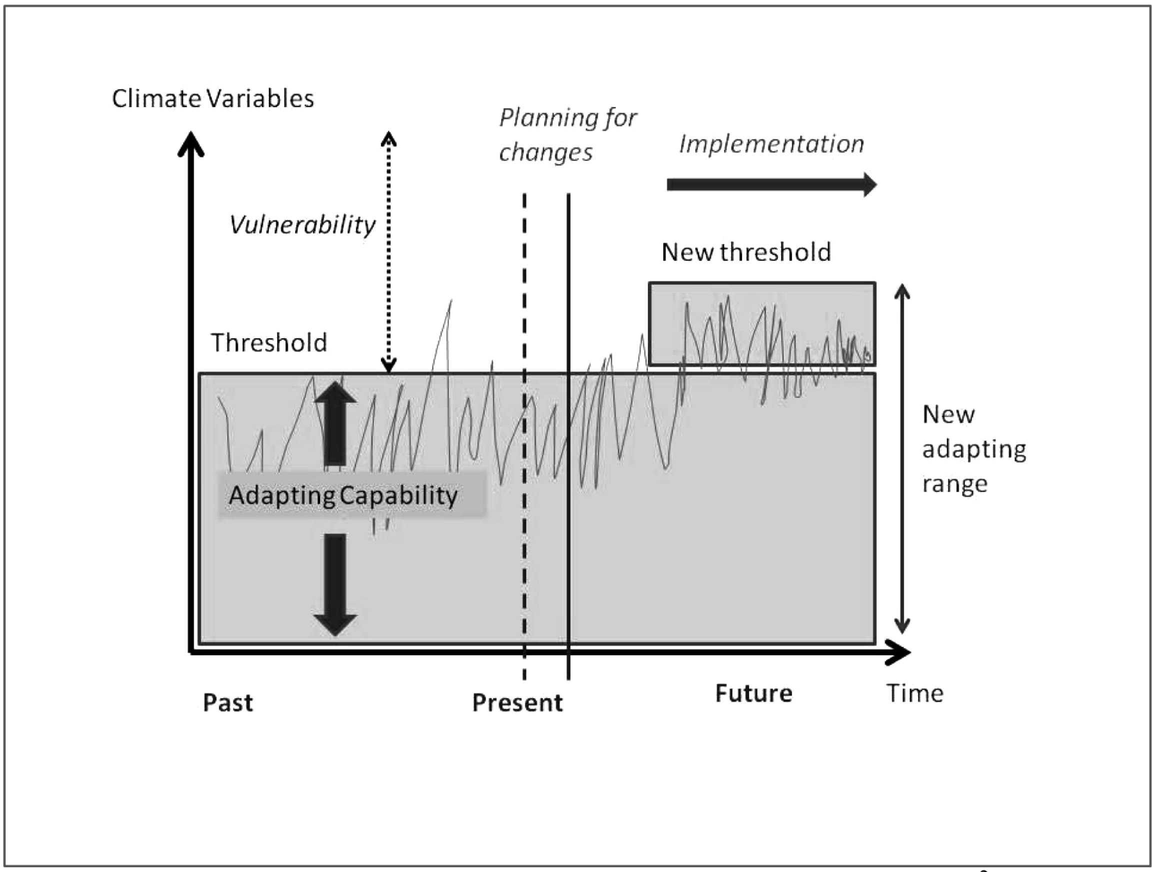


Figure 2: Vulnerability and adapting capacity of a business[2]

Climate Change Impact Assessment Approach

The overall assessment flow itself[3] is quite clear. Figure 3 provides an overview of the assessment tasks and activities. Further explanations of the study methodology are given in the sections that follow. The most challenging aspect of such an assessment is the uncertainties involved. The climate models are highly technical and under license arrangements. Resolution is not high, and the downscaling process is difficult and expensive. Assumptions also need to be made on future emissions scenarios. Furthermore, short term assessment is not possible as the emission scenarios have not yet happened.

[2] With reference to Willows, RI and Connell (2003), "Climate Adaptation Risk, Uncertainty and Decision Making", UKCIP Technical Paper, UKCIP, Oxford

[3] CLP Climate Change Adaptation Final Report, July 2014, ERM Hong Kong Limited

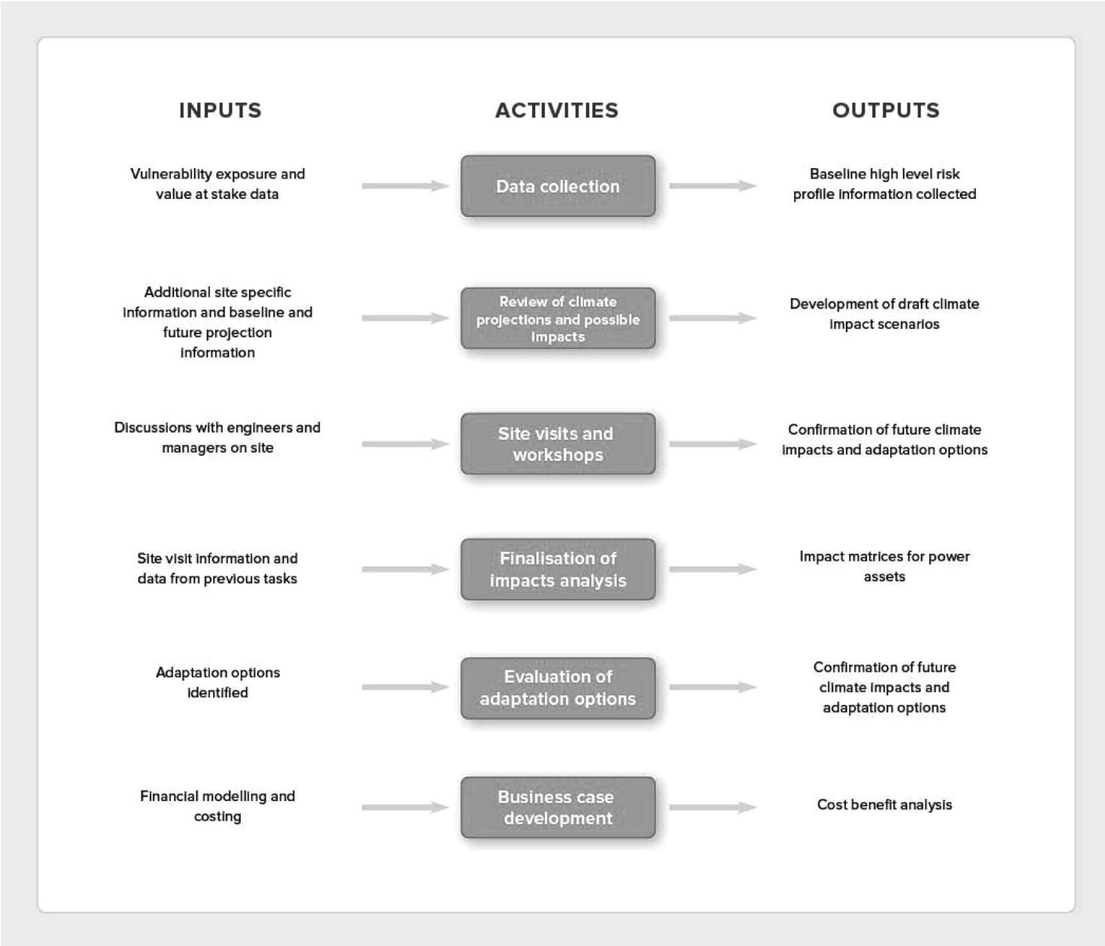


Figure 3: Typical assessment flow of CLP's climate adaptation assessment

Data Collection

This is the preparatory step in which information about the subject asset was collated. This includes historical weather data, site layout, as well as key potential vulnerabilities of the asset.

Review of Climate Projections and Possible Impacts

Future climate projections and impact scenarios for each asset were developed through climate models. The task was carried out through the review of publicly available information including the latest Assessment Report published by the Intergovernmental Panel on Climate Change (IPCC), and information obtained from the assets in relation to the impact of weather related events in the past and other data on historic weather patterns (e.g. temperature, rainfall and wind). The commonly used climate variables are increase in typhoon intensity / frequency; temperature, flooding, storm surge, wind gust etc. The specific set of climate variables were decided on a site specificity basis and the projected change in climate variables assessed against each key component required for the ongoing running of the asset being assessed.

Models approximate the complexity of the real world and consequently have limitations that affect the interpretation of results. Despite this, models enable complex issues to be examined logically and consistently across defined timeframes. As with modelling assessments, the modelling results require careful interpretations. It is therefore necessary to undertake sensitivity analysis to evaluate the robustness of the model's key findings. In addition, forecasting does not intend to predict the future, but rather is an assessment of what would likely happen given the structure of the model and its input assumptions.

Given the inherent and considerable uncertainties in predicting future weather events, scenario based approach was adopted to define future climate change impacts. High, Medium and Low future climate impact scenarios were developed for the physical impacts most likely to affect the operations.

Risk Analysis

Once a range of climate change impacts and risks were identified, the risks were assessed on assets, operational and supply chain to broadly understand which business areas are most vulnerable to changing climatic conditions. Descriptions of the three risk categories used are:

- **Asset risks** predominantly cover climate change impacts and risks to electricity infrastructure assets and equipment critical for the operation of the plant and generation of power.
- **Operational risks** refer to risks that hinder the plant's ability to generate power either efficiently or at all.
- **Supply chain risks** are risks from extreme weather events or climate change that affect critical logistic operations e.g. supply of coal to site or electricity transmission grid.

Onsite Workshops

An onsite workshop would be held to go over the climate risk matrix. Holding workshop with site operators was an important step because this allowed us to develop a more detailed understanding of the operations and physical conditions surrounding the sites and to discuss how weather has affected operations in the past with engineers and managers on site. Furthermore, the on-site engineers and managers were those who would ultimately be responsible to consider and adopt the proposed adaptation measures. Any adjustment would then be made subject to the discussions help onsite.

Evaluation of Adaptation Options

Adaptation options would be established at this point for the asset being assessed to prevent or reduce negative impacts, and sometimes enhance positive impacts of future physical climate and energy demand scenarios. The basis of this task was built upon the adaptation options identified with the site-level staff during the interactive discussion workshops.

Cost Benefit Analysis

A cost benefit analysis (CBA) supports the decision making process by giving monetary values to the risks and opportunities and enables a comparison of like quantities. A CBA was conducted for the impacts identified. The criteria used include factors such as cost, effectiveness, impacts and benefits of each adaptation option:

- **Cost**: The estimated cost to implement an adaptation solution.

- **Effectiveness**: The likely level of success that an adaptation solution may have in mitigating a climate change induced risk. The risk rating (for example high versus medium) is included when considering the effectiveness of the solution.
- **Environmental and social impacts**: The negative impacts an adaptation solution may have to the surrounding environment and local communities.
- **Financial and social benefits**: The scale of financial savings and social benefits such as efficiency, safety and environmental improvement an adaptation solution may provide.

Climate Risks and Adaptation Options

From the climate assessments we have performed on our conventional and renewable power stations under our operation, we have noticed both similar and site specific climate risks and adaptation options. The table below listed some of the findings as examples:

Conventional Energy Power Stations	
Examples of identified higher risk items	**Examples of adaptation options**
Dust and wind storms impacting buildings, facilities and equipment.	Develop an extreme weather safety program focusing on activities and behaviour prior to, during and after fog, dust, wind and lightning storms, heat waves and flood.
Increased rainfall and flood to coal yard creating wet coal reducing efficiency	Cover a section of the coal yard to protect from rain and assist in moisture control. This may also reduce self-ignition from higher temperatures by providing shading.
Increased temperature related impacts to human health and productivity	Educating employees on appropriate behaviour and restricting activities during extreme weather events will help reduce employee accidents and fatalities.
Ambient temperature increase	Model the thermodynamic processes to identify changes in plant performance output expected by higher temperature. Adjust operations and maintenance to manage temperature increases. Arrange placement of temperature prone equipment in lower temperature environments on site if possible. Increase preventative maintenance work prior to high temperature months. Additional temperature protection (insulation), fan cooling and air conditioning for critical electrical equipment may be required for high temperature days. Heat sensitive equipment that cannot be protected by shading or cooled by air conditioning could be cooled externally by high pressure misting (fogging) systems.

Renewable Energy Power Station (the following example is a windfarm)	
Examples of identified higher risk items	**Examples of adaptation options**
Increasing Extreme Weather Events	• Improvement of road surfaces and drainage channels • Strengthening and stabilizing transmission towers • Increased inspection & monitoring of internal grid & access roads Develop emergency response plans • Ensure back-up supplies and materials are available to minimize disruption and downtime • Monitor the frequency and intensity of wind gusts and ensure appropriate insurance for turbine downtime and damage is maintained • Increase the resilience of local communities to extreme weather and climate change.

The following section provides a more specific case study on how climate adaptation measures are taken in CLP's power stations and network in Hong Kong.

Climate Adaptation Case Study – Hong Kong

Serving the Hong Kong community for 115 years, CLP provides world-class electricity supply reliability at over 99.999%. Between 2013 and 2015, on average a CLP customer experienced 1.5 minutes unplanned power interruption every year, a level which is much lower than New York, London and Sydney. Our way of life in Hong Kong, based on the high rise buildings where we live and work, means that we are uniquely dependent upon an extremely reliable electricity supply. Because of climate change, extreme weather conditions occur more frequently with stronger destructive power, posing an increasing threat to power supply reliability.

There were over 180 typhoons passing by Hong Kong within 300km from 1951 to 2014. At least four super typhoons hit Hong Kong during the period. A super typhoon can produce violent winds, powerful waves and storm surges, and torrential rains and floods which may pose potential threats to power supply through damage to facilities.

Preventive measures: Super Typhoons

CLP Power has implemented a number of measures to counter the potential impact of super typhoons since 2004. These include enhancing the structure of the 400kV pylon to withstand super typhoons with wind gusts up to 300 km/h, the creation of a typhoon response protocol and coordinating system. These measures, together with regular drills, are aimed at constantly improving CLP's ability to respond to emergencies and to maintain a safe and reliable electricity supply.

With incidents of super typhoons increasing globally, CLP has implemented an Emergency Restoration System to enable the rapid construction of temporary pylons, shortening the time it takes for power to be restored when an existing pylon is damaged from several months to just two weeks.

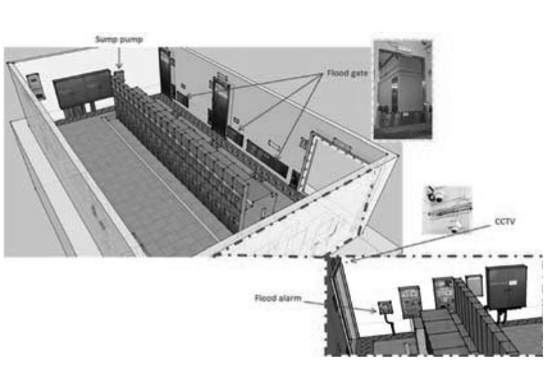
A temporary pylon (left) constructed in an emergency drill, alongside a conventional pylon (right).

Protecting Ourselves from Storm Surges

A storm surge is triggered by a raised sea brought about by tropical cyclones. If this coincides with a spring tide, water rises much higher than normal sea levels and causes severe flooding in coastal areas. An example of this was Hurricane Sandy which caused a storm surge in New York in 2012, flooding five substations and causing a loss of power to more than 2 million customers for periods ranging from four days to two weeks.

Hong Kong faces a similar risk from storm surges. In 2008, Typhoon Hagupit swamped Tai 0 with floods up to three metres deep in low-lying areas. Several hundred households were affected. In 2013, Super Typhoon Usagi, if it had taken a slightly more southern route, would have followed the same trajectory of Typhoon Wanda in 1962 and might have caused the sea levels in Victoria Harbour to rise to four metres.

We conducted flood risk assessments to determine if further mitigation measures would be needed to cope with the possibility of increased severity of storm surges and the global trend of rising sea levels as a result of climate change. A number of preventive measures have been done at targeted CLP generation, transmission and distribution substations, which included installation of flood gates, sealing of the cable inlets and equipping the substations with sump pumps and flood alarm systems. Besides, a flood calculator, which estimates the flooding risks at CLP substations based on the Hong Kong Observatory's latest information on estimated sea levels, was launched which would allow for timely supervision and coordination by operations centre to ensure supply reliability.



Preventive Measures: Vegetation Management

More than 30% of CLP Power's transmission network is carried through overhead lines which are prone to be affected by foreign objects. Hong Kong has a large number of fast-growing tree species, and trees that make contact with power lines can interrupt the normal power supply.

CLP set up its vegetation management team in 2001 to perform daily checks on power cables, and to adopt vegetation management techniques such as pruning trees that might affect overhead power cables. The pruning of trees can be carried out even when the lines are carrying live electricity in order to reduce the disturbance to the customers. Thanks to the team's efforts, the number of power failure incidents caused by trees has been reduced by 80% since their work began.

The above measures have helped strengthen CLP's emergency response capability and provide a safe and reliable power supply to our customers.

CONCLUSION

Climate adaptation for the energy sector typically includes measures that build power system resilience – to resist and recover from the effects of extreme whether events – and also flexibility – so that the power system is agile enough through speed, form, amount and efficiency to ensure stable supply. Ms. Joyce Coffee, Managing Director, Notre Dame Global Adaptation Index (ND-GAIN) commented that, "An effective way to lessen the harm from natural disasters and extreme weather events, due to climate change or other causes, is through improvement in the resilience and adaptability of the infrastructure, community and associated supporting systems to address prevalent and emerging risks."

DAMAGE ASSESSMENTS OF COASTAL FLOODING FOR HONG KONG AND THE PEARL RIVER DELTA DUE TO CLIMATE CHANGE-RELATED SEA-LEVEL RISE

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Abstract: *The adverse impact of climate change associated extreme weather events are becoming more significant globally, particularly the flood impact on coastal and low-lying areas such as the Pearl River Delta (PRD). This study used a quantitative framework to obtain order-of-magnitude estimations of human and economic damages from potential severe flood events caused by sea level rise for the PRD region in southern China by 2100. The assessment framework employs statistical analysis to combine different source of climate and social-economic data to assess the potential damages. It is found that without adaptation, sea level rise will significantly increase the flood risk in this region. For instance, in the PRD region, with a 75 cm sea level rise by 2100, the annual deaths, displacements and economic damage is estimated to be around 2000, 15 million and US$40 billion, respectively. Our results provide motivation for regional authorities to adopt a long-term adaptation plan to reduce exposure and vulnerability to flooding, thus managing the risks in this region.*

1. INTRODUCTION

Worldwide, flooding is a major natural disaster affecting many communities throughout history. Globally, flooding killed about 100,000 persons and affected over several million people each year in the last decade of the 20th century (Jonkman, 2005; UNISDR, 2009). In terms of economic losses, floods are the number one natural disaster, accounting for over one third of the total estimated cost of all the natural disasters (Loster, 1999). Jongman et al. (2012) estimate that 75% of people exposed to 100-year river flooding are currently living in Asia. In coastal areas, floods can be more harmful due to the average population densities in coastal areas are around three times higher than the global average (Small & Nicholls, 2003). With sea level rise (SLR) due to climate change in the background (Church et al., 2013), higher, more frequent and more damaging storm surges are expected in the short-term future.

The Pearl River Delta (PRD) region in Guangdong province is the third largest river system in China, and it is one of the world's economical dynamic region. This region is vulnerable to the rising sea level and is also frequently affected by storm events and associated coastal flooding. The Shuttle Radar Topography Mission shows that the elevation of a large area of the PRD region is below 2 m (Jarvis et al., 2008). Hong Kong and the PRD is affected by about six tropical cyclones per year, and its low-lying areas are susceptible to the associated storm-surge floods with high water levels (Lam & Lam, 2005; Li & Li, 2011; Zhang, 2009). The direct economic loss due to storm surge event reached more than 10 billion RMB.(Zhang et al., 2008). Some studies focusing on global coastal cities have also suggested that the assets exposed to extreme sea levels in HK and PRD cities (e.g., Guangzhou and Shenzhen) are significant at tens of billion USD (Hallegatte et al., 2013; Hanson et al., 2011). This study uses a framework focused on assessing the potential flood risk in HK and the PRD region by 2100.

2. DATA AND METHODOLOGY

DATA

The sea level data are collected hourly by Hong Kong Observatory (HKO) at the North Point and Quarry Bay stations. The annual average sea level from 1957 to 2012 in HK is shown in Figure 1 with increased at an average rate of 21±3 mm per decade. The maximum value of the 24-hour record within the day was selected as the daily maximum tidal gauge data and was used to characterize the extreme sea level for HK and PRD region from which the return period of coastal flooding due to storm surge is obtained. Global Flood damage data are built on the *Global Active Archive of Large Flood Events*, which is developed and maintained by the Dartmouth Flood Observatory (DFO). We mainly use the ***Damages*** (deaths, displacements, economic damage) and flood magnitude (is a logarithm function (base 10) of the product of flood severity, duration and affected area) from the DFO archive from 1985-2013 (Brakenridge, 2014). The social-economic data are from World Bank (2011) and Guangdong Statistical Yearbook (2011).

Our methodology is based on a sequence of steps in statistical analysis. We project the future sea level at certain return period (1-to-100-years event) to current return period by using daily maximum sea level by applying Generalized Pareto Distribution. The future sea level project is following the Fifth Assessment Report Intergovernmental Panel on Climate Change (IPCC AR5), with 40 cm – 75 cm by 2100 (Church et al., 2013). Subsequently, we establish the relationship between flood return period and flood magnitude based on the parameter definition of DFO dataset. The vulnerability factors for Hong Kong and the PRD are estimated from the social economic-data compared with the related countries in the DFO dataset. Due to we just focus on the order-of-magnitude estimation, in study we only focus on two countries with the most flood cases in DFO, namely, China and U.S. The vulnerability factors of Hong Kong and the PRD region are estimated from the two countries. Finally, the future damage assessment is estimated by regression analysis on flood magnitude-damage function for HK and the PRD that integrate the results of exposure and vulnerability sectors.

