SHAPING SUSTAINABLE URBAN FEATURES

POLICY SUGGESTIONS FOR HONG KONG

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ENERGY

This section covers the electricity and gas sectors in Hong Kong, examining the status and potential of solar, wind and biogas, as well as the feasibility of international energy connections. The environmental implications of the new Liquid Natural Gas Floating Storage and Regasification Unit are also considered.

Renewables

In *Hong Kong's Climate Action Plan 2030+* the Environment Bureau estimates Hong Kong to have 3-4% realisable renewable electricity generation by 2030. This is an unjustifiably cautious aspiration and moreover it is not explicitly a target, meaning that it is non-binding with regards to government action and review.

The technically feasible renewable energy resources of Hong Kong exceed this figure by a factor of ten; even accounting for the realities of economic, political and miscellaneous other considerations it is possible for Hong Kong to achieve a much higher proportion of renewable energy by 2030. The most economically and technically feasible renewable energy sources are analysed below.

Solar

Academic estimates for the potential of rooftop photovoltaic solar generation range between 6-14% of electricity demand, not including the installation of floating PV or the use of quarry faces and other land. The government itself estimates the total PV potential of Hong Kong as being 5944 GWh/year or about 14% of the total electricity demand of 2017.

Singapore has set the precedent in South-East Asia for rapid solar expansion. This has been across two key areas: the rooftops of government-owned housing and floating PV. Singapore's Housing Development Board has currently committed 230 MW of solar capacity over 4,550 housing blocks, accounting for 66 percent of Singapore's target of 350 MW by 2020 (Housing & Development Board, 2018c). As HDB targets installing solar in 5,500 housing blocks by 2020 (Ibid.), capacity is likely to rise further. Meanwhile the Hong Kong Housing Authority manages 780,000 flats (Hong Kong Housing Authority, 2018). However, there have been no plans to install solar on these rooftops; neither has the government changed restrictive regulations, such as one that prevents construction on more than 50 percent of a public housing block's rooftop due to fire risk (Mah et al., 2018).

Floating PV has immense potential; the World Bank estimated in 2018 that the global potential is 400 GW (**about 80 times Hong Kong's total electricity demand!**) Singapore is set to have installed over 60 MW of capacity by 2020. On the other hand, although Hong Kong's government has begun to explore floating PV - installing two pilot systems of 100 kW each in Shek Pik and Plover Cove Reservoirs in 2017 (Water Supplies Department, 2017) - it has failed to issue tenders for the installation of facilities, whereas Singapore, which installed test facilities in the same time period, has committed to constructing large-scale projects. Taken together, Singapore's current solar projects should total over 1 GW, demonstrating the results which can be achieved when positive action is taken.

New technologies will facilitate the expansion of solar energy generation. Building-integrated solar panels, for example translucent or vertically integrated PV, are likely to become commercially feasible in the near future, further increasing Hong Kong's capacity for generating solar electricity.


(Hong Kong City Portal, 2019)

In conclusion, Hong Kong has ample unexploited potential for solar power. The *Climate Action Plan 2030+* justifies the government's reticence to commit resources to solar energy by noting the cheaper price of generating electricity from fossil fuels, but with the increasing urgency of the climate disaster (and the falling costs of solar) this is a weak and near-sighted position to take.

Wind

Hong Kong's Electrical and Mechanical Services Department estimated the suitable offshore wind energy potential as 8058 GWh/year (18% of 2017's total demand.) The rooftop wind generation potential of Hong Kong is estimated at 3000 GWh/year (7%.) Land-based wind-generation is estimated at 2630 GWh/year (6%.) With a combined potential of 31% of Hong Kong's 2017 total electricity demand, wind power represents a significant opportunity for emissions reduction - it is therefore all the more concerning that the government should demonstrate so little initiative and ambition in this area.

Biogas

Hong Kong sends approximately 9000 tonnes of municipal solid waste daily to landfill sites, of which 3600 tonnes is food waste, making up the largest component. The recycling rate of biodegradable municipal waste (BMW) is shockingly low at 0.6%, compared to South Korea's 95%, Taiwan's 31%, and Japan's 25%. Sending biodegradable waste to landfill not only unnecessarily fills limited (and ecologically harmful) landfill sites, but also emits methane, a highly potent greenhouse gas, directly into the atmosphere.

To contribute to a circular economy, it is possible to valorise BMW in four predominant destinations: biomass electricity generation, conversion to city gas (for direct domestic or industrial use,) vehicle fuel, and plant or animal feed.

