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THE FUTURE DIRECTIONS AND BREAKTHROUGHS OF HONG KONG ENVIRONMENTAL INDUSTRY

TECHNICAL REPORT

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Executive Summary

The Annual Forum of the HKIE-Environmental Division was held on 17 April 2015 at Hong Kong Exhibition and Convention Center with the leadership of the Chairman of the Organizing Committee Ir Elvis AU, and the Chairlady of the HKIE-Environmental Division, Ir Professor Irene LO.

Increasing world population, sustainability challenges and changing styles call for a radical improvement of resource efficiency, environmental quality and energy sustainability. Under such momentum, the global size of environmental industry and its workforce may grow by 60 to 100% over the coming decade. Regionally, the environmental industry will become a new pillar of economic growth with the coming 13th five years plan (2016-2020) and a major new environmental law promulgated in Mainland China. China is now a world leader in green technology investments, and thereby constitutes one of the fast growing and important regional markets for Hong Kong on environmental technologies and related services. However, positioning Hong Kong to fully seize such opportunity presents great challenges and requires joint actions, commitment and investments from all stakeholders.

By providing a platform of discussion and valuable sharing of experiences and expertise among various stakeholders including local and oversea professionals, experts, academics, research institutions, businesses and policy makers, the Annual Forum 2015 aimed at exploring potential future axes for boosting the breakthroughs of Hong Kong environmental industry in the current regional context of large market opportunities. The Forum noticed significant efforts invested by local stakeholders to stimulate the growth of environmental market in Hong Kong for the development of the industry. Nonetheless, the breakthroughs of the environmental industry require adopting appropriate new strategies.

Based on a proper consolidation of on-going achievements, the stakeholders, in new partnerships with diverse educational and research institutes (both local and oversea institutes), could emphasize to direct the growth and development of the environmental industry with promising waves such as sustainable circular economy, “Smart City” models and green built environment for long term economically successful innovations.

The transition towards sustainable circular economy requires a potential study with experimentation and observatory to highlight the large socio-economic and environmental benefits (in terms of resource saving and recovery, energy cleaning and efficiency, local market growth, profit earning, job creating, technology development, businesses expansion etc.), and a long term policy to define future paths. A long

term vision should be extended to around 2050 allowing for flexibility in the paths with consistency. Flourishing new options such as "low energy grid building" (high energy efficiency, sustainable building design, resource saving and much reduced emissions) and "product eco-cycle" (advocating for high efficiency in product recycling and resource recovery), could be integrated into the circular economy to diversify local environmental market and foster its rapid growth with greater competitiveness for the industry. Sustainable circular economy transforms patterns of economic growth. Circular economy involves transformation of industrial organization and allocation, urban infrastructure, environmental protection, technological paradigms and social welfare distribution. As highlighted during the Forum, the development of a partnership with oversea professionals could be fruitful in such new direction.

The development of "Smart City" model in Hong Kong by combining diverse vital options such as energy efficiency, social innovation, new information technologies, advanced bio and nanotechnologies, green building design, sustainable urban management and monitoring systems with appropriate political instruments and strategic plans, will undoubtedly contribute to build up a world class highly skilled professionals for long term innovation and boost the development of the environmental industry. A Smart City maximizes benefits to city administrators and residents while minimizing adverse effects on the environment and economy.

By adopting "Smart City" principles in public policies and connecting available resources for citizens, Hong Kong will be able to bring higher efficiency, interconnectivity and security to public. A thoughtful "Smart City" design plays a crucial role in managing infrastructures, services and consumers' behavior, in reducing carbon footprint and minimizing climate risks and drastic environmental damages. However, as suggested by Hong Kong Science Park, concerted effort of all stakeholders for conceptualizing and commercializing "Smart City" concept is crucial to fully enjoy the benefits of the model in Hong Kong. The transition towards "Smart City" requires city administrators to fully consider citizens and businesses as stakholders and technology as a dynamic enabler.

The Government and all stakeholders (businesses, diverse experts, Universities /R&D Institutions, NGOs, professional bodies, public, etc.) are recommended to closely work on all flourishing lines to stimulate and sustain innovation, creativity and technological advancement in order to position Hong Kong environmental industry as regional leader in environmental business. This seems to be the key for real breakthroughs of the sector.

1. Introduction

Global adverse environmental burden induced by heavy pollution and climate changes has triggered public concern and forced a broad awareness on environmental protection with increasingly stringent regulatory regimes. Circular economy, smart cities, green built environment, energy sustainability, low carbon society and innovative green technologies become new sources of eco-growth, and hold promises for a new wave of environmental industry around the world. In Hong Kong, the Government, in collaboration with local stakeholders, is actively promoting the development of green business with various initiatives and major environmental programmes and infrastructure investments. Regulations, incentives and funding supports with continuous professional skill improvement schemes have been also established to stimulate the development of local environmental industry.

The potential for Hong Kong environmental industry to grasp regional significant market opportunities is further fueled by the implementation of the Close Economic Partnership Agreement (CEPA) with the Mainland China from 2004 onwards (which provided Hong Kong with preferential access into the regional market), the coming 13th five years plan (of which green business remains a major policy driver of the national development in China) and the promulgation of new major environmental law in the Mainland. As a world leader in clean technology investments, China becomes the most important regional market for Hong Kong environmental industry. The environmental demand market in the Mainland is projected to grow yearly by 15-20% under the new policy. All these aspects provide with great opportunities for Hong Kong, but also with critical challenges, since the development of a label of Hong Kong environmental industry with full integration into innovative and rapidly advancing technological needs remains a cross-cutting and challenging issue with multidimensional constraints and obstacles.

It is therefore opportune for HKIE-Environmental Division to promote the discussion on the future directions of environmental industry in Hong Kong by bringing together various stakeholders including professionals, experts, academics, research institutions, businesses and policy makers, in order to position Hong Kong to seize opportunities available. This technical report summarizes discussed salient aspects including current status of green business development in Hong Kong, specific experiences from abroad expertise, barriers to environmental business expansion, and recommendations for enhancing the competitiveness of Hong Kong environmental industry towards real breakthroughs. The Annual Forum 2015 provided with the particularity of a quality discussion panel among key players in environmental industry, engineering and applied research subsequent to the technical sessions, and the conception of the Forum as a green event, a benchmark of the HKIE-Environmental Division.

2. Overview of Hong Kong Environmental Industry

2.1 Definition and Assets

The environmental industry encompasses both environmental goods and service providers. This consists of revenue generation associated with design, implementation and operation of environmental infrastructures, manufacture of environmental equipment and products, environmental monitoring, measurement, pollution control (air, water, noise, land), waste management (collection, handling and recycling), energy conservation and carbon reduction, environmental impact assessment and all activities related to nature and biodiversity conservation. The environmental industry in Hong Kong is characterized by number of potential assets including global informational network, talents, broad mindset, intellectual property rights protection, financial strength (sized firms and multinationals), experiences on the regional market, with mastery of sophisticated technical capabilities in some key areas (water treatment conservation, waste recycling, noise and air pollution control, green building) as underlined by speakers (WK Lo; KS Wong).

These assets are enhanced by the advantageous partnership between Hong Kong and Mainland China under the CEPA with increasing need of clean technologies in China. Moreover, energy efficiency and environmental protection remain key focus in the 12th National Five-Year Plan (2011-2015) and the coming 13th (2016-2020). The "zero liquid discharge" policy and the newly promulgated environmental law particularly provide with great opportunities for Hong Kong environmental industry. Cleaner Production Partnership Programme encourages and facilitates Hong Kong-owned factories in the Pearl River Delta region to adopt cleaner technologies. The regional cooperation plan on building a quality living area is also expected to transform the Greater PRD region into a low-carbon, high-technology and low-pollution city cluster of quality living (WK Lo; KS Wong).

2.2 Supporting Instruments from Hong Kong Government

Besides existing regulations on air, water, waste, noise, and energy efficiency, to stimulate public environmental awareness, diverse programmes and funding supports consisting of environmental infrastructure investment (worth HK$ 150 billion in total, with HK$40 billion in the next five years), energy efficiency, R&D support & facilitation, green consumerism & education, green building, source separation of waste, producer responsibility scheme, Innovation and Technology Fund (ITF), the Recycling Fund (RF), Green Transport Fund (GTF) and the Environmental Conservation Fund (ECF)

with human capita development under the New Technology Training Scheme (NTTS) and the Professional Services Development Assistance Scheme (PSDAS), have been established by Hong Kong Government to promote the growth of local environmental market. In 2013, about HK$ 5 Billion was invested to provide financial support to environmental related research and education projects under the ECF, HK$ 190 million to support more than 100 projects under the ITF, HK$ 300 million for public transport cleaning under the GTF and HK$ 1 billion worth Government's green procurement representing 15% of total Government procurement. Moreover, HK$ 1 billion is available for the RF in 2015 to provide more incentives for land, capital, technical assistance and other forms of support for the environmental industry to build modern recycling facilities. Long term planning study of waste treatment and transfer facilities that assure sustainable waste management services is on-going (KS Wong; WK Lo).

2.3 The Development of Green Business in Hong Kong

(1) Green Building and Property Expertise

In accordance with Hong Kong Government Policy and targets for energy efficiency and carbon emission reduction from buildings, the green building business is currently holding an important position in local environmental industry. One of the important triggers of green building business expansion is the Building Environmental Assessment Method (BEAM), a voluntary green building assessment scheme developed locally in 1996 and suitable for compact high-rise cityscape in the sub-tropical areas. Recently upgraded to BEAM Plus, this green building assessment tool has enhanced the market awareness, green professional design, creative engineering and entrepreneurship in Hong Kong, and has become one of the most comprehensive building assessment system in the world with a labelling system established for market differentiation as showed on Fig.1 (Konrad Wong).

Figure1: BEAM Plus Green Building Labelling System

Incontestably, BEAM Plus has significantly contributed to boost the development of green business in diverse fields such as green building design, energy assessment, energy saving products and technologies, green roof, renewal energy equipment, testing certification services, ozone depletion substances phasing out, detoxification, waste and water recycling technologies, low carbon construction materials etc. In 2014, green hotel became a green building benchmark for the industry with over 90,000 rooms, a score of 8.0 on booking.com, over 149 technical visits, 93% of average occupancy rate, and 14 awards (Konrad Wong).

Under the impulsion of Hong Kong Green Building Council, a series of Building Energy Performance Recognition Scheme is currently under development. The tool will analyze the electricity consumption of the applicant and compare with similar office type for the development of energy benchmark in Hong Kong. Energy performance rating will then be advised as platinum, gold, silver, bronze, green, or no rating as described on Fig.2. Under such upgraded tool, a sub-metering is essential in providing more accurate data. Energy assessment shall be tied with the requirements of BEAM Plus Mandatory Energy Use Intensity (EUI) to improve overall electricity consumption of buildings with possible incentives for target achieved performers. Mandatory benchmarking, reporting, and performance verification will be established in line with technological innovation needs (Konrad Wong).