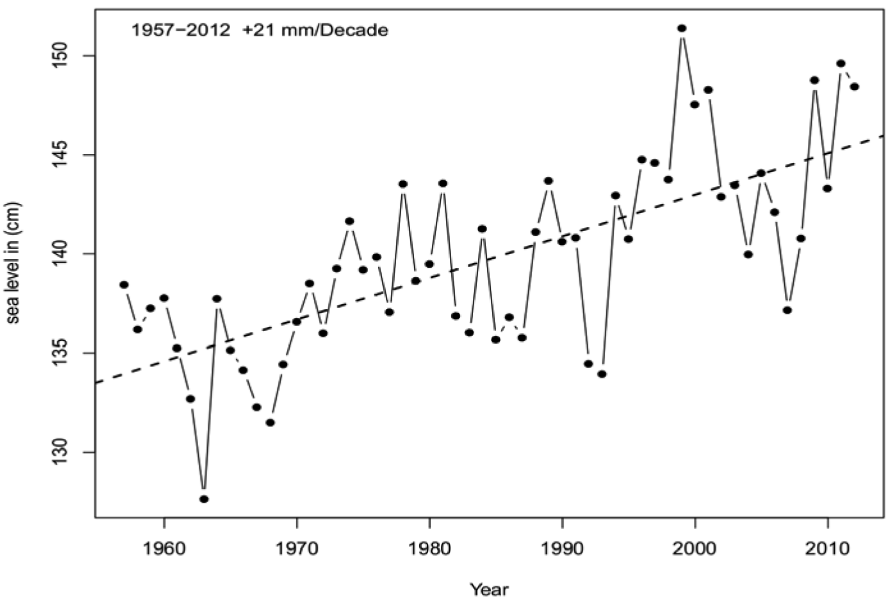

Figure 1: Annual mean sea level values at NPQB station in Hong Kong (1957-2012).
On average, the mean sea level in NPQB station rose at a rate of 21 mm per decade during 1957-2012.

3. RESULTS

Figure 2 shows decreasing of flood events return period as a function of mean sea level rise (MSL) since 2000. With sea level rise 40 cm (the lower projection from IPCC AR5) a 200-years flood events will become to a 20-years event. However, as the higher level projection, with 80 cm sea level rise, the 200-years events will become to an annual event. However, the impact the flood events is different for different regions. Figure 3 illustrates the difference in the number of people killed between China and the U.S. as a function of flood magnitude. It shows that the slope of China and the U.S. are remarkably different, at 0.61 and 0.27, respectively. The difference in the log-linear regression slope indicates that on average, at the same flood magnitude level, the U.S. experiences far fewer deaths than China. For instance, at a flood magnitude of 8, the estimated total number of deaths is about 130 *(exp(8*0.61))* in China and only 9 *(exp(8*0.27))* in the U.S. This characteristic could be considered as a vulnerability difference, and the slope value here is regarded as vulnerability factors. Using the same method, we estimate the other two damages (displacements and economic damage). Subsequently, we selected the two related social-economic data (population density and GDP per capita) to identify the vulnerability factors for Hong Kong and the PRD region. Consider the high population density of Hong Kong and relative lower GDP per capita than U.S., we estimate the vulnerability factors for Hong Kong is 1.5 times higher than U.S., and for PRD region, we are following the same number with China. By combining the two results, we estimate the annual average loss for Hong Kong and the PRD by 2100 due to future flood events.

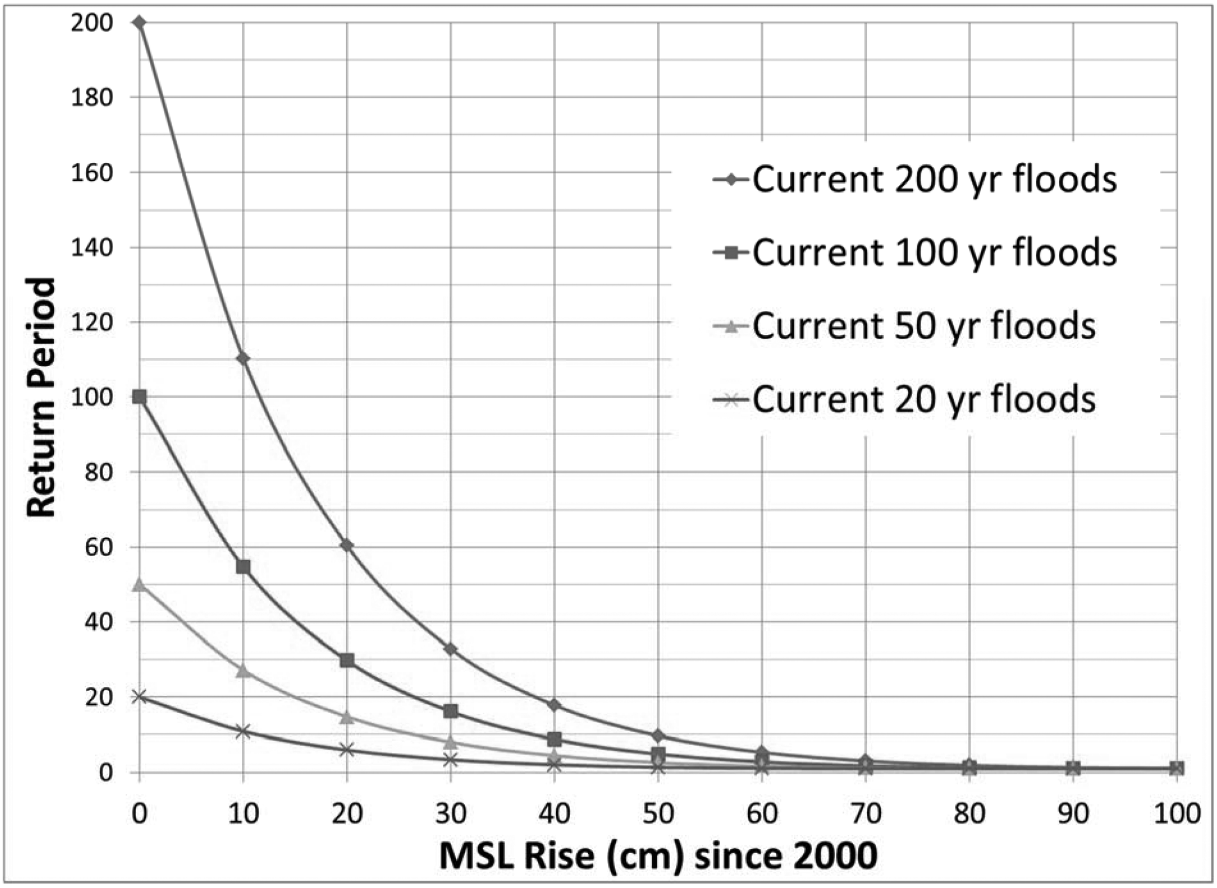

Figure 2: Shorten of the flood events return period as a function of mean sea level rise (MSL) since 2000

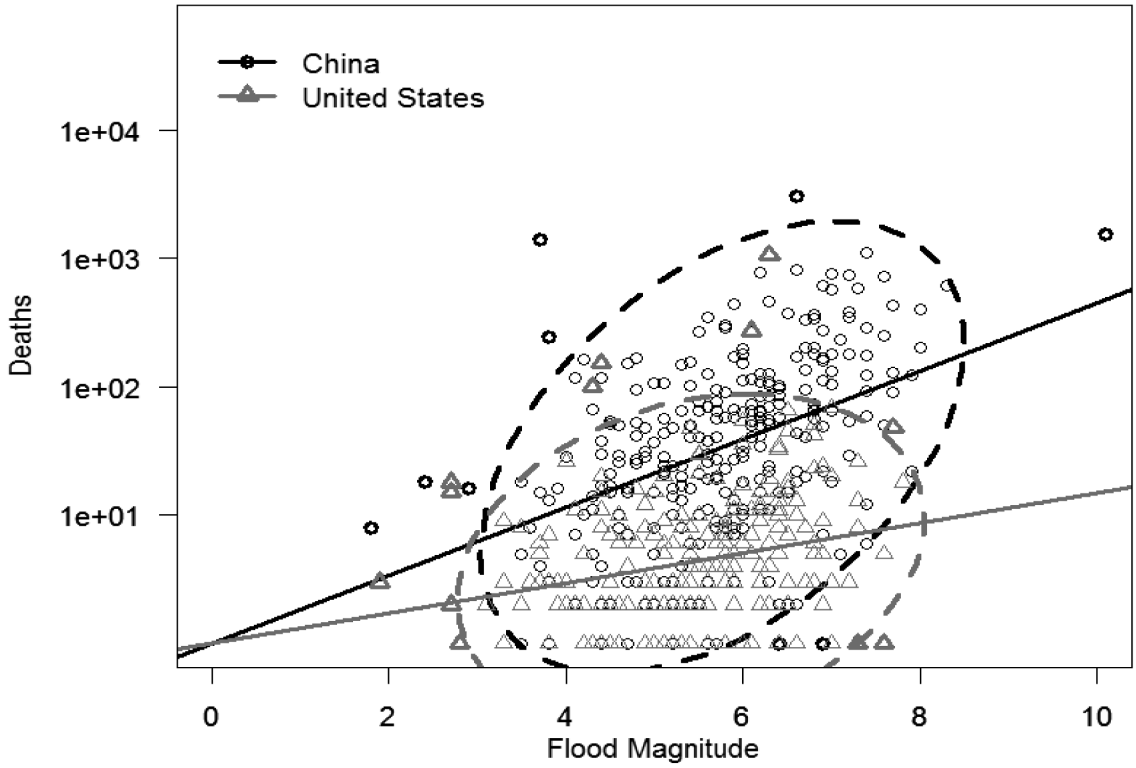

Figure 3: Logarithm of number of deaths as a function of flood magnitude in China and the U.S, the points in the ellipse are used for regression analysis, outside points are regarded as the outliers.

Table 5: Summary of annual average loss of future damages by 2100 for Hong Kong and the Pearl River Delta (PRD)

	PRD	**Hong Kong**
Deaths (people)	**300-2000+**	**200-1000+**
Displacements (people)	**1-15+ million**	**0.5-3 million**
Economic Damage (in 2013 USD)	**1-40 billion**	**1-4 billion**

4. CONCLUSIONS

Our results suggest that a region's flood vulnerability is partly related to its level of socio-economic development. The PRD region, which is less developed than Hong Kong, is more vulnerable to human costs (death and displacement). However, the economic losses suffered by Hong Kong could be considerably higher as a city. With a rising sea level, the probability of extreme coastal flood disasters of high magnitude will increase significantly. In the absence of proper protection and adaptation, potential losses can be very high. For example, with an SLR of 75 cm by 2100 the annual average loss in Hong Kong will lead to about 1000 deaths, 3 million people displacements, and $4 billion (in 2013 USD) in economic losses. In the PRD region, it will result in about 3000 deaths, 15 million people displacements, and $40 billion (in 2013 USD) in economic losses.

The Hong Kong government's Climate Change Strategy and Action Agenda has not incorporated a detail flood risk assessments (Environment Bureau, 2010). Even though the report outlined adaptation options such as monitoring (flood warnings) or updating flood risk maps, these options were not discussed in detail. This may be considered okay from a localized flood risk point of view because of the relatively highly topography and reclamation our infrastructure has been built upon. However, we emphasize that Hong Kong, like any other major cities, rely on nearby regions to provide and support its essential services (including food, energy and water).

Even Hong Kong is not physically flooded, a wide-spread and prolonged flooding of the PRD region (which our food and water supply is heavily depended on) may cripple Hong Kong's ability to function normally. We are all familiar with how much higher price we have to pay for food in the market after the passage of a storm or a particularly severe cold spell. A prolonged flood of over a couple of weeks, similar to those in Bangkok or Brisbane in 2011 in the PRD would not just affect the PRD, but also severely impact the livability of Hong Kong. Hence, it is critical for Hong Kong to take flood risks in the PRD more serious, and work with the PRD in climate adaptation and resilience planning to make sure that region and Hong Kong's ability to provide essential services can readily recover after a severe regional storm surge event.

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TOWARDS LOW-CARBON HONG KONG: HK ELECTRIC'S EXPERIENCE ON RENEWABLE ENERGY DEVELOPMENT

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Abstract: *The Hongkong Electric Co., Ltd (HK Electric) is giving unswerving support in reducing greenhouse gas emissions and investing in low-carbon future. Harnessing indigenous renewable energy including wind and solar energies is one of the effective means HK Electric has actively and positively perused. With the successful commissioning of HK's first commercial scale wind turbine on Lamma Island in early 2006, HK Electric has been carrying out further studies for developing an offshore wind farm of 100MW within the territorial waters in Hong Kong. The operation of the proposed offshore wind farm with an estimated annual generation of around 175 million units of electricity would offset emission of 150,000 tonnes of* CO_2*. Apart from exploring wind energy, HK Electric is also active in developing solar power projects. A solar PV system of 550kW capacity has been commissioned on the roof tops of the station buildings in Lamma Power Station in July 2010, representing the largest of its kind being in service in Hong Kong. The capacity of this solar PV system has been increased to 1MW in 2013. The expanded solar power system is expected to generate more than 1.1 million units of electricity annually and reduce 915 tonnes* CO_2 *emission. This paper serves to share HK Electric's experience on renewable energy development for the migration to a low carbon future.*

FIRST COMMERCIAL SCALE WIND PROJECT – THE LAMMA WINDS

Recognizing the importance of sustainable development and the pressing need to improve air quality in Hong Kong, HK Electric commissioned the "Lamma Winds", Hong Kong's first grid-connected wind power station, in February 2006 at Tai Ling of Lamma Island. "Lamma Winds" is an 800kW wind turbine, and is the first utility scale renewable energy facility ever built in Hong Kong. Notwithstanding the green nature of the wind turbine project, a full EIA was carried out to ascertain the construction and operation of wind turbine for power generation would not cause unacceptable long term and cumulative impacts to the environment. The EIA has critically assessed the overall acceptability of any environmental impacts in relation to the issues including noise, ecological, landscape and visual, air quality and water quality. The EIA also specified the conditions and requirements for the detailed design, construction and operation of the wind turbine in order to mitigate the identified environmental impacts to the acceptable levels.

The EIA concluded the project would comply with all environmental standards and legislation upon implementation of specified mitigation measures, and there would be no adverse impacts on the environment. An Environmental Permit for construction and operation of the wind turbine on Lamma Island was issued to HK Electric in November 2004, and the wind turbine was put into operation in February 2006. By March 2016, "Lamma Winds" has generated about 9 million units of green electricity, offsetting more than 7,400 tonnes of carbon dioxide emission. It represents an average capacity factor of about 13% over the past few years with the highest in 2009 at 15.7%.

Fig. 1 – Lamma Winds

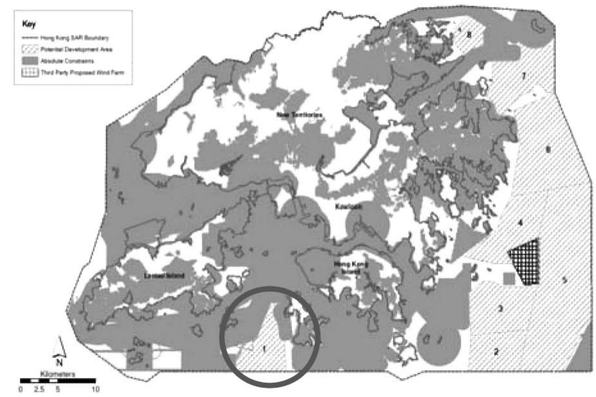

Fig. 2 – Potential Offshore Wind Farm Sites

Lamma Winds has not only enabled HK Electric to gain precious experience in utilizing wind for power generation, but also laid solid foundation for subsequent exploration of larger scale wind farm project in the territory.

DEVELOPMENT OF AN OFFSHORE WIND FARM IN HONG KONG

To help meeting the renewable energy target set out in the First Sustainable Energy Strategy for Hong Kong in 2005 for having 1-2% of the total power generation in the territory comes from renewable sources, HK Electric has since been keen to explore further feasibility for wind energy application.

As revealed from the Council for Sustainable Development, a wind farm viable to produce 1% of the electricity need for Hong Kong requires a land take equivalent to 240 Victoria Parks. Experience from Lamma Winds also supports that developing sizable onshore wind farms in Hong Kong is not viable due to the lack of land and onshore wind resources. As such, HK Electric considered developing an offshore wind farm within Hong Kong territorial waters being the way forward to achieve this sustainable target. To meet the Government's renewable objective, a wind farm of capacity 100MW was being considered.

Site Selection

HK Electric commenced a comprehensive territory-wide Site Selection exercise and Environmental Impact Assessment (EIA) study in 2006 to address all key environmental related issues for development of the proposed offshore wind farm. Related environmental, physical and social constraints were taken into consideration in order to identify the most appropriate location for the wind farm such that potential environmental impacts on sensitive areas can be minimized.

The wind farm siting assessment undertaken in accordance with the EIAO-TM identified 8 short-listed sites for further evaluation. Among these short-listed sites, the most preferable site was located at about 3.5km southwest of Lamma Island as it had the least overall environmental impacts. Other technical merits of the southwest Lamma site included the shallower water depth and the shorter transmission cable linking to Lamma Power Station compared with other potential sites in the eastern waters of Hong Kong. In addition, a rapid logistic support can be offered from Lamma Power Station during construction phase of the project, as well as the maintenance support during operational phase.

Environmental Impact Assessment

Detailed EIA study on Southwest Lamma Site commenced in mid-2008. It covered impacts on water quality, terrestrial ecology, marine ecology, landscape & visual, fisheries and other aspects. The EIA report concluded that there would be no significant adverse impacts on the environment, especially on water quality and fishery, associated with the wind farm construction and operation. The wind turbine foundation would altogether take up 0.16 hectare of Hong Kong waters. The report also revealed that loss of fishery operation habitat would be less than 1% of Hong Kong waters even if fishing was prohibited within the wind farm footprint area. A string of mitigation measures were proposed to further minimize any potential disturbance to the environment, particular on the marine mammals and avifauna species, including:-

- No percussive piling works from December to May
- Restriction on working vessels speed;
- Use of quieter hydraulic tools for foundation work;
- Establishment of an exclusion zone around the work area to minimize impact to marine mammal.
- Construction work to be temporarily suspended in case any marine mammal is spotted by qualified marine mammal observers.

The EIA report was approved on 14 May 2010 and HK Electric was granted an Environment Permit on 8 June 2010.

Technical Studies

Apart from the EIA study, HK Electric has engaged various consultants to look into the technical feasibility of the project, including verification of wind resources by computer simulations, technology review on the shortlisted wind turbine models, design options of the wind monitoring stations, impact on grid stability as well as potential marine navigation and aviation impacts, etc. Close contacts with major suppliers in the market and the offshore marine specialists have been maintained to explore the most practical solutions for tackling all the challenges associated with the project. Every detail is carefully studied and optimized to ensure smooth implementation of the project. These efforts will help draw up clearer criteria and direction for selecting suitable key components including type of wind turbine foundation, size and class of wind turbines as well as location and configuration of the substation, etc.

General Information of Wind Farm

Wind Turbine Arrangement

The planned capacity of the offshore wind farm is about 100MW featuring up to 33 wind turbines, each being 3 to 3.6MW which will be linked up by cables to an onshore substation in Lamma Power Station Extension where the output voltage will be stepped up for connecting to the main grid. The site boundary of the wind farm occupies an area of about 600 hectares and the water depth ranges between 17 and 23m. The preliminary layout is shown in Fig. 3.

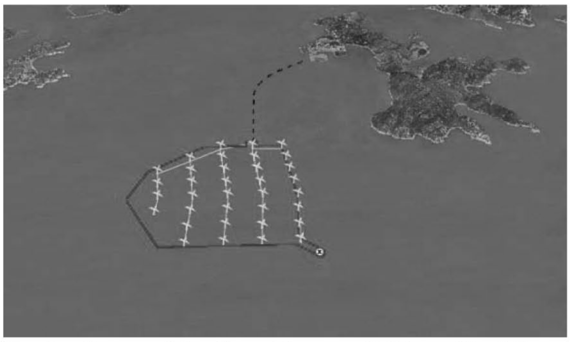

Fig. 3 – Proposed Southwest Lamma Offshore Wind Farm

Table 1 - General Information of Offshore Wind Farm

Location	3.5 km Southwest of Lamma Island
Wind Farm Capacity	100 MW
No. of Wind Turbines	Up to 33
Wind Turbine Capacity	3 – 3.6 MW each
Hub Height	Around 80m above mean sea level
Site Boundary Area	600 Ha.
Water Depth	17 – 23 m

Foundation Design

Different types of foundation design, viz: monopile, tripod, gravity base and suction caisson foundation have been considered in EIA study. Monopile foundation of 5-7m diameter was assumed in the EIA as the preferred design option as in view that it is commonly adopted in various European offshore wind farm projects. Construction time for monopile foundation is short, with piling of 30 wind turbines can be expected to complete in about 4 months. The foundation type will be finalized upon completion of a detailed study at engineering design stage.

Wind Turbine Installation

The turbine components will be delivered to Lamma Power Station Extension serving as a harbor to provide lay down area for the pre-assembly works. Once assembled, the turbine components will be transferred to an installation vessel for the subsequent on-site erection works. HK Electric is currently open for all viable installation options and will keep observing the industry practice and availability of jack up barges suitable for the offshore installation works.