China has considerable experience in the area of biogas; by the end of 2014 there were 35,533,000 rural households in China using biogas, 30% of suitable households. The experience of China, as well as Sweden and other European countries, could be beneficial to incorporating the biogas cycle into Hong Kong civic governance.

(chinadailyhk, 2019)

VALORISING BMW: CREATING A CIRCULAR ECONOMY

ELECTRICITY PRODUCTION

Initial projects already exist in Hong Kong, and taken along with facilities currently planned for construction, could provide up to 1.5% of the total electricity demand by 2030.

CITY GAS

This practice has already been adopted in limited circumstances in Hong Kong, for example at the Shuen Wen Landfill site (https://www.epd.gov.hk/epd/mobile/english/environmentinhk/waste/prob_solutions/msw_lgu.html)

This could be of great long-term strategic importance to decarbonising Hong Kong's energy usage, as otherwise (without vast electrification of cooking and heating) the 8% of energy consumption represented by gas would be impossible to render carbon neutral

BIOGAS FUEL FOR VEHICLES

It has multiple benefits, in that it reduces the use of imported fossil fuel supplies while also burning more efficiently than petrol and diesel, with lower emissions of nitrogen oxides and harmful particulates

It is estimated that biogas from food waste could be used to fuel approximately 10,000 private cars (about 2.2% of the fleet,) reducing CO2 by about 80,000 tonnes/year (about 1.1% of total 2011 transport emissions)

This has been widely practised in countries such as Sweden, France and Norway, Sweden being the world leader in this sector with over 30 upgrading plants (Patterson et al., 2011)

In Linkoping in Sweden, food waste provides enough biogas fuel for approximately 6% of registered vehicles, including city buses and taxis (Cleantech Ostergotland, 2014).

Feasibility of international energy sharing

Hong Kong is currently connected to the South China Power Grid and imports electricity from the Daya Bay nuclear power plant, accounting for about ¼ of total electricity usage. Increasing the amount of nuclear or renewable energy imported from China could significantly reduce the carbon intensity of Hong Kong's electricity supply. As China has considerable renewable energy resources and will likely maintain a higher percentage of renewable electricity than Hong Kong for the foreseeable future, increased electric integration with China would reduce Hong Kong's greenhouse gas emissions.

There is currently a long-distance sub-oceanic cable in planning between the UK and Iceland, know as the UK-Iceland Atlantic Super Connection. It is intended to be up-and-running by the mid 2020s and would be the longest of its kind, making greater use of Iceland's abundance of renewable geothermal energy and returning economic benefits to both countries. The Atlantic Super Connection's length would be 1400 Km - a cable lain from Hong Kong of shorter than this length could reach Vietnam or the Philippines, and the distance to Taiwan from Hong Kong is only about 630 Km.

A potential environmental benefit of the planned Liquid Natural Gas Floating Storage and Regasification Unit (see below) would be if it were used to purchase biogas on an international market; using the same infrastructure of pipelines and power stations, but purchasing carbon neutral gas from countries with a comparative economic advantage in its production, there is the potential for an internationally integrated system of low carbon energy.

In conclusion, there are two realities that must be come to terms with: Hong Kong does not have sufficient indigenous low carbon energy resources to meet 100% of its requirements; Hong Kong must become carbon-neutral in the second half of the century to comply with the Paris agreement. It follows that international integration is a necessary part of a long-term decarbonisation strategy. This should not distract from the short-term necessity of exploiting the considerable resources of solar and wind, but the three abovementioned international options should simultaneously be explored.

LNG Floating Storage and Regasification Unit

A Liquid Natural Gas Floating Storage and Regasification Unit (LNG FSRU) is planned to begin operation in 2020 - an Environmental Impact Assessment (EIA) commissioned by the Environmental Protection Department and CLP Power (the acting proponent) has found the project to imply no 'unacceptable' environmental impacts. The LNG FSRU industry has a very good safety record, with no prior major incidents.

The environmental impacts of the station can be categorised as follows:

Construction phase

The dredging and laying of the pipeline will cause disruption and disturbance to the seabed.

The EIA study concludes no 'unacceptable' impact to marine life on the seabed, due to the low ecological value of the area disturbed and the brief nature of the disturbance.

Operation phase

The facility will discharge cooled seawater (used to reheat the LNG in 'regasification') containing 'antifoulants.'

'No unacceptable ecological impacts are expected due to a small drop in temperature.'