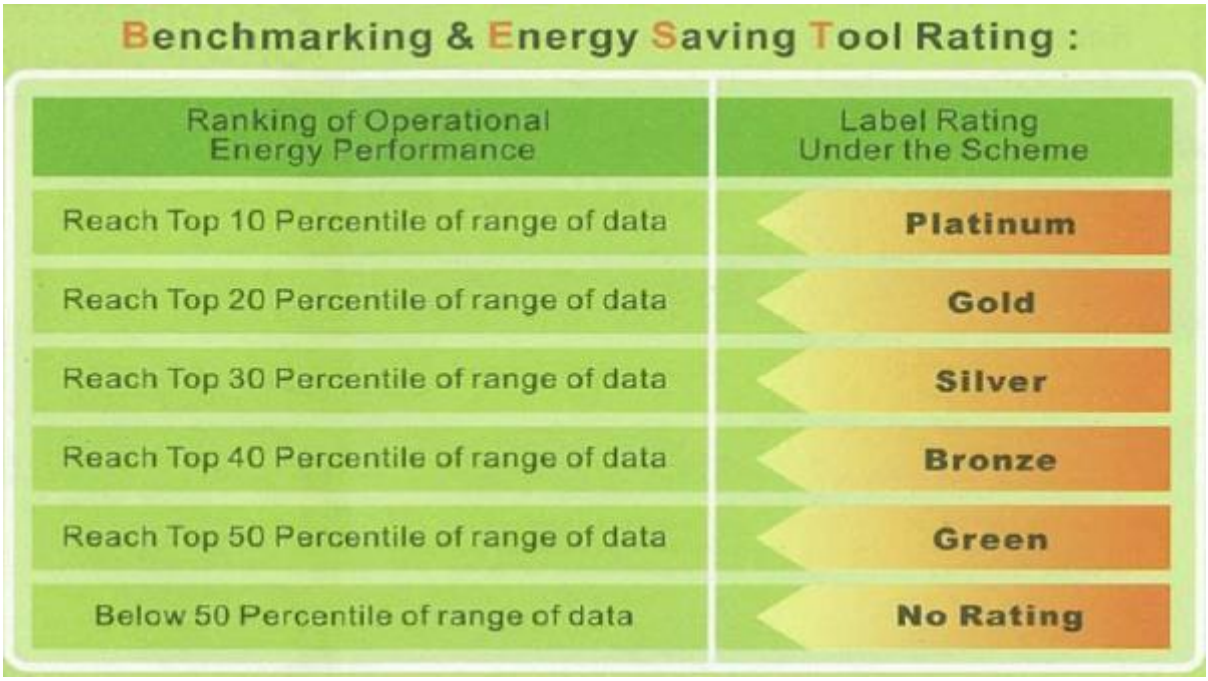

Figure 2: Benchmark and Energy Saving Tool Rating in BEAM Plus

One of key players revealed by the Annual Forum in green building business, who is taking advantage from the expending green building catalysts under BEAM Plus and Government regulations within its sustainable development roadmap, is Swire Properties Limited. Incorporated in 1972 and listed on the Main Board of the Stock Exchange of Hong Kong in January 2012, Swire Properties Limited operations span Hong Kong, Mainland China, UK and USA. Environmental responsibility is a key element of the Group commitment to sustainable development. The sustainable development approach in Swire Properties Limited is not only driven by global trends, government regulations, industry standards and practices tenants & customers' expectations, investors / shareholders' expectations, but also by the Swire Pacific Sustainable Development Policy and key principles that ensure environmental considerations are an integral part of decision-making, management and culture. The Group aims to comply with all environmental regulations and requirements related to operations and development activities. The Group assesses the environmental impact of all activities and seeks to integrate environmental considerations into the planning, design, construction, operation, maintenance and demolition of all facilities and services.

The Group monitors environmental impacts under the Sustainable Development Steering Committee through greenhouse gas emissions, waste generated in the operation, construction and demolition of buildings, water used in building operations, noise pollution and impacts to air quality. Such strategy has stimulated the growth of awareness in various fields of sustainability such as: benchmarking and target setting, financial (dis)incentives, consumption disclosure, carbon trading, capacity building, BEAM Plus (taken as norm), BEAM for GFA concession, GRI reporting standards, ESG report from HKSE, Building Energy Efficiency Code, sustainability development standards, awards and recognition, green labeling, eco-friendly products, sustainable food sourcing, air quality concerns, waste, energy, water, and microclimate (Amie Lai).

The sustainable development approach in Swire Properties Limited takes into account well-being of both business and communities. This approach is guided primarily by a Sustainable Development Policy in managing the environmental, social and economic risks and opportunities of business decision-making and supplier Code of Conduct. The Group also contributes to Hong Kong policy development on sustainability in a number of ways, including responding to government consultation requests and public forums and participating in various institutions and membership organizations. Swire Properties Limited supports building rating schemes since they provide a mark of quality that commercial tenants, buyers, investors and employees recognize and value. In Hong Kong, 14 of Swire properties are rated Excellent or Platinum, the highest ratings under BEAM Plus. The Group also aims to achieve BEAM Platinum for new

projects in Hong Kong, and the US Leadership in Energy and Environmental Design (LEED) Gold standard for selected parts of our new developments in Mainland China (Amie Lai).

The speaker (Amie Lai) has also shared with participants in the Annual Forum, the value chain management with enhanced green procurement and eco-cost development as next step of green business development in the Group, described on Fig.3 &4. Swire Properties Limited therefore emphasizes green procurement for both products and services through sustainable procurement policy, sustainable food policy, green office guide, company portal, green procurement guidelines, guidelines for specific services, supplier code of conduct, service / product specific EHS requirements, Hong Kong Green Purchasing Charter membership, the implementation, assessment and reporting on green purchasing policy, strategy for performance improvement, and achievements enhancing.

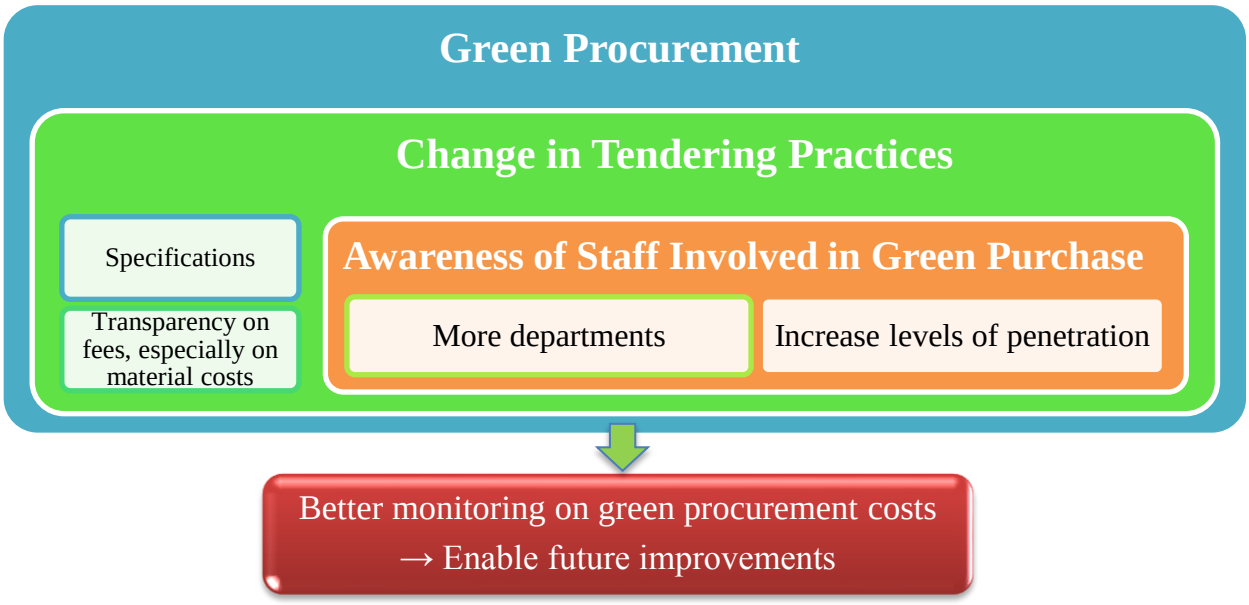

Figure 3: Green Procurement Strategy in Swire Properties Limited

In Mainland China, particularly in rural areas, Swire Properties Limited is developing the eco-cost in coupling with the eco-dwellings that use locally-sourced construction materials to promote green livelihood for villagers and support sustainable rural development.

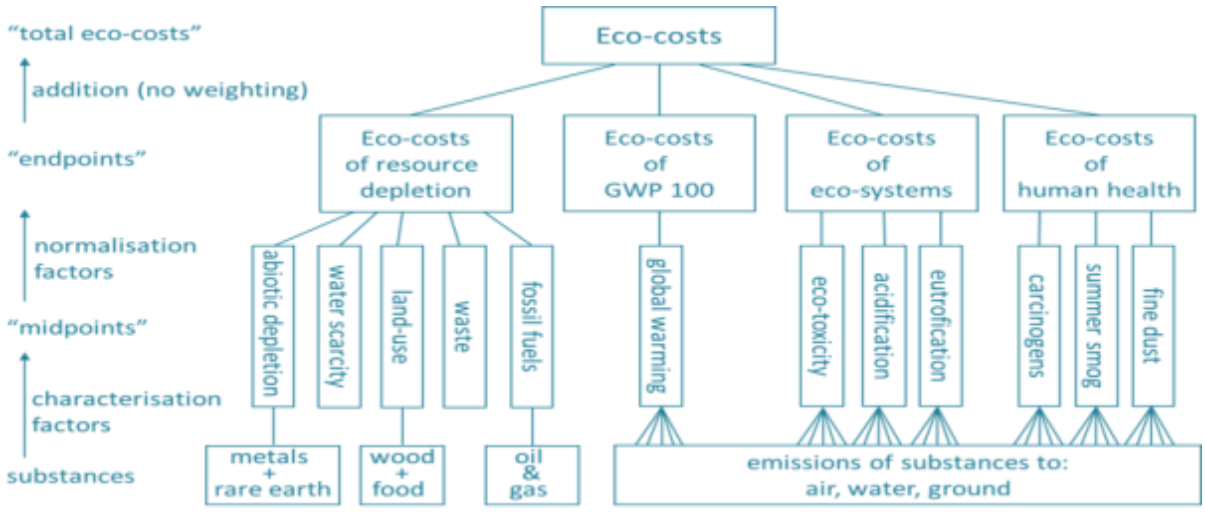

Figure 4: Eco-Cost Development in Swire Properties Limited

(2)Development of Waste to Eco-construction Materials Technology

Increasing construction and demolition waste (due to intensive construction activities) coupled with difficulties in handling glass bottles provides an opportunity for the development of eco-construction materials in Hong Kong. In terms of regulation support, the Hong Kong Government has revised the General Specifications for Civil Engineering Works in 2006 by providing guidelines to regulate the use and implementation of the recycled aggregates. According to the revised specifications, recycled aggregates can be used in the drainage works, earthworks, and carriageway sub-base. Moreover, the Technical Circular issued by the Development Bureau in 2011 encouraged the use of recycled and other green materials in public projects with a set of comprehensive specifications developed to ensure minimum quality requirements. On another hand, BEAM Plus provided good incentive for the private projects to stimulate the use of green construction materials. The Hong Kong Green Building Council (HKGBC) has also recently introduced the Green Product Labeling Scheme in order to encourage developers to employ more green elements in construction. BEAM Plus scheme will be thus revised in near future to enhance incentives for recycled materials use (CS Poon).

