Baseline Review and Proposed Key Strategic Directions for Infrastructure Provision

Planning Department
October 2016

In collaboration with:

Development Bureau
Environment Bureau
Civil Engineering and Development Department
Drainage Services Department
Environmental Protection Department
Water Supplies Department

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本廁所現已使用「再生水」
"Reclaimed Water" is used

1 Preface

1.1 The effective and efficient operation of a city relies on the provision of essential quality infrastructure to provide water supply, energy supply, sewage treatment, waste management, and flood prevention. Timely establishment, expansion and upgrading of supporting infrastructure is essential to support social and economic activities.

1.2 Other than provision of adequate infrastructure, promoting smart, green and resilient (SGR) infrastructure should also be one of the key strategic directions in our spatial planning strategy to reduce carbon emission, tackle extreme weather events caused by climate change, deliver multiple benefits (e.g. waste-to-energy), as well as minimize land take of infrastructure, and minimize constraints/adverse impacts on surrounding developments.

1.3 This paper gives an overview on the conditions and capacities of the existing infrastructure of territorial significance, namely water supply, drainage, sewage treatment, waste management and energy supply. It also looks into the planning and practice of SGR initiatives in infrastructure provision carried out by the Government so as to facilitate the formulation of key strategic directions for infrastructure development[i].

Figure 1.1 Jordan Valley Park, formerly a landfill
Source: http://www.hkinmoscow.gov.hk/eng/photos_events_details_zd.html#zone_d-2

This topical paper constitutes part of the research series under "Hong Kong 2030+: Towards a Planning Vision and Strategy Transcending 2030" (Hong Kong 2030+). The findings and proposals of the paper form the basis of the draft updated territorial development strategy which is set out in the Public Engagement Booklet of Hong Kong 2030+.

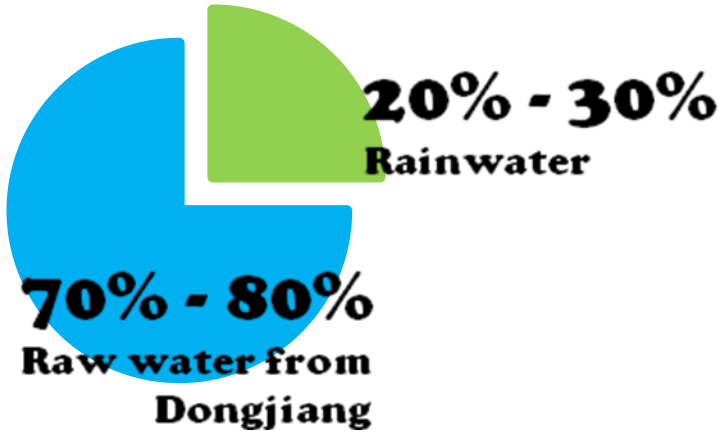
[i] Two topical papers entitled "Smart, Green and Resilient City Strategy" and "Environmental Protection and Nature Conservation for Sustainable Growth" are also relevant to planning and development of infrastructure. Transport infrastructure is elaborated in another topical paper entitled "Transport Infrastructure and Traffic Review".

2 Water Supply

A. Fresh Water

2.1 The two main sources of fresh water in Hong Kong are rainfall from natural catchment and supply of raw water from Dongjiang at Guangdong, which account for 20% to 30% and 70% to 80% of total fresh water supply respectively [1].

Figure 2.1 Main sources of fresh water in Hong Kong



2.2 Hong Kong lacks natural lakes, rivers or substantial underground water sources. Therefore, Hong Kong has now 17 impounding reservoirs and about one-third of the territory is designated as water gather grounds to collect rainwater. However, the yield of locally collected rainwater is fluctuating year by year and is far from sufficient for meeting the demand in Hong Kong. In light of the above, the Government imports raw water from Dongjiang to meet the needs of freshwater.

Figure 2.2 High Island Reservoir in Sai Kung East Country Park

Source: Water Supplies Department

2.3 The raw water is conveyed to water treatment works (WTWs) for treatment before supplying for potable use. At present, there are 21 WTWs and 171 fresh water service reservoirs in Hong Kong. For most of the cases, treated water from WTWs is conveyed to service reservoirs to meet daily fluctuation in water demand and storage for system breakdown and fire-fighting.

Figure 2.3 Tuen Mun Water Treatment Works

Source: Water Supplies Department

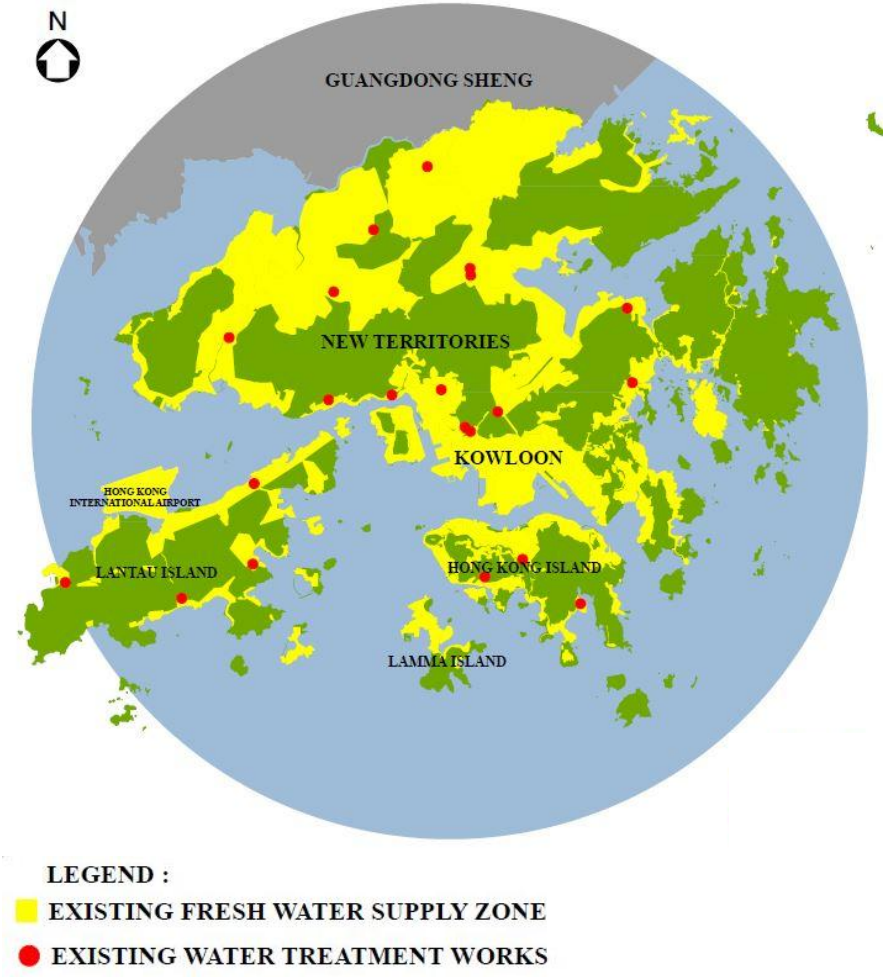


Figure 2.4 Location of Existing Water Treatment Works and Fresh Water Supply Zones

Source: Water Supplies Department

2.4 In order to enable adequate supply of water for the growing population and economic activities, there is a need either to upgrade the existing water supply facilities, or to build new facilities in certain areas, especially in the districts with planned new developments, such as Sheung Shui, Fanling, Tuen Mun, Yuen Long and North Lantau.

2.5 During the water treatment process, chlorine is used to disinfect the treated water. Chlorine is hazardous, WTWs storing chlorine equal to or more than a threshold quantity[ii] are designated as Potentially Hazardous Installations (PHIs). For every PHI, a Consultation Zone[iii] is delineated. Development proposals falling within a Consultation Zone have to be submitted to the Coordinating Committee on Land-use Planning and Control relating to Potentially Hazardous Installations (CCPHI) for consideration.

[ii] The threshold quantity of chlorine storage is 10 tonnes or any storage in one tonne drum.

[iii] Consultation Zone (CZ) is an area delineated for every PHI, within which proposed development will be referred to the Coordinating Committee on Land-use Planning and Control relating to Potentially Hazardous Installations (CCPHI) for consultation. The extent and the size of the CZ is determined with regard to local variation in topography, the types of PHI and their storage capacities.

B. Flushing Water

2.6 Water Supplies Department (WSD) has started using salt water for toilet flushing since the 1950s to save precious freshwater resources. Salt water is extracted from intake at sea front pumping stations from where sea water is pumped to salt water service reservoirs and to users along flushing water mains network.

Figure 2.5 New salt water pumping station in Wan Chai

Source: Civil Engineering and Development Department

2.7 Currently, there are 52 salt water service reservoirs in Hong Kong. With the recent completion of the infrastructure for supplying salt water to Pokfulam and Northwest New Territories, the salt water supply network now covers 85% of the population in Hong Kong. To meet further demand for flushing water, upgrading and expansion of existing salt water supply systems, or construction of new salt water supply systems would be required.

Success of Hong Kong's seawater flushing system

Hong Kong is the first city in the world systematically utilising sea water for toilet flushing. In 2001, WSD's seawater flushing system was awarded first place in the prestigious Chris Binnie Award for Sustainable Water Management by the Chartered Institution of Water and Environmental Management of the United Kingdom. Hong Kong was the first winner of the Chris Binnie Award outside Europe.

2.8 In the light of the committed and planned developments, some districts including Shatin, Ma On Shan, Tuen Mun, Yuen Long and Tung Chung require new or upgraded salt water supply system.