‘The EIA report concludes that there will be no adverse waste management implication arising from the Project.’ No ‘unacceptable’ impacts to marine mammals are expected during either the construction or operation phase of the FSRU. The EIA also recommends the project to form a fund contributing to the marine environment and the local community

Although the immediate ecological impacts of constructing and operating the FSRU are apparently negligible, there still remains a crucial longer term strategic environmental problem with the implementation of this project. Hong Kong is seeking to decrease the carbon intensity of its energy supply by dramatically increasing the use of gas power. Gas has a lower carbon intensity than coal but it is still a fossil fuel which relies on the emission of CO2 for energy; quick reductions in carbon dioxide will be realised as a transition is made from coal to gas, but having a majority of electricity generated by burning gas will present a barrier to further progress.

The international goals laid out in the 2015 Paris Agreement necessitate the world to become carbon neutral by approximately 2050. To comply with the Paris Agreement, countries must plan a feasible pathway to carbon neutrality through their Nationally Determined Commitments. **Even though gas reduces carbon emissions (and air pollution) in the short-run, committing to fossil-fuel infrastructure at this stage while clearly neglecting the renewable sector does not represent a feasible pathway to carbon neutrality unless the imported gas will come largely from renewable sources i.e. biogas.** Furthermore, building this station will reduce gas prices in Hong Kong, making it harder for renewable energy sources to compete in the market

Conclusion

In conclusion, the immediate ecological impacts of the FSRU are expected not to be ‘unacceptable’ (according to a report chartered by the proponents.) However, continuation of an LNG programme could be a retrograde step toward the long-term goal of carbon neutrality.

TRANSPORT

CURRENT ELECTRIC VEHICLE (EV) SITUATION IN HONG KONG AND EXISTING POLICIES

As of January 2019, Hong Kong had 11,548 electric vehicles (EV) on the road[1]. This constitutes to just 1.5% of the city's total vehicle population. There is still a lack of government led incentives and supportive infrastructure at the moment. The Environmental Protection Department has taken the following measures to promote the use of EV's in HK:

· A tax break for privately-owned electric vehicles was recently capped by the government to HKD 97,500 in 2017. The tax break was seen as one of the instrumental reasons for EV fleet growth in HK but the cap on the tax break has slowed the trend. Private car owners that arrange to switch and scrap their existing fuel-powered car for an electric vehicle receive a higher tax concession of HKD 250,000.

· Enterprises who procure EV's receive a 100% profits tax deduction on capital expenditure on EV's in the first year of procurement.

· A HKD 300 million "Pilot Green Transport Fund" was created to fund the testing implementation of eco-friendly technology in the public transport and goods vehicles sector. This scheme was criticised for not being expanded to the private sector.

· The government also spent HKD 180 million on 36 single-deck electric buses. 30 of which are already in service.

Challenges facing electric bus deployment in Hong Kong

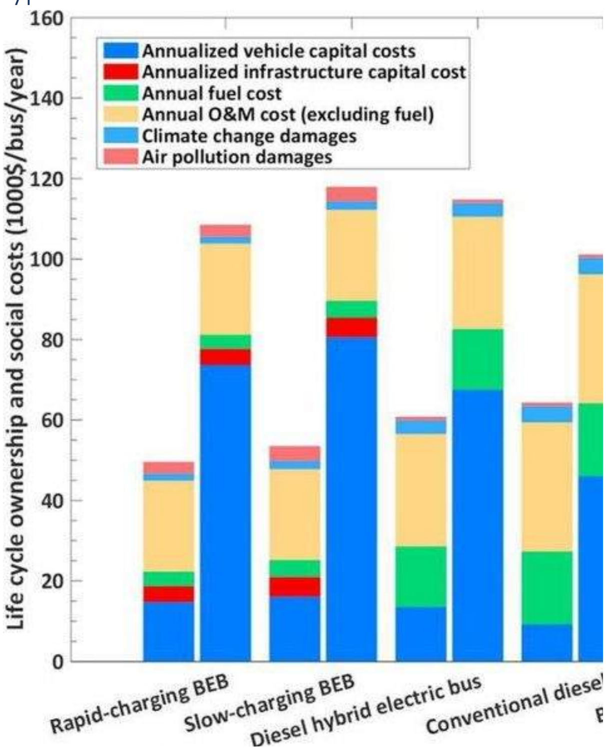
Regarding the existing trial of single-decker electric buses in HK, there have been problems with brakes, doors and bells near the start of the trial. The government ordered 8 supercapacitor buses which can be charged in 20 minutes and have a range of 20-30 km which are suited for short routes and 26 battery electric buses with a range of around 190 km. Additionally, bus operators are required to provide charging facilities in bus stops/depots. The trial also found that due to a lot of bus routes in Hong Kong consist of uphill sections, these routes increased energy consumption by around 16%. High demand for air conditioning in hot seasons also draws power from batteries and reduces the range. Under the most intense conditions, the range of the buses dropped to 150 km whereas the required range was between 200 to 300 km. The main concerns in whether the batteries of the buses can cope with the intensity of rush hour commutes and how space / power capacity of charging facilities can cope with demand. As 95% of buses in HK are double deckers, the relatively primitive international electric double decker bus market also limits the implementation of electric buses.