Under such favorable conditions, construction aggregates and bottle glass recycling for sub-base and paving applications has been developed by the Hong Kong Polytechnic University with successfully commercialization in collaboration with stakeholders involved in construction activities. The glass bottles

are collected in collaboration with local NGOs, soft drink and dairy milk companies, hotel associations and Environmental Protection Department (EPD). Due to the limited size of the paver market in Hong Kong, it is estimated that a maximum of 10,000 tons of post-consumer glass bottles can be recycled annually for pavers, which accounts for about 10% of the local glass waste generated. A trial of integration of recycled glass into cement and paving block manufacturing was carried out in association with the local cement manufacturer in 2014. The main purpose was to study the feasibility of incorporating crushed recycled glass powder as filler in the production of the ordinary Portland cement (OPC) and sand replacement in existing recycled paving block (manufactured with construction aggregates). The collected glass bottles were crushed to the size of glass sand and delivered to the cement plant as showed on Fig.5 (CS Poon).

Glass Bottles Collection | Glass Crushing | Glass Sand (less 3.35mm size)

Figure 5: Glass Bottle Collection and Crushing Process

At the plant the glass sand was further grinded with other constitutes of OPC (clinker and gypsum) using the plant's grinding equipment to produce a new type of cement (Eco-glass cement). The test results of the cement produced were encouraging and showed that it is possible to incorporate about 3% of recycled glass sand in the production of CEN 1 52.5N OPC and recycled paving block (by using construction and demolition waste) without compromising the overall quality. The study process is summarized on Fig.6. Technically, the eco-glass paper is conceived with fine construction aggregates in conjunction with the recycled glass sand. The recycled fine aggregates, glass sand, river sand, cement and water are mixed in pre-designed proportions before undergoing a vibration and compaction process by a block making machine to form the pavers as displayed on Fig.7.

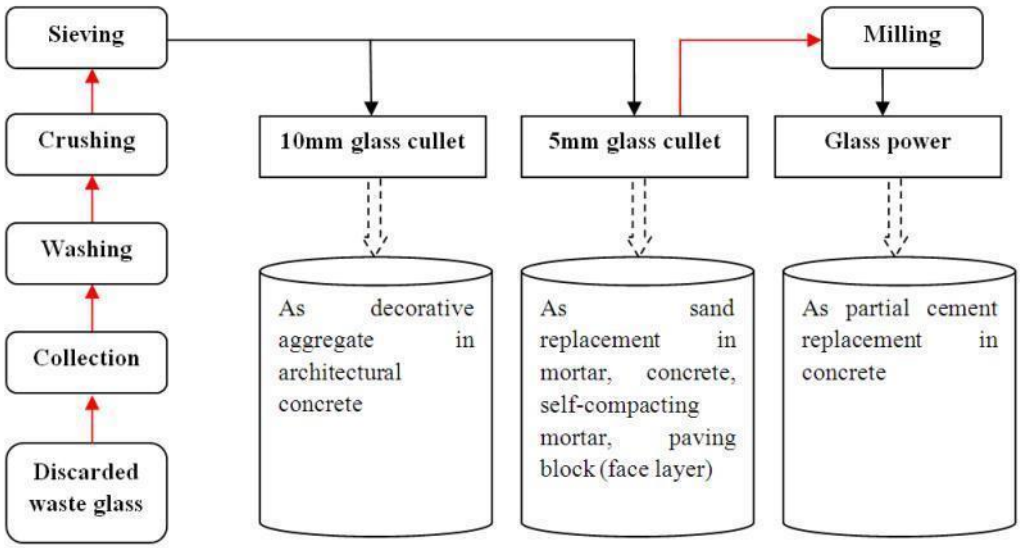

Figure 6: Integration of Glass Sand into Concrete and Paving Block Manufacturing

Figure 7: Eco-Glass Paving Block Manufacturing and Usage

The eco-glass products (both eco-glass cement and block pavers) have been launched in the Hong Kong market since 2014 with achieved significant in terms of energy consumption for manufacturing and life cycle greenhouse gas (GHG) emissions as showed in Tables 1 &2.

Table 1: Energy and GHG Emission for OPC and Eco-Green Cement

Cement Type	Energy consumption, MJ/t		GHGs emission (CO_2 kg eq/t)	
	Assessed	Variation with OPC (%)	Assessed	Variation with OPC (%)
OPC (90/5/5)	4910.43	---	1016.70	---
Eco-GC (90/5/3/2)	4788.86	2.48	993.64	2.27

Table 2: Energy and GHG Reduction for Eco-Block Pavers

Types of block	Energy Saving Compared with Ordinary Block (%)	CO_2 eq. Saving Compared with Ordinary Block (%)
1G Eco-block	**31**	**19**
2G Eco-block	**37**	**23**
3G Eco-block	**32**	**20**

However, some challenges have to be overcome to promote the development of such business. Currently, there is only one cement producer in Hong Kong and it is not likely to have another local cement plant in the foreseeable future to comply with tender requirements (minimum three producers). The market demand could not support more than two sizeable suppliers. Also, it is not currently possible to specify wide applications of this cement according to the guidelines of the technical circular of the Development Bureau. Furthermore, private cement users and other engineering contractors cannot justify commercially the purchase of environmentally friendly cement with a premium if there is no financial incentive, nor specification / technical requirement (CS Poon).

In short, a successful sustainable resources management requires the involvement of various stakeholders including the Government, developers, contractors, architectural and engineering consultants, materials suppliers and the general public. The green business could be better developed if the government adopts a green purchasing policy for public projects and provides enhanced incentives for developers for construction greening; the architects, engineers and contractors understand the differences between conventional and recycled products and are open to use recycled products in their respective projects; the suppliers provide a steady supply of recycled products with consistent quality; the developers are willing to pay a premium for recycled construction materials; sufficient education to the general public about the importance of sorting at source (CS Poon).

(3)Development of Zero Liquid Discharge Technology

One of advanced environmental technology firms revealed during the Annual Forum is Dunwell Enviro-Tech Holdings Limited. Establishment in 1969, Dunwell has come to stand for advanced technology, high quality and excellent customer services. Dunwell has captured the booming of Hong Kong economy and lived through various economic and political cycles. Currently, Dunwell business covers oil, solvent re-refinery, manufacture, trading and marketing of lubricants, environmental-related technologies, precision of metal components, industrial equipment, lubricating oil analysis services, and specific chemicals (Daniel Cheng).

Dunwell is taking market advantage from increasing regional stringent environmental regulations, in particular in Mainland China. In fact, China published a development plan for energy saving with stringent environmental protection in 2012. One of the key areas in this plan is wastewater recycling driven by strict regulation on wastewater discharge. Pharmaceutical, petrochemical, energy and food industries are the main targets on the highest standard of such regulation well known as Zero Liquid Discharge (ZLD). While most of industrial processes generate a wastewater stream, the objective of a ZLD system is to recover and reuse all water, to avoid emissions. The restriction of wastewater discharge requires water recovery processes involving biological and chemical treatment, membrane filtration, concentration, and finally evaporation. The process is briefly described below (Daniel Cheng):

-Pre-treatment: the wastewater is filtered using membrane technology such as ultra-filtration. The water stream is thus directed through porous membranes into a permeate.

-Evaporation: concentrate from filtration enters a brine concentrator which is a mechanical evaporator using a combination of heat and vapor compression to evaporate the brine solution, resulting in a wet sludge.

-Crystallization: the crystallizer converts the sludge to solid waste with high pressure steam which further evaporates the water and facilitates formation of crystals. Any remaining water should be therefore clean enough for reuse.

The solid content known as ‘salt cake’ can then be disposed of according to its constituents, which in turn depends on the nature of the original industrial processes. For the most toxic type of wastes such as biocide concentrate from the pesticide or pharmaceutical industry for example, incineration is usually the

safest mode of disposal. Some hazardous waste can be treated in a specific waste treatment unit such as a hazardous waste treatment plant. Unfortunately these types of units are not widespread in China and eventually the hazardous waste may be disposed of to landfill. Less hazardous waste from power plants on the other hand can be disposed of to landfill. In rare cases, the waste is homogeneous enough to be considered as a byproduct and can be reused directly as industrial salt (Daniel Cheng).

The process is relatively energy efficient. Moreover, to save costs and reduce the capacity needed, comprehensive water audits are usually performed which also ensure that the system deals only with the most polluting streams. Installing ZLD technology is therefore often beneficial for the water management; encouraging operating departments to detail water usage, avoid wastage and spur recycling by conventional and far less expensive solutions. However, when considering ZLD, the capital cost necessary for installing an evaporator and crystallizer can be prohibitive. Dunwell has developed appropriate software to optimize related cost and accessory needs. Currently, Dunwell is operating such technology in Inner Mongolia (Fig.8) and Shanxi. As stated by the speaker, it is a great chance for Hong Kong environmental industry to grasp such business opportunity and connect to the Mainland market.

Figure 8: ZLD Pilot Plant for Coal Gasification in Inner Mongolia (China)

(4)"Smart City" Conception and Green Business Opportunities

With increasing population growth, pollution, climate change issues and costly environmental degradations, the conception of sustainable city requiring improvement of life quality, environmental protection, management system, energy efficiency and economic mobility; development of human capital, social innovation, green properties, supporting policies; adoption of clean technologies and green infrastructures and services; constitutes challenging issues of most of developed cities. The concept of "Smart City" emphasizes all urban initiatives in line with the promotion of above key aspects. As such, proper transition towards smarter city requires reinventing cities by considering citizens as key stakeholders; technology as a dynamic enabler; and business as a partner. Imporatnat factors such as smart Government policies and programs, broad uptake of energy management systems by industrial firms, business transparence, emission reduction, carbon tax and trading, energy benchmarking, enhanced collaboration among firms, improved energy efficiency along the entire supply chain, research and innovation, will be helpful to institute this level of change as sumarized on Fig.9 (Allen Ma).

As such, "Smart City" development incontestably promotes the development of advanced clean technologies for improved city management, and thereby stimulates the development of green economy. Energy efficiency is a key point of a smart option for cities, particularly because of its short payback periods. An analysis of low-carbon investments in six cities in India, Malaysia, Indonesia, Peru and the United Kingdom came up with cost-saving solutions that would reduce carbon emissions by 14-24% per year by 2025 with quick payback. Energy efficiency also helps alleviating demand for new coal-fired power plants. In South Africa, peak electricity demand is expected to almost double by 2025. Despite, the local utility company, Eskom is under pressure to stop building coal-fired plants because of environmental concerns.

End-use efficiency investments will help providing a solution for these concerns, along with other reforms like pricing adjustments and public financing. In Lulea (Sweden), residual gases produced by a steel mill are used in a nearby combined-heat-and-power (CHP) plant to heat most of the buildings in the city, as well as to power the mill. The upshot is that local consumers pay some of the lowest prices for heating over whole Sweden. As stated by the speaker (Allen Ma), there are several models of Smart Cities developed worldwide. Common used European approach mostly focuses on the recovery of efficiency in the management of the various utilities. This model highlights the close simulitude between smart city and sustainable city. Other models focues on the specialization of the city in a specific vital activity (energy efficiency, IT, social innovation etc.) around which converge all other activities for the city reinvention.