Wind Monitoring Station

Background

To facilitate detailed engineering design and wind farm optimization, HK Electric has set up a wind monitoring station at the wind farm site to collect meteorological and oceanographic data that are necessary for detailed design of the wind farm. The wind monitoring campaign has been commenced since March 2012. The station adopts the technology of Light Detection & Ranging (LIDAR) system, which makes use of the Doppler shift of a laser beam scattered by microscopic airborne particulates to measure the wind speed. The LIDAR system is now receiving more attention from developers and consultants in the field in recent years as it has a number of technical advantages when compared with the conventional tower structure wind monitoring mast, including:

- High portability suitable for adopting as temporary installation for short term wind monitoring.
- Foundation design requirement for the temporary offshore platform will be far less stringent, hence substantial reduction in foundation cost and construction time.
- Overall installation cost lower than a provision of a full height met mast.

An independent certifying body has been engaged for project validation including design verification, site installation audit and certification of measured data to ensure the meteorological and oceanographic data collected by the wind monitoring station is suitable for detailed design of the offshore wind farm.

Construction Challenges

Construction of the offshore wind monitoring station was much of a challenge. The weaker soil stratum encountered during the construction stage has resulted in a longer than expected pile length compared with the design. 4 steel foundation piles were driven by hydraulic hammer to about 60m below seabed to support the wind monitoring station structure which is subject to large wind and wave loads standing on soft marine mud.

Fig. 4 – Equipment Installation of Wind Monitoring Station

To alleviate the underwater noise during percussive piling, bubble jackets have been installed around the piles to minimize any impact to the nearby marine mammals. Marine mammal observers have been deployed on board the vessel to alert piling operator in case marine mammal was found within the 500m radius exclusion zone. Soft start of the pile hammering has been adopted to minimize disturbance to the mammals.

Gripping on hold of the favourable sea conditions was crucial for the success of work amid the highly exposed sea area. The entire offshore construction works fell onto the monsoon period spanning from October to February. To ensure smooth pursuance of the offshore construction in particular to the wind monitoring equipment installation process, on-shore preparation and testing were carried out in an advance stage to minimize the offshore working duration. A trial lifting was conducted at Lamma quayside to ensure safe lifting procedures to be followed in the offshore environment.

Fig. 5 – Overview of Wind Monitoring Station

Weather forecast data including the wind speed, wave height and current condition have been closely monitored for work planning, despite sudden work suspension would be required due to presence of the unexpected swell. A combination of crane barge and helicopter has been deployed for the successful installation of the wind monitoring station.

The wind monitoring station is powered by renewable energy installations comprising three sets of 600W small wind turbine and fourteen pieces of 95W solar PV panels on board of the station. A diesel generator is also provided as back-up to support its continuous operation if necessary.

Safety facilities including marine navigation lights, fog horn, remote surveillance, aviation lights, aviation marking and radar reflector, etc. are provided to ensure the wind monitoring station would not cause unacceptable impact to aviation and marine navigation safety.

The wind monitoring campaign is still ongoing aiming at collecting additional data for optimizing the offshore wind farm design.

Public Engagement

Public engagement is essential towards successful project development. As is the case for other offshore wind farm projects in Europe, development of the proposed offshore wind farm project in Hong Kong requires extensive consultation and engagement with stakeholders. Pursuant to conditions of the Environmental Permit, HK Electric has set up a Stakeholder Liaison Group and a Fisheries Review and Consultation Committee to solicit views from relevant stakeholders and the fishery sector in relation to development of the proposed offshore wind farm project.

Environmental Benefits

The offshore wind farm is expected to produce 175 million units of electricity per year, adequate for the consumption of about 50,000 4-person households in Hong Kong. It can supplant the use of around 62,000 tonnes of coal per annum, hence a reduction of 150,000 tonnes of carbon dioxide.

DEVELOPMENT OF THE LARGEST COMMERCIAL SCALE TFPV SYSTEM IN HONG KONG

Apart from wind energy application, HK Electric also explores wider use of solar energy for generation of clean electricity.

In mid-2009, HK Electric conducted a feasibility study for installing a solar photovoltaic system in Lamma Power Station which recommended installing a Thin Film Photovoltaic (TFPV) System of capacity 550kW with 5,500 photovoltaic modules, each of 100W nominal capacity on the rooftops of Unit 1-8 Main Station Building. The TFPV is grid connected to the electrical system of Lamma Power Station.

Environmental Considerations

Although the TFPV system is an emission free power generation system and the existing Lamma Power Station is an exempted designated project under the Environmental Impact Assessment Ordinance, a review on the environmental impacts arising from construction and operation of the TFPV project in accordance to Technical Memorandum on the Environmental Impact Assessment Process has been conducted. It was concluded that the development of the TFPV would have insignificant changes to the surrounding environment.

Selection of PV Module

Two main types of solar cells are available in the market, namely amorphous silicon (a-Si) thin film PV and crystalline silicon (c-Si) PV. Comparing the pros and cons of these two types of PV modules, a-Si TFPV was finally chosen due to the following:

- The thickness of silicon materials for TFPV is only 1/200 of that for crystalline PV so that less silicon is required for production. The energy payback period for a-Si TFPV is 1.5 years, while that for c-Si PV is 2.5 years.
- Temperature coefficients for maximum power output (Pm) of a-Si TFPV and c-Si PV modules are -0.25% and -0.4% per ºC rise on module temperature respectively, which means TFPV's ability to maintain power output level at high temperature is better than crystalline PV module.
- Rate of decrease in conversion efficiency at weak light for a-Si TFPV module is less significant than c-Si PV module. Hence TFPV modules are able to produce power more effectively at low irradiance conditions, resulting in a higher capacity factor throughout the year.


Fig. 6 – Lamma TFPV System


Fig. 7 – Amorphous Silicon Thin Film PV Panel

All the TFPV panels were manufactured in the Shenzhen plant of Du Pont Apollo Limited (Du Pont Apollo). Established in 2008, the plant was a pilot project under the "Shenzhen-Hong Kong Innovative Circle" co-operation agreement made between Shenzhen Municipal Government and the Hong Kong SAR Government for promotion collaboration of technology research and development. HK Electric is their first customer for installation of a commercial scale TFPV system when order was placed in 2009.

Table 2 – Specification of Amorphous Silicon Thin Film Photovoltaic Module

Dimensions of PV Module	**1,410 mm x 1,110 mm x 35 mm**
Effective Conversion Area	**1.4 m2**
Weight of PV Module	**Approximate 26kg**
Max. Power Output per PV Module	**100 Wp**
Operating Temperature	**-40 ~ 85 ºC**
Maximum Mechanical Load	**5,600 Pa**

TFPV System Design

The TFPV modules are mounted on concrete supports facing southward at about 22º inclination in order to capture maximum solar irradiation. PV strings formed by TFPV modules connected in series are grouped in PV array combiner boxes for feeding DC power to PV inverters for converting to AC 380V 3-phase power supply for grid connection to the electrical system. Associated electrical components such as AC power panels, isolation transformers, metering panels and cables have been installed to form a complete workable system. To cater for the adverse outdoor conditions, all electrical equipment installed outdoor are weatherproof type with proper protection from sunlight, lightning and overvoltage.

For better operation flexibility and overall system availability, HK Electric has adopted 10kW and 12.5kW 3-phase PV inverters instead of using large capacity PV inverters. PV inverters will connect to the grid automatically when the grid voltage and frequency are within operating range.

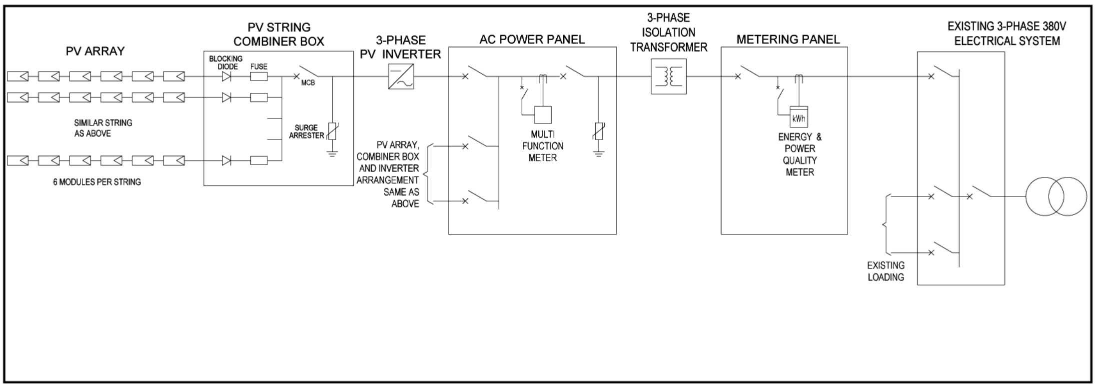

Fig. 8 – Simplified Single Line Diagram of PV System

To facilitate systematic, efficient and effective monitoring and control of the TFPV system, a Remote Monitoring System has been set up in the Central Control Room of the Power Station to monitor the overall performance of the TFPV system, environmental data and equipment status.

Fig. 9 - Remote Monitoring Computor at Central Control Room

Construction Challenges

Since the TFPV system is physically located on the rooftops of the Main Station Buildings, a large quantity of PV modules, concrete blocks, PV module fixing accessories, electrical equipment, cables and cable supports were required to be transported from ground for installation. A 250 tonne class mobile crane was employed for the lifting work. Absolute care had to be exercised to ensure perfect site safety during the uplifting work, especially during rainy and windy conditions. Overall project schedule lasted for about 15 months from commencement of feasibility study in April 2009 till the total completion in end June 2010.

The Lamma Thin Film PV System Extension

With the successful commissioning of the solar PV system in July 2010, HK Electric decided to further increase the total capacity of the solar power system to 1MW. More locations, including the rooftops of New Store Building, East Bridge Road etc. in Lamma Power Station, were selected for the TFPV system extension.

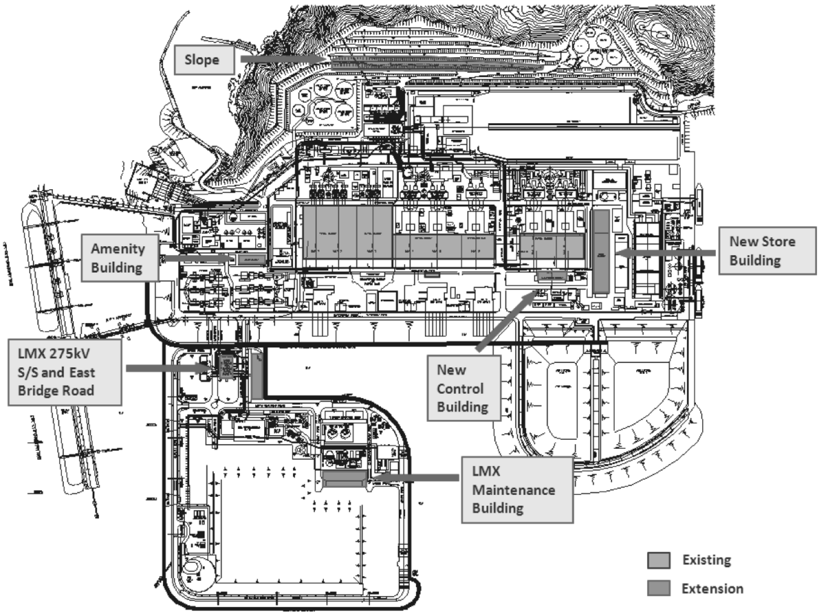

Fig. 10 – Location of Existing TFPV System and the Extension

The TFPV extension has completed in 2013. The extension accommodates 2,694 sets PV modules with rated output of 142W and 468 sets PV modules with rated output of 145W making the total capacity of the solar PV system extension at 450kW.

Table 3 – Comparison of the TFPV System and the Extension

	TFPV	Extension
Total Installed Capacity	550kW	450kW
Type of TFPV	Amorphous Silicon	Amorphous / Microcrystalline Silicon (Tandem Junction)
Dimension of PV module	1,409 mm x 1,110 mm	1,409 mm x 1,110 mm
Maximum Power Output	100W	142W & 145W
Quantity of PV Modules	5,500 pieces	3,162 pieces

Plant Performance

Since commissioned on 1 July 2010, the TFPV system has generated a total electricity output of more than 5.3 million kWh by early March 2016 which offset about 4,400 tonnes of CO_2 emission.

Electricity output of TFPV system varies with solar irradiance condition. Fig. 11 shows the actual irradiances and output data of a hot summer day on 18 July 2010 as well as a stormy day on 22 July 2010 on which "Black Thunderstorm" signal was hoisted in the afternoon. The result shows that electricity generated from the PV system under cloudy and rainy conditions was still about 1/3 of that generated under sunny condition with strong solar irradiance.

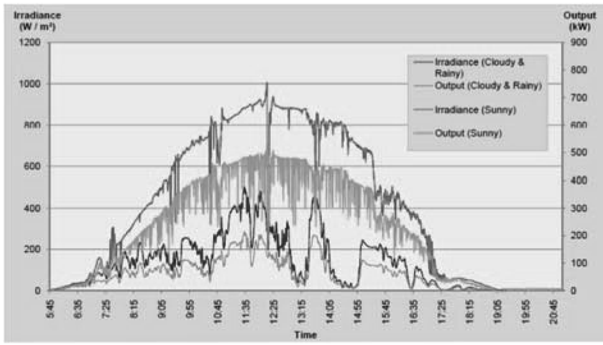

Fig. 11 – Power Output in Response to Solar Irradiance Variation

Environmental Benefits

The expanded solar power system is expected to generate more than 1.1 million units of green electricity annually and reduce 915 tonnes CO2 emission, equivalent to planting more than 39,000 trees. However, from the actual operating data obtained so far, above design output figures might prove to be conservative.

CONCLUSIONS

For the past few years, HK Electric has put in great engineering efforts and resources to develop renewable energy projects and other emission control projects in support of government's sustainable policy while fulfilling its commitment to helping combat climate change and improve air quality in Hong Kong.

Following the introduction of the first wind turbine of 800kW capacity on Lamma Island as a demonstration project, HK Electric has been embarking on developing a 100MW offshore wind farm at southwest of Lamma, which is expected to produce 175 million units of electricity per year, adequate for the consumption of about 50,000 4-person households in Hong Kong.

Apart from harnessing wind energy, HK Electric also explores solar power generation. The successful commissioning of the largest solar PV system at Lamma Power Station in July 2010 marked another milestone for HK Electric in developing renewable energy for power generation in Hong Kong.

HK Electric will continue its efforts in exploring more opportunities of renewable energy applications for power generation in Hong Kong to move towards a sustainable and low-carbon environment.

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ACCELERATING CARBON REDUCTIONS THROUGH MULTI-STAKEHOLDER ENGAGEMENT AT HONG KONG INTERNATIONAL AIRPORT

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Abstract: *Airport Authority Hong Kong (AAHK) proactively engages with airport business partners and other stakeholders, in order to accelerate carbon reductions at Hong Kong International Airport (HKIA). This paper illustrates the approach AAHK takes and provides examples of key carbon reduction measures. AAHK's multi-stakeholder approach is also applicable to other multi-tenant sites in Hong Kong.*

INTRODUCTION

Managing the carbon footprint of a multi-tenant infrastructure, like the Hong Kong International Airport, is a challenging task. Success depends not only on an airport operator's (i.e. the Airport Authority Hong Kong's) own efforts but, more importantly, on its close interaction and collaboration with the numerous organisations at the airport community, including airlines, aviation service providers, logistic companies and government authorities.

Effective carbon reduction management at every large-scale facility requires the same level of collaboration. This collaboration is especially important for the AAHK, given that:

- It is a relatively small organisation with a staff of about 1,500 that outsources the great majority of the airport's daily operation to its franchisees and business partners, who collectively employ the vast majority of the 73,000 staff[1] working at Hong Kong International Airport (HKIA);
- HKIA is one of the world's busiest airports, handling 68.5 million passengers, 4.38 million tonnes of cargo and over 390,000 aircraft movements in 2015[2]; and
- It has a strong commitment to environmental management, which is demonstrated by its public pledge in May 2012 to make HKIA the world's greenest airport.[3]

To realize the ambitious goal of being the world's greenest airport, AAHK has to set an environmental strategy that moves beyond its own control regime, and increases its sphere of influence to guide or influence activities that are not under its direct responsibility. AAHK has adopted a stakeholder engagement approach, which is similar to the 'control, guide, influence' system developed by Airport International Council (ACI), in its environmental footprint reduction initiatives (Figure 1).[4] The objective of this paper is to set out AAHK's approach to stakeholder engagement, with a particular focus on its airport-wide carbon reduction programme and to outline the achievements and lessons learnt from these programmes, as well as the key green infrastructure of HKIA.

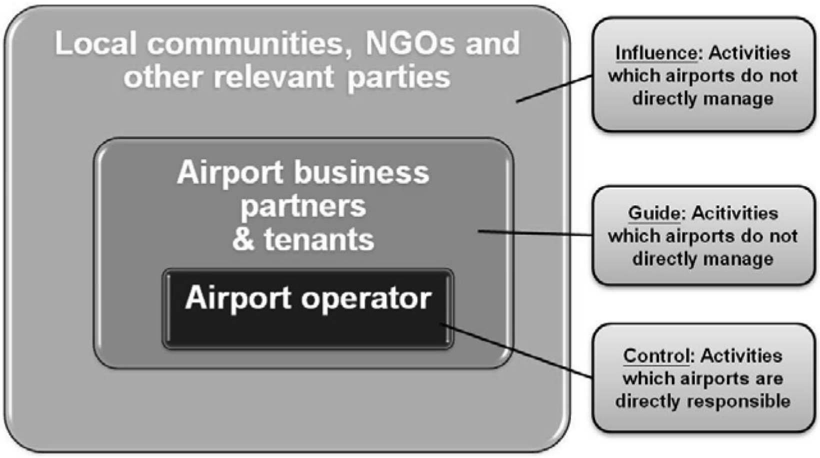

Figure 1: AAHK's approach to stakeholder engagement in its environmental footprint reduction initiatives

HKIA CARBON REDUCTION PROGRAMME

Scopes and Sources of the Facilities' Greenhouse Gas Emissions

Carbon / greenhouse gas (GHG) emissions are commonly categorised into three different scopes according to the nature, ownership and control of the emission source[5]. ACI's 'Guidance Manual on Airport Greenhouse Gas Emissions Management'[6] is used for further defines the emission scopes for airports, and provides examples of the principal airport and airport-related sources in each scope category (Table 1). 'Guidelines to Account for and Report on Greenhouse Gas Emissions and Removals for Buildings (Commercial, Residential or Institution Purposes) in Hong Kong', published by Environmental Protection Department and the Electrical Mechanical Services Department**,** provides a systematic and scientific approach to account for and report on the GHG emissions and removals from buildings in Hong Kong.

Table 1: Emissions scopes and examples of airport and airport-related emission sources

Scope 1: Direct GHG emissions from sources that are owned or controlled by the airport operator
Emission sources: • Power plants and/or emergency power generators • Vehicle fleets including ground service equipment (GSE) • Firefighting and maintenance equipment
Scope 2: Indirect GHG emissions from the off-site generation of electricity (and heating or cooling) purchased by the airport operator
Emission source: • Electricity (and heating and cooling) generation
Scope 3: GHG emissions from airport-related activities from sources not owned or controlled by the airport operator
Emission sources: • Aircraft main engines and auxiliary power units (APU) • Vehicle fleets, including GSE, owned or controlled by others • Ground transport to and from the airport (ie surface access)

Establishing a Carbon Reduction Programme

HKIA started the airport-wide HKIA carbon reduction programme in 2008. The key milestones of the programme are summarised in Figure 2.

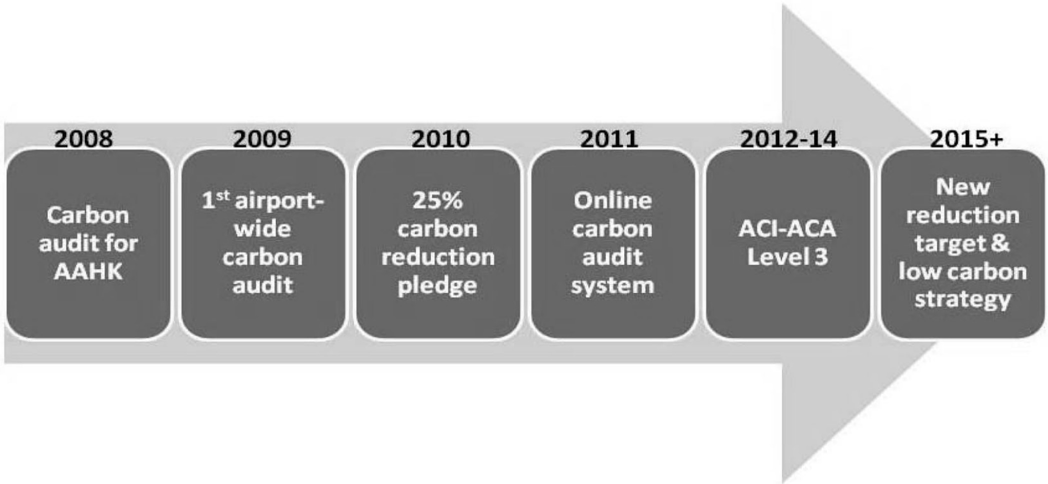

Figure 2: HKIA's Carbon Management Roadmap

- In 2008, following the release of the Hong Kong Government's guidelines for carbon auditing[7], AAHK conducted the first carbon audit of its own buildings and facilities at HKIA.
- This was then followed by an airport-wide audit in conjunction with its business partners in 2009. This audit laid the foundation for AAHK to develop and formalise the airport-wide HKIA carbon reduction programme.
- In 2010, AAHK, together with some 40 airport business partners (BPs), pledged to reduce airport-wide carbon emissions by 25 per cent per workload unit (WLU) by 2015, based on 2008 levels[8]. One WLU is equal to one passenger or 100kg of cargo.
- In 2011, AAHK developed and launched a proprietary online carbon audit system (CAS) that provides an advanced carbon monitoring and reporting platform for AAHK and its BPs.
- HKIA's efforts in carbon management and reduction were recognised in December 2012 when it was awarded the 'Optimisation' level in ACI's Airport Carbon Accreditation scheme. This is the second-highest level of accreditation, and HKIA was the first airport in the Asia-Pacific region to achieve this standard[9]. The key to achieving this level of recognition is to engage airport stakeholders to report on the airport's Scope 3 emissions.