Shenzhen is a world leader in public transport electrification with 99% of it's taxis and the largest fleet of electric buses in the world at over 16000. Given Shenzhen's similar level of urbanization, climate and population to Hong Kong, the fact that they have successfully electrified their public transport shows that this is possible to accomplish in HK. Following the implementation of electric buses, Shenzhen Bus Group has estimated it conserved 160,000 of coal and reduced CO_2 emissions by 440,000 tons annually.

Electric buses are expensive (approx. 1.8 million yuan per bus). More than half the cost was subsidized, split between the central and local governments. There are also operational subsidies of 500,000 yuan if buses are run for over 60,000 km. Shenzhen Bus Company had 180 depots constructed, and some can accommodate around 20 buses at a time. However, charging points must still be rented from the government and the private sector. The buses are charged overnight for 2 hours and have 200 km range per charge.[3] Proper coordination of time of charging with operation schedules and city-wide electricity demand, and opening charging ports to private cars helps optimize electricity costs.

A study conducted by the World Bank found that although the upfront cost of electric buses is a lot higher than conventional diesel powered buses, the life cycle costs are similar with the total 8-year procurement, energy and maintenance costs being $375,457 and $342,855 for a diesel bus as the buses are cheaper to maintain. In Shenzhen, bus manufacturers provide a lifetime warranty for vehicles and batteries which incentivizes bus quality and lowers the cost for bus operators. Some operators also lease vehicles from manufacturers for a lower upfront investment.

Below is a diagram from a study by Carnegie Mellon University which compares life cycle costs for different bus types.



Shenzhen's 22,000 taxis have all been required to switch to electric by the end of 2018. The city has built 40,000 charging piles to facilitate charging but competition for available charging space in busy areas of the city remains a problem. This will be an even larger problem in Hong Kong's urban areas and purpose-built charging car parks will need to be built to accommodate this.

London - A double decker solution

The world's first electric double decker electric bus fleet was unveiled in London in 2018 and is scheduled to begin service in 2019. The fleet consists of 68 fully electric double-deckers manufactured by a joint partnership with Chinese manufacturer BYD/Alexander Dennis and British manufacturer Optare. The government aims to have 240 electric buses running by 2019 with all new double-deckers being electric. These buses have a range of around 190 miles (300km), can be charged in 4 hours and have a 12-year battery warranty. **They can carry 54 seating and 27 standing which is 30% less than a typical high capacity double decker in Hong Kong that can carry around 130 passengers.** Therefore with existing models, bus operators would need to purchase more electric buses to have carrying capacity on par with their diesel fleets.

Summary of China's EV policies and Recommendations for Hong Kong

China is committing to end the sale of fossil fuel powered vehicles by 2030. The government drives EV adoption through a range of financial incentives and market intervention.

Financial incentives

EV owners are exempt from paying purchase taxes. This policy will be in effect until 2020.

There is a consumer subsidy program which gave - up to RMB 55,000 ($8,736) for each BEV (Battery electric vehicle) and up to RMB 30,000 ($4,765) for each PHEV (Plug in hybrid). It will decrease by 20% in 2017 and 2018 based on 2016's standard, and by 40% in 2019 and 2020 based on 2016's standard. **China plans to phase out the subsidy entirely by 2020.**

As mentioned previously, the decrease in subsidies has hurt EV adoption in Hong Kong. **Instead, we recommend keeping the previous levels of subsidies in order to further incentivize switching to EV's until they make up a sizeable portion of vehicle population, and if they ever reduce the subsidies, they should come up with a phase-out scheme well in advance of any subsidy cuts.**

Central and local governments tend to split subsidy share in half to prevent fraud. There have been cases of subsidy cheating in the past. Subsidy cheating should be less of a problem in Hong Kong as firms are more transparent and easier to monitor.