The energy efficiency model for example considers that smart city will greatly enhance the efficiency of service and resources provision to users such as water usage, building management, mobility and transportation, smart energy grids, and public services.

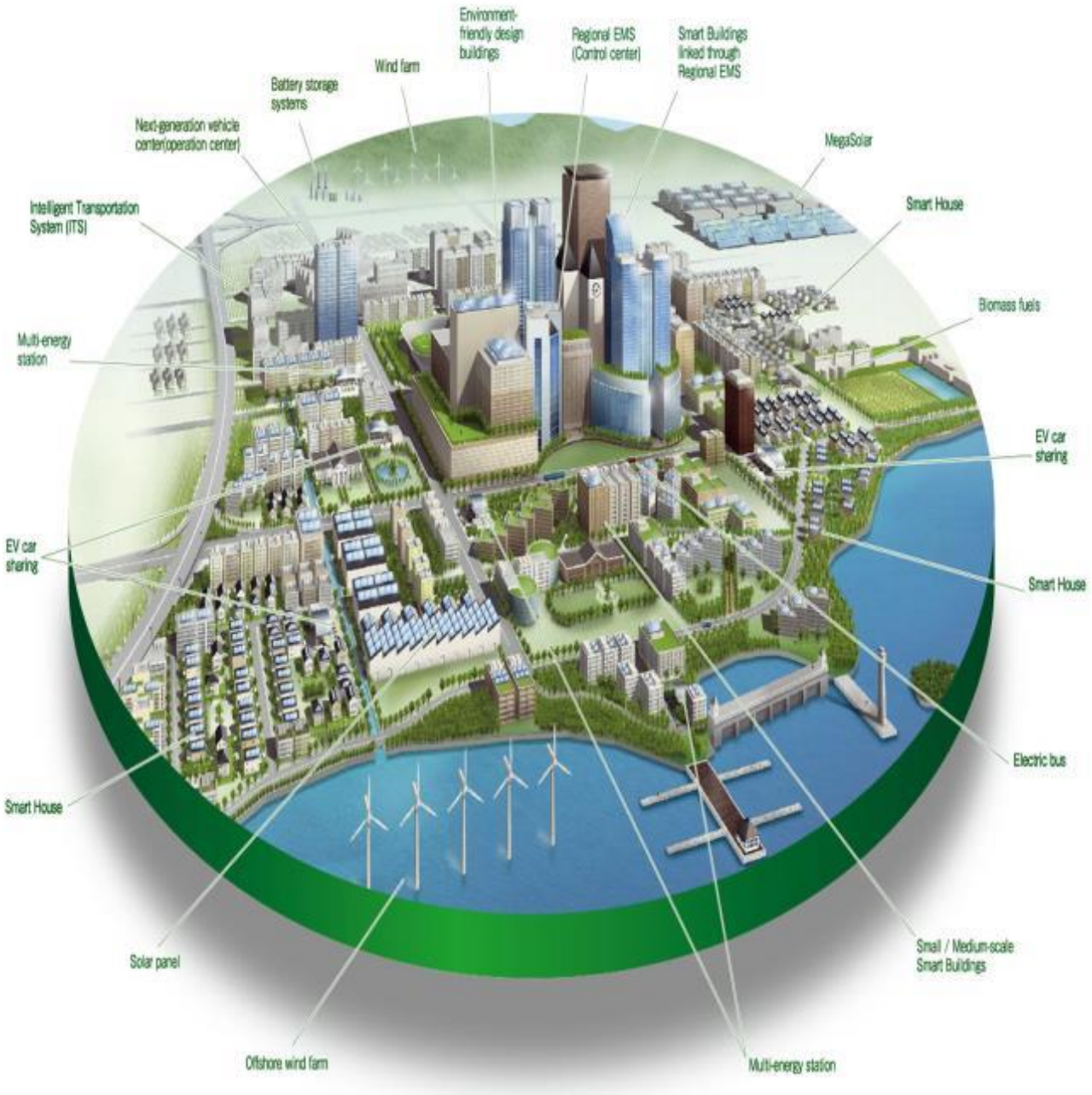

Figure 9: City Reivention Strategy

The social model implemented in North Asia focuses on the development of smart city as an opportunity to drive social innovation. Illustrated by the Fujisawa sustainable smart town, such concept integrates infrastructure and information technologies. The main purpose is to provide services beyond the management of pure big data and connectivity. The information technology model illustrated by Chicago (USA) and Singapore is based on massive deployment of sensors with connectivity infrastructure and big data management capabilities that enables the implementation of smart solutions by making proper use of the information. In such model, the smart city takes full advantage from new technology systems, operations and services. Collaboration among disparate agencies to operate on data would bring the best social services and public commitment.

Hong Kong is learning from existing smart cities and integrating a combination of diverse models. Besides the high mobile device penetration rate, there are many smart city technologies being locally developed and implemented. Improvement of building designs will reduce energy and enhance efficiency and undoubtedly boost the local green business.

Science Park has designed its Phase 3 comprising thirty nine smart building design features of energy efficiency to become one of the largest demonstrations of green building in Hong Kong. Other important urban infrastructures such as smarter bus routing, cross-harbor traffic management and public surveillance systems can be implemented with extensive wireless communication network and high mobile device penetration rate in Hong Kong. Some 3,000 datasets under 17 broad categories are available on the Government public sector information portal to bring convenience to the public, promote innovation, business opportunities and encourage entrepreneurship. It is envisaged that the number of hotspots providing public Wi-Fi services will be doubled to 20,000, making Hong Kong wide Wi-Fi penetration among the highest in the world.

All of these initiatives tender to diversify business opportunities and promote the development of local green business. However, a persistent lack of the technologies integration and sharing of collected data among sectors subsists. Concerted effort of all stakeholders for conceptualizing and commercializing smart city concept, are necessary to fully enjoy the impact of smart city in Hong Kong (Allen Ma).

2.4 Economic Weighting of Hong Kong Environmental Industry and Challenges

Number of speakers and participants highlighted the value added of environmental industry in Hong Kong estimated to about HK$ 7.1 billion in 2013 (0.3% of Hong Kong GDP), representing a growth of 5.2% from the level of HK$ 6.8 billion in 2012. The workforce was evaluated to about 40,650 persons in 2013 (1.1% of total employment in Hong Kong) with an increase of 2.9% in comparison with estimated 39,520 persons in 2012. These estimates cover key activities such as sewerage and waste management, environmental engineering, consultancy services, environmental technology import/export, and wholesale trading of environmental products and equipment (WK Lo; KS Wong).

Obviously, despite its growing trend, the economic weighting of the environmental industry in Hong Kong remains relatively weak with regards to existing potential assets. The sector is facing serious challenges that curb its rapid development. Existing supporting measures from local Government seem to be insufficient. Difficulties related to innovation, specific regulation, workforce skills, high up-front invest costs, capacity building, research in advanced technology development, increasing risks, appropriate network development, funding (for small and middle firms) and cooperation among companies in sharing experiences and adjusting their operations with potentially large transaction costs, have been mainly underlined during the Forum. On the other hand, the development of appropriate waste management system is associated with the barriers such as difficulties in making producer responsibility and waste charge mandatory, lack of demand for recycled products, influence of economic factors on recycling strategies, lack of public adhesion, difficulties for attracting tenants to Eco-Park and setting preventive system for tenancy abuse.

Basically, in sight of the presence of certain multinationals, most of the companies in the environmental industry are small and medium-sized enterprises, thus have generally limited capabilities and resources in developing and integrating increasing need of innovative environmental technologies. These obstacles have undoubtedly weakened the ability of the industry to response to the market requirements and fully take advantage of the large opportunities. Hence, systematic proactive strategies that combine and synchronize government priorities and all stakeholders' involvement, is an urgent imperative to mobilize resources and boost Hong Kong environmental industry towards real breakthroughs. Valuable experiences from broad expertise might be inspiring to local stakeholders.

3. Regional Experiences and Perspectives on Environmental Industry

3.1 Learning from Taiwan

In Taiwan, enhanced continual improvement of urban waste management associated with intensive research in technology development, strategic plan, incentive schemes and diverse legislative instruments, has triggered the expansion of local environmental industry. Stakeholders' adhesion and commitment in the development of green business enabled the environmental industry to meet international standards and be identified as one of potential emerging competitive industries in Taiwan.

(1) Waste Management Policy

With the population growth, economic development and environmental degradation, Taiwan Government successively regulated local waste management system with various instruments to promote the source reduction, reuse, and recycling, with the advisory and support of the United States Environmental Protection Agency (US-EPA), from 1974 to onwards. The major instruments are the Solid Disposal Act, Resource Recycling Act, and Excessive Package Reduction Act, stimulated by the objective of "zero waste". Taiwan Government also established the Recycling Fund Management Board and launched a series of practices such as pay-by-bag collection fee system, mandatory garbage separation, trash off the ground, plastic bag limitation, package reduction, one-time-use product reduction and prevention of hazardous substances (Harvey Houng).

(2) Implementation Strategies

Since 1980s, intensive promotional activities of the regulations on waste had been carried out in Taiwan with the implementation of garbage open dumping, the introduction of Extended Producer Responsibility, incineration, Four-in-on Resource Recycling Plan, source reduction of plastic bags (particularly from Government agencies, schools, hyper and supermarkets, chain convenience stores, chain fast-food restaurants, department stores and shopping malls), resource regeneration and reuse, Mandatory Garbage Sorting, Resource Recycling Plan for general waste, reactivation of landfill, and biomass-to-energy programme. Promotion of source reduction brought multiple benefits such as lowering operational cost, enhancing corporate image and decreasing waste generation.

In terms of source reduction promotion, Taiwan EPA was committed to combining environmental groups, enterprises and local governments in resource guidance to create a trend of source reduction among industries in society. The "Environmental Tableware Package Design Contest" encouraged people to prepare their own environment friendly tableware. The "Use Less Plastic Bags" activity promoted in 2001 required restaurants to use washable tableware instead of plastic bags. These events received enthusiastic response and support from stakeholders, and became the important foundation stone in "Limitation on Use of Plastic Bags for Purchasing and Disposable Plastic Tableware." Government agencies and schools had the responsibility of setting good examples and education to public. The EPA also proactively contributed to the promotion of the policy of non-disposal of tableware (including cups, bowls, dishes, plates, boxes, chopsticks, spoons, knives, forks, stirring sticks, etc.) in order to enhance the source reduction programme.

In line with the trend of international source reduction, product design was taken into account. Achieved success for "Excessive Packaging Limitation," "Limitation on Manufacture, Import and Sale of Mercury Containing Dry Cells," and "Limitation on Import and Sale of Mercury Thermometers" illustrated the efforts invested by EPA in reducing solid waste and improving public quality living environment and industries sustainability. Stakeholders definitely adhered to the packaging improvement strategy. In 2006, the manufacture, import and sale of manganese-zinc cells and non-button type alkaline manganese cells that contained over 5 ppm of mercury, were prohibited as well (Harvey Houng).

Another key strategy highlighted by the speaker, is the establishment of "Website for Bulk Waste Recycling" in Taiwan to provide relevant information on bulk waste recycling and links to auction websites of counties and cities. On the other hand, the "Regulations for Collection of Solid Waste Clearance and Disposal Fees" was implemented in order to promote the principles of "users pay" and "polluters pay". With regards to the resource recycling, the four-in-one Program combined communities, recycling firms, local governments and recycling fund. Since 2003, the EPA has promoted a bulk waste recycling plan to keep subsidizing counties and cities in purchasing cleaning machinery and planning construction of recycling facilities. In 2012, counties and cities have been assisted in building 17 bulk waste smash, reuse plants and 14 refurbish and repair plants.