Key Success Factors

The success and achievements of the HKIA carbon reduction programme are attributable to the following four key factors (Figure 3):

Figure 3: The "4Ps" principle of HKIA carbon reduction programme

a) Pledge: public commitment from senior management

The 25 per cent carbon reduction pledge set in 2010 was the world's first airport-wide carbon intensity reduction pledge[8]. The pledge, supported by the Hong Kong Government at ministerial level, AAHK's senior management, the BPs and environmental non-governmental organisations (NGOs), set a carbon intensity reduction target for over 40 BPs and demonstrated the commitment of the whole airport community. This public commitment serves as a compelling driver for the successful and continuous implementation of the HKIA carbon reduction programme.

b) Platform: investing in calculation tool

AAHK invested HK$550,000 to develop an online Carbon Audit System (CAS) as a reporting platform to calculate and monitor HKIA's airport-wide carbon emissions[11]. The CAS is made available to all 46 participating BPs at no cost, enabling them to enter all data relevant to carbon emissions, and to calculate and analyse their carbon performance on a single unified platform. Additional ongoing investments were made to further enhance the audit boundary and user interface of the system.

c) Partnership: engagement with BPs

Stakeholder engagement is the core of the HKIA Carbon Reduction Programme. A total of 46 BPs currently support the programme, including airlines, airline caterers, government departments, cargo handlers and ground service providers[11]. Participating organisations voluntarily provide their carbon data through the online CAS platform. Rather than dictate the carbon reduction measures the BPs should take, AAHK encourages them to devise their own reduction measures and instead facilitates the sharing of best practices through a dedicated website (http://www.hongkongairport.com/eng/csr/carbon-reduction/index.html) which showcases the reduction measures adopted (Figure 4). In this way, each of the participating BPs determines the best solutions for its own situation, but also benefits by learning from the best practices of other participants.

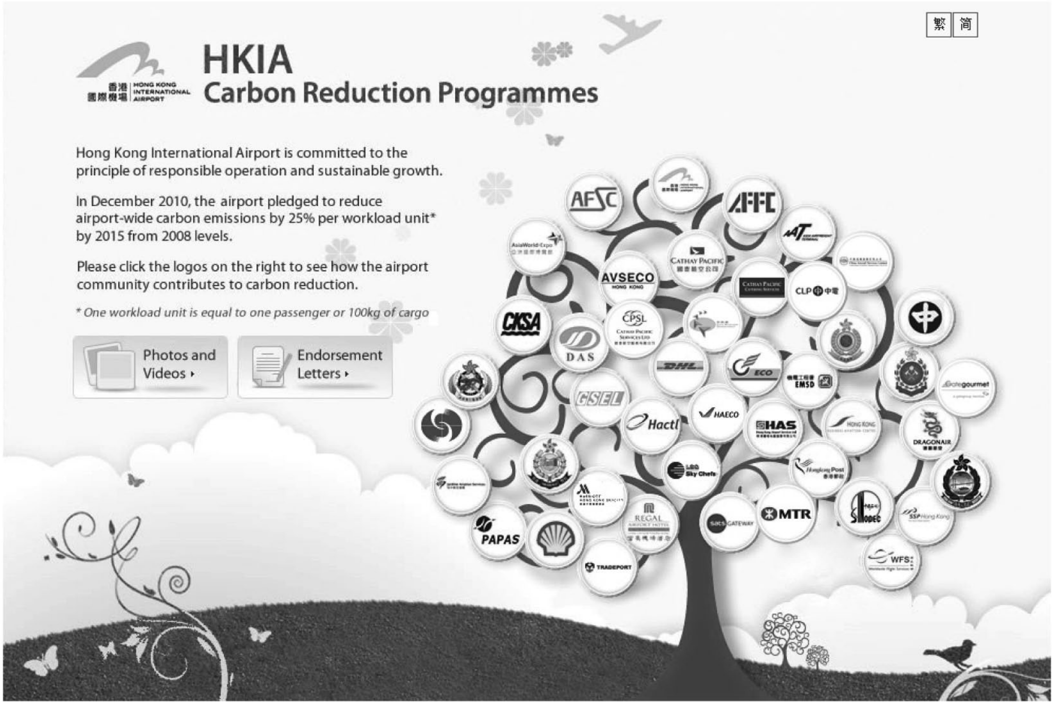

Figure 4: A dedicated carbon website sharing and showcasing the carbon reduction measures of HKIA

To ensure the BPs are equipped with the necessary knowledge and skills, AAHK has organised over 30 carbon workshops, sharing and training sessions since the launch of the programme in 2008[12]. Moreover, AAHK has trained five internal staff members as certified carbon auditors to conduct free on-site carbon data checking for participating BPs every year[11]. This data checking, together with the external verification required by the ACI's Airport Carbon Accreditation scheme, significantly increase the accuracy of carbon data submitted by BPs, and improves the robustness of the HKIA carbon reduction programme. The annual carbon audits, which AA provides at no charge to each participating BP, also provides another opportunity for AAHK to understand their needs and to provide assistance accordingly. In addition, AAHK manages a quarterly Airport Community Environmental Forum to communicate with BPs on carbon-related issues. Attendees are encouraged to share their experience and best practices for carbon management with other BPs.

d) Performance: carbon emission reductions

In order to reduce its own emissions, AAHK has completed a number of carbon reduction measures which are summarised below:

i) LED replacement programme

LEDs consume less energy than conventional lighting, helping to reduce environmental impact and energy costs. In 2009, AAHK began its LED replacement programme, the largest project of its kind in Hong Kong. The project was completed in March 2015, 100,000 LED lights were installed, covering various facilities and areas, saving around 18.2 million kWh of electricity annually and reducing CO_2 emissions by 11,500 tonnes. The AAHK is also sharing its best practice and expertise in LED technology with tenants.

At the time there were a number of challenges facing this ambitious initiative including an immature market for environmentally-friendly light solutions and limited supply. To overcome these barriers, the AAHK's Technical Services Department worked with the Government's Energy Liaison Group to develop a set of far-reaching specifications for LED lighting in Hong Kong. These specifications have since become the AAHK's procurement standard and set a benchmark for other large organisations' replacement programmes.

ii) Electric vehicles replacement

Since July 2013, AAHK has required all newly registered saloons operating in the Airport Restricted Area (ARA) to be electric vehicles (EVs). To facilitate the transition to EVs and electric ground service equipment (EGSE) operating at HKIA, AAHK completed the installation of 204 EV chargers and 68 EGSE chargers in 2015. AAHK has increased the number of EV and EGSE chargers in new infrastructure such as the Midfield Development. As at December 2015, AA owns 48 electric saloon vehicles, 8 electric vans and 20 EGSE. By July 2017, all saloons on the airside must be EVs.

iii) Green buildings and sustainable design

HKIA's terminals are designed to be thermally efficient. They use modern glass façades and building envelopes to reflect heat and reduce cooling loads. North-facing roof skylights optimise natural light during daytime, while minimising heat gain from direct sunlight entering the buildings. Light sensors automatically reduce indoor lighting when there is sufficient daylight. Innovative cooling systems are in place at Terminals 1 and 2 to cool only the bottom three metres of our large indoor spaces, leaving the air above at ambient temperatures.

The Midfield Concourse is designed to be highly environmentally friendly, and aspires to be one of the first BEAM Plus Gold Standard certified buildings in Hong Kong. 35 green initiatives cover aspects ranging from material, energy and water use to high-efficiency construction methods.

iv) Auxiliary power unit ban and provision of fixed ground power/pre-conditioned air

Aircraft on the ground normally use their auxiliary power units (APUs), which are small engines located at the rear of aircraft, to provide electrical power and air-conditioning to the cabin when the main engines are switched off. To reduce aviation fuel burn and the associated emissions, AAHK offers fixed ground power (FGP) and pre-conditioned air (PCA) systems for aircraft on the ground. In December 2014, AAHK implemented an APU ban that controls the usage of APUs at frontal stands. In order to meet aircraft needs for electrical power and cabin cooling once the ban came into effect, AAHK upgraded all FGP and PCA systems - a total of 136 FGP units and 96 PCA units.

Reduction in HKIA's Carbon Emissions

Multi-tenant facilities should identify the distribution of the GHG emission sources within their community. AAHK accounts for approximately 40 per cent of the airport-wide carbon emissions while the BPs account for the remaining 60 per cent[10]. Through engaging and collaborating with BPs, AAHK is able to accelerate the rate of airport-wide carbon reduction. As of end 2014, AAHK achieved a 22.4 per cent reduction in the airport-wide carbon intensity compared to the 2008 level[10], HKIA remains on track to meet its 25 per cent reduction target. Figure 5 illustrates HKIA's carbon emissions performance between 2008 and 2014.

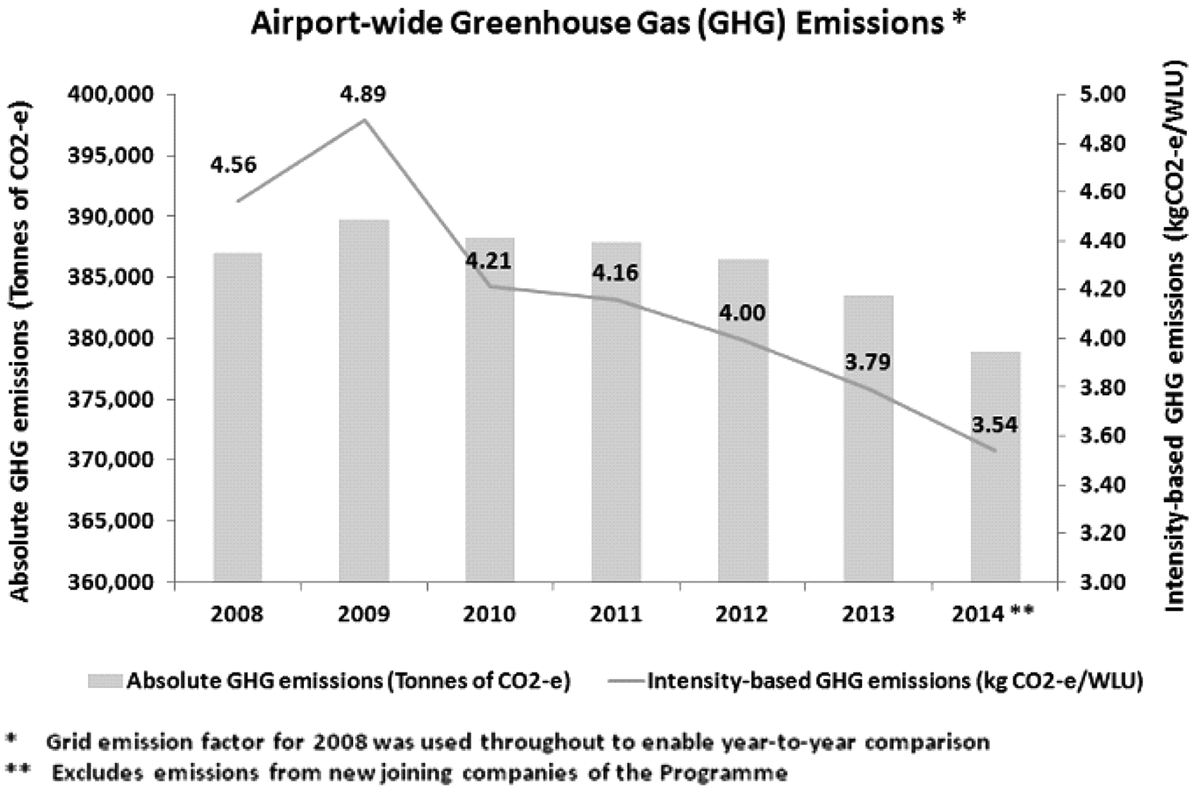

Figure 5: HKIA carbon emissions performance between 2008 and 2014

CONCLUSIONS

Airport operators such as AAHK play an important role in accelerating the reduction of the airport's carbon footprint by expanding its efforts from its immediate operations to the wider facility community and other key stakeholders. The HKIA Carbon Reduction Programme demonstrates how footprint reduction may be accelerated by engaging and collaborating with different stakeholders. Hardware improvement within HKIA also contributes to the rate of carbon reduction. Looking forward, AAHK will continue the Carbon Reduction Programme by setting a new airport-wide carbon reduction target in 2016. The similar engagement models not only apply to other environmental aspects such as air quality, general waste management and water consumption, but also other multi-tenants facilities operators.

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THE PROMOTION OF ELECTRIC VEHICLES IN HONG KONG - POLICY AND MEASURES

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Abstract: *Electric Vehicles (EVs) have no tailpipe emissions and are efficient in converting energy from the grid to power at the wheels. Replacing conventional vehicles with EVs can help improve roadside air quality and reduce greenhouse gas emissions. This paper outlines the policy and measures of the Hong Kong SAR Government (the Government) in promoting the use of EVs.*

INTRODUCTION

Roadside air pollution is a common challenge for cities. The dense and compact cityscape in Hong Kong steepens the challenge. To tackle the pollution problem, the Government has been implementing a comprehensive strategy to reduce vehicle tailpipe emissions. The key measures include tightening the standards of the emissions of newly registered vehicles and vehicle fuels as soon as practicable, enforcing a vehicle inspection and maintenance programme, retrofitting polluting vehicles with emission reduction devices and mandating the retirement of pre-Euro IV diesel commercial vehicles. Efforts are also being made to promote the use of EVs.

EVs have no tailpipe emissions and are efficient in converting energy from the grid to power at the wheels. Replacing conventional vehicles with EVs can help improve roadside air quality and reduce greenhouse gas emissions. Commercial vehicles account for over 97% of respirable suspended particulates (RSP) and 95% of nitrogen oxides (NOx) emissions of the vehicle fleet. Both are the key air pollutants at the roadside. Replacing commercial vehicles with EVs would improve roadside air quality substantially. At issue are what can be done to promote the use of EVs in general and how ready the EV technology is for commercial applications.

THE STATUS OF EV TECHNOLOGY

As at end January 2016, EVs on the local market included 26 private car models, six light goods vehicle models and seven coach models. The dominance of electric private cars is a reflection of the constraints of the current EV battery technology, which are essentially high production cost, limited service life and low energy density. The last one is particularly detrimental to the ability of EVs taking up commercial duties because of its adverse implications for payloads – goods and passengers – and the driving range afforded by a full charge. Improvement is however forecasted in coming years.

A study of the European Commission (EC)[1] completed in 2011 forecasted that in early 2020s, the price of battery could be reduced by about 50%. It also reported that the current battery life should exceed seven years and might be around 10 years for 'average' use. The United States Advanced Battery Consortium[2] anticipated that by 2020, the average battery life might be in the 13 to 15 years range. The US Department of Energy made it a goal[3] in 2012 for EV batteries to reduce by 2022 –

(a) the production cost to a quarter of the current level;

(b) the size by half; and

(c) the weight by half.

If materialized, the battery cost would be reduced to US$125/kWh from US$500/kWh by 2022. The rated densities would be increased from 100Wh/kg to 250Wh/kg, 200Wh/l to 400Wh/l, and 400W/kg to 2000W/kg. These batteries would make EVs more competitive with their conventional counterparts.

Long charging time is another challenge, particularly for commercial vehicles, many of which could not afford the time for charging amid their busy work schedules. A more effective way to charge an EV needs to be developed.

POLICIES

Despite significant technological advancements in recent years, EVs have yet to become a true rival to conventional vehicles. Instead of waiting for the EV technology to further develop, the Government has been proactive in promoting the use of EVs. The promotion could help build up confidence on EVs and provide impetus for further advancement of the EV technology, which will maximize the potential of EVs to clean up roadside air pollution and reduce greenhouse gas emissions. In addition, the Government has made the use of zero emission franchised buses over the territory the ultimate policy objective[4]. The EV promotion efforts are elaborated in the ensuing paragraphs.

MEASURES TO PROMOTE THE USE OF EVs

Even if there are suitable EVs on the market, vehicle buyers might not opt for EVs because of higher price premium, worry about charging and doubt on the performance and reliability of EVs. To address these concerns, suitable measures have to be introduced.

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1 A report from CE Delft commissioned by the European Commission, "Impacts of Electric Vehicles – Deliverable 2, Assessment of electric vehicle and battery technology": http://ec.europa.eu/clima/policies/transport/vehicles/docs/d2_en.pdf

2 The United States Advanced Battery Consortium LLC (USABC), a collaborative organization operated by Chrysler Group LLC, Ford Motor Company and General Motors. Its mission is to develop electrochemical energy storage (EES) technologies which support commercialization of fuel cell, hybrid, and EVs. It seeks to promote long-term R&D within the domestic EES industry and to maintain a consortium that engages automobile manufacturers, EES manufacturers, the National Laboratories, universities, and other key stakeholders.

3 http://www.energy.gov/eere/vehicles/vehicle-technologies-office-batteries

4 The policy was announced in the Policy Address of 2010-11

To help formulate strategies and measures to promote the use of EVs, a Steering Committee on the Promotion of EVs led by the Financial Secretary has been set up. To date, the key measures that have been introduced include the Government leading by example, tax incentives for acquiring EVs, setting up chargers and subsidy for the trial of EVs. These measures can also encourage EVs suppliers to put suitable EVs on the local market.

Government Leading by Example

The Government has been taking the lead in using EVs, having regard to the availability of suitable EV models in the market and operational requirements of the user departments. So far, 245 EVs have already joined the Government vehicle fleet, accounting for about 4% of the Government fleet. The Government will continue to lead by example in using EVs.

Tax Incentives

EVs could be 30% to 230% more expensive than conventional vehicles. For example, an electric light goods vehicle is priced between HK$390,000 and HK$1,000,000 while the average price of a diesel counterpart is about HK$300,000. An electric coach with 60 seats costs about HK$3,000,000 while the average price of its diesel equivalent costs about HK$1,300,000. The price premium is due to small production volumes and high production cost of EV batteries. Although EVs have lower operational cost in respect of energy and maintenance expenses, the upfront higher capital outlay could discourage prospective vehicle buyers from opting for EVs. To overcome the price hurdle, the Government has –

(a) waived the first registration tax for EVs since 1994. The current waiver will last up to end March 2017; and

(b) allowed enterprises which procured EVs to have 100% profits tax deduction for the capital expenditure on EVs in the first year of procurement.

The Charging of EVs

Public Chargers

There is no harmonized standard for EV chargers. The diversification of standards is more serious for large commercial vehicles, which usually require considerable power to support their daily operation and the charging to be completed within a manageable time. At present, EV manufacturers have their own design specifications to cater for the need of their heavy duty commercial EVs. In comparison, the charging standards of electric private cars, which account for about 95% of the EV fleet, are less diverse such that public chargers could be made possible. The Government has thus been working with the private sector to set up public chargers for cars while watching closely the development in respect of the chargers for commercial vehicles.

Electric private cars can be charged by connecting to household charging sockets (i.e. 220V and 13A). It takes about seven to 11 hours to charge up the battery fully or to a level sufficient to sustain a day's operation for an average private car driver. Furthermore, the latest electric private car models could all be charged by medium chargers designed to IEC 61851 standard (single phase, 32A) with the charging time reduced by up to 60%. The charging time could be further reduced by quick chargers (such as CHAdeMO, GB, CCS DC Combo, or design standards of individual EV manufacturers such as Tesla) but at the expense of the service life of the EV batteries. Depending on vehicle models, quick chargers could fully charge an electric private car in about an hour.

Like other places, electric private cars should normally be charged at their owners' homes or workplaces. The public charging network is to provide primarily opportunity charging to extend their travel range when needed.

There are now about 1 300 public chargers in Hong Kong set up by the Government or the private sector. They include about 900 standard chargers, over 200 medium chargers, 15 CHAdeMO quick chargers and 142 quick chargers applicable to other charging standards (including GB, CCS DC Combo, or design standards of individual EV manufacturers such as Tesla) covering all 18 districts. Among these chargers, medium chargers are best placed to serve the need of opportunity charging because of its popularity and shorter charging time. The Government will upgrade more chargers to medium chargers. Furthermore, the two power companies are upgrading their standard chargers to medium chargers and quick chargers. The Electrical and Mechanical Services Department (EMSD) has also installed some outdoor medium charging poles for trial.

The Government will enhance the EV charging network by upgrading more standard chargers to medium chargers, and support property management companies to install more charging facilities.

Private Chargers

To help EV owners to set up chargers at their own parking spaces, EMSD has set up a dedicated team and a hotline (Tel: 3757 6222) to provide technical support. Besides, guidelines have been issued to prospective EV buyers on how to set up chargers at their own car parks, and letters were issued to some 7 400 owners' organizations appealing for their support. The two power companies have also enhanced their technical support with committed service pledges to their customers who intend to install charging facilities at the car parking spaces of residential or commercial buildings, and allow the setup of sub-meters and check meters/ timers for charging EV owners.

We have also noted that there are companies in the local market providing one-stop service, including installation of charging facilities and provision of charging service, to the private housing estates.

New Buildings

Since April 2011, the Government has been granting concessions on gross floor area[5] to developers, who make their car parks "EV charging-enabling". To qualify for the concession, all parking spaces are required to put in place at the building construction stage the charging infrastructure, including electrical wiring and provision of sufficient power

[5] Practice Note for Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers APP-2 (http://www.bd.gov.hk/english/documents/pnap/APP/APP002.pdf).

supply, to facilitate future installation of EV chargers. As at end 2015, about 80% of parking spaces in the approved new development plans have already been EV charging-enabling to facilitate future installation of EV chargers.

Besides, the planning guidelines for new buildings have been amended to recommend at least 30% of car parking spaces to be installed with EV chargers.