Energy credit policy

Manufactures are assessed on their EV production, vehicle quality and fuel consumption and earn credits on this performance. If a target on these credits is not met, companies are fined or must buy credits from other manufacturers. The target is around 4-5% of total vehicle sales in 2020 must be EVs. This quota should increase over time as China continues to drive EV transition.

EV charging stations

Local governments on the mainland receive subsidies to build charging terminals depending with the number of EV's on the road. In HK, this could be adapted to have car owners that aren't using EV's having to pay a charging tax that is put into building these charging ports. Residential developers can also be given subsidies to install these facilities.

Regarding public street-side charging stations, the government should aim to work with electricity companies and building owners and to incentivize the development of charging infrastructure - especially for existing buildings.

Studies will need to be conducted on how an increasing number of electric vehicles being charged will affect the power grid. A study conducted by the UK national grid predicts that annual and peak electricity consumption may only increase by single digit percentages (although peak usage will be higher).[9]

Given Hong Kong's lack of space, the local transport authority have been looking into building underground car parks. If planning of these car parks in urban areas of Hong Kong can be achieved and charging facilities installed, this will greatly improve the convenience of electric vehicles - allowing vehicles to be charged while people are at work.

Research and Development

In 2006, the government appropriated RMB1.16 billion ($184 million) to support R&D via the National High Tech R&D Program (863 Program) administered by the Ministry of Science and Technology (MOST). According to the latest National Key Research and Development Program of China for the country's 13th Five-Year Plan, 20 EV research projects would receive about RMB 700 million ($111 million).

There has been some interest in turning Hong Kong into a production centre for EVs. This is because a of a rise in the cost of a production licence on the mainland, which now costs between 3 to 4 billion yuan (US$462-616 million). Hong Kong only requires a less expensive World Manufacturers

Identifier license. The local government should strive to attract carmakers to invest in the city through land subsidies and supply side labor, capital and logistical support. Carmakers can still outsource component production to the mainland, but the final assembly of the car must be done in Hong Kong. This plan should also stimulate economic cooperation between Hong Kong and the mainland.

Battery technology

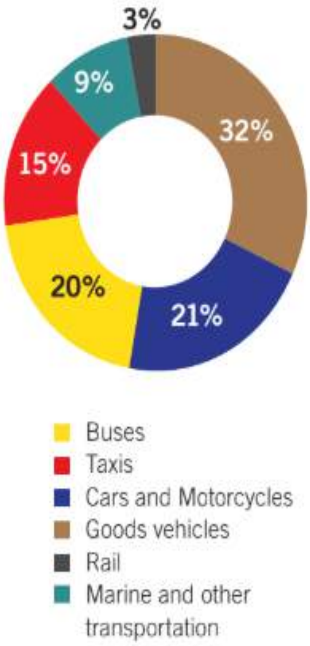
The cost efficiency of batteries has increased massively in the past decade. According to Bloomberg, the price of Lithium-ion batteries are projected to fall to below $100/kWh by 2030. While this is good news for making EV's more affordable, it also stresses the need for more advancements in battery technology due to the rapidly slowing rate of decrease of Li-ion battery price. Also due to the limited supply of raw materials for these batteries, the government must also look into ways of disposing and recycling used batteries. This is an issue that must not be ignored if EV's are to be sustainable in the long term.

The government should be facilitating partnerships with vehicle companies on the mainland and worldwide to spearhead electric commercial vehicle development. Through the aforementioned idea of attracting both foreign and local carmaker investment in the city, partnering with other cities in China or Asia to create an EV bus battery "standard" which all bus manufacturers must comply with should reduce the cost of bulk buying batteries and drive down costs of EV adoption.

As the electric bus trial in Hong Kong shows, existing electric bus models are unable to meet the requirements of Hong Kong public transport demand. A potential solution to the range issue is to adopt buses that have swappable batteries which will increase and since batteries throughout the fleet can be continuously swapped out and charged, there will be a lower peak demand on the power grid. Studies into planning transport systems under this power model have been done and should provide a solution whilst we wait for battery capacity to improve.

Commercial vehicles

Figure 25 Transport sector energy end-uses, 2012



(Source: Hong Kong Energy End-use Data, EMSD)

32% of HK transport energy usage comes from goods and commercial vehicles. For larger fleets that operate from central hubs e.g. links from Hong Kong ports, large freight businesses, electrification of the fleet will be relatively easy to accomplish. Policies used to transform the bus sector are applicable here. However, as a large proportion of freight vehicles are operated by private firms, there must be extra financial incentives in place.