The Government of Taiwan has also recently established a labeling system for public to dissociate recyclable items from general garbage. Manufacturers and importers are requested to label recycling marks on the recyclable products or containers in order to comply with the four in-one Program. The recycling facilities, such as trucks and bins, of each environmental protection unit, public location and

vending points are currently required to print visible recycling marks for public recognition. The holistic strategies of resource reduction and recycling management are described on Fig.10. The list of mandatory recyclable products is displayed in Table 3 (Harvey Houng).

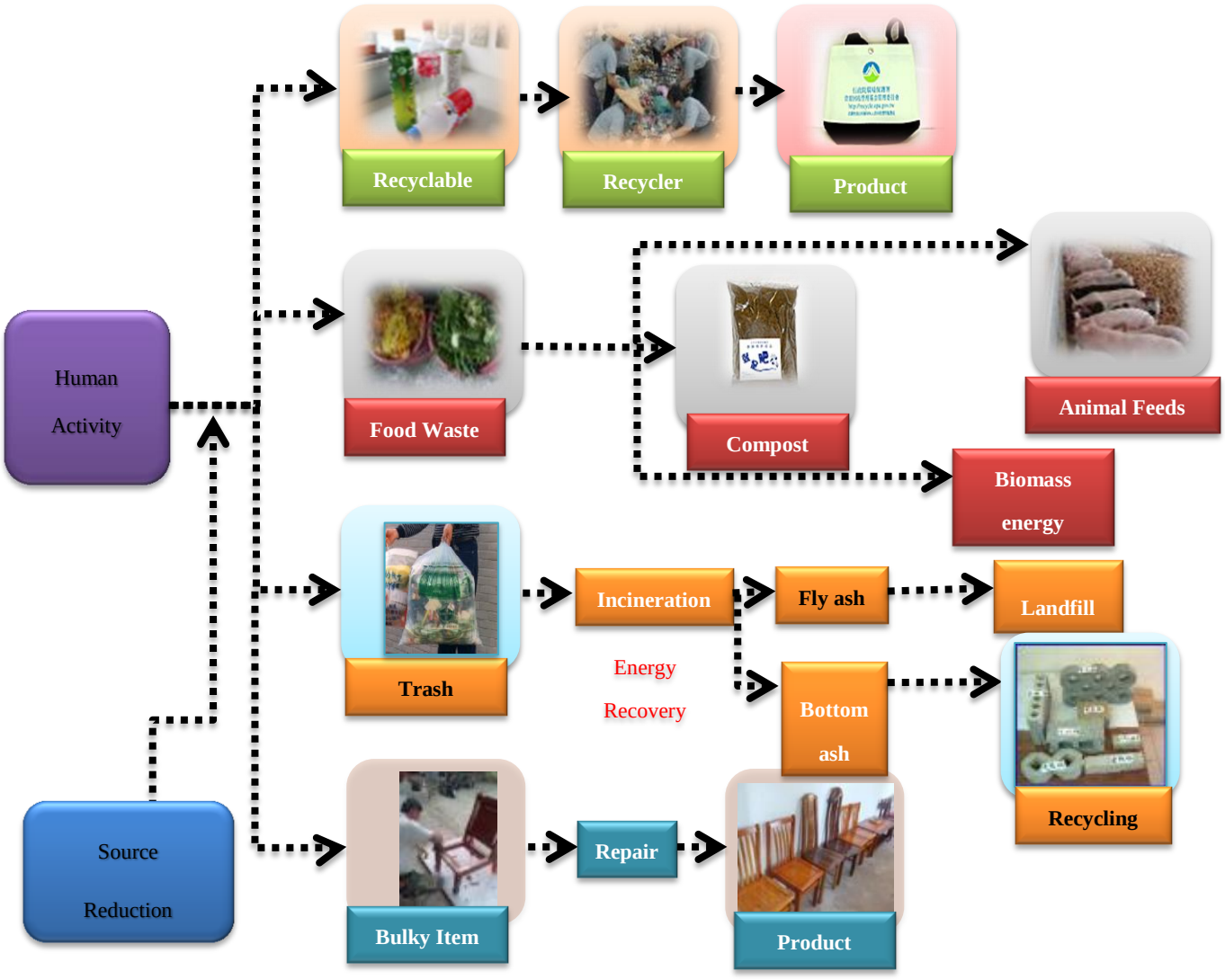

Figure 10: Integrated Waste Recycling Management System in Taiwan

Table 3: List of Recyclable Products

Type		Item	Type		Item
Containers	**1**	(1) Iron	**Articles**	**7**	(15) Dry batteries
	2	(2) Aluminum		**8**	(16) Mobile cars (17) Motorcycles
	3	(3) Glass		**9**	(18) Tires
	4	(4) Aseptic packs (including paper, aluminum foil and plastic composite materials) (5) Paper (refers to paper sheets that have undergone wax impregnation or coating or have been laminated with plastic film or aluminum foil)		**10**	(19) Lead acid batteries
	5	Plastic (6) Polyethylene terephthalate (PET) (7) Polystyrene (PS); foam (8) Polystyrene (PS); no foam (9) Polyvinyl chloride (PVC) (10) Polyethylene (PE) (11) Polypropylene (PP) (12) Other plastics (13) Bio-plastics		**11**	Computer appliances (20) Notebook computers (21) computer casing (22) motherboards (23) hard disks (24) power supplies (25) monitors (including CRT and LCD) (26) printers (27) Keyboards
				12	Electronics and electric appliances (28) Television sets (29) Refrigerators (30) Washing machines (31) Air conditioners, heaters (32) Electric fans
	6	(14) Agricultural chemical		**13**	(33) Light sources (Fluorescent tubes, lamps and light bulbs)

(3) Potential Outcome for the Development of Local Environmental Industry

The intensive promotional activities for sustainable waste management and commitment of stakeholders resulted in outstanding performance in resource recycling. In 2012, the daily amount of garbage removed per person was 0.397 kg, corresponding to 60% less than the highest record noticed in1998. Resource recovery rate was 54% with proper trash treatment of 99%. Average daily waste collected for disposal significantly decreased from 1.143 kg per capita in 1997 to 0.387 kg per capita in 2013. Since 2008, the "Limitation on Import and Sale of Hg Thermometer" policy reduced 850 kg of mercury distribution each year. More than 96% trash was treated by incineration in 2013. In terms of energy regeneration, Taiwan has achieved more than 8.8 million KWh of electricity generated per day from incineration activities.

Due to the installation of bulk waste recycling plants and purchase of machinery in various counties and cities, the bulk waste recycling rate in the nation had increased from 12.6% in 2005 to 57% in 2011, and the incineration and landfill rate had decreased from 87.4% to 43%. Statistics on the national bulk waste recycling rate from January to November of 2012 showed an increase of 65%. From 2007 to 2012 counties and cities in Taiwan have sold 165,000 pieces of renewable furniture and bicycles, representing NTD 127.97 million. In 2013, waste recycling rate reached 55%. Yearly use of plastic shopping bags have been reduced by 2 billion pieces (reduction of 58%) versus 86% for plastic disposable tableware.

Achieved standard in waste management with advanced green technologies and improved planning of resource circulation resulted in the implementation of the cradle-to-cradle principle in Taiwan, the first in whole Asia in 2010. Adopted strategic programmes, research, supported with capacity building and legislation have boosted the environmental industry in Taiwan with diversification of clean engineering and services such as environmental consulting services, environmental equipment manufacture, monitoring, certification and testing, green building design, detoxification services, liquid waste and wastewater treatment, green construction material business, eco-packaging business, energy efficiency technologies, clean petroleum and chemical business, etc. Should Hong Kong learn from Taiwan, enhanced regulation, Extended Producer Responsibility programme, cradle-to-cradle principle, intensive promotional activities to drive all stakeholders' commitment, capacity building (information system, education, enhanced training on know-how, and diffusion of technologies), research in advanced technology development and incentive schemes can be considered as key drivers of performance (Harvey Houng).

3.2 Learning from Korea

In Korea, the promotion of environmental industry development is essentially driven by the integration of economy and sustainability. The strategy consists of integrated long-term policy and action plans in linkage with conservation, green vision, environmental ethic, education, sustainable production and consumption, clean technologies, eco-efficiency and quality living condition. The main purpose is to set up conditions conducive for the growth of environmental services, equipment manufacturing, e-business, distribution and logistics. Moreover, building up a world-class environmental industry based on advanced high technologies such as information (IT), bio and nanotechnologies, is a key aspect of the integrated sustainable economy model. Environmental technological innovation and productivity are thus considered core factors of national economic development (Chang Lee).

In this vision, supportive legislation and promotional activities are conceived on fundamentals such as eco-industry structure, win-win synergy between environment and economy, energy efficiency with wider dissemination of new and innovative renewable energies, capacity building, research, spread of environmental management, supportive funding, waste recycling, water treatment and conservation, and environmental monitoring systems (Chang Lee). As a result, about 49,913 companies were active in the environmental consisting of 14,913 for environmental equipment manufacturers (29.8%), 15,801 for wholesale and retail firms (31.6%), 3,808 for construction environmental management and green procurement (7.6%), 287 for water treatment and conservation (0.5%), 3,153 for environmental services (7.0%), and for 11,591 waste treatment, resource recycling and environmental restoration (23.2%) in 2012.

The economic weighting of environmental industry in Korea is about 82.22 trillion won (US$ 6.85 Billion as showed on Fig.11) corresponding to 6.5% of GDP of Korea with major environmental aspects including waste (43.9%), water (22.3%), environmental plant (13.6%), and noise control. Environmental monitoring equipment sector plays an important role in the expansion of environmental industry. In 2012, related economic weighting was estimated to about to 933 trillion won, consisting of 139 trillion won for testing and inspection for environmental monitoring (15% of total weighting). The main monitoring aspects are water quality with TMS monitor, outdoor and indoor air quality and noise with AirKorea, NAMIS monitors (installed and being operated at various kinds of buildings with tele-monitoring systems) and CLEANSYS (Fig 12). Should Hong Kong learn from Korean experience, the development of information technology, high advanced clean equipment, legislation, enhanced public capacity building, green technologies and environmental monitoring systems are the main factors of the environmental industry expansion and competitiveness (Chang Lee).