Subsidy for the Trial of EVs

Electric Franchised Bus Trial

To achieve the objective of using zero emission buses over the territory, the Government has allocated $180M for franchised bus companies to purchase 36 single-deck electric buses (including 28 battery-electric buses and eight super-capacitor buses) and their charging facilities for trial to assess their operational efficiency and performance under local conditions. The trial started progressively at the end of 2015 and will last for two years. If the trial is successful, the Government will encourage the franchised bus companies in a suitable way to use electric buses on a larger scale, taking into account affordability of the companies and passengers.

Pilot Green Transport Fund

The Government set up a $300 million Pilot Green Transport Fund (the Fund) in March 2011 to encourage the local transport sector to test out green innovative transport technologies applicable to ferries, taxis, public light buses, vehicles of charitable / non-profit organizations providing services to their clients, franchised buses and non-franchised public buses, as well as goods vehicles (including special purpose vehicles). EVs are a key target for trial.

For trial of EVs, the Fund will subsidize half of the price of the trial vehicle or the price premium between the trial vehicle and the conventional vehicle of the same type, whichever is higher, plus half of the setting up cost of the charging facilities, if applicable.

As at the end of February 2016, there were 64 EVs approved for trial, including six electric taxis, three electric light buses, 11 electric buses and 47 electric goods vehicles. During the trial, the EV owners have to record the mileage, energy consumption and maintenance details on a daily basis for evaluating their performance. The monitoring reports will also be uploaded to the website of Environmental Protection Department (EPD). To promote the their use, the Government will organize seminars and experience sharing workshops to provide the transport trade first-hand information on the trial findings, and invite transport technology suppliers to showcase their products. So far, we have held four seminars or experience sharing workshops for trials under the Fund.

As at the end of February 2016, 15 electric light goods vehicles, two electric buses and one electric taxi have completed their two-year trials. Currently two electric taxis, seven electric buses and 23 electric goods vehicles are on trial. 18 interim and final reports have been uploaded to EPD's website. In summary, most of the EVs incurred an electricity expense 40% to 90% less than the fuel expenses of their conventional counterparts. However, the long charging time and limited travel range could be a constraint in their deployment. As for their availability for service, it varied from model to model. Furthermore, drivers did not find driving EVs a major challenge. Below are the key trial findings –

Electric Vehicle Model	**Battery capacity (kWh)**	**Energy economy (km/kWh) / (km/L)**	**Energy cost saving (%)***	**Utilization Rate (%)**
Smith Edison Panel Van (LGV#)	36	1.1 - 2.0	37 - 67	55^ - 100
Micro-Vett Electric Doblo (LGV)	44.4	2.9 - 3.8	60 - 80	85 - 100
Renault Kangoo Van Z.E. (LGV)	22	3.7 - 5.3	78 - 87	87 - 99
Mitsubishi Minicab MiEV (LGV)	16	4.5 – 5.0	88 - 91	99 - 100
BYD e6 (taxi)	61.4	3.3 - 4.2	41 - 52	91 - 99
Shandong Yixing Feiyan (bus)	360	0.62 - 0.64	78	72
Wuzhoulong FDG6102EVG (bus)	324	0.6 – 0.64	71 – 75	43 – 46@

\# LGV : light goods vehicle
* Compared with the fuel expense of conventional vehicles.
^ Due to delay in spare part delivery.
@ The low utilization rate was due to overheating of the traction motors and the supplier had to replace the motor. The replacement took about six months.

OUTCOMES AND OUTLOOK

Owing to the above promotion efforts, the number of EVs increased to 4,629 at the end of February 2016, an over 40-fold increase from less than 100 at the end of 2010. Most of them are private cars because of the current state of the EV technology.

There are now over 50 EV models (including private cars, light goods vehicles, taxis and buses) on the local market. Vehicle vendors are also sourcing suitable EVs, including commercial ones such as electric buses and light goods vehicles, which will further promote the use of EVs.

WAY FORWARD

The growing interest in promoting the use of EVs worldwide will encourage EV manufacturers to advance the EV technology. While awaiting more advanced EVs, particularly those for commercial applications, we will continue to promote proactively the use of EVs including encouraging EV suppliers to put suitable EVs on the local market.

As for the charging network, we will continue our collaboration with the private sector to enhance it. In coming years, we will upgrade more public standard chargers to medium-speed chargers, and continue to support property management companies to install more charging facilities.

CONCLUSION

EVs are a promising technology to improve roadside air quality and reduce greenhouse gas emissions. With concerted efforts of the Government and the private sector to promote its use as well as the further development of the EV technology, EVs will eventually be a true rival to conventional vehicles.

DEVELOPMENT OF ELECTRIC VEHICLES AND BATTERIES

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Abstract: Electric vehicle is now a must technology for transportation. The number of electric vehicle goes up rapidly in the last few years. The new design of electric vehicle components allow higher controllability and safety as well as higher performance. A number of recent technologies are discussed in the paper. This includes the active suspension, in-wheel motor, integration of vehicles parts, battery management system and super-capacitor.

INTRODUCTION

Electric vehicle (EV) is now a high priority development of academics, industry and government. Today most of the vehicle manufacturers may have at least one model of EV or under development. The commercial electric private cars have a range of 160km per charge in average. Some high performance EV has range of 500km per charge. The performance of an EV is mainly governed by the battery. Battery accounts for nearly half of a vehicle cost and suitable battery technology is now the current major development in vehicle. In fact battery is not the only energy unit in a vehicle. The other energy storage include super-capacitor, fuel cell are also suitable candidate. The battery safety is also an important R&D work for EV. Besides the energy storage, other governing technology for EV includes conductive charger, wireless charger, motor, motor drive, power distribution, suspension and necessary technology for the EV development. The associate development in EV includes the body design, vehicle control unit, battery management, and even smart grid are now the challenge technology for EV. In this paper, the technologies in EV and the energy storage are discussed.

ELECTRIC VEHICLES

Electric Vehicle General Concept

The general EV functional block can be seen in Figure 1. The general configuration include the power components including the motor, motor drive, battery and charger. They are all connected by the DC link distribution line which is connected with the battery units. The battery units is the main energy storage for the vehicle, but is regulated by the battery management unit (BMS). The lower components are mainly for control, lighting, and other smaller actuators. The DC-DC converter that is to provide the DC power to other equipment. Vehicle control unit (VCU) is to control the whole vehicle.

It is seen that the key components of a vehicle is simpler than a fossil fuel vehicle. Many of the mechanical subsystem has been eliminated. Therefore the efficiency is higher. The maintenance is less demanding in EV because of the simple structure.

For the overall energy usage, the energy of the EV is derived from electricity. The energy is generated by power plant, or in the future from the renewable energy, therefore actual emission using EV must be low. The road side emission is therefore virtual zero.

There are some complains of the EV emission such that it could increase the emission from power plant and that makes the total emission of road transportation is higher. This concept is incorrect. The typical efficiency of an electric motor is 93%. The efficiency of a power plant is 45%. The overall efficiency from fuel to the wheel is therefore 42%. EVs also have power regeneration when the vehicle is going downhill, decelerates or brakes. This will cause the efficiency by at least 63%. For a petrol fuel vehicle, the engine efficiency is 16%. Therefore the EV has an efficiency advantage of 4 times of a petrol vehicle. Therefore if EV is being used to replace all petrol vehicles, the total emission due to road transportation could be reduced to 25%.

The other advantage includes the zero or low speed torque. The electric motor is using torque control. This make the EV has high torque during startup. The associated energy consumption is therefore further reduced. The idling consumption of EV is zero whereas petrol vehicles do have emission. Therefore the overall emission of an EV could have a factor of more than 5 in efficiency.

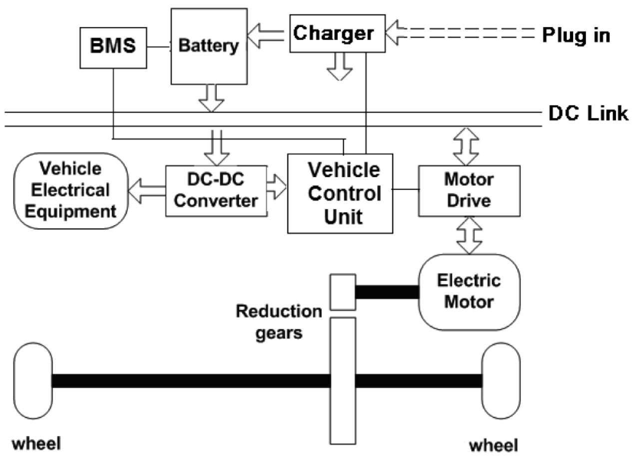

Figure 1: A typical schematic of an EV

Important Vehicles that should be Electric or More Electric

Today we can see that private car, SUV, mini-bus and bus are all have electric version. Therefore are many other vehicles that has serious road side emission due to its operation and feature such that their engine cannot be turn-off during operation. This includes

Concrete mixer truck

Like the concrete vehicle, their roller is needed to be continuously rotated in order to ensure the concrete can be mixed and does not solidify. Even though under idling or parking, the engine of the vehicle is needed to be on.

Freezer truck

The Freezer truck is mainly for frozen food delivery. The temperature should be kept to -22 Deg C. The vehicle is needed to have the freezer on before the vehicle starts to run.

During idling and parking, the engine is needed to be on in order to power the freezer. The power using of a freezer is also very high. A typical freezer is more than 10hp.

Fire engine and ambulance

They are not all electric vehicle, but they usually needs extra amount of electricity to power the equipment in the vehicle. Addition energy storage, charging units and power converters are needed.

Mobile office vehicle

Following the office and building cost and rent going up, mobile offices have been setup in an electric vehicle or vehicle. For example, clinic and post office. They need high energy storage to supply the air-conditioning, computer and other equipment.

The above examples clearly show that energy storage or battery is now urgently needed for mobility application and the associated power electronics system including DC-DC power converter and battery charger needs enhancement.

ADVANCED EV COMPONENTS

Besides the basic battery and motor units as the key traction equipment, recently substantial research and development have been placed on other components as follows:

Active Suspension

Conventional hydraulic suspension suffers from slow dynamic response and has no self-learning and the adaptation is slow. The new active suspension is based on a linear motor that is able to adjust its vertical force to cancel the vibration due to the uneven road surface. Figure 2 shows a 4-phase suspension system [1]. The machine is based on switched-reluctance principle and therefore no permanent magnet is needed.

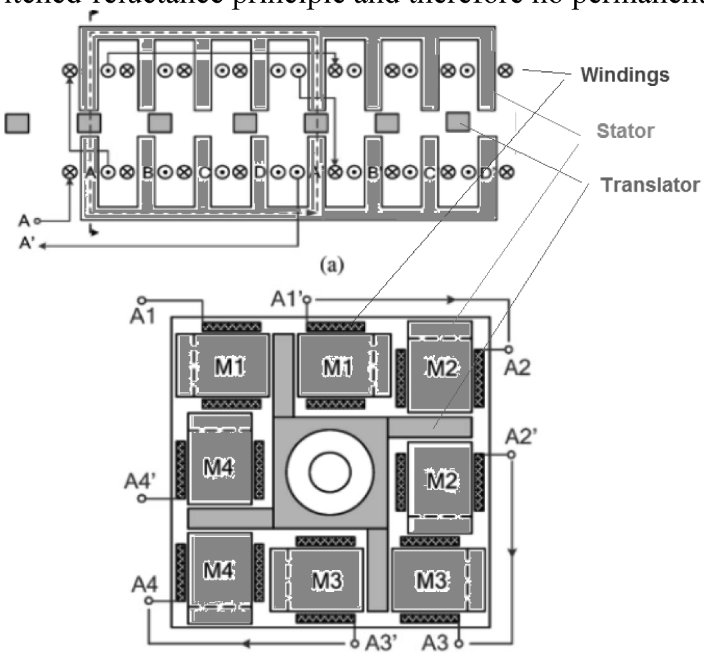

Figure 2: 4-phase active suspension model

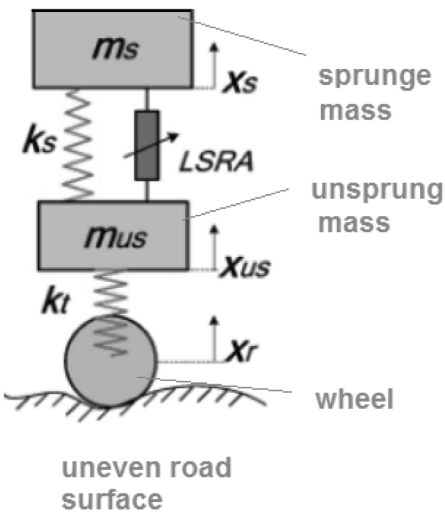

Figure 3: Suspension system model

In-wheel motor

With the motor embedded inside a wheel, more space and room are created by the design, and the transmission, gear box, shaft and crutch are eliminated. The design is benefited from the elimination of mechanical loss as compared to the conventional system.

The motor is based on a switched-reluctance motor concept and therefore the permanent magnet is not needed. Rare earth material for making the magnet is therefore not the concern of the in-wheel motor [2]. The motor has 4 sets of stator windings and each winding gives a quarter of the torque. The fault tolerance of the motor can be enhanced because even one winding is malfunctioning, the other 3 can give good portion of torque to maintain the function of the motoring.

The steering is control by wiring. No physical connection between the steering wheel and the in-wheel motors. The steering can be realized by difference speeds. Part of the braking can be provided by the in-wheel motor through motor drive control.

Figure 4: In-wheel motor internal structure

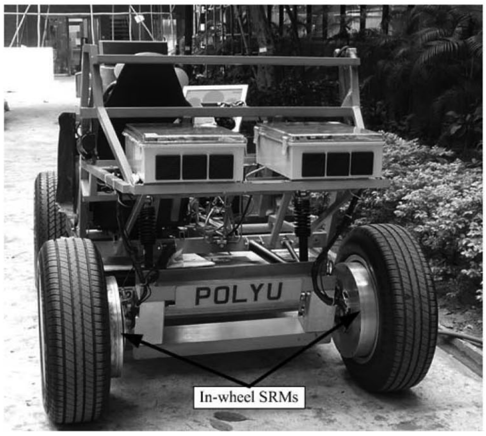

Figure 5: The in-wheel motor vehicle

Integrated motor drive and charger

Electric motor drive and the charger do not operate simultaneously for an EV. They are both based on an inverter circuit. Therefore a re-design of the circuit topology has been done, these two parts can be consolidated into a simple component to provide the same function. Part of the inverter legs is used for motor drive and also as the battery charging in form of the H-bridge converter.

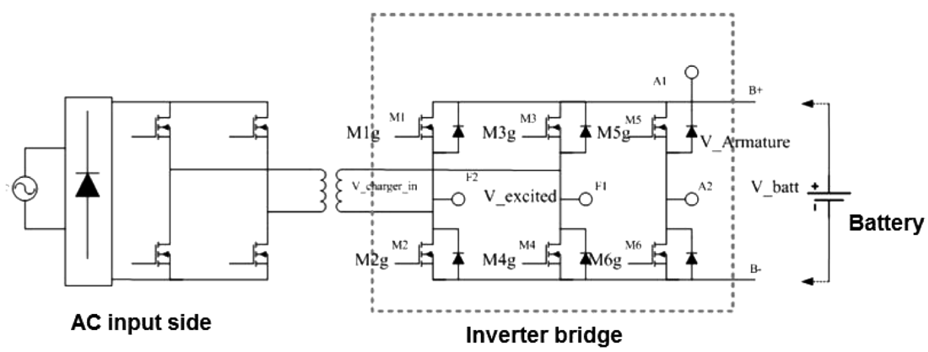

Figure 6: Integrated battery charger and motor drive

BATTERY SYSTEM

Battery management system

A battery management system (BMS) [3] is to management the battery operation in order to ensure the system is safe to work. Optimization of the battery performance is needed. It also communicates to the vehicle control units and other monitoring system of the vehicle to provide necessary action to the battery.

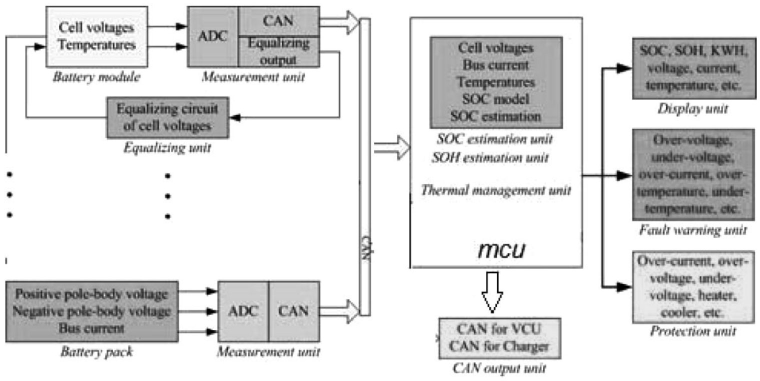

Figure 7: A typical BMS for EV

EV battery consists of tens to hundreds of battery cells to make up the voltage and current ratings. Each of the battery cells is not identical to others and the voltage could vary during the charging and discharging. For example the Li-ion cell is limited to work below 4.2V. If one cell reaches 4.2V before the others, a balancing system is needed to balance the voltages of the cells otherwise overcharging will be resulted if the charging does not end, or the actual state of charger (SoC) is not 100% if the charging stops too soon.

Battery Balancing

Following for the above balancing requirement of the cells, power electronic circuit has been proposed to develop a list of the active circuits. The circuit allow energy to transfer from the higher charged cells to the lower charged cells. There is another concern of the voltage sensing. Theoretically each cell needs a sensor in order to detect any over- or under-voltage. This increase the risk of failure as too many sensors are installed. The proposed balancing circuit is shown in Figures 8 and 9. Figure 8 is conventional and a buck-boost converter based is transfer energy from a higher voltage cells to a lower voltage cells. Figure 9 is to copy the voltage to a corresponding capacitor to achieve the balancing. Both circuits have a number of extensions and they both can provide active and high efficiency method of cell balancing. Both circuit can operate even without voltage sensors.

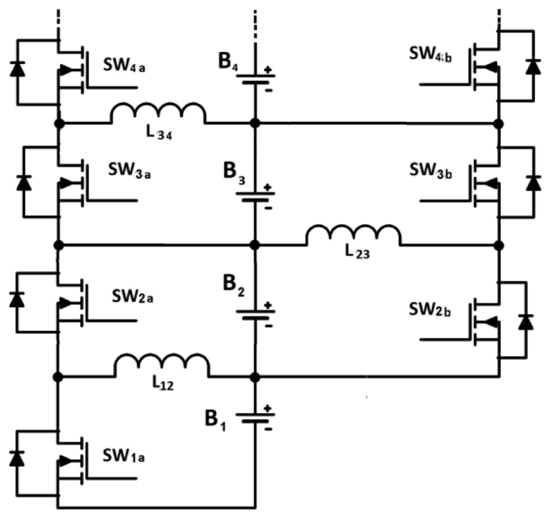

Figure 8: Buck-boost balancing

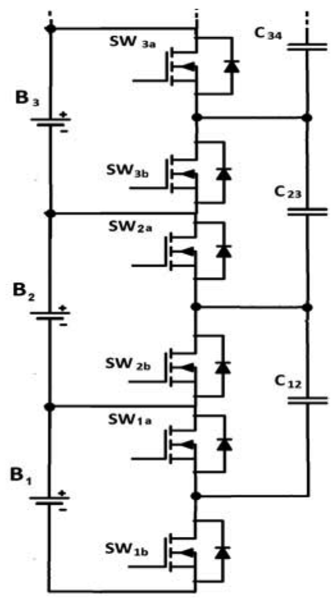

Figure 9: Switched capacitor balancing

Super-capacitor

Super-capacitor is not battery, but it offers high current and longer life time. Usually the number of cycles is more than 0.5 Million. The capacitor has higher safety factor than battery. It has better thermal stability, wide temperature range and higher robustness under thermal and mechanical stress condition. Basically the super-capacitor can be used to replace the battery. But the energy density of super-capacitor is lower than battery. Therefore presently, it is being used for short distance or as a support to the EV battery.

Another new concept is called the body integrated super-capacitor. Figure 10 illustrates the principle. The super-capacitor panel is shown in Figure 11. The energy storage is now installed the panel and therefore no additional space is needed. The balancing and protection system is installed inside the panel.

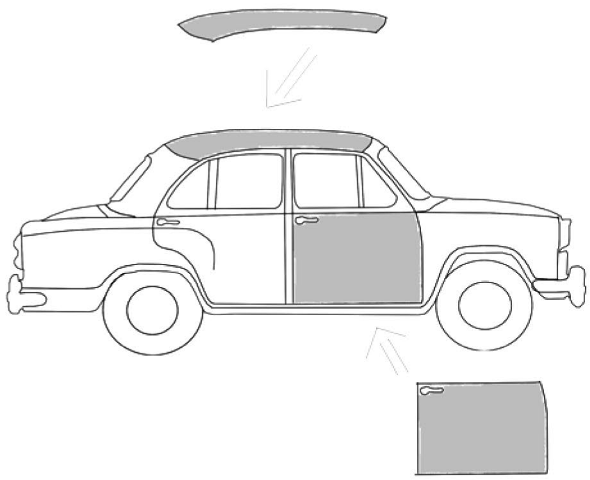

Figure 10: Body-integrated super-capacitor.

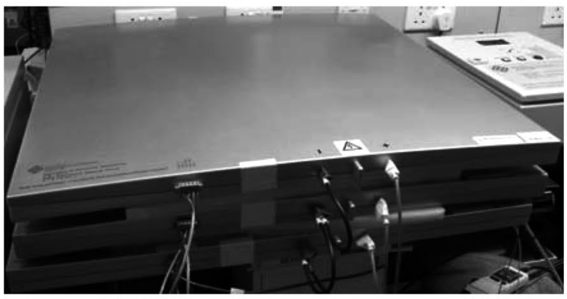

Figure 11: The super-capacitor panel

CONCLUSIONS

A number of EV parts have been discussed for the near future electric vehicle development. The proposed new technology in electric vehicle enhances the performance of EV and safety. The future EV design will have a significant change as the parts and components could be different form the conventional petrol vehicles.