The government should set firm targets for commercial vehicles emissions as soon as possible and provides financial support for operators to switch to EVs - starting with those with operations from a central hub. At the same time, facilitating partnerships with vehicle companies on the mainland and worldwide to spearhead electric commercial vehicle development. Perhaps using a similar strategy with the buses mentioned previously.

Sweden has implemented two ways of electrifying freight called the ERS (electric road system). One method involves overhead lines installed at existing motorways which connect to heavy duty vehicles using pantographs. The second method involves special road lanes with a rail which vehicles connect to with an arm under the vehicle. The second method is accessible to both heavy and medium duty vehicles. The benefits of this technology is that it only requires modifications to existing road infrastructure rather than the construction of new, which is crucial given Hong Kong's lack of space. The main downside being the additional road maintenance required however widespread adoption of technologies like this will drive investment and improvements. Especially if adopted throughout the city and with neighboring cities could reduce vehicle emissions in the Pearl River Economic Zone.

Retrofitting & Hybrid Vehicles

Key messages:

- Diesel vehicles, particularly trucks, buses, and light buses are the main source of street-level pollution in Hong Kong
- The rapid nature of Hong Kong's transportation systems means that the typically long charging times of most electric and hybrid vehicles poses a serious problem the implementation of carbon-

neutral vehicles. Thus, it is important for Hong Kong to be able to both reduce the charging time for electric buses and to schedule charging times for optimum efficiency

- Most charging stations create space constraints due to their size, making it more difficult for buses to vehicles on the go

- Solutions such as the K12A bus launched by Chinese manufacturer BYD, which is 27 metres long, seats 250 passengers and is fully carbon neutral cannot be implemented in Hong Kong due to the nature of the streets and infrastructure of the city(Cvshow, 2019). Hong Kong's roads are too narrow and densely populated to accommodate solutions designed for South-American nations, no matter how successful these solutions are.

Key Challenges

The long charging time for electric buses poses serious problems for bus-schedule arrangement and traffic congestion in Hong Kong. On average, buses are out on the road for 12 hours and 150 miles or more per day (Bullis, 2011). It is clear that without some ability to recharge en-route or a rapid development in battery technology, electric buses cannot be deployed in Hong Kong's transit systems.

Nations have approached these issues in two differing ways. US company Advanced Vehicle Manufacturing (AVM) and Chinese technology company Yinglong have collaborated in making an electric bus that could **fully recharge their 150 mile range in 10 minutes** (SMMT, 2019). After 10,000 charge cycles, the bus keeps 95% of its energy efficiency. The vehicles have a 12 year - 500,000 mile design life and are zero emission vehicles (SMMT, 2019). The buses utilize 'AVM 350 kW CCS 2.0' fast chargers, which are smaller than traditional charging stations (32" x 65" 9or 87") x 71" // -2500 lbs). The combination of the fast charging properties and the small size of the charging stations would allow for fewer charging stops for buses with less inconvenience to general traffic and space constraints along the bus-routes in general.

The drawback for this vehicle is its limited seating range. On average, the large double-decker buses used in Hong Kong can seat 90–130 people depending on the manufacturer and model. In its current model, the AVM bus is a single decker, and thus can seat significantly less, which would make it difficult to implement within Hong Kong's busy transport system. Still, its developing fast-charging stations answer many of Hong Kong's problems regarding space constraints and charging times regarding electric buses in public transport