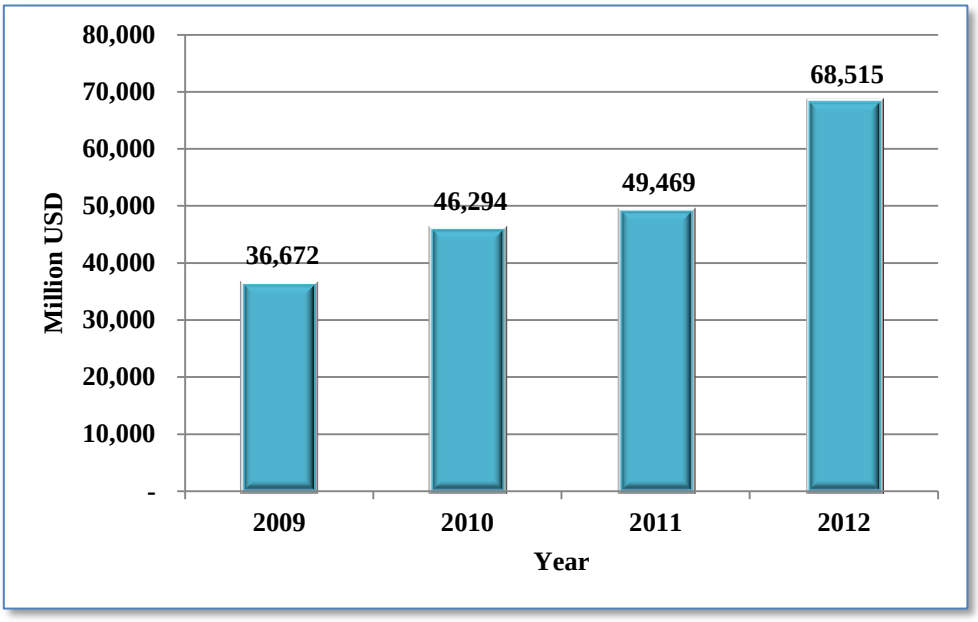

Figure 11: Weighting Trend of Environmental Industry in Korea

Figure 12: Development of Environmental Monitoring in Korea

4 Circular Economy as Cross-cutting Driver for Environmental Industry Growth

Circular economy is a model of economic development which advocates for environmental protection, pollution prevention and sustainable development through conservation of resources, reusing, and recycling. The model aims to minimize environmental impact from sources and reduce overall waste. Further triggered by international financial crises and economic downturns, such system likely decouples economic growth from efficient use of natural resources and ecosystems to create more value, not only by cost savings, but also by developing new markets or growing existing ones (regeneration of resources and conservation rather than exploitation of new ones). Thus, the circular economy comes up with innovation and new business models that foster the development of the environmental industry.

4.1 Relevance of Product Eco-Cycle Model to Environmental Industry in Asia

In general, the circular economy approach is beneficial for both developing and developed countries. It enables developing countries to industrialize and developed ones to reduce vulnerability to resource price shocks without placing unsustainable pressure on natural resources and breaching environmental limits. In Asia, the system has been practiced in many countries from national initiatives down to communal levels. However, following persistent barriers curbed its rapid development and might comprise targeted environmental and socio-economic performance (Thomas Tang):

-Lock-in to resource-intensive infrastructure and development models: the physical infrastructure of production, consumption and trade is highly geared to once-through manufacturing models.

-Political obstacles to putting an appropriate price on resource use: subsidies that encourage excessive use of resources will need to be removed and all ‘externalities’ incorporated into the price of resources and energy.

-High up-front costs: there are significant up-front investment costs and potential risks for businesses (retooling machines and factories, building capacity, new distribution and logistics arrangements).

-Complex international supply chains: supply chains have to be reorganized to enable information and material to flow in both directions and facilitate reuse and remanufacturing.

-Lack of consumer enthusiasm: promotion of product certification or labeling system is needed.

-Challenges for company-to-company cooperation: incorporating circular economy practices can require multiple companies to adjust their operations with potentially large transaction costs and delays in negotiating with partner companies.

Overcoming these barriers imperatively requires the conception of an appropriate strategy that enables Asia to fully reap the benefits from the circular economy. The recycling sector is particularly found to have poor reputation in environmental and social performance in many countries. The Product Eco-cycle model might be one of adequate ways to be adopted in order to boost the circular economy over the continent. The model offers an opportunity for eco-efficiency and the implementation of socially responsible practices to redress the damage to the sector's image. Innovation will play a key role in this model to come up with more value-added ideas and improve the processes as well as the products.

(1) Implementation of the Product Eco-Cycle Model in Asia

The model can be applied to diverse products, in particular electrical appliances, foods, packaging, construction and demolition materials, textiles and clothing etc. Based on Fig.13, the implementation steps can be briefly summarized as follows:

-The term of 'Second Life' is applied to remanufactured or reconditioned products that can be used as efficiently as the original product. Matching supply closely with demand is essential since the success of the Product Eco-Cycle relies on a streamlined flow of products and materials across the cycle.

-Point of sale is a crucial stage in the Eco-cycle since the exchange of reusable goods with post-consumer use goods takes place here. Producer Responsibility practices will facilitate this exchange to keep retailers and wholesalers engaged.

-Reverse supply chains will sort, collect and return the post-consumer products back to the secondary manufacturers.

-Prior to the secondary manufacturing stage, products have been designed for disassembly so that the useful components are retained with least disruption to the functioning product.

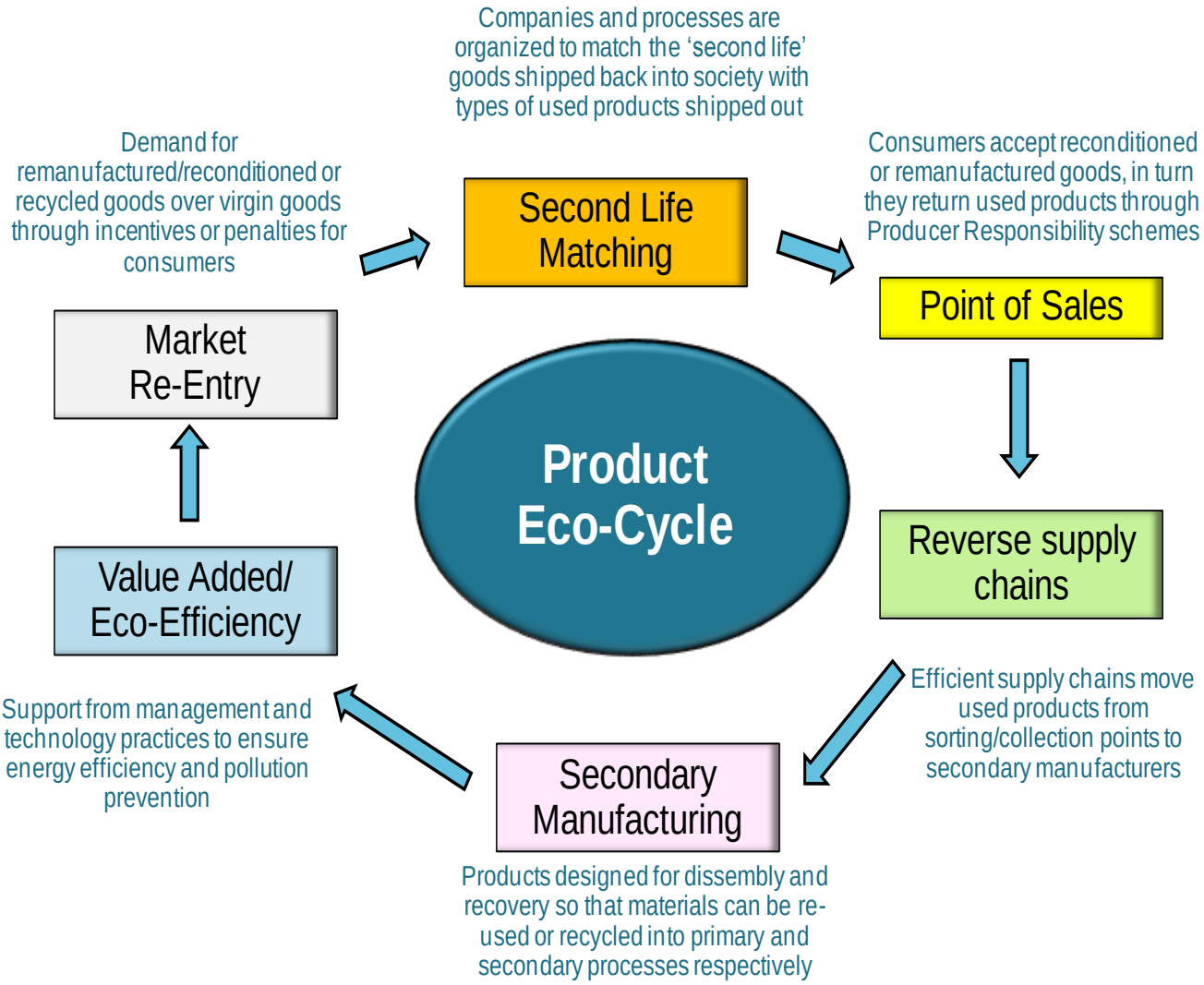

Figure 13: Implementation of Product Eco-cycle Model

As described on Fig.13, the Product Eco-cycle traces the path of products across the entire life cycle from raw materials to post consumer use. The main objective is to maximize efficient use of resources for effective recovery, not just as a means of improvement in waste management but also overall quality of life for society. In the Product Eco-cycle model, materials can be separated into biological and non-biological. For materials like plastics, glass and paper, these are usually part of one-trip products which are discarded after use. The paradigm shift is to re-design products to enable its retaining in the original shape and form for reuse. The materials will therefore have more value. One way to retain the value of a

product is to 'rent' it out to enable the consumer to return the product when it is no longer in use. Glass bottles for example can be reused many times if designed properly. The best use for biological products is aerobic or anaerobic digestion. This provides opportunities for landscape designers and engineers to create 'green' urban infrastructure and space for growing crops (Thomas Tang).

(2) Implications for Environmental Industry in Asia

The Product Eco-cycle model diversifies activities and services with advanced technologies and creates new business opportunities to foster the development of the environmental industry. Table 5 below shows examples of how environment industry expansion can be driven by the Product Eco-cycle. However, the Key for the development of the environment industry around the Product Eco-cycle model will be the role of standards testing laboratories to ensure that second life products and materials are just as good as the original ones (Thomas Tang).

Table 5: Environmental Professional Services Driven by the Product Eco-cycle Model

Product Eco-cycle stage	Professional services
'Second Life'	Testing laboratories to verify that the performance of 'second life' products meet adequate performance standards
Point of sale	ERP and systems experts to plan and forecast sales
Reverse supply chains	Logistics companies to sort, collect and return the post-consumer products back to manufacturers.
Secondary manufacturing	Process engineers and product designers to design machine tooling and products respectively. Material technologists to identify better materials, which can be introduced in the manufacturing process.
The recycling sector	Consultants to introduce eco-efficiency and socially responsible practices as well as innovative practices.
For market re-entry	Marketing and branding companies to promote consumer demand for remanufactured and reconditioned goods.

4.2 Experiences from Abroad Expertise

(1) Business and Societal Value of Circular Economy in Netherland

In the Netherlands, TNO (Dutch National Institute for Applied Research) was commissioned to investigate the potential benefits and opportunities of the circular economy. The starting point of this investigation was to get a grip on the current level of circularity of the Dutch society. The analysis resulted in a number of recommendations for the Government. An overall recommendation is to set up a long term vision in order to boost the development of the circular economy. Key aspects of the long term vision are summarized below (Ton Bastein):

-Develop a coherent education and research plan for the circular economy;
-Make a comprehensive assessment of the pros and cons of existing rules and regulations on waste;
-Increase knowledge and awareness of raw materials in each value chain;
-Ensure that stakeholders who run high risk groundbreaking innovation projects receive a permanent and true advantage;
-Review the effectiveness of a broad set of fiscal and financial incentives to promote circular behavior;
-Determine the impact of incineration plants on the viability of circular business cases and take appropriate action;
-Develop the role of the Government as active and expert 'launching customer';
-Use the international playing field to help the circular economy move forward in the Netherlands.