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POLICIES FOR PROMOTING LOCAL USE OF GREEN AND LOW CARBON FOOTPRINT FUEL IN HONG KONG

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Abstract: *As a land-scarce society with a high population density, Hong Kong, a regional transport and logistics hub, faces a unique set of development challenges.*

The Government of Hong Kong has made fighting climate change the key element of its environmental policy, with important commitments and plans included in the Climate Change Report 2015 and the Energy Saving Plan for Hong Kong's Built Environment 2015~2025+, both incorporated in the recent Policy Address. An inter-departmental committee, to be chaired by the Chief Secretary for Administration, will be created to discuss Climate Change policy, including the definition of new carbon intensity targets for 2030.

This paper discusses policies and incentive schemes that could be implemented to promote the local use of biodiesel, a green and low carbon footprint fuel, in Hong Kong. Long term measures to promote clean transport will require the establishment of a level playing field for transport fuels, incorporating in the price the externalities of the different alternatives, or mandating environmental performance. Short term measures, that require less legislation, are also presented in the paper. These measures are urgently needed to support the incipient operation of the existing plants in Hong Kong and ensure that there is enough production capacity to support bigger schemes.

INTRODUCTION

There is worldwide acceptance that we need to achieve zero, or near-zero, carbon emissions by 2050 if we are to stop the current global warming trend.

As we have seen in the COP21[1], leading cities, including London, Sydney and New York, have committed to ambitious targets, putting in place strong mitigation programmes. New York, for example, has set itself the target of reducing GHG by 80% from 1990 levels by the year 2050.

Despite our high GDP per capita, our current carbon targets are still based on CO2 intensity and are marginally better than the rest of China (50-60% from the 2005 level by 2020 in Hong Kong vs. 40-45% in China, in the same time frame). We have not committed yet to a reduction in absolute terms. Carbon intensity targets can make sense in China, that needs to tackle poverty and increasing population, but Hong Kong, wealthy, with a stable population and almost no industry, should be leading the way with commitments to absolute GHG emissions cuts similar to other advanced world cities.

[1] 2015 United Nations Climate Change Conference, Conference of the Parties (COP)

CONTRIBUTION OF BIODIESEL TO CLIMATE CHANGE

Transport sector GHG emissions:

Current government policies to reduce GHG emissions in the transport sector are focused on promoting electric and energy efficient vehicles and cleaner fuels:

- Extending rail and prioritise public transport;
- Encouraging energy saving across transport sector;
- Promoting energy efficient vehicles and clearer fuels; and
- Improving pedestrian experience.

These policies have not been enough to reduce absolute levels of GHG. Emission trends for Hong Kong published in the Climate Change Report by the Environment Bureau show a continuous increase of absolute emissions, from 33,000 kilotons C02eq in 1998 to 43,000 kilotons CO2eq in 2012 (latest data reported by the government). The contribution of the transport sector is also higher than ever (+7,000 kilotons CO2eq, 17% of the total in 2012), and will become progressively more important as power generation is decarbonized with the change in fuel mix.

Heavy duty transportation still relies on diesel. The extension of the rail system or the improvement of the pedestrian experience will not have an impact on goods vehicles. Electrification of the heavy duty vehicles will be challenging due to the high demand on the battery system in terms of power and capacity. Tests done with electric and plug in hybrid public buses in Hong Kong (KMB) have reportedly been unsuccessful, and logistic companies are not planning the electrification of their fleets in the near future. With no active policies to promote low carbon diesel, the emissions of these fleets will remain substantially unchanged.

Contribution of biodiesel to mitigation

Even if we forget the fact that there are vulnerable poor countries affected by our emissions, Hong Kong will have to bear the social cost of carbon resulting from changes in human health, property damages from increased flood risk, and changes in energy system costs, such as increased costs for air conditioning. These costs have to be incorporated in our policy decisions.

In this respect, we think that active policies to promote GHG savings in transport through the use of waste based biodiesel are cost effective. Depending on the type of waste used, GHG savings of used cooking oil/grease trap/inedible lard biodiesel are in the range of 85% to 90% per unit of energy[2]. This means that for every unit of fossil fuel diesel energy replaced with its biodiesel equivalent, emissions are reduced to as little as 10%-15%.

In terms of absolute reduction, a B7 mandate (7% biodiesel content is the limit in EN590 diesel specifications, that can be used in all diesel engines without modifications) on the entire diesel consumption in Hong Kong (1.4M tons a year) results in savings of approximately 270-290 kilotons of CO2eq per year.

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[2] Renewable Energy Directive, Directive 2009/28

We also believe that there should be a local biodiesel market comparable, at least, with the volume of waste lipids produced in Hong Kong. Local collection of waste, local transformation and local consumption of the resulting biodiesel is the most environmentally efficient option, as well as the safest from a food safety perspective, as the incident with contaminated lard in late 2014 has shown us. It is fair to say that Hong Kong is now a "free rider" in terms of waste management. Most of the waste recovered is sent to Europe, were the taxpayer is "footing the bill" for the waste treatment (while booking the corresponding GHG saving). This is morally unacceptable and not sustainable.

We estimate that there are almost 60,000 tons of lipid waste currently available in Hong Kong, combining the current collection of used cooking oil, grease trap waste and inedible animal fat. Furthermore, the amount of lipid waste recoverable in Hong Kong is not a fixed value: it results from the legislation and the technologies applied. Proper legislation on waste oils will increase the amount of used cooking oil recovered and crack down illegal grease trap waste handling. Additional technology can substantially increase the amount of animal fat recovered from meat and bone residue from wet markets, food processing facilities and slaughtering houses, now processed inefficiently in substandard facilities. Proper waste treatment can increase the oil recovery in the grease trap waste sludge from Kowloon West Transfer Station. Even part of the food waste can be processed for lipid recovery with technology being developed in Hong Kong's universities. The development of these activities requires a stable framework for the current biodiesel producers.

POLICIES FOR THE PROMOTION OF LOW CARBON FUELS

In terms of reduction of carbon intensity of transport fuels, there are a number of policies that have been successfully implemented internationally:

- Mandatory blending targets (US, most of the countries in the EU);
- GHG reduction targets in transport fuels (Germany, California); and
- Price on GHG emissions through a proper carbon tax scheme (Canada), or introducing taxes/tax waivers on fuels based on their GHG saving.

Setting mandatory blending targets

The EU Renewable Energy Directive (RED) requires a 10% share of renewables in transport by 2020. Current mandates are in the range of 4%-8%, with plans to move to 10% before the RED deadline.

In Southeast Asia, Indonesia is moving to a B20 mandate, and Malaysia to B10.

This policy has the advantage of simple regulatory implementation and enforcement, although care has to be taken to specify only biofuels with high environmental performance (waste based low GHG footprint biofuel), so that the volume based target results in maximum GHG savings.

GHG reduction targets in transport fuels

Since January 1, 2015, Germany's mineral oil sellers must reduce the greenhouse gas emissions of their products by 3.5% (4% in 2017 and 6% in 2020). These targets have to be achieved through the incorporation of alternative fuels. The final 6% requirement in 2020 is the final target set by the EU Fuel Quality Directive.

Another example of GHG savings target is the Californian low-carbon fuel standard (LCFS), enacted in 2007. The LCFS requires oil refineries and distributors to ensure that the mix of fuel they sell in the Californian market meets the established declining targets for GHG emissions. The final target is the reduction of 10% in the carbon intensity of California's transportation fuels by 2020.

Hong Kong could follow the same path, including requirements in GHG savings in the specification of their fuels in the Air Pollution Control (Motor Vehicle Fuel) Regulation. This policy of tightening fuel specifications has already proven successful for the reduction of sulphur.

Fuel taxes based on GHG savings

Hong Kong has historically preferred voluntary measures promoting clean energy and energy saving over mandatory schemes. A preferential tax status for biodiesel over diesel could be enough to drive oil companies and clients to incorporate biodiesel in the transportation fuel mix.

Tax on diesel was waived by the government to promote the use of 10 ppm (Euro V) sulphur diesel (reduced from $2.89 per litre to $0.56 per litre in Dec 2007 and further reduced to zero in July 2008), eliminating the tax advantage that biodiesel had (biodiesel is a non-dutiable commodity). This measure was always considered provisional. The Legislative Council's plan was to review the measure and make 10 ppm diesel fuel standard mandatory in 2009, in tandem with the EU. But the tax credit, with a cost of HKD 5 billion per year, has never been reversed, despite the mandate of the EU of 2009. Even Pearl River Delta mainland China has mandated 10 ppm sulphur diesel.

We understand the difficulties or reversing a tax scheme affecting relevant stakeholders. One option would be to modify the Euro V specification to include a minimum amount of biodiesel (and therefore requiring a biodiesel blend to qualify for tax exemption). This would substantially maintain the reduced diesel price resulting from the tax credit, (against a small premium for biodiesel), while still making the change from Euro 5 of to B7 voluntary. We should expect the same success achieved for the sulphur reduction.

SHORT TERM INCENTIVE SCHEMES

As mentioned before, The Hong Kong Climate Change Report 2015 recognizes biodiesel as a low carbon choice and reaffirms the commitment of the government to actively support it, including the promotion of biofuels use in government vehicles and non-road mobile machinery and the recovery of waste cooking oils for biodiesel production as mitigation measures to deploy.

This commitment has already resulted in a number of initiatives, welcomed by the industry:

- B5 is currently being used in the majority of the governmental departments. There is a plan to expand the program to the rest of the departments;
- Development Bureau is running a pilot scheme requiring its contractors to use B5. There is a plan to expand this to the rest of the works/departments this year;
- Within the Statutory Corporations, the Airport Authority is already using B5 in all of its vehicles;
- The Government (EPD) has recently appointed a major consultancy firm, AECOM, to carry out a management study for the objective of promoting wider use of biodiesel in Hong Kong; and
- There is an active communication campaign, addressing key stakeholders.

Legislative Council initiatives have focused on the upstream collection of used cooking oil:

- On the 25th of September 2015, LegCo Panel on Food Safety and Environmental Hygiene met to discuss the Substandard Lard Incident and Food Safety Issues. All biodiesel producers were invited to the Panel Discussion. Conclusions included the need to develop authorization and monitoring systems to ensure proper handling of UCO and GTW and the promotion of local biodiesel production and consumption.

As a continuation of these initiatives, additional actions of support could be implemented within a short timeframe, with an immediate impact much needed by the local biodiesel producers.

Public transportation: franchised public bus services

Buses represent a substantial part of the fuel consumption (21% on energy basis), and therefore of transport related GHG emissions. There are currently five companies providing franchised public bus services:

- Kowloon Motor Bus Company (1933) Limited;
- Citybus Limited;
- Long Win Bus Company Limited;
- New World First Bus Services Limited; and
- New Lantao Bus Company (1973) Limited.

These companies have their own fuel depots, and purchase fuel in bulk from major oil distributors operating from Tsing Yi terminals. This helps B5 implementation, as the change doesn't involve any modification in petrol stations. Actually, all bus companies have B5 available from at least Shell and Chevron, who have already adapted their terminals to deliver blends, and are offering listed prices for B5 together with Euro V diesel. As B5 is compatible with all diesel engines, there is no technical barrier for the conversion of bus fleets to B5.

Fares of franchised bus services are charged according to a scale of bus fares determined by the Chief Executive-in-Council. The Administration takes into account a variety of factors known as the Modified Basket of Factors ("MBOF") when assessing bus fare adjustment for the purpose of making recommendations to CE-in-Council. Changes in operating costs are one of the factors considered in the MBOF. Fuel costs have dropped significantly, and the Legislative Council has recently enquired whether the authorities have assessed if there is any room for lowering the fares in view of the persistently low auto-fuel prices at present.

Future negotiations of the fare adjustment (the formula is applied quarterly) could include the incorporation of B5 in the fleet.

Hong Kong Government

Although the government has launched an aggressive scheme to promote the use of biodiesel in its Departments, it could encourage the availability of retail biodiesel by discussing with the major oil distributors the availability of B5 or B7 in some petrol stations for its road fleet (police, fire department, etc.). This availability could be also extended to the supply of diesel to the marine fleets, which could help the accessibility of B5 for recreational vessels too.

Government's contractors

Development Bureau has run pilot scheme for B5 in Public Works. This trial covered various types of construction machinery like air compressors, generators, excavators, crawler cranes, rollers, etc. The feedback of the trial (conducted from late 2013 to mid-2014) has been positive. As a result, the Department plans to introduce mandatory use of B5 for non-road based machinery in new public works contracts in tenders invited from early 2016 onwards. An email was sent to construction companies in mid-November, informing them of this scheme.

We see this as an extremely positive plan, and we look forward for its quick implementation. Additionally, due to the low diesel price environment, the government could consider extending the mandate to all construction works (i.e. including also works of tenders invited before 2016). There is now a company (Gammon Construction Limited) already voluntarily using B5 in all their sites.

Statutory Corporations

Dedicated to improving air quality and lowering its carbon footprint through the use of alternative energy, the Airport Authority (AA) has been promoting the use of biodiesel in its vehicles at the Hong Kong International Airport (HKIA) for a long time. In October 2009 the AA implemented B5 biodiesel as the standard fuel across its diesel fleet and set up a number of biodiesel refuelling points across the HKIA.

The AA example could be extended to the rest of the Statutory Corporations. Again, their commitment to reduce the carbon footprint of their activities could encourage the oil operators in Hong Kong to change some petrol stations to B5. Statutory Corporations that could be part of the scheme are the Urban Renewal Authority, the Hospital Authority, Hong Kong Science Park Corporation, Ocean Park Corporation, and the MTR.

DISTRIBUTED GENERATION

Hong Kong has an excellent example of distributed generation with the Zero Carbon Building.

A zero carbon building is a building with zero net energy consumption or zero net carbon emissions. Low/zero carbon buildings have attracted much attention in many countries because they are considered as an important strategy to achieve energy conservation and reduce greenhouse gases emissions[3]. Examples of

- Self-sufficient solar house, Freiburg, Germany
- Plus Energy House, Ministry of Federal Ministry for Transport, Building and Town Planning, Germany
- Beddington Zero Energy Development, London
- Pusat Tenaga Malaysia's ZEO Building, Malaysia
- BCA Academy, Singapore
- The Samsung Green Tomorrow House, South Korea

This ZCB in Hong Kong generates on-site renewable energy from photovoltaic panels and a tri-generation system using biofuel made of waste cooking oil and achieves zero net carbon emissions on an annual basis. Beyond the common definition of a 'zero carbon building', ZCB exports surplus energy to offset embodied carbon of its construction process and major structural materials[4]

Although there are other options to decarbonize electricity production (conversion of coal to gas, wind, solar), distributed generation with biodiesel can be an efficient option when diesel is already being used, like construction site generation and off grid gen-set generation. A good example of the latter is CLP's first off-grid commercial RE supply project for Dawn Island[5]. In construction site generation, Gammon has been using B5 extensively for years as mentioned earlier[6].

OTHER CONTRIBUTIONS OF BIODIESEL

Although we have discussed above the advantages of biodiesel in terms of GHG reduction in diesel transportation, we would like to emphasize that local production of biodiesel can play an important role in addressing other developmental challenges in Hong Kong:

- **Food safety:** At best, used cooking oil and grease trap are poured down the drains or dumped in the trash for our already-packed landfills. At worst, it is reprocessed and channelled back into the food supply. In December 2012 a dozen Hong Kong restaurants were found to be using cooking oil made from "gutter oil" containing carcinogen benzo(a)pyrene. In September 2014, another gutter oil scandal: non edible lard from Hong Kong was used for bakery, subsequently distributed in Taiwan and Hong Kong. Reprocessed cooking oil can increase chances of heart disease and diabetes, has implications for Alzheimer Disease and can have adverse impacts on children development;

- **Economic development:** Since the 2010-2011 policy address of former Chief Executive Donald Tsang Yam-kuen, New Energy Technology has been a target for development in Hong Kong. Local biodiesel plants form part of key environmental infrastructure in the region, together with other leading projects like the sludge incinerator, the organic

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3 Zero Carbon Building web page, zcb.hkcic.org/Eng/Features/whatiszcb.aspx

4 *Ibid*

5 http://www.emsd.gov.hk/minisites/symposium/2011/session/ppt/E1_PPT_Paul%20Poon.pdf

6 http://www.gammonconstruction.com/uploads/files/gam_sr_2013/files/assets/seo/page15.html

waste treatment facilities and the future MSW waste to energy incinerator. The biodiesel plants in Hong Kong are:

- o Integrated in the community, with important value remaining in HKSAR through payments to restaurants and collectors;
- o A hub of knowledge in chemical engineering; and
- o A technology platform for future environmental developments;

- **Energy security:** Hong Kong is particularly vulnerable to fluctuations in the international energy prices, (ranking 99th out of 129 jurisdictions measured by the World Energy Council), as it imports 99.96% of its primary energy. Current installed local biodiesel capacity is enough biodiesel to replace 10% of the fossil diesel used in every diesel vehicle on the roads;

- **Air pollution:** Hong Kong suffers HK$40 billion in economic losses to the community from air pollution and 3,069 premature deaths (Anthony J Hedley et al., 2012). Biodiesel reduces:
  - o Particulate matter emissions by 10-20% for nano, ultrafine, fine and coarse size range with biodiesel blends up to 20% an up to 40% in the case of B100 (Shu-Mei Chien *et al.*, 2009);
  - o Volatile organic compounds by ~60% (Chiung-Yu Peng *et al.*, 2012);
  - o Polycyclic aromatic hydrocarbons (PAHs), many of which are carcinogens, by ~10% (Shu-Mei Chien *et al.*, 2009);
  - o Unburned hydrocarbons (HC) by ~20% (U.S. Environmental Protection Agency, 2002);
  - o Carbon monoxide (CO) by ~10% (U.S. Environmental Protection Agency, 2002);
  - o Benzene: ~20% in emissions of the carcinogen benzene (S.L. Ferreira *et al.*, 2008); and
  - o NOx emissions are equal or lower for blends below B10 (Jon Andersson *et al.*, 2011).

CONCLUSIONS

Hong Kong has a moral responsibility, as wealthy leading city, to do more than mainland China, and much more than most of the world, on greenhouse gas reduction, with policies in line with other world class cities.

Biodiesel would be the best and quickest way of mitigating heavy duty vehicle GHG emissions, offering 85-90% GHG savings for every unit of energy replaced. As mentioned before, with Hong Kong’s installed capacity of 100,000 tonnes of biodiesel, using the entire production of biodiesel for blending in B7, translates into a reduction of 270-290 kilotons of CO2eq per year.

The current market situation, with very low diesel prices (benefiting construction companies, public transportation concessionary companies and logistic operators), offers a unique opportunity to implement these measures.

Active policies from the Government are required to “level the playing field” in terms of GHG emissions. Effective and proven policies are mandates, GHG reduction targets on transportation fuels or differential tax schemes, as discussed above. We believe that a mandate could be easily implemented and that, alternatively, a change in the specification of Euro V, including a minimum quantity of biodiesel, would be the most efficient voluntary measure to achieve a rapid change.

While these policies are implemented, a number of short term incentive schemes could be implemented to help the growth of the local biodiesel production, blending infrastructure and consumer confidence. These schemes require the active participation of public transportation companies, the government, the government contractors, statutory corporations.

Biodiesel from waste offers us the rare opportunity to alleviate several of Hong Kong's major development challenges at once, without requiring significant trade-offs. With the right support, Hong Kong can make greater use of this solution today.

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Global experience in carbon pricing: potential implications for Mainland China and Hong Kong

The HKIE Environmental Division Annual Forum
April 18, 2016

Contact:
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Joshua Hodge

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Carbon Pricing: Theory

- A price on a pollutant, like CO_2 or more generally Greenhouse Gases (GHGs)—comes about:
  - through a tax set by a government or
  - by the establishment of a market for pollution allowances that can be traded

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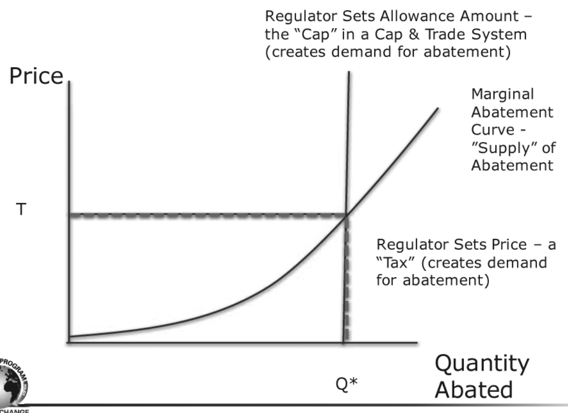
Carbon Pricing: Theory



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Carbon Pricing: Theory

- Carbon pricing works by creating economic incentives:
  - Regulators do not need to guess who can more easily abate or the best technological solution.
  - Individual firms and consumers are free to make their own choices—the carbon price tips their economic interests towards cleaner options.
  - The "benefits" of carbon pricing are as an alternative to "command and control"; with less flexibility costs are higher "by definition" unless the government knows every detail of abatement options open to polluters.
  - Example: US markets for SO2 and NOx allowances

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Differences between Tax and Cap and Trade

- With a tax the price is set and is invariant (unless or until the regulator changes it) but the quantity emitted is uncertain.
- With Cap and Trade, the allowable emissions are set with certainty (unless or until the regulator changes it) and the price is uncertain.
- Theoretical work has demonstrated an efficiency preference for a fixed price (i.e. tax) over cap and trade when there is uncertainty and the abatement cost is more sensitive to that uncertainty than the damages from the pollution.
  - But this difference is exaggerated by the implicit assumption that the tax or cap is set once and for all and by the nature of the uncertainty—is cost uncertainty noise around a trend

Implementation Challenges with Both

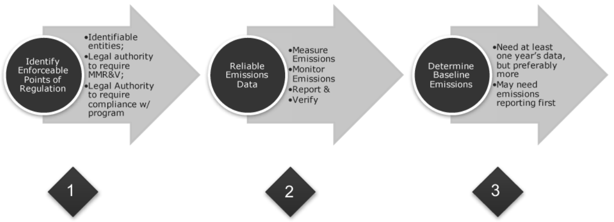
- Who/what pays the tax or is responsible for surrendering allowances?
- What is the incidence of the tax or carbon price—who actually bears the cost?
- What is covered, how is it measured?
- Outside credits, opt in provisions?
- Free allowances (to who) or auctioned?
- Revenue from Tax or Auction—what happens to it?
- Interaction with existing regulations and policies
- Banking, borrowing—allowances as a new currency or financial instrument?
- Price caps and collars?
- What is the right tax rate, when/how does it change if needed?