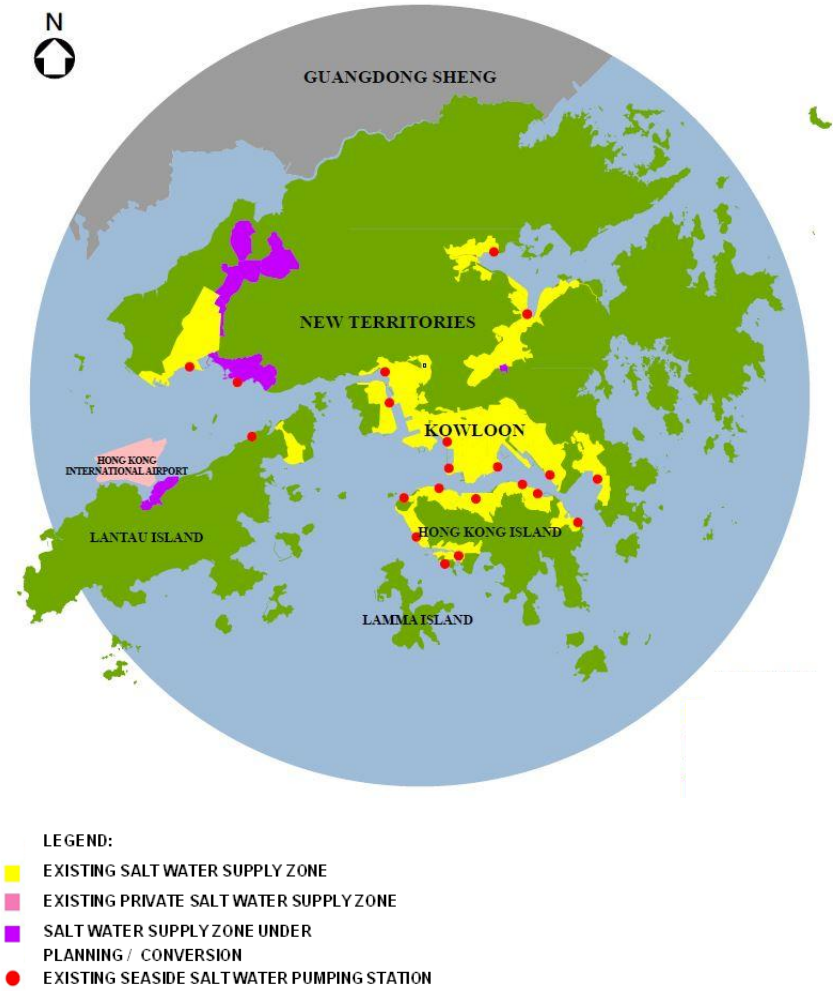


Figure 2.6 Coverage of Salt Water Supply
Source: Water Supplies Department

C. SGR Initiatives in Water Supply

Total Water Management Strategy

2.9 In the light of the increasing number of extreme weather events caused by climate change, WSD promulgated the Total Water Management (TWM) Strategy in 2008 to better prepare Hong Kong for uncertainties such as climate change for a period up to 2030. The strategy aims to contain demand growth rate and promote water conservation and to strengthen water supply management and achieve sustainable use of water resources in Hong Kong.

2.10 The furtherance of the TWM Strategy since 2008 provides a solid foundation for Hong Kong to moving towards sustainable use of its precious water resources. At present, Hong Kong enjoys a reliable supply of fresh water from our local catchment and Dongjiang. Nevertheless, Hong Kong's water resources is facing a number of challenges including the potential impacts of climate changes, the competition of various cities in Guangdong Province for the Dongjiang water, the projected growth of population and economic growth and hence water demand. With a view to timely introducing new initiatives to strengthen our resilience and preparedness to water–related uncertainties and challenges and providing an insight on how Hong Kong's long-term water demand can be met, WSD has been conducting a comprehensive review of the TWM Strategy since October 2014.

Water Gathering Ground

2.11 It is also worth noting that about one-third of the land area in Hong Kong is designated as Water Gathering Grounds (WGGs). Discharges of effluent within these WGGs should comply with the Water Pollution Control Ordinance (WPCO). In order to protect the local raw water source at WGGs, the Government has been controlling development and activities within WGGs. A majority of the WGGs falls within Country Park areas and hence is protected under the Country Parks Ordinance.

Water Reclamation

2.12 In pursuance of sustainable use of water resources in Hong Kong, water reclamation is one of the water management initiatives under the TWM Strategy. It refers to the use of reclaimed water to replace high quality fresh water for non-potable purposes. Reuse of treated sewerage effluent, grey water [iv] recycling and rainwater harvesting [v] are examples of water reclamation.

Figure 2.7
Sewage pumping station with water supplied by rainwater harvesting system
Source: Drainage Services Department

What is Reclaimed Water? Reclaimed water is highly treated wastewater which is clear in appearance, odourless and is safe for use. It is widely used in other countries, such as for road cleaning, car washing and fire-fighting.

2.13 To take forward the initiative of using reclaimed water, WSD has commenced the infrastructure design for supply of reclaimed water to the north-eastern part of the New Territories for toilet flushing and other non-potable uses in phases, starting with Sheung Shui and Fanling from 2022 onwards.

Seawater Desalination

2.14 To better prepare Hong Kong for uncertainties in a reliable fresh water supply, it is recommended to diversify the water supply resources and to develop new water resources under the TWM strategy including seawater desalination.

What is Desalination? Desalination removes dissolved salts and impurities from seawater and turns it into fresh, drinking quality water. Reverse osmosis (RO) is a proven and mature desalination technology, and has been adopted in many desalination plants around the world.

[iv] Grey water is part of domestic wastewater, some sources of grey water include washing basins, baths, washing machines, etc.

[v] Rainwater harvesting is an approach to collect rainwater on the roof and supply rainwater for other uses such as irrigation.

2.15 To put forward this initiative, a pilot plant study was completed in 2007, and confirmed the technical feasibility of seawater desalination using RO under local conditions for producing potable water in compliance with the World Health Organisation guidelines for drinking water quality.

2.16 A site of 10 ha in Tseung Kwan O (TKO) Area 137 has been reserved for the construction of the first desalination plant using RO technology in Hong Kong. TKO Area 137 is a suitable location for siting the proposed desalination plant in terms of the quality of nearby seawater and its close proximity to a strategic water supply network. The first stage of the desalination plant will have a water production capacity of 135 000 cubic metres (m^3) per day with provision for future expansion to the ultimate capacity up to 270 000 m^3 per day to meet about 5% (10% if expanded) of Hong Kong's fresh water demand.

Inter-reservoirs Transfer Scheme

2.17 To maximise local yield and alleviate flooding risk, WSD and Drainage Services Department (DSD) are collaborating on an inter-reservoirs transfer scheme involving the transfer of surplus water from the Kowloon Group of Reservoirs to Lower Shing Mun Reservoir during heavy rain, and then to the Sha Tin WTW.

Figure 2.8 Proposed Desalination Plant in Tseung Kwan O Area 137

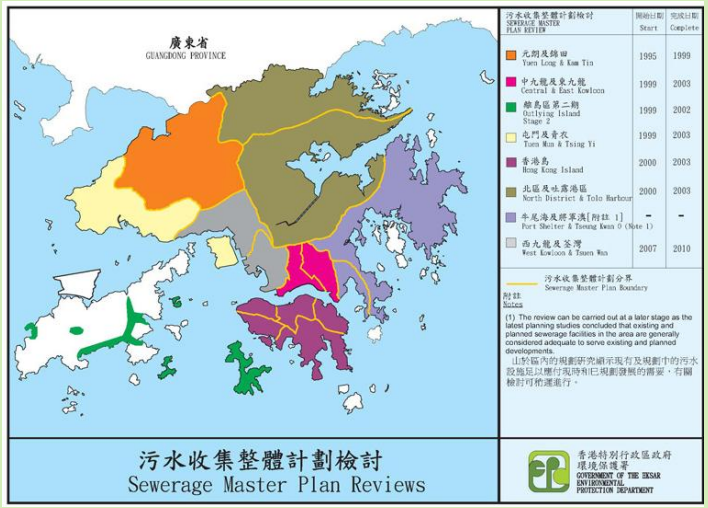
3 Sewerage

A. The Sewerage System

3.1 Our sewerage system is serving 93% of population in Hong Kong. The public sewerage network runs 1,730 kilometres in length, and there are 230 sewage pumping stations and 70 sewage treatment works (STWs) across the territory [2].

3.2 The whole territory has been divided into catchment areas and 16 Sewerage Master Plans (SMPs) were produced to cover all the areas since 1989. In view of the new and changing development proposals and the latest population forecasts, these SMPs have been subsequently reviewed. SMPs provide a blueprint of the sewerage infrastructure required to collect sewage on a catchment-by-catchment basis and direct it to treatment facilities. To cater for the present and future development needs, recommendations on sewerage works from these SMPs are being implemented progressively.

Sewerage Master Plans (SMPs) Reviews



The SMPs are subject to regular review in light of revised population forecasts and the expected level of development, to ensure that the scope of sewerage works proposed under the SMPs is able to cope with the rapid changes. In 1995, the Environmental Protection Department re-grouped the SMPs into 8 areas for conducting SMP Review Studies. Various projects recommended under these Reviews are being implemented by the Drainage Services Department on a priority basis.

3.3 In 2014/15, about 2.8 million m^3/day of sewage collected from residential, commercial and industrial premises are properly treated prior to disposal to the receiving water bodies.

3.4 About 70% of the sewage is collected from population and development in the catchments of Kowloon, northern and south-western of Hong Kong Island. The sewage collected is conveyed via deep sewage tunnels to the Stonecutters Island STW for centralised treatment and disposal.

Figure 3.1 Stonecutters Island Sewage Treatment Works
Source: Drainage Services Department

3.5 The remaining sewage flow generated in other catchments is collected by sewerage networks and treated in regional or local STWs completed in accordance with various SMPs.