Rapid charging: another possible solution

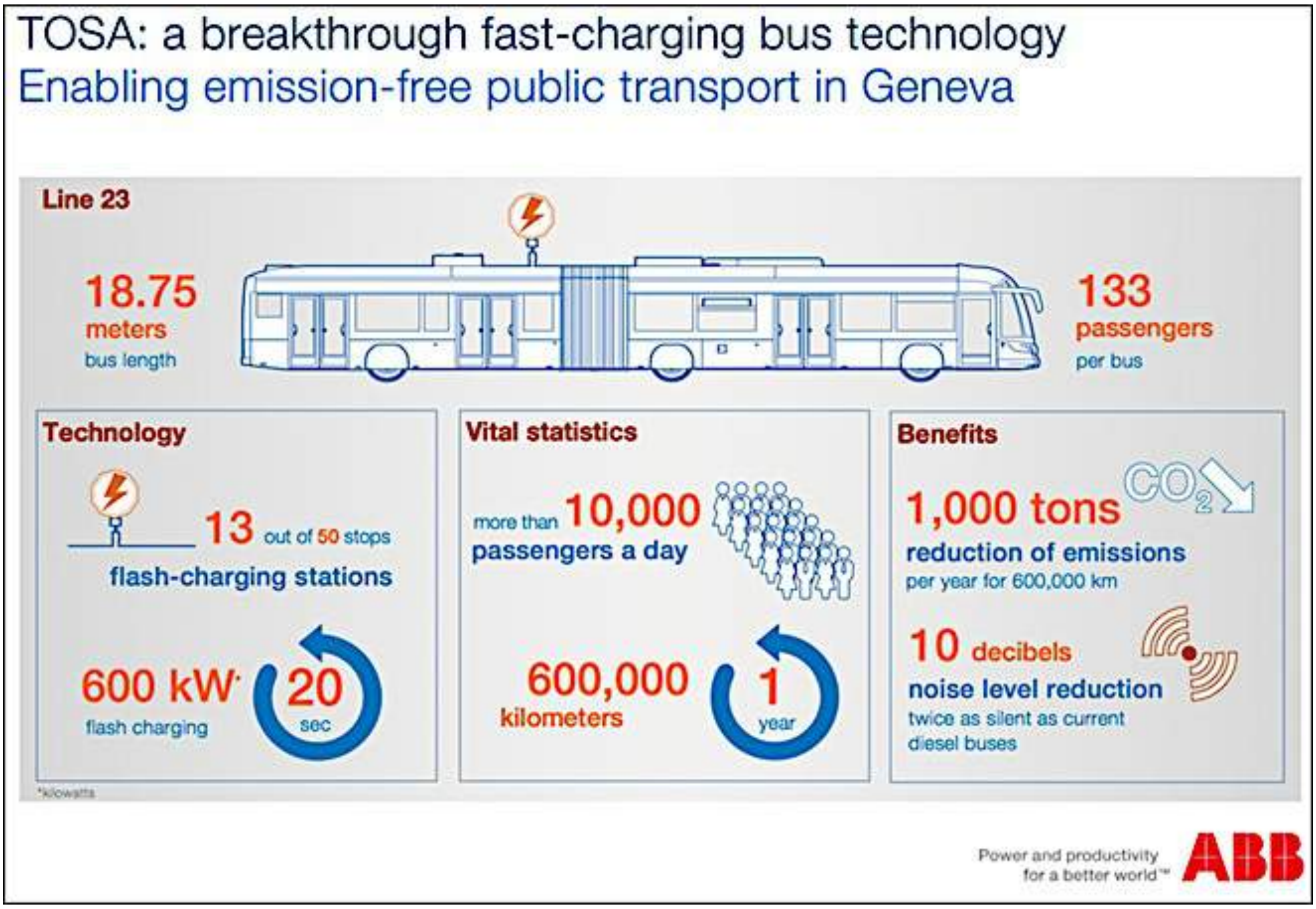
Swiss company ABB developed their 'flash charging' TOSA bus in 2016 as an answer to issues regarding high transportation capacity and energy efficiency for traditional electric buses. The buses have a capacity of 110 persons (a standard double-decker's is 132) and utilize **flash-charging technology.** This means that they partially recharge within the 15-20 seconds they drop off/let on passengers, making sure there are no scheduling delays during the day. This bus would necessitate infrastructural overhaul (as a large number of special stations need to be built), but could also be a long-term solution for the city's public transport.

The buses use two differing types of charging stations.

Flash-charging stations at selected stops provide a short high-power boost at 600 kilowatt (kW) for 15 to 20 seconds.

Terminal feeding stations deliver prolonged charges of 4-5 minutes at 400 kW to fully top-up the on-board batteries. The terminal chargers are an IGBT-based rectifier, which convert the incoming AC supply to a DC one (Warner, 2019).

The Swiss city of Geneva has run a pilot with this technology since May 2013, which was so successful that they commissioned a fully operational route by Spring 2018. The ordered 12 buses for Geneva are predicted save as much as **1,000 tons** of carbon dioxide per year (compared with the existing diesel buses).



Hydrogen Vehicles

London utilises a mix of electric and hybrid buses in order to cut down on emissions whilst still managing a complex transportation schedule. Hybrid buses make up 30 per cent of London's bus fleet (London City Hall, 2019). The buses are quieter, more fuel-efficient and cleaner than standard diesel buses, reducing emissions by between **30-40 per cent.**

For hydrogen buses, if the hydrogen itself is produced from a carbon-neutral source such as London's waste, solar or wind power, we have the potential for carbon-neutral and emission-free energy. An answer to this in the HK context might be manure-produced biogas; China has abundant biomass potential implying the bioenergy should be an important option of non-fossil energy. In this analysis, we present a representative biogas project (the Deqingyuan project, DQY) in Beijing and conduct a cost-benefit analysis for the whole value chain. DQY is the first large-scale biogas project in China that utilizes 100% chicken manure as a feedstock and integrates biogas production with ecological agriculture using advanced technologies.