Experiences with Carbon Pricing

- Cap and Trade:
  - China
  - EU ETS
  - Kazakhstan
  - Korea
  - New Zealand
  - RGGI (US)
  - Switzerland
  - WCI (Canada and US)
- Carbon Taxes:
  - British Columbia ($10-$30 per ton – increases over time)
  - Norway ($6-$48 per ton – varies by industry)
  - Sweden (up to $130 per ton)

Let us take a closer look at Cap and Trade…

Key Design Elements of a Cap and Trade System - 1



What is the scope of the program? What sectors will it cover?

How will facilities emissions measure, monitor and report emissions?

What is our emissions starting point?

Source: Litz, 2013

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Key Design Elements of a Cap and Trade System – 2

What is our environmental goal? How much should we reduce?

Where does allowance value go?

What rules apply in the trading program? What flexibility exists?

Source: Litz, 2013

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EU ETS: The World's Largest ETS

- **Market for CO_2 emission allowances**
  - operational since 1 January 2005
- **First transboundary emissions trading system**
  - implemented in very limited time after initial EU market skepticism
- **Largest emissions trading system worldwide**
  - >10,000 installations and >40% of EU greenhouse gas emissions
- **Three trading periods: 2005-2007, 2008-2012, 2013-2020 (design of a fourth period, 2021 - 2030 underway)**- with significant development between periods
- **Emissions allowance allocation method**
  - Member States could auction up to 5% between 2005 to 2007
  - Member States could auction up to 10% between 2008 to 2012

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EU ETS: Coverage

- **GHGs covered include CO2, N2O and PFCs**
- **Sectors phased-in over time, based on sector-specific production or capacity thresholds:**
  - **Phase 1**: Electricity Generation and Major Emissions-Intensive Industries (incl. Oil Refineries)
  - **Phase 2**: Aviation within EU; international aviation introduced, later dropped, to be reintroduced in 2017
  - **Phase 3**: CCS, Petrochemicals Manufacturing and remaining Metals Manufacturing

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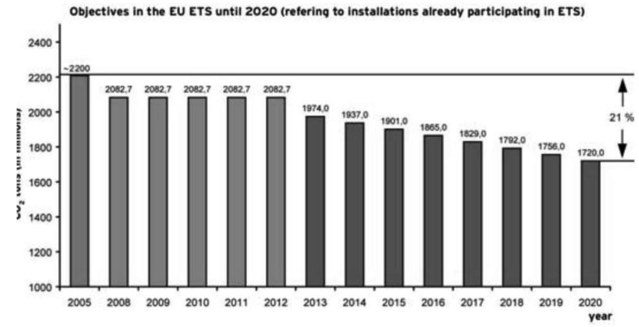
EU ETS: Emission Cap 2005 - 2020



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How has the EU ETS fared?

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EU ETS: A Timeline

2005 – 2007	2008 – 2012	2013 - 2020 and thereafter
EU ETS 1st Trading Period	EU ETS 2nd Trading Peri	EU ETS 3rd Trading Peri
Pilot phase: learning by doing	Stabilization and further operationalization	Consolidation and EU-wide harmonization
	First Kyoto Protocol Commitment Period	Nucleus of a linked carbon market

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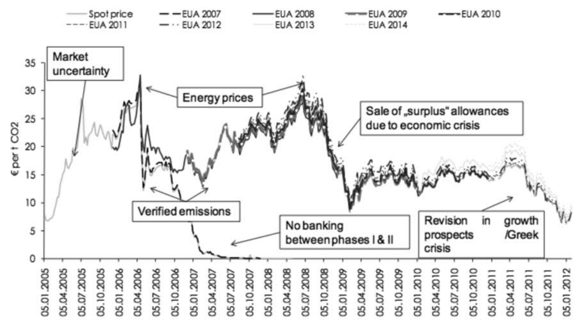
Price Volatility in Phases 1 and 2



Sources: Kettner et al., Point Carbon

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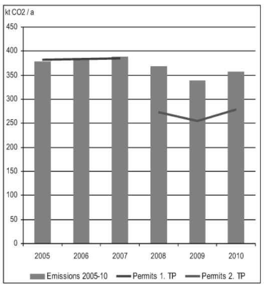
Has it Reduced Emissions?

- Depends on who you ask.
- Effectiveness was limited due to the economic crisis in 2009 and 2010.
- Analysis by the Australian "Productivity Commission", an independent advisory body, of EU ETS effects on German and UK energy sectors:
  - Estimated increase of 7% in use of gas for Germany and 10% for UK in 2010, induced by the EU ETS
  - Calculated emission reduction effects of the EU ETS in 2010: 2.4 Mt CO_2 in Germany and 7.7 Mt CO_2 in UK
- Other estimates: 2-5% emission reduction in 1st period alone (Ellerman)



Source: German Emissions Trading Authority

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New Investments in Low-Carbon Technologies – ETS or Other Regulations?

- According to a market survey by ZEW, 57% of ETS companies in Germany planned to invest in CO_2-abatement measures in 2010, up from 40% (2009).
  - 19% of the companies stated CO2 emissions as the main reason for their investment decisions (up from 5% in 2005-09)
- Danish Oil and Natural Gas plans to switch its energy production from 85% fossil-based and 15% renewable-based today to 15% fossil / 85% renewable by 2040.
- Plans for several coal-fired power plants in Germany were cancelled in recent years and partly replaced by plans for gas-fired power plants.

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Key Lessons from the EU ETS

- **Cap-Setting: too generous in the first trading period?**
  - Protecting domestic industries vs. integrity, effectiveness of the scheme
- **Allocation: gradually moving away from free allocation**
  - Political haggling: Allowances are an asset worth 30 – 50 billion Euro
  - Keep allocation and cap-setting separate
  - Auctioning revenue important benefit
- **Let the market work!**
  - Carbon prices in the EU have been undermined by the implementation of overlapping energy and environmental policies including:
    - Renewable energy subsidies (esp. in Germany)
    - Energy efficiency mandates

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Now, let us take at look plans for Cap and Trade in Mainland China…

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Pilot Cap and Trade Systems in Mainland China

- As part of the 12th Five-Year Plan, the Chinese government selected seven areas to establish pilot emissions trading systems. These are located in:
  - Beijing
  - Tianjin
  - Shanghai
  - Chongqing
  - Hubei
  - Guangzhou
  - Shenzhen

National ETS for Mainland China

- In September 2015, China announced that it would launch a national emission trading system in 2017.
  - The ETS will cover power generation, steel, cement and other key industrial sectors
  - The system will impose caps on ~10,000 companies when it launches in 2017, regulating 3 – 4 billion tons of CO_2
  - The ETS was the centerpiece of the the Chinese commitment (INDC) at COP 21 in Paris
- China is expected to retain the ETS pilots even after the national system debuts.
  - The government's expectation is that carbon prices among exchanges will tend to unify based on a national standard of quota allocation

Linking Hong Kong to a Mainland ETS

- The Guangzhou and Shenzhen ETS's have long sought to link their systems to Hong Kong.
- In January 2016, Hong Kong announced a new target of reducing the city's energy intensity by 40% by 2025.
- In February 2016, Xie Zhenhua, China's special representative for climate change, formally invited Hong Kong to join the new National ETS.

Coverage: How do the Systems Compare?

Region	GHGs	Covered CO2 emissions (Mton)	Share of total emissions	Direct or indirect emissions	Number of covered entities	Emissions threshold for coverage (tons Co2/year)	Historical emissions period
EU-ETS (Phase 1)	CO2	2014	47%	Direct	11,500	>10,000	1996 - 2004
Guangzhou	CO2	209	42%	Direct & Indirect	830	>20,000	2010-2012
Shenzhen	CO2	32	40%	Direct & indirect	635	>5000	2009-2011
National ETS (planned)	CO2	TBD	TBD	TBD	~10,000	TBD	TBD

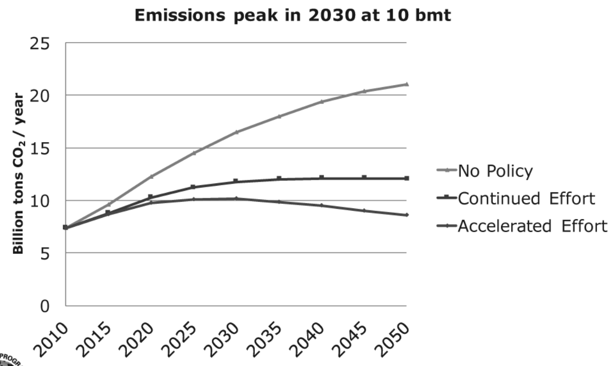
Source: Zhang et. al, 2014

Mainland China and the Paris Agreement

- Against the backdrop of the 13th 5 Year Plan, China’s INDC put forward two new goals:
  - Reducing CO2 emissions per unit of GDP (known as carbon intensity) by 60 to 65 percent below 2005 levels by 2030
  - Increasing its forest carbon stock volume by around 4.5 billion cubic meters from 2005 levels by 2030

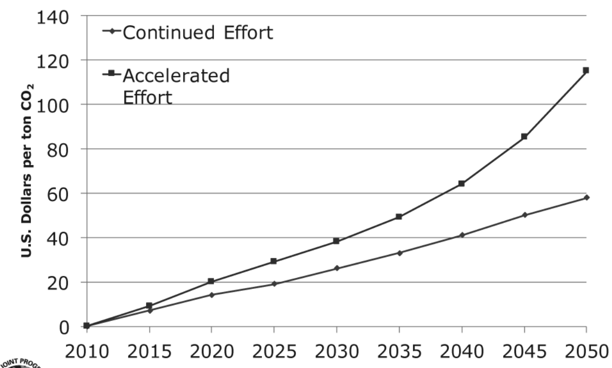
http://globalchange.mit.edu/

With the Accelerated Effort described in the INDC, MIT projects Mainland Chinese Emissions to peak in 2030..



http://globalchange.mit.edu/

and for Carbon Prices to approach USD $40/t by 2030



http://globalchange.mit.edu/

Lessons for Hong Kong from the Global Experience

- **Start slowly.** One way to do this is for Hong Kong to pursue its own ETS pilot, work out the kinks, and explore linkages later.
- **Have a flexible system.** Be able to adjust the cap if it becomes clear the price is inappropriate.
- **Auction allowances.** Avoid free allocation of allowances despite inevitable political pressure to do so.
- **Don’t combine policies.** Avoid diluting the effectiveness of carbon pricing with overlapping renewable energy subsidies, energy efficiency or fuel economy standard mandates.
- **Cover as many sectors as possible.** Minimize exceptions.

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Thank you!

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MINIMISING THE COST OF HONG KONG MAKING AN APPROPRIATE CONTRIBUTION TO GLOBAL GHG MITIGATION

J Robert Gibson
Civic Exchange

Abstract: *By the 2015 Paris Agreement, the Nations of the World set the target of achieving carbon (GHG emission) neutrality in the second half of this century. Pricing carbon emissions and introducing carbon emissions trading will facilitate this transition at minimum cost. Hong Kong's good governance and entrepreneurial traders enabled it to benefit from a similar market in the past – textile quotas in the 1970s and 1980s. Hong Kong's early participation in China's National carbon market is likely to be the lowest cost way for it to make an appropriate contribution to carbon emissions reductions the Paris Agreement implies for advanced cities. Further, this action will increase opportunities for Hong Kong to earn its living by providing some of the engineering and financial services that China needs for its transition to a low carbon economy.*

INTRODUCTION

This paper addresses four questions:

1. What is an appropriate contribution for Hong Kong to make to GHG mitigation?
2. How can Hong Kong reduce GHG emissions?
3. What is the easiest way for Hong Kong to put a price on carbon emissions?
4. What is the benefit to Hong Kong of a cross-border carbon market?

WHAT IS AN APPROPRIATE CONTRIBUTION FOR HONG KONG TO MAKE TO GHG MITIGATION?

The global context on GHG mitigation

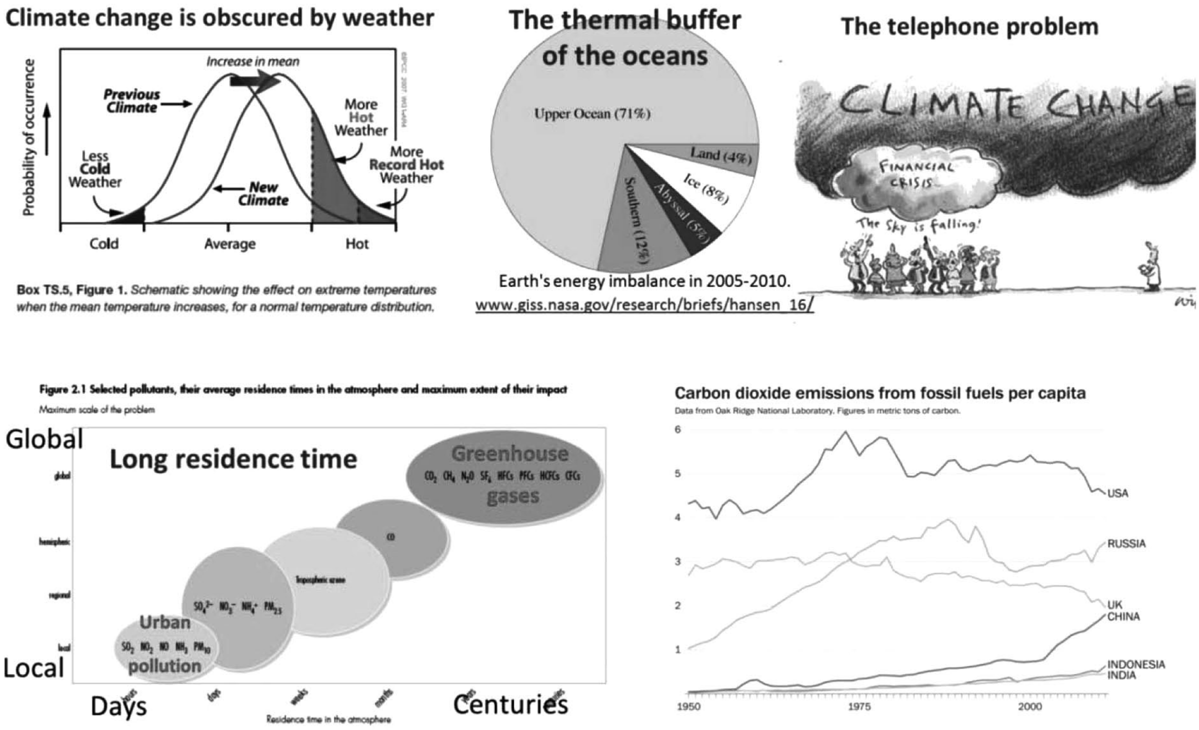
The 2015 Paris Agreement adopted the objective of holding the increase in global average temperature well below 2°C above preindustrial levels and pursuing efforts to limit the increase to 1.5°C. It was agreed to achieve this goal by peaking global GHG emissions as soon as possible and undertaking rapid reductions thereafter so as to achieve a balance between anthropogenic GHG emissions and their removal through [natural] sinks in the second half of this century (UNFCCC-COP, 2015, pp. 3-4).

The Paris Agreement sets up a 'pledge and review' mechanism for countries to work together to achieve this target. One way of describing this is to imagine you go to an excellent dinner with your friends. At the end of the dinner each person puts on the table their contribution towards paying the bill – this being the pledge; and someone adds up the money pledged – this being the review. If it is not enough everyone is asked if they can pay more, and the process is repeated until there is enough to pay the dinner bill.

Our civilization is 'dining well', and the initial pledges made in Paris, called 'Intended Nationally Determined Contributions' (INDC) fall well short of the reduction in GHG emissions required to keep the temperature increase to 2°C let alone 1.5°C.

Why are the INDCs inadequate? I believe there are five main reasons:

Figure 1:



Climate change is obscured by weather (IPCC, 2007, p. 53); The thermal buffer of the oceans (GISS, 2012); The telephone problem (The Sydney Morning Herald, 2008); Long residence time (United Nations Environment Programme, 2007, p. 43); Carbon dioxide emissions from fossil fuels per capita (The Washington Post, 2015)

Firstly, climate change is obscured by weather. That is the daily variation of the weather is much greater than the impact of climate change. To determine if we have climate change, we must examine the statistics of the weather over a period of years.

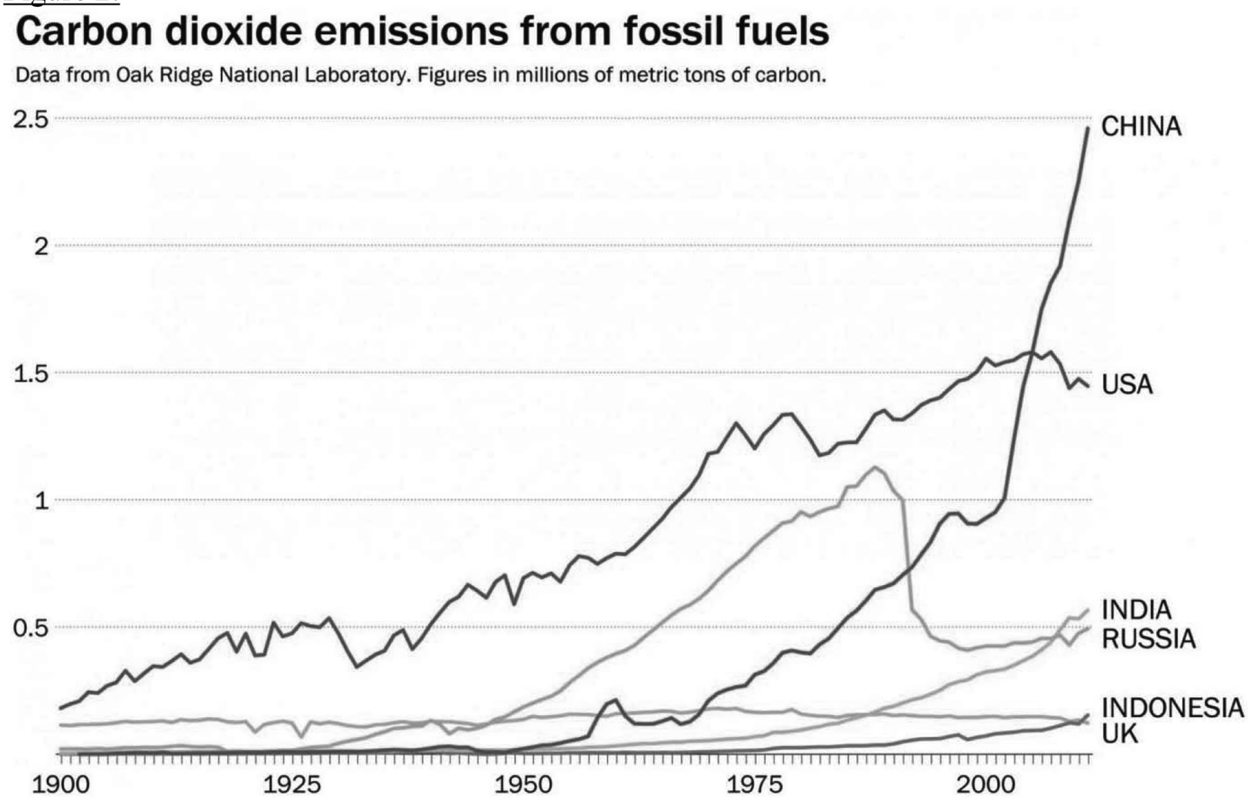
Secondly, we focus on the change in land and air temperatures. Yet, about 96 per cent of the Earth's energy imbalance warms the oceans and melts ice and only four per cent warms the land and atmosphere. Further the El Niño / La Niña oscillation transfers heat between the oceans and the air causing land temperatures to fluctuate. For example, land temperatures peaked with the 1998 El Niño and then changed little until early 2015 when El Niño started to create another peak. To observe Earth's energy imbalance, we should look not at land surface temperatures but at the increase in sea levels which reflect the thermal expansion of oceans and the water flowing into them from the melting of ice which is on land.

Thirdly, we have 'the telephone problem'. Just as the immediacy of a phone ringing takes precedence over more important matters so events such as the 2007/8 financial crisis and the current migration into Europe takes precedence over the long-term need to reduce our GHG emissions.

Fourthly, climate change due to GHG emissions needs long-term global action. This is not like Beijing's visible air pollution which can be corrected within weeks if factories are shut. CO_2, the main GHG, spreads evenly around the world and remains there for well over a century.

Finally, differences in the stage of development and per capita emissions of countries make it difficult to get agreement on how to share the burden of taking action. For example, India argues that its low per-capita emissions compared to the US and EU justifies it substantially increasing coal-fired electricity generation. The large size of the Major Emerging Economies such as India and China, however, means their growth in per capita emissions has a major impact on global GHG emissions. While the graph in figure 1 shows China's per capital emissions are below the UK's, the graph in figure 2 shows the substantial amount by which the total of these emissions now exceed those of the US.

Figure 2:



(The Washington Post, 2015)

Given the context outlined above, what is an appropriate contribution by Hong Kong to GHG emissions mitigation?

The HKSAR Government participated in the UN process which led to the Paris Agreement as part of the Chinese delegation. What has it pledged so far?:

- Firstly, in its Hong Kong Climate Change Report 2015 (HKSAR Government Environment Bureau, 2015) it advised it will use China's pledge to reduce carbon emissions intensity by 60-65 per cent between 2005 and 2030 as a reference when shaping its mitigation plans.