Figure 3.2 Major Sewage Treatment Works in Hong Kong
Source: Extracted from DSD's Sustainability Report 2014 – 2015

B. Enhancing the Sewerage System for New Developments

3.6 The existing and planned design capacity of STWs are about 3.00 million m^3/day and 4.01 million m^3/day respectively. In the light of the growing population and economic activities, timely provision of additional sewage treatment capacity in some sub-regions, especially the Metro and North West New Territories sub-regions, would be needed.

Harbour Area Treatment Scheme (HATS)

3.7 Victoria Harbour is a precious public asset of Hong Kong, both culturally and economically. To improve the water quality of the Victoria Harbour, the Government has implemented the largest environmental programme, namely the HATS, since late 2001. HATS is a two-stage programme which involves the implementation of an integrated sewerage system that will collect and treat all of our sewage from both sides of the harbour area in an efficient, effective and environmentally sustainable manner.

3.8 Since the implementation of HATS, the water quality of the Victoria Harbour has significantly improved. Upon full operation of the facilities in Stage 1 in 2001, dissolved oxygen in the harbour waters has been increased, and the levels of key pollutants (e.g. Unionised Ammonia, Nutrients, E.coli) in the harbour waters have generally decreased.

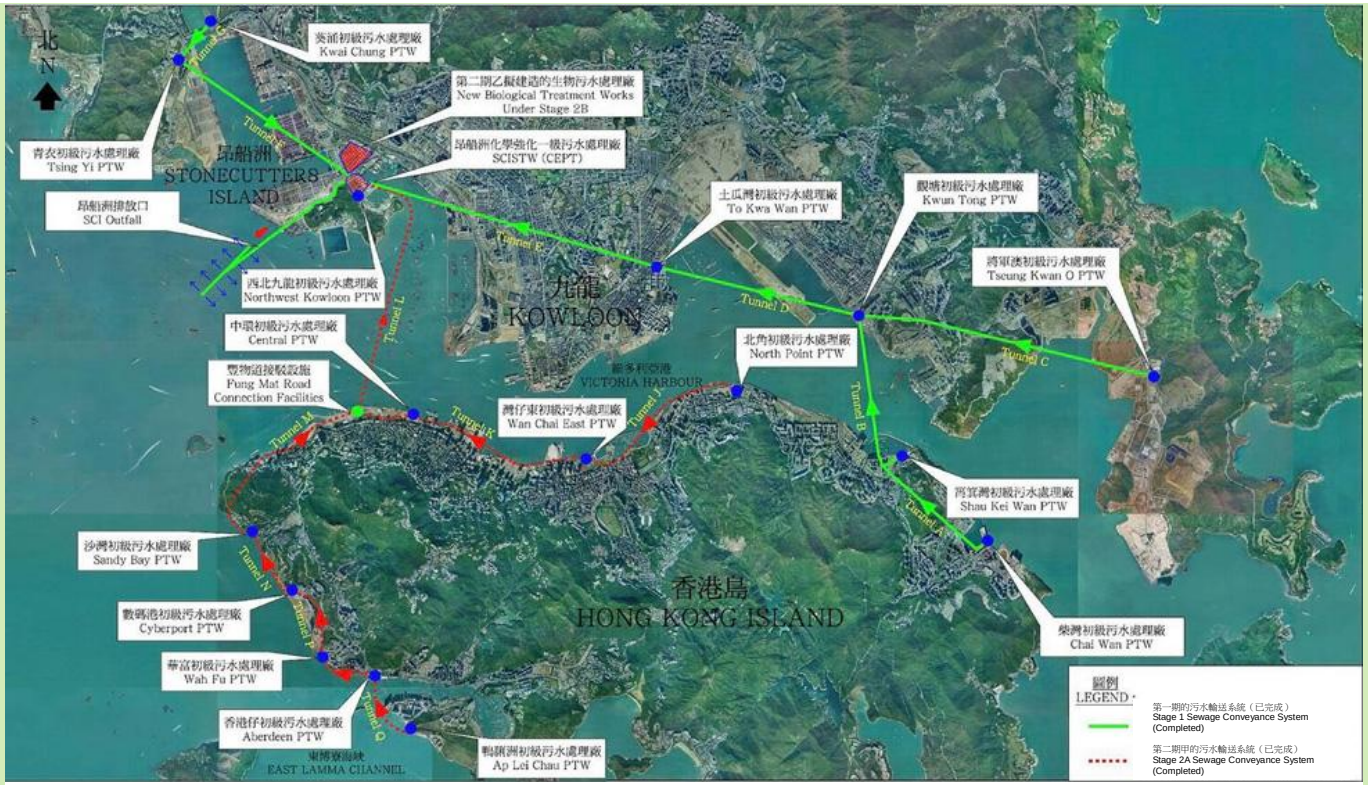
3.9 HATS Stage 2A has provided adequate capacity to handle the projected sewage flow and the bulk of Victoria Harbour will be in compliance with the Water Quality Objectives upon its commissioning in 2015. It is considered that Stage 2B which aims to add an underground biological treatment facility adjacent to the Stonecutters Island STW is not critical. Nonetheless, the implementation of HATS Stage 2B will be kept under review.

3.10 To further improve the water quality of Victoria Harbour, the Environmental Protection Department (EPD) is carrying out a consultancy to work out practical options and a programme to improve the quality of coastal water of the harbour by tackling near shore pollution.

Accomplishment of HATS

STAGE 1 (Commissioned in 2001)

The HATS Stage 1 comprises the construction of a chemically-enhanced primary treatment plant at Stonecutters Island, an outfall tunnel, the comprehensive upgrading of seven preliminary treatment works, and a 23.6 kilometre-long system of deep tunnels for collecting sewage from urban Kowloon, Tsing Yi, Kwai Chung, Tseung Kwan O and eastern Hong Kong Island and conveying it to Stonecutters Island. The Stonecutters Island STW treats around 75% of the sewage generated in the harbour area. The water quality of Victoria Harbour has been substantially improved.



Schematic Layout of Sewage Conveyance System constructed and implemented under HATS Stage 1 and 2A, and location of Biological Treatment Works under Stage 2B
(Source: Extracted from EPD's Environmental Performance Report 2012)

STAGE 2A (Commissioned in 2015)

For the remaining 25% of sewage entering the Harbour, the Government has developed the Stage 2A of HATS to treat all sewage from the northern and south-western areas of Hong Kong Island. Stage 2A comprises upgrading works on the 8 preliminary treatment works on the northern and south-western shores of Hong Kong Island, construction of a tunnel system to transfer preliminary-treated sewage to Stonecutters Island, expansion of the existing chemical treatment process and adding new disinfection facilities. Today, the sewage generated in the harbour area, which previously received only preliminary treatment, is redirected to the expanded Stonecutters Island STW for chemically-enhanced primary treatment with disinfection before discharge before being discharged to the Harbour.

Stage 2B

An underground biological treatment facility will be added to provide secondary sewage treatment in HATS Stage 2B. While the water quality improvements are being monitored upon the commissioning of Stage 2A, the implementation of Stage 2B will be kept under review taking into account the water quality situation and the latest technological development in biological treatment.

Improvement of Sewage Treatment Facilities

3.11 The Government has been proactively expanding and upgrading the existing sewage treatment facilities to cater for the growing population and new development in the New Territories.

3.12 To accommodate population growth in Tuen Mun, upgrading works has been carried out to Pillar Point STW to raise sewage treatment capacity and upgrade its treatment level from primary treatment to chemically enhanced primary treatment with ultraviolet disinfection.

Figure 3.3 Upgraded Pillar Point Sewage Treatment Works

Source: Drainage Services Department

3.13 Besides, in view of the rapid development of North District, the Government is planning to uplift the treatment capacity of Shek Wu Hui STW progressively and upgrade its treatment level from secondary treatment to tertiary treatment so as to protect the ecology at Deep Bay.

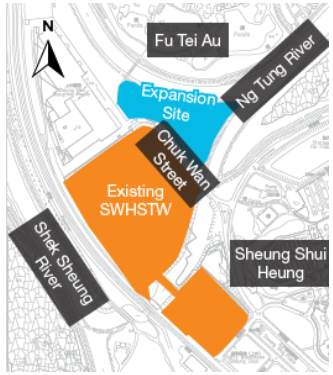


Figure 3.4 Existing Shek Wu Hui Sewage Treatment Works *(Left)*

Source: Drainage Services Department

Figure 3.5 Expansion Scheme of Shek Wu Hui Sewage Treatment Works *(Right)*

Source: Drainage Services Department

C. SGR Initiatives in Sewage Treatment

Relocation of Sewage Treatment Works to Caverns

3.14 The Government has been proactively minimising the land demand of infrastructures in order to reduce the environmental disturbance to the community and release the precious land for other uses. For instance, relocation of STWs to caverns is one of the major solutions being vigorously investigated by the Government.

3.15 Indeed, the construction of Stanley STW in caverns in the 1990s has proven to be a success. The Government is studying the relocation of the Sha Tin STW to the cavern. According to the completed consultancy for the major works of the relocation of Sha Tin STW to cavern at Nui Po Shan of A Kung Kok, 28 hectares of land can be released for beneficial uses for the community.

Figure 3.6 Sha Tin Sewage Treatment Works
Source: Drainage Services Department

Figure 3.7 Existing Sha Tin Sewage Treatment Works and the Relocation Site
Source: Drainage Services Department

3.16 Other than developing new land resources, the relocation of STW to caverns can reduce environmental impacts caused by the operation of the STW. For instance, caverns can act as natural barriers which are highly effective in odour control. Landscape and visual impacts are also minimized with major facilities hidden inside the caverns.

Water Reclamation

3.17 DSD has introduced the pilot schemes of reusing treated effluent in Ngong Ping and Shek Wu Hui STW. The schemes have shown that use of reclaimed water is technically feasible.