In this vision, the Dutch Government started in recent years, the so-called VANG programme ("From Waste to Resource" Programme) to connect policy objectives with innovation possibilities. It encompassed waste and resource policy, and facilitated the transition with long term goal for circular economy development. The programme has been implemented by pulling together a consortium of consultants and institutes (Realization and Acceleration of the Circular Economy, RACE) that addressed actions in areas of research, regulations, financial and fiscal incentives to come up with a platform to develop knowledge and business models on the circular economy. The platform worked on defining and stimulating circular design; studying and stimulating high-quality reuse; making an inventory of barriers; stimulating and accelerating new value chains; raising public awareness around the topic of circular economy; involving young people in the transition towards circular economy and creating a portfolio of best practices circular projects (Ton Bastein).

A central element in the transition management was the experiments so-called field-labs consisting of three aspects such as roadmap (activities are developed according to a vision and action plan that are supported by stakeholders, Government, businesses and NGOs) to provide outlook for a future circular market/society; incubator (conditions are provided for a variety of experiments / R&D pilots, covering short term, midterm and long term time-to-market) to create variety; observatory (field-labs results monitoring) to provide valuable insights into achieved progress to ensure it unfolded as expected by the roadmap. Field-labs offered the physical space and participation of real stakeholders for innovations to be tested under realistic conditions. Field-labs typically resulted from partnerships and cooperation between businesses, entrepreneurs, educational institutions, governments and end-users. In addition, private initiatives involving businesses have been founded (Ton Bastein).

Implementation of these strategic action plans came up with potential outcome such as added value, efficiency improvement in the demolition and construction process, cost-savings, new jobs, environmental merits, introduction of packaging tax to finance the start of the Plastic Hero system, fast growth (52% of materials will be recycled in 2017), emission cleaning (reduction of CO_2 and heavy air pollutants), reduction of resource scarcity (through efficient use and recovery), reduction of ecosystem pollution with high demand for recycled materials, to foster the societal and environmental industry development in the Netherlands. The reforms enabled the environmental industry weighting to reach EURO 7.3 billion (1.2% GDP) with about 54.000 new jobs and fast technological development. The reforms also highlighted promises opportunities driven by initiators, enhanced cooperation in product chain (including end-users), new financial arrangement and additional tailor-made incentives. However, although the transition towards the circular economy is still on-going in the Netherlands, in-deep improvement of the system requires adding benefits for business and Government, introducing disruptive technologies (ICT, biotech, and nanotech), and evolutionary experimenting the field-labs with real stakeholders. Furthermore, joint effort of various industry sectors appears to be crucial (Jacqueline Cramer, Ton Bastein).

Should Hong Kong learn from Dutch experience in circular economy, it is important to start a potential study for the circular economy. The study shows stakeholders and the public that the circular economy does not just cost money but also can earn money and create jobs. Setting out a long term policy is a must, especially in waste infrastructures to define the path in the future. A long term vision should extend to around 2050 allowing for flexibility in the paths with consistency. Private enterprises play a key role in the transition to the circular economy. There is also an important role for the Government to facilitate the commitment of stakeholders. The situation in the Netherlands shows that front running enterprises need a level playing field, space for experimentation (rule free zones), recognition by the Government (by acting

as launching customer) and support in crossing the innovation. Hong Kong has experimented with new technologies in live conditions such as the project on de-centralized food waste composting at community level. However, this was not put into a programme where multiple technologies were tested, monitored and evaluated systematically to enable stakeholders attending the field-labs to learn from each other. Setting up a portfolio of field-labs as is currently done in the Netherlands might also be interesting for Hong Kong. An observatory is also needed to monitor the progress of the field-labs, collect and share the results and insight of the field-labs (Ton Bastein).

Nevertheless, prior to a real transition towards circular economy, significant improvement is needed in current waste management system in Hong Kong. The Dutch experience showed that pricing was key aspect in developing a market for waste. Pricing not only triggered consumers and producers to create less waste, but also provided the cash flow for setting up and maintain waste management schemes. In Hong Kong situation, it seems worthwhile to study all potential elements of a pricing and MSW charging system (besides the taxation of building and demolition waste) in order to stimulate systemic change. The Dutch Government has played an important role in setting conditions and targets for waste policy. This helped professionalizing and centralizing waste management according to sustainability principles. Most of the measures (separation, pricing, ban of landfilling) are now widely accepted. NGOs have also played a key role in raising public awareness and putting pressure on the Government for action. Technological progress (in the fields of incineration, separation, recycling) was also crucial in the development of the Dutch waste management system. Any long term systemic change in waste management should take into account the future development of waste levels, not impede incentives to reduce waste levels and not base capital investments on exaggerated waste level expectations (Ton Bastein).

(2) Building Sustainability as Driver for Circular Economy in Switzerland

In Switzerland, some of identified limitations of the circular economy are its residual waste and pollutant emissions due to raw material exploitation and fossil energy consumption. The circular economy therefore needs to be more efficient to limit the use of raw materials, decrease fossil and other non-renewable fuels consumption, and thereby increase the quality and lifetime of the products. This will reduce the cycle's waste production and environmental nuisance. For this purpose, building sustainability (in terms of energy efficiency, eco-design, services, material life cycle etc.) is one of plausible ways to boost the development of circular economy and subsequently, to stimulate the environmental industry expansion in Switzerland. Basically, Swiss building stock accounts for almost half of Switzerland's primary energy demand. The

SIA (the Swiss Society of Engineers and Architects) has therefore set the goal for 50% reduction of energy consumption before 2050 based on 2000W and 1 ton CO_2 society (Erdjan Opan).

The objective of 2000-Watt-Society (48 kilowatt-hours per day by 2050 without lowering standard of living) is extremely ambitious. This means a 75% to 80 % improvement in energy efficiency, which poses a major challenge for research and development. The SIA advocates for a sustainable basis for Switzerland's building stock to encourage an intelligent use of the resource energy, by reducing fossil energy and greenhouse gas emissions. New buildings must reach these objectives over their whole life cycle. This includes three major steps:

-Sustainable renovation of buildings through a holistic architectural process;

-The SIA efficiency path energy (construction, operation and mobility);

-Reduction of energy consumption, emissions of greenhouse gases and pollutants over the whole life cycle (construction, operation, decommissioning).

Such guideline aims to create the best possible preconditions for achieving building sustainability. The main purpose is to set a course for the future which ensures that developments in the area of building keep moving in the right direction. In terms of energy consumption, as the most important sector in Switzerland, the building development takes on a pioneering role in this process. It is up to developers and investors to integrate this objective in the phase of strategic planning .With the publication of the Technical Specifications, "SIA 2032 Embodied Energy of Buildings" and "SIA 2039 Mobility-Energy Use Depending on the Location of the Building", a basis has been provided for calculating energy use in these two important areas (embodied energy and mobility) according to generally accepted and comparable methods. The two areas embodied energy and mobility are given equal consideration along with the energy required for operation. The calculation of the total energy balance and the corresponding greenhouse gas emissions in accordance with the Technical Specifications allows the comparison of a project value with the target values used for project optimization (Erdjan Opan).

One of the most plausible ways to achieve the energy efficiency goal is to link buildings together with energy grids. There is much more potential to improve energy efficiency by connecting buildings with different usages in a grid than the sum of all energy efficiency potential of the individual buildings. These grids, also called anergy grids (low energy), are based on the interconnection of different warm and cold

sources, in order to create an efficient system, using renewable energy and waste energy of one building to power another one. The project "Campus Science City" at ETH Zurich is an illustration of such system with the targets of sustainable energy supply (heating and cooling) for the growing campus; low emissions (a reduction of CO_2 emissions by 50% in absolute figures, despite of ongoing growth); high security of energy supply (mix of energy sources and redundancies); high life cycle cost efficiency; low usage of primary energy by using waste heat (anergy). On the "Science City" campus, the buildings were connected to an anergy network consisting of five earth probe fields functioning as geothermal storage and three loops, one coming from the geothermal storage, a second one used as a return loop, and the last one used for free cooling, as showed on Fig.14 (Erdjan Opan).

To increase the energy efficiency, the focus must be enlarged to the neighborhood of the building, the entire area or campus including all of its buildings, to enable the use of wider energy efficiency potential. Electrical and thermal grids between buildings will be created, enabling the transfer of waste heat from one building to another. These thermal grids are functioning with low temperatures and bi-directional supply draw energy for the operation of a heat pump and /or supply waste heat from the cooling system into the grid. In addition, these anergy grids can be supplemented with seasonal geothermal storage, solar heating and natural air cooling systems to keep the anergy use and supply in balance (Erdjan Opan).

According to the speaker (Erdjan Opan), the first stage of the project, which was completed in 2012, has reduced the CO_2 emissions by up to 10,000 tons per year. Various substations, including heat pumps and cooling stations, will be constructed, in order to connect all the buildings of the campus. Up to nine storage fields are planned to meet the energy requirements until 2025. If the available energy exceeds the needed amount, it might even be possible to include other buildings in the immediate surroundings of the campus into the grid. Pioneering buildings which have already been realized showed that achievement of energy efficiency goal is not only feasible and affordable, but it also allows the necessary freedom in terms of architecture and urban planning to react to project-specific circumstances using creative and appropriate means. This has been achieved by considering energy budgets for each of the three main energy uses directly linked to a building (construction, operation and mobility).

Such sustainability approach, which could be served as a model for Hong Kong, is expected incontestably to drive high efficiency in the circular economy, diversify the environmental market and green business opportunities in terms of services, advanced clean technologies, environmental job tasks, building comfort, construction material life cycle cost reduction, sustainable architectural design, and waste and pollution phasing out, leading to the development of the environmental industry in Switzerland.