- Secondly, in the January 2016 policy address (HKSAR Government, 2016), the Chief Executive of Hong Kong confirmed the target set in May 2015 to reduce the Hong Kong's energy intensity[1], by 40 per cent compared by 2025 compared to 2005. As page 66 of the May 2015 paper notes, achieving this target depends on community support and passing the necessary legislation.

The HKSAR Government has not yet made, or discussed, 2030 or 2050 commitments. It is reasonable, however, to expect that China complying with the Paris Agreement will include its advanced cities, such as Shanghai and Guangzhou, moving towards carbon neutrality by 2050 with Hong Kong deciding to make a similar commitment.

HOW CAN HONG KONG REDUCE ITS GHG EMISSIONS?

Hong Kong's action to reduce carbon emissions can comprise:

- Reducing demand for energy through improved energy efficiency and life-style changes.
- Planning our city to reduce the need to travel and maximise the extent to which low carbon intensity public transport is used.
- Decarbonising electricity supply coupled with switching from fossil-fuel to electric powered vehicles and appliances.

These actions require both policy changes and improvements in technology. Initial steps to improve efficiency are low cost or can even lead to cost savings. However, with zero carbon electricity generation as the goal, the subsequent changes will lead to higher costs for consumers. Long-term technological advances may eventually reduce these costs; however in the 2030/50 timeframe, we will need to continue to burn fossil fuels and will have to capture the resulting CO_2 emissions and pump them underground. It is the marginal cost of this 'Carbon Capture and Storage' that is likely to determine the price which needs to be put on GHG emissions.

How do we get our community to agree to this? The key arguments are:

1. The polluter pays principle: GHG emissions damage the climate and should be paid for.
2. Motivating decarbonisation: If GHG emissions are priced then business and consumers will work towards reducing them.

WHAT IS THE EASIEST WAY FOR HONG KONG TO PUT A PRICE ON CARBON EMISSIONS?

As noted above, Hong Kong will need to pay for its carbon emissions long-term. The question, therefore, is how to introduce this price with minimum economic disruption. Further, how might Hong Kong put this price on soon in order to accelerate the decarbonisation of its economy?

Two actions which can be taken:

1. Future-proof our decisions on investing in long-term assets by including a 'Shadow Carbon Price' into investment evaluation. For example, the Scheme of Control Agreements for the power companies could require them to use a 'shadow carbon price' for carbon emissions when calculating costs of different ways of meeting electricity

[1] Emissions intensity is defined as units energy consumed per unit of GDP

demand. The end result of this may be investing in assets which have a higher cost in short-term, but will be lower-cost once a carbon price is introduced.

2. The HKSAR Government could make a revenue neutral tax switch from taxes on property (rates) to a tax on the carbon content of energy used. If, for example, this is introduced for Commercial Buildings, it may significantly improve the payback period of investments to improve energy efficiency. It might even be popular. While no one likes paying taxes, it is preferable to pay a tax on energy consumption which one can manage down rather than a fixed property tax.

WHAT IS THE BENEFIT TO HONG KONG OF A CROSS-BORDER CARBON MARKET?

Hong Kong's successful Textile Quota Market

Hong Kong's successful operation of a textile quota market in the 1970s and 1980s is a 'concrete' example of the benefits a market in permits (Lee, 1988).

Textile quotas were imposed under the Multi Fiber Agreement between 1974 and 2005 to limit the export of clothes to the US and Europe. They were designed to protect textile industries in Developed Countries from being driven out of business by imports from Developing Countries.

Each Developing Country was given a quota of garments that it could export to a given Developed Country. If the Developing Country did not use all its quota in one year then it received less in the next year.

The Hong Kong Government initially allocated the quota based on past sales and then set up an excellent mechanism for companies to sell quota to each other. Thus, a profitable business could buy quota for expanding sales while a weak business could sell quota. The trading system allowed the companies which could get the most value from the quota to use it. It also led to Hong Kong using its quota in full each year and thus gaining quota share over time.

The potential for Hong Kong to benefit from China's National Carbon Market

Hong Kong, given its good governance and entrepreneurial traders, could make a success out of a carbon market in the same way as it benefited from the textile quota system.

Hong Kong combining with the carbon emissions market in China has the following advantages:

1. It is likely to be more cost effective to save carbon emissions in the Mainland than Hong Kong. Buying credits which pay for projects in the Mainland would thus reduce Hong Kong's cost of meeting part of its emissions target.
2. Hong Kong earns substantial income providing services. Part of the arrangement for Hong Kong participating in the China's National carbon trading scheme should be access for its engineering and financial services to work on carbon reduction projects in China. Further, Hong Kong's stock exchange should be able to trade the carbon credits for China's National carbon trading scheme.

What lessons can Hong Kong learn from Switzerland's plans to link with the European Union Emissions Trading Scheme?

Switzerland is an interesting case study for Hong Kong to consider (CDC Climat research, EDF, IETA, 2015) as it is a small territory looking to trade carbon emissions with the much larger European Union. Switzerland has committed to reduce GHG emissions from 1990 levels by 20 per cent by 2020 and 50 per cent by 2030 (Federal Office for the Environment, Switzerland, 2015). Action it has taken to achieve these goal includes:

1. From 2001, it put a price on GHG emissions through a 'carbon levy' paid by about 1,900 firms. The proceeds of this levy funded building energy efficiency upgrades and reduced individual health insurance and business payments for social security.
2. From 2009, permitting firms to voluntarily join its carbon trading scheme to allow them to find lower cost means of abatement than the carbon levy.
3. In parallel, it has been negotiating to link its scheme with the European Emission Trading Scheme (EU-ETS). These negotiations have been going slowly, perhaps due to the EU-ETS's current surplus of credits and hence low carbon price. The negotiations, however, position Switzerland to link with the EU-ETS once conditions are favourable.

This three-step process is low risk as it has, to use the Chinese saying, the merit of '*crossing the river by feeling the stones'*. It is a path Hong Kong can follow while it waits to see the form China's National Emissions Trading scheme will take.

CONCLUSIONS

It is appropriate, given its high standard of living and dependence on trade, for Hong Kong to commit to carbon neutrality by 2050 as its contribution to the Paris Agreement's target of global carbon neutrality in the second half of this century. Putting a price on its carbon emissions and trading emissions credits both reduces the cost of meeting this commitment and should allow Hong Kong to earn income from its engineering and financial service industries contributing to carbon reduction projects in Mainland China. The first steps to achieving this objective are for Hong Kong to:

1. Put a levy on its own carbon emissions through a revenue neutral switch from property taxes to a levy on the carbon content of energy and building 'shadow carbon prices' into infra-structure investment decisions.
2. Follow Switzerland's example of setting up its own carbon market as a voluntary alternative to paying a carbon levy and then explore linking this to China's National Carbon Trading scheme.

ACKNOWLEDGEMENT

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Green Event Management Guideline

Introduction

This guideline provides a reference point for the Hong Kong Institution of Engineers for setting standards in areas which impact the environment when organizing an event. Those who are organizing events should give due consideration to these sustainable guidelines taking into account actual circumstances, unless if an alternative approach is considered to be better.

This guideline covers the following areas:

A. Selection of Venue
B. Communication and Promotion
C. Printing of Materials
D. Food and Beverage Selection and Arrangement
E. Waste Management
F. Facility Arrangement and Event Management
G. Reporting and Audit

The guideline is written to assist the end-users in organizing an event, and they are not intended to provide technical information.

A. <u>Selection of Venue</u>

a. Give first priority to venue with green initiatives adopted in their operation. The attributes of the venue should include but not limited to the following:
    i. Energy efficient facilities;
    ii. Strong recycling programme;
    iii. ISO 14001 Certification
b. Encourage overseas guest to choose airlines that are fuel efficient, and select hotels that have the same characteristics as mentioned in Point a.
c. Select venue that is easily accessible by public transportation to promote the use of mass transportation by the attendees.
d. Alert attendees to use the environmentally preferable choice of mass transit, and provide information to attendees about the public transit system (e.g. MTR station and exit).

B. <u>Communication and Promotion</u>

a. Communicate and promote the event by emails and e-channels;
b. Provide E-registration process;
c. Use of environmental friendly materials such as cardboard to prepare banners or similar promotional materials.

C. Printing of Materials

a. Minimize and optimize handouts by making information available online. Provide attendees the option of downloading materials via dedicated websites;
b. Use of environmental friendly paper;
c. Use of environmental friendly ink (e.g. water soy based ink) for printing;
d. Print on both sides.

D. Food and Beverage Selection and Arrangement

a. Communicate with attendees ahead of time about tea breaks/lunch/dinner to ensure proper portions are served;
b. Request to the caterer that bottled water should not be served;
c. Request to the caterer that non-disposal glasses/cups should be used such that drinks are refillable by pitchers or other means;
d. Request to the caterer to use non-disposal utensils;
e. Request to the caterer that table cloth should not be used for coffee breaks;
f. Request to the caterer that condiments should be served in bulk rather than packages;
g. Use beverages that are manufactured locally, and favor food that is seasonal and locally sourced;
h. Plan the size and type of food provision carefully to avoid food surplus. Provide low carbon menu.

E. Waste Management

a. Provide well-labelled recycle boxes, in particular paper, in the venue;
b. Request to event location manager to provide large containers in case bulk recycling of materials is required;
c. Donate leftover food to local NGO or food bank;
d. Provide bins to collect and recycle name badges;
e. Reuse signs where appropriate.

F. Facility Arrangement and Event Management

a. Communicate with the event location manager to maintain indoor air temperature at 25.5^0C $\pm 2^0$C;
b. Communicate with the event location manager to maintain the relative humidity range between 40 to 70%;
c. Recommend the use of computer for presentation (e.g. power point). Flipcharts should not be used;
d. Turn off lights in areas where they are not needed;
e. Recruit volunteers to monitor green activities on the date of the event;
f. Avoid issuing souvenirs to minimize waste generation. Recommend to provide electronic carbon offset certificates to the speakers if souvenir is required.

G. Reporting and Audit

a. Report of carbon emission of the event referencing to the Guidelines to Account for and Report on Greenhouse Gas Emissions and Removal for Buildings (Commercial, Residential or Institutional Purposes) in Hong Kong – 2010 Edition by EPD and EMSD and other recognized standards or guidelines;
b. Review and audit of the report by a Certified Carbon Auditor (or a 3rd party verifier);
c. Publish results of carbon auditing online.

Example of Green Event Organization – 2015 HKIE EVD Annual Forum

A. Selection of Venue

Hong Kong Convention and Exhibition Center was selected to be the venue for the 2015 HKIE EVD Annual Forum due to its commitment to green management.

Green Policy

- **P**romote sound environmental programmes continuously, progressively explore, test and implement new & innovative eco-friendly initiatives.
- **R**educe energy consumption, minimise waste generation, promote water conservation, and lower carbon emission level.
- **O**btain a balance between serving our customers better and the environment interests to achieve important environmental goals.
- **T**arget setting to evaluate environmental programmes & measure performance.
- **E**nhance environmental protection, communicate our green policies and programmes and increase engagement of our stakeholders including customers, staff, their families, suppliers and contractors.
- **C**omply fully with applicable local & international laws and regulations related to the environment.
- **T**endering process utilising sustainable procurement practices - choose suppliers & contractors that adopt environmentally-friendly practices.

Green Investment

- Annual capital expenditure and expenses on green equipment and services accounted for an average of 15% and 25% of the total capital expenditure and expense of HML respectively in the past three fiscal years.
- Over 15,000 pieces of T5 fluorescent tubes have been installed in the Hong Kong Convention and Exhibition Centre (HKCEC) which use less mercury, but achieve better lumen maintenance and longer lamp life.
- More than 600 sensor faucets have been installed to save water usage.
- A food waste decomposer is used to process food waste into compost for use in farms and schools, while an oil filter machine is used to save cooking oil

B. Communication and Promotion

There was a dedicated website for the promotion of the event. Registration can be received using email.

C. Printing of Materials

Environmental friendly materials were used for printing, and it was highlighted in the programme.

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Printed in Hong Kong

D. Food and Beverage Selection and Arrangement

A message was displayed at different locations in the serving hall to highight that no table linen was arranged as an environmental friendly approach in organizing an event. In addition, condiments were served in bulk.

No Table Linen

Table cloths are not used in order to promote a more sustainable approach in organizing an event. The absence of table cloths would minimise materials to be used, and also reduce the need for water, energy, and chemical to wash the linens.

E. Waste Management

Name badges are recycled.

F. Facility Management and Event Management

Carbon offset certificates were issued to the speakers as souvenirs.

G. *Reporting and Audit*

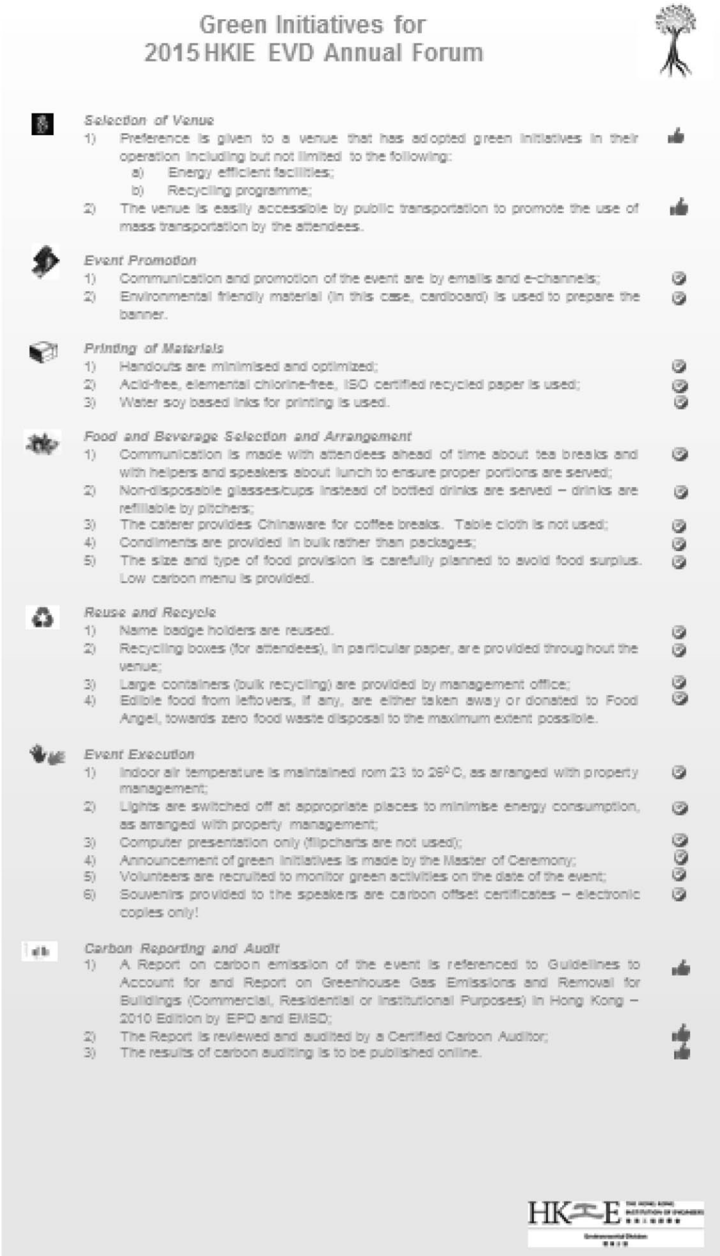
Carbon emission calculation was performed for the arrangement of the event.

			our case	EF	tCO2-e (HKIE)
Scope 2	Venue (sf)	4000	3152.68	1.48	1.1664916
Scope 1	**Material**	Proceedings			0.3856272
	Transportation				
	Local participants	For 300 participants	300	1.69	2.535
	Oversea travel	Taiwan, Taipei	1	0.29	0.29
		Korea, Soul	1	0.38	0.38
		Netherland, Amsterdai	2	1.6	3.2
		Switzerland, Zurich	1	1.6	1.6
Results		**Total tCO2-e**			9.5571188
		round up			10
		Carbon price	per ton		$150
		suggested carbon credit to offset (tonne)			10
		Final cost			$1,500

		Paper	4.8 * Table 7, page 38
For normal A4 paper			
assume 500 sheets per ream			
80 g / m2			
A4 size	297 x 210 mm	0.06237 m2	
1 ream of A4	in (g)	2494.8	
	in (kg)	2.495	
No. of A4 paper per proceedings		46	
No. of copies		350	
Total number of page for 300		16100	
Paper used	in (No. of ream)	32.2	
	kg of waste	80.339	
Carbon	in (kg CO2-e)	385.6272	

H. *Overall Green Management Promotion*

The following poster was included in the programme and it was displayed in the serving hall to further promote this environmental friendly initiative.



Green Initiatives for
2015 HKIE EVD Annual Forum

Selection of Venue

1) Preference is given to a venue that has adopted green initiatives in their operation including but not limited to the following:
   a) Energy efficient facilities;
   b) Recycling programme;
2) The venue is easily accessible by public transportation to promote the use of mass transportation by the attendees.

Event Promotion

1) Communication and promotion of the event are by emails and e-channels;
2) Environmental friendly material (in this case, cardboard) is used to prepare the banner.

Printing of Materials

1) Handouts are minimised and optimized;
2) Acid-free, elemental chlorine-free, ISO certified recycled paper is used;
3) Water soy based inks for printing is used.

Food and Beverage Selection and Arrangement

1) Communication is made with attendees ahead of time about tea breaks and with helpers and speakers about lunch to ensure proper portions are served;
2) Non-disposable glasses/cups instead of bottled drinks are served – drinks are refillable by pitchers;
3) The caterer provides Chinaware for coffee breaks. Table cloth is not used;
4) Condiments are provided in bulk rather than packages;
5) The size and type of food provision is carefully planned to avoid food surplus. Low carbon menu is provided.

Reuse and Recycle

1) Name badge holders are reused.
2) Recycling boxes (for attendees), in particular paper, are provided throughout the venue;
3) Large containers (bulk recycling) are provided by management office;
4) Edible food from leftovers, if any, are either taken away or donated to Food Angel, towards zero food waste disposal to the maximum extent possible.

Event Execution

1) Indoor air temperature is maintained rom 23 to 26°C, as arranged with property management;
2) Lights are switched off at appropriate places to minimise energy consumption, as arranged with property management;
3) Computer presentation only (flipcharts are not used);
4) Announcement of green initiatives is made by the Master of Ceremony;
5) Volunteers are recruited to monitor green activities on the date of the event;
6) Souvenirs provided to the speakers are carbon offset certificates – electronic copies only!

Carbon Reporting and Audit

1) A Report on carbon emission of the event is referenced to Guidelines to Account for and Report on Greenhouse Gas Emissions and Removal for Buildings (Commercial, Residential or Institutional Purposes) in Hong Kong – 2010 Edition by EPD and EMSD;
2) The Report is reviewed and audited by a Certified Carbon Auditor;
3) The results of carbon auditing is to be published online.

HKIE

Calculation for Offsetting Carbon Emissions

The Hong Kong Institution of Engineers Environmental Division Annual Forum
Hong Kong's Role in Low Carbon Development: Challenges and Way Forward

Date: 18 April 2016
Venue: Hong Kong Convention & Exhibition Centre

		Description	Annual Forum	EF	tCO2-e
Scope 1	**Materials**	Proceedings			0.77
	Local Transportation	Based from past experience, the EF is 1.69 tCO2-e for local traveling for an event with 200 participants with no flight	300	1.69	2.54
	Overseas Travel	Beijing, HK - please refer to CX's Carbon Calculator	1	0.54	0.54
Scope 2	**Venue (sf)**	For a venue of about 4,000 sq ft, the estimated emission can range from 0.2 to 1.48 tCO2 - eqv (for a one day event)]. For this event, a conservative approach is adopted and thus a EF of 1.48 is used for calculation	3,152.68	1.48	1.17
		Total tCO2-e	tonnes		5.01
		Roundup	tonnes		6
		Carbon Price - Selected from Carbon Care Asia's Website	per ton		80
		Suggested Carbon Credit to Offset (tonne)			5
		Final Cost			**$400**

Detail Calculation for Scope 1 - Materials (Proceedings)

Item No.	Description	Annual Forum
1	For Normal A4 Pape, Emission Factor is 4.8 based on Page 38 of EPD/EMSD Guideline	4.8
2	A4 Size Paper - 80g/m2	
3	A4 size - 297 x 210mm	
4	1 ream of A4 paper = 500 sheets	
5	1 ream of A4 paper = 80g/m2 x 0.297m x 0.210m x 500 sheets	
6	Total Weight (g) =	2,494.8
7	Total Weight (kg) =	2.5
8	No. of A4 paper per proceedings	100
9	No. of copies	320
10	Total number of page for 320 copies	32,000
Paper used	in (No. of ream)	64
	kg of waste	159.7
Carbon	in (kg CO2-e)	766.4
	in (tCO2-e)	0.766

Overseas Travel Calculation

Calculation Result

The amount of carbon dioxide emissions attributable to your journey(s) is shown below.

By offsetting your emissions you will be funding worthwhile and credible projects that reduce emissions on your behalf.

Payment can be made either by credit card or by utilising your Asia Miles. At present payments (other than those using Asia Miles) can only be made in Hong Kong dollars.

The amount of carbon dioxide emissions attributable to your journey(s) is shown below.

Destination	Trip Type	Passengers	Cabin Class	CO2 Emissions	Equivalent	Asia Miles	
Hong Kong > Beijing	Round Trip	1	Business	0.54 tonnes	HKD 14.27	351	Remove
			Total:	0.54 tonnes	HKD 14.27	351	

Add another trip >

Total Contribution

Offset Your Carbon Emissions

Payment can be made either by credit card in Hong Kong dollars or by utilizing your Asia Miles.

◉ **HKD 14.27** - OR - ○ **351**
Currency Converter