Figure 3.8 Reclaimed water treatment plant in Shek Wu Hui Sewage Treatment Works
Source: Environmental Protection Department

3.18 Another large-scale water reclamation scheme was launched at Sha Tin STW in 2011. Sha Tin STW can generate over 1,000m^3 of reclaimed water every day for plant cleaning, garden irrigation, toilet flushing and chemicals dilution. Together with Ngong Ping STW and Shek Wu Hui STW, there are currently 5 sewage treatment works equipped with water reclamation facilities.

Utilisation of Biogas

3.19 To further enhance the utilization of biogas, DSD also plans to install an additional biogas micro-turbine at Yuen Long STW.

Ngong Ping Sewage Treatment Works

Ngong Ping STW, commissioned in 2006, is the first tertiary treatment plant with reclaimed water facilities in Hong Kong. It receives sewage arising from Ngong Ping and nearby tourist attractions. The UV disinfected effluent in the STW receives further chlorination to provide safe supply of reclaimed water. Reclaimed water is supplied for flushing in nearby public toilets and the toilets in the Cable Car Terminal. It is also used in controlled irrigation and fish pond in the plant.

Reclaimed water used in fish pond in the STW
Source: Drainage Services Department

4 Drainage

A. Stormwater Drainage System

4.1 Hong Kong adopts separate systems to handle stormwater and sewage discharges respectively. The conventional stormwater drainage system is to convey the surface runoff to the sea as far as possible and its design focuses on the performance aspect. As such, the drainage catchment characteristics and land development scenarios are the governing factors being considered.

4.2 In the course of development, it is inevitable that some parts of the natural land need to be developed and hence paved or the drainage path is altered, causing impact to the drainage system.

Figure 4.1 Yuen Long Bypass Floodway is constructed to improve drainage capacity of Yuen Long Town

Source: Drainage Services Department

4.3 Special attention on potential drainage impact should be paid to districts such as Northern Lantau, Rural North East New Territories and Rural North West New Territories where several committed or planned development projects are going to be carried out. Each of the development projects will be assessed by drainage impact assessments to address the drainage issue caused by the respective development.

4.4 In the past years, DSD has adopted various flood mitigation measures including stormwater interception tunnels, stormwater storage and upgrading stormwater conveyance drains to reduce flooding hazard so as to protect public safety. In the recent years, DSD has actively advocated “Blue-Green infrastructure”, emphasizing the building of scenic environment. It promotes greening, biodiversity, beautification and water-friendly activities at the same time achieving effective drainage with a view to constructing sustainable drainage facilities and building a better environment for the public.

B. Enhancing the Capacity of the Drainage System

Drainage Master Plan Review Studies

4.5 In view of the rapid development and changing drainage needs, DSD is carrying out review studies for the drainage master plans of different regions in phases, and devising drainage improvement strategies to cope with the increasing drainage needs. Improvement measures and flood prevention projects will be recommended in the review studies to enhance the flood protection level and reduce the flooding risks of different districts.

4.6 Up to now, review studies for Yuen Long, North District, Happy Valley, West Kowloon and East Kowloon were completed. The review of Tai Po, Sha Tin and Sai Kung districts are underway and expected to complete shortly. Review studies for the northern Hong Kong and Lantau and outlying islands commenced in 2014 and 2016 respectively. Those for the remaining catchments will follow in the coming years.

4.7 Long-term improvement measures on drainage systems are implemented to address flood risk. Prominent drainage projects from the Drainage Master Plan including Yuen Long Bypass Floodway which can intercept 40% of the runoff in the Yuen Long catchment with a series of environmental designs, and improve drainage capacity in Yuen Long Town and its peripheral village area; and Hong Kong West Drainage Tunnel with stormwater tunnel diverts rain water from mid-level upland areas and discharges direct to the sea, the installation of tunnel reduces the flooding risk of the downstream areas in northern Hong Kong Island. Three other drainage tunnels are installed and in operation in Kai Tak, Lai Chi Kok and Tsuen Wan.

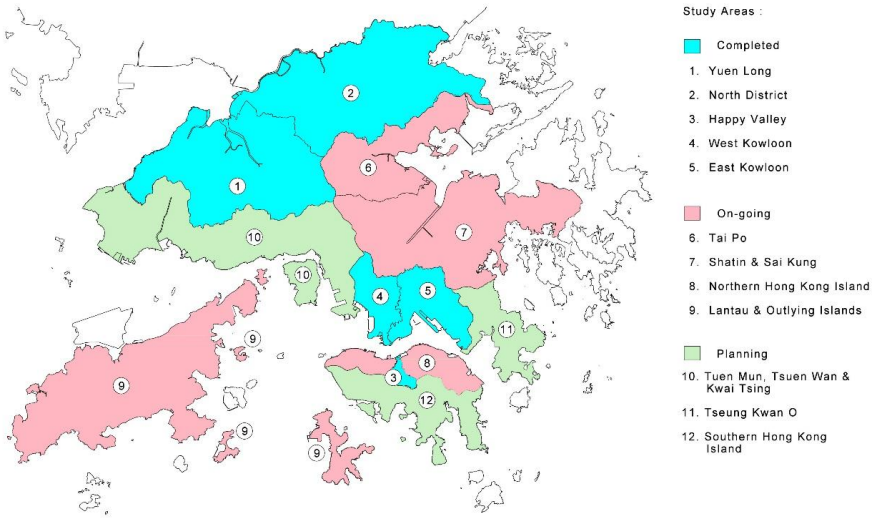


Figure 4.2 Drainage Master Plan Review Studies

Source: Drainage Services Department

Enhanced Capacity to tackle Climate Change

4.8 Climate change increases the occurrence of extreme weather events. It is anticipated that in the 21st century, Hong Kong will experience more extreme rainfall events, and the threat of storm surges associated with tropical cyclone will rise. These extreme weather events may threaten the stormwater drainage system by overloading the capacity of the system.

4.9 With the consideration of the drainage impact brought by the climate change, DSD has been improving the drainage system by not only enhancing the capacity, but also making the system more resilient to climate change.

C. SGR Initiatives in Drainage System

Sustainable Drainage Systems

4.10 Sustainable drainage systems refer to an approach to managing rainwater falling on roofs and other surfaces through sequence of actions. The key objectives are to manage the flow rate and volume of surface runoff to reduce the risk of flooding and water pollution. The system can also reduce pressure on the stormwater drainage network and can improve biodiversity and local amenity.

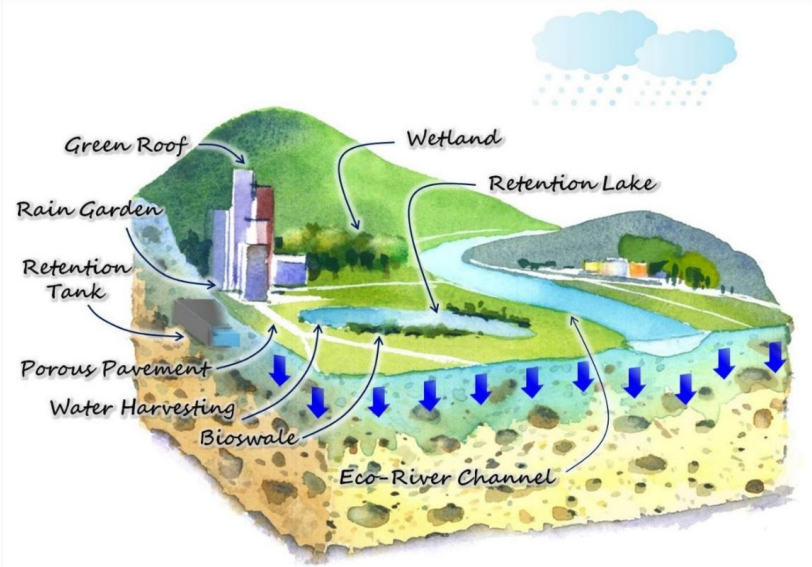


Figure 4.3 Sustainable Drainage System

Source: Drainage Services Department

4.11 DSD has been implementing the initiative of developing sustainable drainage systems in Hong Kong. In the upgrading project of Stonecutters Island STW, elements of sustainable drainage systems have been incorporated, such as the provision of green roof, bioswale, rain garden, porous pavement to minimize the impact of excessive runoff.

Figure 4.4 Porous pavement in Stonecutters Island Sewage Treatment Works
Source: Drainage Services Department

4.12 To alleviate the flooding risk in Happy Valley and Wan Chai districts, DSD has constructed an underground storage tank beneath the Happy Valley Recreation Ground. It serves as a flood detention system to provide a temporary storage of the floodwater during storm event so as to relieve the flooding hazards in urban areas of the Happy Valley catchment. The integrated design of the recreation ground and the underground storage tank showcases smart use of land to achieve multiple benefits.

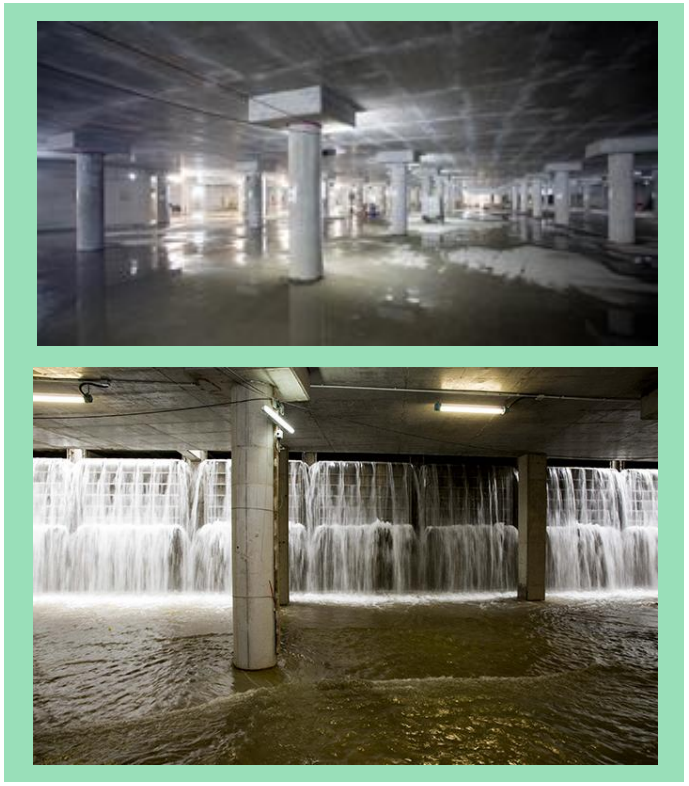


Figure 4.5 Happy Valley Underground Stormwater Storage Tank
Source: Development Bureau

4.13 The establishment of the "Happy Valley Underground Stormwater Storage Scheme" is a sustainable and integrated solution to adapt to the extreme weather situations. Many innovative elements have been incorporated in the scheme, in particular the Water Harvesting System. The system collects groundwater, excess irrigation water and rainwater from sports pitches and reuses in irrigation and toilet flushing after proper on-site treatment, which saves about 220,000 cubic meters of precious water every year.