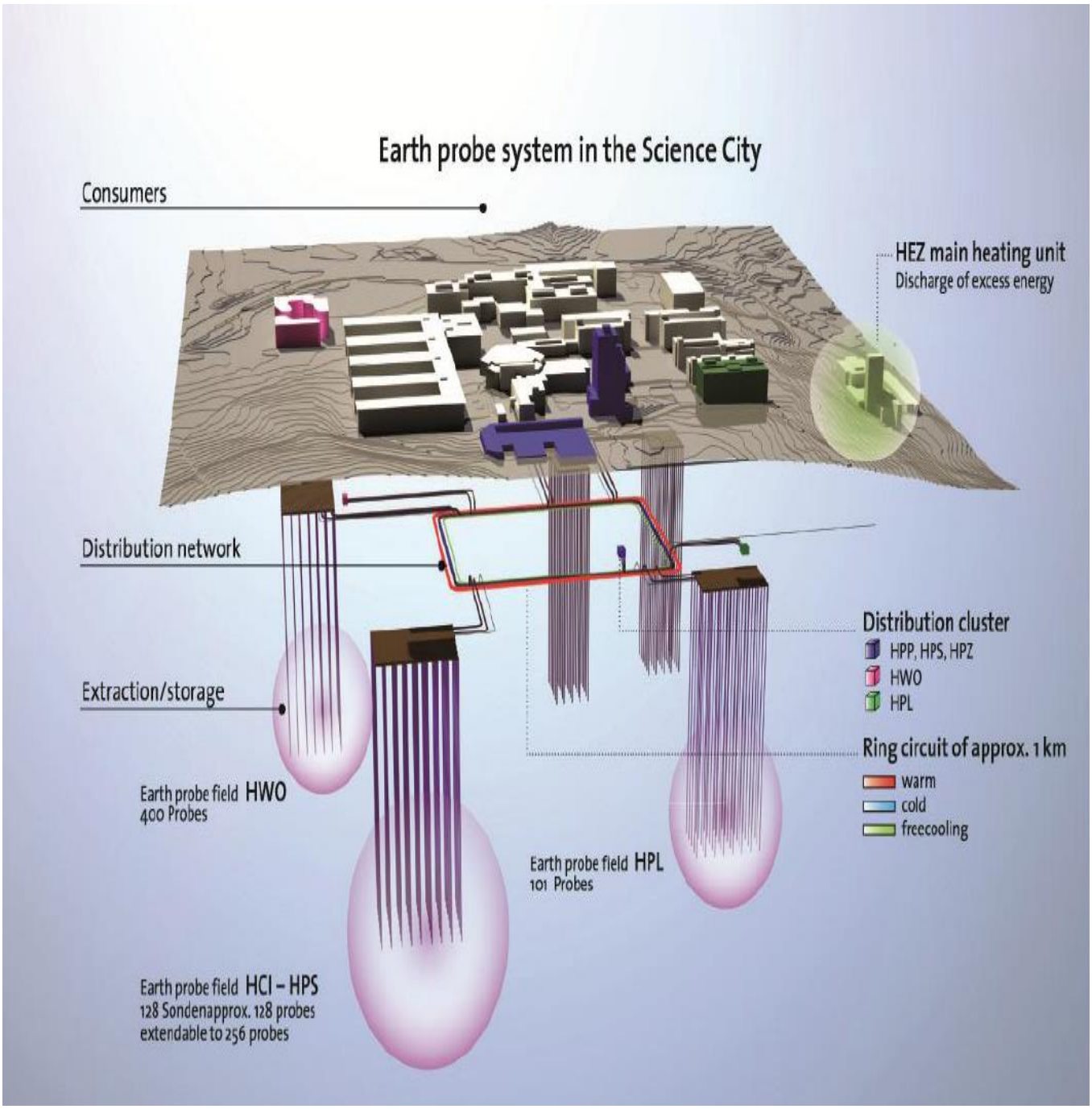

Figure 14: Schematic Representation of the Anergy Grid on Campus "Science City" at ETH Zurich

5 Discussion Panel: Boosting Hong Kong Environmental Industry Breakthrough

As evoked in the introduction section, besides key notes, presentations with discussion for each technical session, the Annual Forum 2015 has provided with the particularity of discussion panel among key players in environmental industry, engineering and applied research. The main objective was to further focus on critical challenging issues, perspectives on plausible future directions, and strategies for a real breakthrough of the environmental industry in Hong Kong. The discussion panel has thus served as complementary analysis platform to the relevant diagnostic and suggestions highlighted from the technical sessions.

5.1 Challenges Analysis

As underlined by most of participants, the environmental industry in Hong Kong is in urgent need of appropriate reforms. The development of the sector is certainly hampered by various obstacles especially in the areas of specific policy, regulations, capacity building, public environmental awareness, incentives, local market environment, finance and technologies. Invested efforts are found globally insufficient, and local stakeholders come under criticism for lagging behind its neighbors (Taiwan, Korea, Singapore and even Mainland China) and other comparable European countries (Netherland, Switzerland).This situation, not only increases risk and uncertainty for environmental business but also inhibits the rapid growth of local demand market.

Weak demand from local market due to low environmental awareness of customers, lack of information and promotional activities on new products, technologies and solutions, significantly hinder the development of the small and middle enterprises operating in the sector. Moreover, despite observed growing tendency for Government green procurement, the consumption of new advanced environmental technologies and products is still weak. This also curbs the interest and motivation for innovation.

The overall weakness of capacity building constitutes a major barrier to the development of the industry. Related critical aspects are education, information, mastery of new environmental technologies, continuous high quality professional development, and research ability in advanced technology development. Obviously, Hong Kong environmental industry is facing serious difficulties to meet and maintain a world class standard in human capital and new technologies. As stated by the President of Hong Kong Environmental Industry Association, technology is identified as the most important advantage

that differentiates a company from others in the fiercely competitive market. It is clear that the industry is highly dependent on technological innovations and development. In fast growing markets like China, investment in advanced environmental technologies is necessary for Hong Kong companies to hold a comfortable position. Unfortunately, limited financial resources and difficulties in banking financing (due to high investment risks associated with current market environment) exert great pressure on the development of Hong Kong small and middle companies. Therefore, building up a professional environment with adequate resources and all-round skilled stakeholders fully integrated into innovative and rapidly advancing technological needs, is crucial for Hong Kong environmental industry to capture regional market opportunities.

5.2 Perspectives on Future Directions for Breakthroughs

It appears clear that the development of Hong Kong environmental industry closely lies in its ability to stimulate local market and increase consumption, and to fully seize regional opportunities.

(1) Short Term Strategy

-First, it is important to build on the success stories already in place. Local demand-pull strategy for environmental technologies, products and services may consist for the Government, of increasing public environmental awareness, by developing proactive political leadership in collaboration with all stakeholders for achieving existing environmental targets based on strategic planning and diverse promotional activities. The Government may reinforce its own procurement policy to influence markets and manipulate market mechanism through levies and subsidies to being about more environmentally beneficial outcomes. This may help to provide a physical and information/knowledge-based infrastructure to facilitate further innovation, new research and development of initiatives with new partnerships between industry and academia. It is also important to reinforce funding supports to help small and middle firms to develop new set of environmental products, technologies and services.

-Second, with the adhesion and commitment of all stakeholders, adoption of policy reforms for enhanced green building regulations to stimulate the change of consumer taste, might create an opportunity for rapid growth of local environmental market, since building is considered as one of the most important sectors in Hong Kong for promoting energy efficiency technologies, green products, materials, services, and resource saving / recovery.

(2) Long Term Strategies

-In a longer term, Hong Kong stakeholders must look towards building up environment industry with flourishing innovation, creativity and technological advancement. Some of key directions that could serve as potential triggers of the development of local environmental market might be the development of "Smart City" model; "Zero Waste" and "Extended Producer Responsibility" policies for the development of sustainable circular economy. However, the development of strategies for permanent innovation appears to be crucial and requires joint actions from the Government and other key players. The main purpose is to direct the environmental market with appropriate policies to produce long term economically successful innovations. Price mechanisms (in particular taxes, subsidies and covenants) could be applied, similar to experiences in Singapore and other regional countries as highlighted by the Funding Director of Singapore ETH.

-Hong Kong stakeholders should also strengthen their collaboration with abroad advanced economies in new technology development. New partnerships with educational institutions at all levels, improved vocational training, profession development and increased support for research need are priorities. In this respect, there could certainly be closer links between Government, businesses and universities. In addition, research programmes could bring together firms that should potentially benefit from a technology in order to ensure exploration of a wide range of potential applications. On the hand, the stakeholders should initiate or reinforce the coordination with international regulatory agencies responsible in guiding new technology development in order to anticipate adequate levels, forms and standards of green technologies.

5.3 Recommendations

Based on the analyzed challenges and proposed future directions, actions needed from Hong Kong stakeholders can be synthetized as follows:

●Communicate clearly the targets on environmental improvement and commit to achieving the targets ;

●Adopt an open-market approach through improving green procurement processes ;

●Provide appropriate policy support, give strong market signals and, where appropriate and in strategic areas, subsidize environmental industry growth and development ;

●Negotiate with regional Governments to lower the barrier to secondary markets of recycled products;

●Provide incentives to environmental industry on innovation through both public and private sectors ;

●Acknowledge the success of local environmental businesses through recognition and fostering their growth by setting up an Environmental Accreditation and Award Scheme;

●Set up loan funds and/or make the best use of the current SME funds for small and middle enterprises for human capital development and innovation for environmental industry purposes;

●Establish an environmental information and technical support center;

●Enhance capacity building and promote research and applications;

●Support and encourage environmental enterprises to introduce advanced technology through the provision of subsidies and tax deductions, reductions, and exemptions as well as any appropriate incentives, facilitation and support for technology piloting;

●Establish a Green Technological Development Fund and award funds to support the research and development of circular economy, in particular, domestic technological innovation in research institutes and enterprises;

●Formulate market entry policies for resource and energy-intensive technology and equipment;

●Explore and establish an economic compensation system / mechanism for the environment using extra charges, resource taxes and fees collected from various charges;

●Encourage manufacturing and operation on the most cost effective scale. For areas with many small enterprises with high pollution, efforts should be made to promote economy of scale;

●Establish market admittance standard for vein industry to take advantage of economy of scale, which is vital for the control of secondary pollution in Hong Kong;

●Establish a long-term circular economy fund (special Government bonds, revenue from issuing a circular economy lottery for the public, waste discharge fee, resource taxes, surcharge levied for purchasing of luxury cars, large electrical household appliances, funds from non-government sources and international sources). Governments should formulate regulations and rules of fund allocation, use, management, and auditing. Selected capital management companies should be entrusted for the management of the fund;

●Make good use of Hong Kong as a show-case in order to capture regional market;

●Leverage their position in the supply chain, and capture the high value added;

●Emphasize on products or services that are exportable;

●Recognize that environmental industry elsewhere began as solution providers to address local issues based on sound policies and measures by all relevant stakeholders and key players;

●Closely collaborate with each other to increase public awareness and local environmental demand;

●Promote collaboration among key players for cost control and knowledge sharing;

●Commit to promoting capacity building and innovation oriented business in collaboration with Academia and international technological quality regulation bodies;

●Learn from oversea successful models.

6. Conclusions

In sum, the development of Hong Kong environmental industry depends on its ability to boost local market and increase consumption. Incontestably, local potential achievements could serve as exportable models for Hong Kong in grasping regional opportunities. Within this process, the consolidation and effective implementation of measures in place with successful achievement of existing targets are imperative. An important aspect is to enhance regulations on green building, and facilitate expansion of businesses in energy efficiency, green design, material recycling, resource saving / recovery and diverse green services, in order to stimulate the change of consumer taste for rapid growth of local environmental market. On the other hand, Hong Kong stakeholders must look towards building up the environment industry with flourishing innovation, creativity and technological advancement. The Annual Forum highlighted plausible future directions such as sustainable circular economy and "Smart City" policies for the breakthroughs of Hong Kong environmental industry. However, the adhesion and full commitment of all stakeholders for the design and implementation of appropriate policy instruments and supporting measures appear necessary for long term economically successful innovations.

Capacity building for innovation in line with market demand requires multi-disciplinary research cutting across several disciplines. Therefore, new partnerships and closer links between stakeholders and educational institutions (both local and oversea institutions) at all levels, for improvement of information systems, vocational training, continuous professional development, support for small and middle enterprises, market studies and research collaboration among different disciplines, are necessary.

Hong Kong has the potential to demonstrate that economic growth and environmental protection are compatible and could take a lead in regional environmental industry to map out pathways for Mainland China and other Asian countries.

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