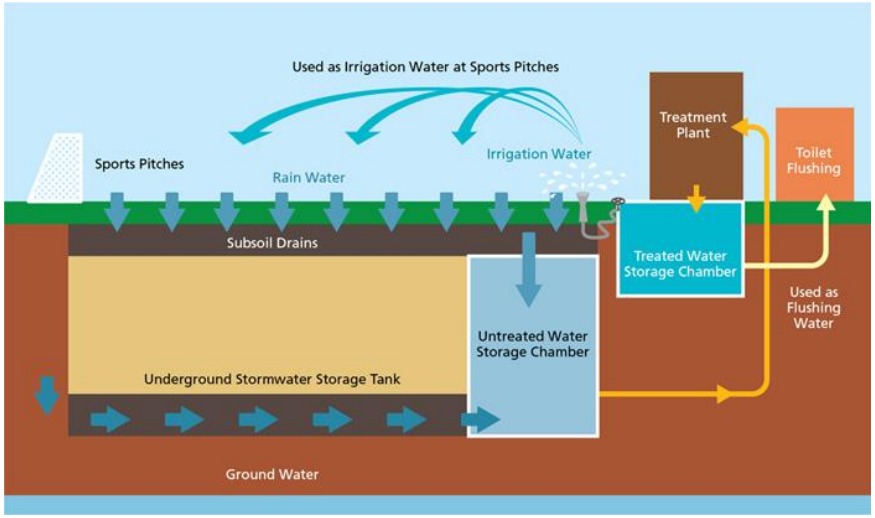


Figure 4.6 Water Harvesting System at Happy Valley Recreation Ground
Source: Drainage Services Department

"Blue-Green Infrastructure" Concept

4.14 The Government is endeavouring to promote environmental conservation and sustainability by incorporating the concept of "Blue-Green Infrastructure"[vi] in the drainage system. Development in natural areas would interrupt the natural drainage system and bring environmental impacts to the natural habitats. With a view to minimising environmental impact, various ecological conservation measures have been implemented in the river improvement works to create a natural environment. Facilities including retention lakes and rain gardens will also be utilised to retain a certain amount of stormwater during heavy rain to attenuate the peak flow.

Figure 4.7 Fish ladder built with natural materials at Ho Chung River, Sai Kung
Source: Drainage Services Department

Figure 4.8 Lam Tsuen River
Source: Drainage Services Department

[vi] "Blue" refers to rivers and water bodies, while "Green" refers to greening landscapes

5 Waste Management

A. Waste Management in Hong Kong

Waste Types in Hong Kong

5.1 The major waste types generated in Hong Kong are municipal solid waste (MSW), construction waste and other special wastes such as chemical waste and livestock waste. Disposal of MSW and construction waste is most challenging in waste management in Hong Kong due to the large volume of waste generated every day.

Municipal Solid Waste

5.2 Municipal waste comprises solid waste from domestic, commercial and industrial sources, but excludes construction waste, chemical waste, clinical waste and other special waste. Food waste is the major constituent of MSW in Hong Kong. MSW is transported by refuse collection vehicle to a network of refuse transfer stations near the urban areas and disposed of at landfills.

Construction Waste

5.3 Construction and demolition (C&D) materials of different nature are abandoned from daily construction works. Most of these materials are reusable inert materials such as rock, rubble, boulder, earth, soil, sand, concrete, asphalt, brick, tile, masonry and used bentonite, which are also known as public fill. These inert materials could be sorted out on site by the works contractor and transferred to the fill banks for reuse in other suitable projects, such as reclamation. The remaining non-inert materials such as bamboo, timber, vegetation, packaging waste and other organic materials, which are not suitable for land reclamation, subject to the recovery of recyclable items, are disposed of at landfills.

Figure 5.1 Island East Transfer Station

Source: Environmental Protection Department

Land filling

5.4 In 2014, more than 14,000 tonnes of solid waste was disposed of at three strategic landfills in Hong Kong every day, of which about 66% is MSW, 26% is construction waste, and 8% is special waste[vii]. The three strategic landfills are North East New Territories (NENT) Landfill at Ta Kwu Ling, South East Territories (SENT) Landfill at Tseung Kwan O, and West New Territories (WENT) Landfill at Nim Wan.

5.5 With funding approval by the Legislative Council on the SENT and NENT landfill extension projects in December 2014, it is anticipated that these strategic landfills could cope with the ultimate waste disposal need of the territory until mid or late -2020s. Yet, sole reliance on landfills for disposal of solid waste is not sustainable because of limited landfill space.

Figure 5.2 West New Territories Landfill at Nim Wan
Source: Environmental Protection Department

[vii] Extracted from Monitoring of Solid Waste in Hong Kong – Waste Statistics for 2014. Special waste such as animal waste and dewatered waterworks sludge are disposed of at landfills; while chemical waste and clinical waste are treated at the Chemical Waste Treatment Centre.

B. SGR Initiatives in Waste Management

Waste-to-Energy

5.6 In view of the large waste load and the limited capacity of waste management infrastructures, an action plan, named "Hong Kong: Blueprint for Sustainable Use of Resources 2013 – 2022" ("Action Blueprint") was unveiled by the Environment Bureau. This Action Blueprint maps out a comprehensive resource management strategy with a target to reduce the per capita MSW disposal rate by 40% by 2022. One of the major initiatives adopted in the future waste management strategy is "waste-to-energy".

5.7 The implementation of the "waste-to-energy" initiative in waste management is critical to reducing landfill disposal. Several modern infrastructures with waste-to-energy technology are introduced to reduce the reliance on land filling, namely integrated waste management facilities (IWMF), sludge treatment facility (STF) and organic waste treatment facilities (OWTF).

Municipal Solid Waste - Integrated Waste Management Facilities

5.8 One of the significant waste infrastructures to be developed is the Integrated Waste Management Facilities (IWMF) on an artificial island near Shek Kwu Chau.

Figure 5.3 Photomontage of Integrated Waste Management Facilities next to Shek Kwu Chau
Source: Extracted from Legislative Council Brief (2011) on Development of the Integrated Waste Management Facilities

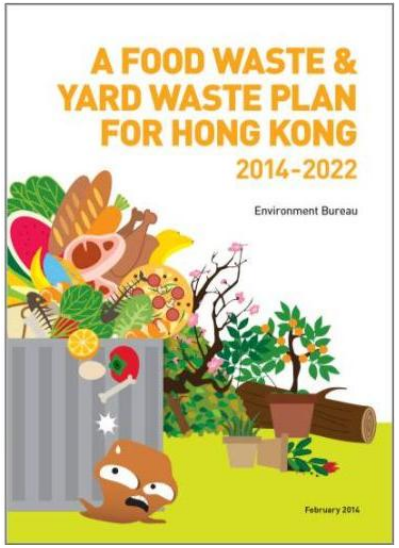
5.9 IWMF is state-of-the-art waste treatment facilities comprising functions of bulk reduction of mixed MSW and recovery of useful resources. Through modern incineration technologies, the combustion can reduce the volume of waste by 90%, and at the same time, recover energy and generate electricity from waste for daily operation of the facilities within IWMF and the surplus electricity will be exported to the power grid sufficient for the use by some 100,000 households.

Figure 5.4 Key Components of IWMF

5.10 Development of the IWMF is a sustainable solution to tackle waste challenge in Hong Kong. This integrated territorial waste infrastructure not only relieves the pressure for additional landfill, but also provides a source of renewable energy. It is estimated that energy generated by waste incineration can reduce about 440,000 tonnes of greenhouse gas emission to be generated by fossil fuel each year [3].

5.11 In addition, the IWMF itself is an environmentally friendly facility which will be equipped with many green features such as desalination plant to provide fresh water supply for on-site use, on-site wastewater treatment plant to treat effluent for reuse, extensive landscape areas and greening. The location and the design layout have been carefully considered, taking into account the prevailing wind, ecological condition, distance from urban area, etc.

Organic Waste Treatment Facilities



5.12 In 2014, about 3,600 tonnes of food waste was being land filled every day, which constitutes the largest MSW category (about 37% of daily MSW disposal at landfills) being disposed of at landfills. To tackle food waste problem, the Environment Bureau published "A Food Waste & Yard Waste Plan for Hong Kong 2014 – 2022" in 2014 which maps out a comprehensive food waste management strategy to reduce landfill disposal of food waste by 40% by 2022. The Government adopts a multi-pronged approach to tackle food waste problem by preventing and reducing food waste at source, and at the same time, establishing infrastructure, in particular organic waste treatment facilities (OWTFs), to treat food waste in a sustainable manner.

5.13 The Government is planning to build a network of five to six OWTFs across the territory in phases, so that nuisance arising from transportation of food waste could be reduced. Operation of the OWTF adopts biological treatment technologies to treat city's food waste while produces renewable energy. The total recycling capacity of the network of OWTFs is expected to be about 1,300 to 1,500 tonnes per day.

5.14 The first phase of OWTF will be located in Siu Ho Wan of North Lantau to treat food waste from the commercial and industrial sectors at a capacity of 200 tonnes per day. The plant is expected to be commissioned in 2017.

5.15 The proposed locations of the second and the third phases are Sha Ling of the North District and Shek Kong of Yuen Long respectively. Site searching and feasibility studies will commence shortly for the remaining OWTFs, while the number and scale of the further OWTFs would depend on the overall waste reduction progress.

Figure 5.5 Artist's Impression of Phase 2 of OWTF
Source: Environmental Protection Department

Sewage Sludge - Sludge Treatment Facility

5.16 The conventional approach of sludge disposal is land filling. The largest part of special waste disposed of at landfills is dewatered sludge from sewage treatment plants[viii]. With the commissioning of HATS Stage 2A and expansion or upgrading of some STWs, more sewage sludge is expected to be generated. Therefore, the Government take the initiative of "waste-to-energy" to develop the first self-sustained sludge treatment facility (STF), named T·PARK in Tsang Tsui of Tuen Mun.

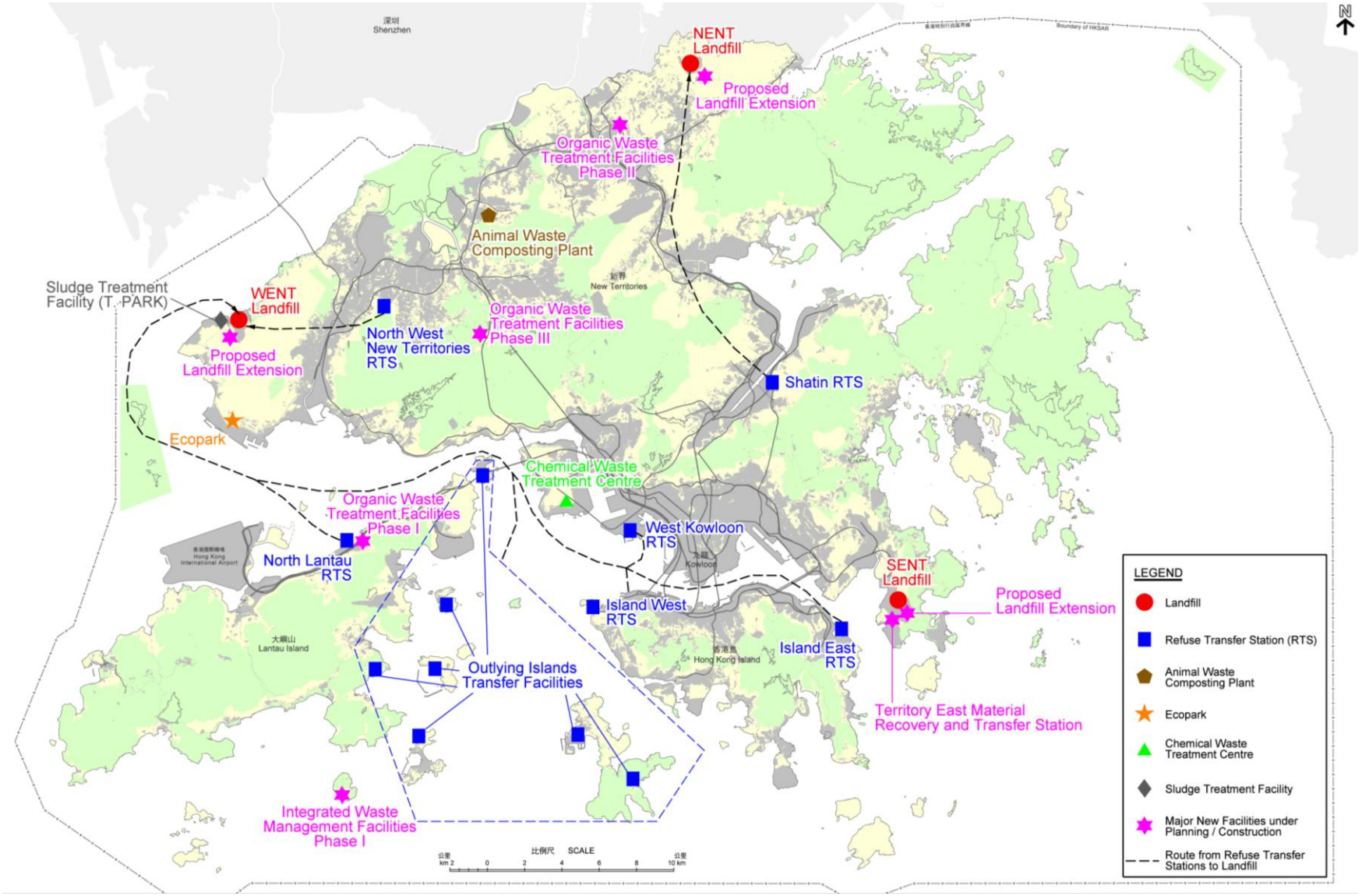
5.17 T·PARK treats sludge generated from HATS and regional STWs by combustion. During the high-temperature incineration process, heat energy is turned into electricity for the operation of the facility's daily operation. When the facility is running at full capacity, surplus electricity can be exported to power up 4,000 households.

5.18 It is anticipated that the design capacity of the STF will be exceeded around 2030, the EPD will commission a study to review sewage sludge arising in Hong Kong and determine sludge management and disposal arrangements in the medium term and long term, including management options to reduce sewage sludge production, on-site treatment at individual sewage treatment works to reduce the need for off-site treatment at regional facilities, and advise on any need for expanding the existing STF or development of a new STF.

Figure 5.6 T·PARK located at Tsang Tsui, Tuen Mun, has been in operation since April 2015
Source: Environmental Protection Department

[viii] According to "Monitoring of Solid Waste in Hong Kong – Waste Statistics for 2014", the average daily quantity of dewatered sewage sludge was 824 tonnes, while the total disposal of special waste at landfills was 1,135 tonnes.

Figure 5.7 Network of Existing and Planned Waste Facilities



Green Construction

5.19 The daily generation of construction waste in Hong Kong is about 57,000 tonnes in 2014, among which 93% is sorted out as public fill and transferred to the fill banks for reuse in other suitable projects, such as reclamation. The remaining non-inert materials, subject to the recovery of recyclable items, are disposed of at landfills.

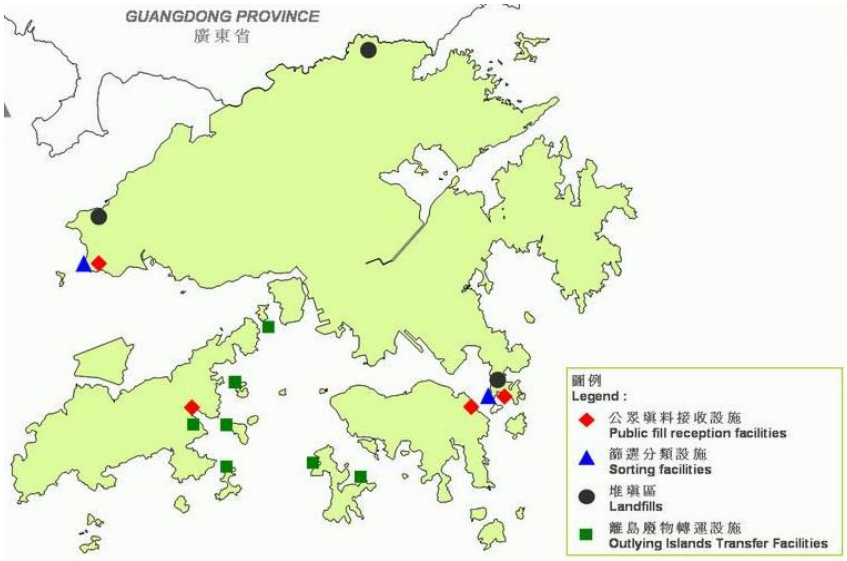


Figure 5.8 Construction Waste Disposal Facilities
Source: Environmental Protection Department

5.20 Temporary stockpiling of public fill has high opportunity cost for the valuable land resource in Hong Kong. Hence, the Government is promoting green construction in the construction industry, with a view to encouraging the construction industry to reduce construction waste among others.

5.21 In order to examine the land requirements of the construction industry, the "Study on Land Requirements for Construction Industry – Feasibility Study" is commenced in September 2015 to evaluate the land use efficiency enhancement measures and project the land requirements of the industry in short, medium and long terms. The Study will take about 18 months to complete.

C. Further Studies on Sustainable Waste Management

5.22 Proposals in the Action Blueprint and the Food Waste Plan have been progressively implemented to achieve the goal of reducing the MSW disposal rate. The Government has commenced a study to identify additional strategic and regional waste facilities for bulk transfer and treatment of solid waste to meet Hong Kong's long term needs. Various technologies, such as co-location and co-treatment technology, waste treatment and bulk waste transfer technology choices will be studied with reference to local and overseas experiences and best practices to facilitate the identification of additional waste facilities.

5.23 A vibrant and sustainable recycling industry is vital for reducing burden on landfills. Other than the establishment of Steering Committee to Promote the Sustainable Development of Recycling Industry in 2013, EPD is reviewing the land requirements for supporting the recycling industry in short, medium and long term, including exploring different options in accommodating recycling operations in a more land efficient manner.

6 Energy Supply

A. Energy Supply in Hong Kong

6.1 Hong Kong relies very much on imported conventional fuel energy as there is no indigenous energy resources such as coal, oil and natural gas. In 2013, the largest fuel type was electricity[ix] which accounted for 54% of total energy consumption, followed by oil & coal products[x] (29%), and then town gas and liquefied petroleum gas[xi] (LPG)(17%). The commercial sector consumed 42% of total energy consumption, followed by transport (32%), residential (21%) and then industrial (5%)[xii].

Electricity Supply

6.2 Electricity in Hong Kong has been provided by two privately owned power companies, namely the CLP Power Hong Kong Limited (CLP Power) and Castle Peak Power Company Limited (CAPCO) (collectively as CLP) and The Hongkong Electric Company, Limited (HEC). The total installed capacity of the two power companies is 12,645 megawatts (MW), with CLP owning 8,888 MW and HEC owning 3,757 MW.

6.3 To meet the electricity demand, the power companies import fuel, such as coal and natural gas, for local electricity generation from their power stations[xiii] or import electricity from the Mainland. In 2015, coal-fired generation contributed to around 48% of the fuel mix on sent-out basis, followed by 27% natural gas and 25% nuclear power imported from the Daya Bay Nuclear Power Station[xiv].

Figure 6.1 Lamma Power Station
Source: Environmental Protection Department

[ix] "Electricity" includes the electricity generated from coal, natural gas, wind and solar power.
[x] "Oil & Coal Products" include gasoline, diesel, kerosene, aviation fuel, charcoal, anthracite, coking coal, semi-coking coal and bio-diesel.
[xi] "Town Gas and Liquefied Petroleum Gas" include town gas, liquefied petroleum gas and bio-gas
[xii] Hong Kong Energy End-use Data 2016, EMSD

[xiii] Hong Kong has four power stations, namely Lamma Power Station, Black Point Power Station, Castle Peak Power Station and Penny's Bay Power station
[xiv] LC Paper No. CB(4)1034/14-15(03)

Figure 6.2 Castle Peak Power Station
Source: Environmental Protection Department

6.4 It is anticipated that the increase in electricity demand will remain moderate. According to the forecasts of the power companies, electricity consumption is expected to grow at about 1% - 2% annually on average in the coming decade. The growth in electricity consumption will be attributable to population growth, New Development Areas and new infrastructures to be built.

6.5 Despite the forecast of moderate growth in electricity demand, the Government has been actively promoting demand-side management of electricity consumption over the years through various policy initiatives and measures to reduce emissions and combat climate change. The target of reducing Hong Kong's energy intensity[xv] by 40% by 2025 was announced in the "Energy Saving Plan For Hong Kong's Built Environment 2015~2025+" published in May 2015.

6.6 The Government will step up the multi-pronged approach in promoting energy efficiency by providing incentives, leading by example and raising community awareness through publicity and public education.

Gas

6.7 Town gas and liquefied petroleum gas (LPG) are the major types of fuel gas used in Hong Kong for domestic, commercial and industrial purposes, while natural gas is used solely for electricity generation and production of town gas.

6.8 Town gas is manufactured and distributed by Hong Kong China Gas Company Limited (HKCG). The two town gas production plants in Hong Kong are located at Tai Po and Ma Tau Kok. By the end of 2014, the transmission pipeline of town gas had increased to 320 km while distribution network reached 3,225 km. The principal uses of town gas are for cooking and water heating for domestic customers and catering and heat processing for commercial and industrial customers. Since 2002, the consumption of town gas has increased at an

[xv] Energy intensity of an economy is a measure of the amount of energy it takes to produce a dollar's worth of economic output; or conversely, the amount of economic output that can be generated by one standardised unit of energy.

average rate of 1.2% per annum. With increasing population, there is a need to develop new town gas production facilities.

Figure 6.3 Tai Po Gas Production Plant
Source: Environment Bureau

6.9 LPG is supplied by seven Registered Gas Supply Companies in Hong Kong. The registered companies import the LPG via sea or land and store the LPG at five terminals in Tsing Yi and one terminal[xvi] in Tuen Mun. Cylinder LPG is still used by a small number of households for domestic purposes such as cooking and water heating.

Figure 6.4 LPG/Oil Terminals in Tsing Yi South

6.10 The Government has been encouraging the use of LPG to replace diesel in commercial vehicles, in order to reduce emission and improve air quality at street level. Nowadays, LPG is used by nearly all taxis and more than half of public light buses in Hong Kong, although “oil and coal products” remains as the main type of fuel used in the transport sector, constituting 80% of the total consumption. Incentive schemes and regulatory actions have been progressively implemented by the Government to phase out diesel commercial vehicles including goods vehicles, light buses and non-franchised buses.

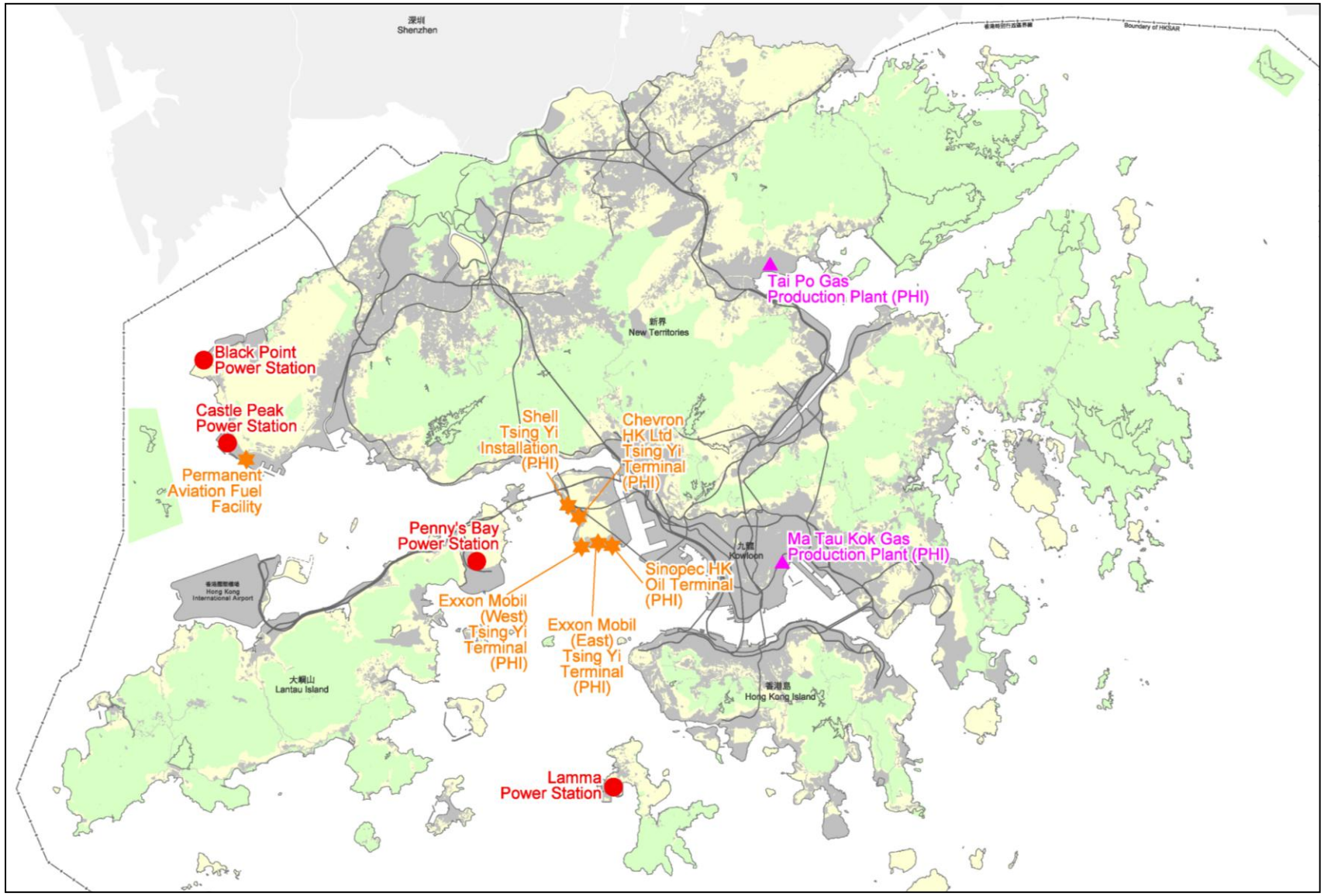
[xvi] The terminal in Tuen Mun is the Permanent Aviation Fuel Facility which stores aviation fuel for providing reliable fuel supply for flights taking-off and landing at Hong Kong’s airport.

6.11 The two town gas production plants in Tai Po and Ma Tau Kok, and the five LPG/oil terminals in Tsing Yi are regarded as potentially hazardous installations (PHIs) which store hazardous materials, such as town gas, naphtha, LPG and petrol, in quantities equal to or less than a specified threshold quantity. These PHIs constrain the development potential of the surrounding areas.

Liquefied Natural Gas - Floating Terminal

6.12 To secure adequate supply of natural gas, the two power companies, CLP and HEC, are jointly exploring the feasibility of building an offshore LNG terminal in Hong Kong. CLP is now conducting an Environmental Impact Assessment Study for the proposed project of building an offshore LNG terminal in waters to the east of the Soko Islands. The operation of this floating LNG terminal is based on the floating storage regasification technology [4].

Figure 6.5 Locations of Power Stations, Town Gas Production Plants and LPG/Oil Terminals



B. SGR Initiatives in Energy Supply

Exploring Renewable Energy

6.13 The physical environment of Hong Kong has imposed a lot of constraints on the wide application of renewable energy resources such as heat and light from the sun, wind, running water, etc. Not only is it costly but its room for development is also limited.

6.14 Nevertheless, the Government is open to the suggestion of further promoting renewable energy. The Government endeavours to increase the use of renewable energy through green procurement for government projects. Government departments are required to consider adopting renewable energy technologies in new government buildings and retrofitting existing buildings.

6.15 For instance, in the high-rise context of Hong Kong, installation of photovoltaic (PV) on buildings and public facilities to generate electricity from sunlight is considered suitable. Currently there are many PV installations throughout Hong Kong, such as Zero Carbon Building, Science Park, Tamar Government Offices, Kai Tak Cruise Terminal, etc.

Building-integrated PV panels on Trade and Industry Tower in Kai Tak

Zero Carbon Building generates sufficient electricity for its own needs from PV panels and bio-fuel made of waste cooking oil

Figure 6.6 Building-integrated PV installations
Source: Energizing Kowloon East Office

6.16 The power companies are also making effort to incorporate renewable energy in their fuel mix. CLP has developed the first commercial-scale standalone renewable energy generation and storage system on Town Island, located off Sai Kung. This project provides electricity to a non-profit drug rehabilitation centre on the island by installation of solar panels, wind turbines and batteries. HEC has built the first commercial-scale wind turbine in Tai Ling of Lamma Island to support the development and application of renewable energy in Hong Kong. HEC has also built the Hong Kong's largest commercial-scale solar power panel system with a generating capacity of 1 MW at the Lamma Power Station.

6.17 CLP is now exploring the feasibility of developing an offshore wind farm up to 200MW in the south-eastern waters of Hong Kong, approximately 9km and 5km east of the Clearwater Bay Peninsula and East Ninepin Island, respectively. The wind farm includes up to 67 wind turbines, an offshore transformer platform, sub-sea collection and transmission cables and research mast. HEC is also exploring the feasibility of building an offshore wind farm in Hong Kong near Lamma Island. The proposed wind farm will be located at a 600-hectare site about 3.5km southwest of Lamma Island featuring up to 33 wind turbines, each being 3 to 3.6MW with total generating capacity of around 100MW.

6.18 Waste-to-energy initiative is also being taken forward by the Government in sustainable power generation in Hong Kong. The Government has been building several new waste treatment infrastructures with waste-to-energy facilities.

6.19 These waste-to-energy facilities is an integrated solution to tackle waste problem and create alternative energy sources in Hong Kong at the same time and same location. It is estimated that the share of renewable energy from waste will make up about 1% of total electricity demand by the early 2020s.

Figure 6.7 Table of waste-to-energy facilities and their electricity generation

Proposed waste treatment facilities	Daily Treatment capacity (tonnes)	Annual Surplus Electricity (kWh)	No. of households can be powered
Sludge treatment facility	2,000	18 million	4,000
Integrated waste management facility	3,000	480 million	100,000
Organic waste treatment facility (Phase 1 and 2)	500	28 million	6,000

C. Smart Energy Use

Encouraging Wider Use of Electric Vehicle

6.20 The Government is promoting the use of electric vehicles (EVs), with a long term target of 30% of private cars being EVs or hybrid[xvii] by 2020, in order to reduce greenhouse gas emissions. The major roadside air pollution source is tailpipe emissions from cars, especially from vehicles powered by diesel. Hence, by achieving the target of wider use of EVs or hybrid vehicles, the roadside air quality can be improved.

6.21 There are over 1,300 public chargers provided by the Government to serve about 5,000 private electric vehicles across the territory. In the near term, the Government has been upgrading more public chargers to medium chargers[xviii], and in collaboration with the private sector, to provide technical support and information in installing charging facilities, so as to encourage wider use of EV.

6.22 Apart from working with the private sector to expand charging infrastructure, it is proposed to specify that new Government buildings should have not less than 30% of the parking spaces with EV charging facilities. For existing Government buildings, EV charging facilities should be installed whenever practicable, particularly for carparks that are open for visitors.

Figure 6.8 EV charging point at government car park
Source: Information Services Department

6.23 To achieve the long term target, EV standard charging facilities should be provided in at least 30% of car parking spaces for private car in new developments[xix]. Concession on gross floor area is given to private developers, so as to encourage them to incorporate "EV-charging-enabling" facilities (i.e. charging infrastructure, including sufficient power supply, cables and ducts) in new buildings, to facilitate future installation of chargers.

[xvii] Hybrid vehicle is a mixture between traditional combustion engine powered vehicle and electric car.

[xviii] About 900 standard chargers, over 200 medium chargers, 15 CHAdeMO quick chargers and 145 quick chargers applicable to other charging standards

[xix] New developments include residential developments, commercial facilities, industrial developments and business developments.

Promoting Green Buildings

6.24 Improving building energy efficiency is crucial to achieving energy intensity reduction by 40% by 2025, because buildings consume 90% of Hong Kong's electricity usage. The Government has been expediting the adoption of green building practices through wider promotion of BEAM Plus and Carbon Audit, promulgating guidelines such as Sustainable Building Guidelines, and applying green technologies in government projects.

6.25 To promote green buildings, the Government takes the lead that all new major government buildings with considerable size are aimed to provide at least 20% greenery coverage at the sites and obtain at least BEAM Plus Gold rating, with incorporation of other passive and active energy efficiency features where appropriate and installation of energy consumption monitoring systems. Retro-commissioning and retrofitting of existing buildings can identify operational improvement that can save energy, such as replacing less energy efficient appliances with more efficient ones (e.g. chillers, elevators, lighting etc.) and installing meters to measure energy consumption. These opportunities in new and retrofit buildings can enhance energy efficient and achieve energy saving and green building transformation in Hong Kong.

District Cooling System

6.26 A district cooling system (DCS) is an energy-efficient air-conditioning system as it consumes 35% and 20% less electricity as compared with traditional air-cooled air-conditioning systems and individual water-cooled air-conditioning systems using cooling towers respectively. The Government is constructing the first-of-its-kind DCS at the Kai Tak Development which will serve the non-domestic buildings in the area. Upon the full completion of the DCS project, the maximum annual saving in electricity is estimated to be 85 million kilowatt-hour. The Government will consider the provision of DCS in New Development Areas and Redevelopment Areas as appropriate to support low-carbon development.

Smart Grid

6.27 "Smart Grid" refers to the integration of information and communication technologies (ICT) into the electrical grid by using sophisticated technologies to achieve energy saving. CLP has established Smart Grid Experience Centre to educate and demonstrate the latest smart grid-specific technologies, such as Smart Meters. The smart grid can support renewable generation and utilisation, strengthen power grid resilience, and engage customers in energy saving and demand side management [5].

7 Proposed Key Strategic Directions and Actions for Infrastructure Provision

7.1 Infrastructural support is indispensible to the operation of a city. Timely provision of infrastructure is important to support population increase and economic growth. Sometimes the land intake for supporting infrastructure is extensive and it is difficult to identify land resources to meet such huge demand. Moreover, the long term land demand from infrastructure is uncertain. Land support measures for the recycling industry and construction industry will also further increase the land demand. Relevant Government bureaux should formulate works and environmental policies so as to co-ordinate the provision of supporting infrastructure.

7.2 Many essential environmental infrastructures such as refuse transfer stations and sewage treatment works are locally unwelcome land uses, and requiring extensive land intake. It is important to devise an innovative strategy to accommodate such indispensable uses and minimize their environmental nuisance and their land-take.

7.3 With a view to improving the quality of living, managing resources prudently and upholding environmental stewardship, we should develop an integrated smart, green and resilient infrastructure system encompassing a range of measures in terms of energy use (e.g. renewable energy, district cooling systems, energy saving infrastructure); waste (e.g. waste-to-energy initiatives in sewage treatment and solid waste treatment process, waste minimisation); water (e.g. total water management); drainage (e.g. drainage rehabilitation and sustainable drainage); buildings (e.g. green buildings and green neighbourhoods). To cope with natural disasters or hazards such as flooding and extreme weather arising from climate change, initiatives to enhance urban resilience to enable quick recovery and to minimize loss should be promoted.

7.4 We should strive for sustainability in our city by formulating strategic directions to carefully guide new developments and improve existing facilities. In terms of supporting infrastructure provision, by reviewing the current good practices carried out by government departments and service operators, four key strategic directions and actions are proposed in the following table. These proposed directions and actions would entail a series of follow-up thematic studies and project-based technical studies for progressive implementation.

7.5 Apart from the infrastructures discussed in the paper, Hong Kong has also become one of the best cities in provision of technological infrastructure. Details of ICT infrastructure are elaborated in another topical paper entitled “A Smart, Green and Resilient City Strategy”.

Proposed Key Strategic Directions and Actions for Infrastructure Provision

Four Proposed Key Strategic Directions and Actions
1. Managing and retro-fitting aging infrastructure
ACTION As the infrastructure continues to age, cost-efficient maintenance and management and retro-fitting are required to increase its lifespan. Well-maintained infrastructure could enhance resilience to adverse circumstances such as natural hazards and accidents.
2. Enhancing the capacity of major infrastructures
ACTIONS To upgrade, expand or construct new facilities for water supply, sewage treatment, flood prevention, and waste management in a timely manner to meet demands and support population and economic growth.
3. Minimising the land demand for supporting infrastructure
ACTIONS Infrastructure should be strategically planned and should be accommodated in a holistic and more land-efficient manner. To co-locate different types of waste treatment and transfer facilities, minimize discharges from infrastructure operation through recycling and reuse measures, better use of caverns and underground space to accommodate essential environmental infrastructures such as refuse transfer stations and sewage treatment works.
4. Pursuing integrated smart, green and resilient infrastructure system
ACTIONS To promote green building design, district cooling system, EV charging infrastructure, waste-to-energy technologies, effluent reuse, blue-green infrastructure concept in drainage system and whole life carbon assessment etc.

ENDNOTES

[1] Water Supplies Department (2008), *Total Water Management in Hong Kong, Towards Sustainable Use of Water Resources*.

[2] Drainage Services Department (2016), Drainage Services Department in Brief 2015-16

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[4] CLP Power Hong Kong Limited (2016), *Media Release on CLP Power Proposes an Offshore LNG Terminal to Ensure Gas Supply Security*.

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