In the case of public transport, an integrated solution which considers both carbon-neutral transport (such as Hydrogen buses) and Hong Kong's biogenous waste is needed to fully reach carbon-reduction goals.

Freight transport

The IPCC predicts that transport emissions on a business-as-usual basis could reach 12 billion tonnes of CO2e by 2050 (McKinnon, 2016)- that is, transport would generate a 60 percent share of all permissible emissions. In particular, freight transport's share of total transport emissions is expected to rise from 42 percent in 2010 to 60 percent by 2050 (McKinnon, 2016). The International Transport Forum (ITF) expects the rate of increase in total tonne-kilometers between 2010 and 2050 to be three times higher in China and India than in the EU and North America.

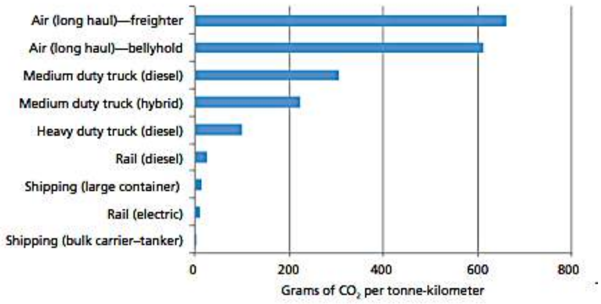


FIGURE 1 Average carbon intensity of freight transport modes. (Source: IPCC, 2014.)

Additionally, road freight vehicles are a central source of global oil demand today: at around 17 million barrels per day (mb/d), oil demand from road freight vehicles accounts for around one-fifth of global oil demand (IEA, 2017).

Reducing carbon emissions from road freight vehicles must include the following:

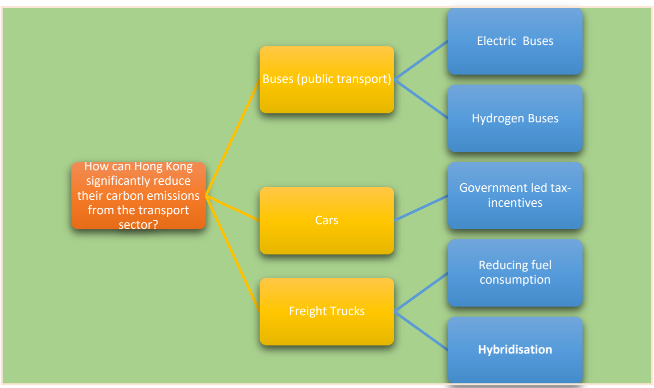
- improving vehicle efficiency
- systemic improvements, i.e. improvements to the way the larger road freight system operates with a focus on reducing the road activity (in ton-kilometres [t-km]) required to deliver the same amount of goods

- the use of alternative fuels, i.e. a switch away from the use of oil-based transport fuels to other fuels, such as natural gas, biofuels, electricity or hydrogen.

Hybridisation for freight transport vehicles

There is considerable potential for hybridisation to deliver fuel savings; however, in most cases, the payback period exceeds three years. Additionally, in terms freight transport, there have been questions regarding the efficiency reliability of electric vehicles. The delivery company DPD recently ran a successful six-month trial starting from Septembe 2018. The 7.5-tonne rigid trucks proved to be '100% reliable'. The model used (Fuso eCanters) produces zero tailpipe emissions and is designed with urban operation in mind, and is currently being used in six cities in Europe, Japan, and the U.S.

Parallel hydraulic hybridisation may be the most cost-effective near-term technology option for municipal utility vehicles, while electric hybridisation tends to be the best option for most other mission profiles. In terms of potential energy savings, it has been found that converting to dual-mode hybrid vehicles could save 8-30% of energy (in terms of near-term technologies and measures that reduce the total cost of ownership over the vehicle or measure lifetime) (IEA, 2017). Parallel hydraulic hybrid are estimated to save 15-25% , and parallel hybrids 6-35%.



Reducing fuel consumption for existing supply chains by limiting speed

The fuel economy benefits that could be gleaned from reducing the speed of freight trucks range from about 7% (US EPA, 2009) up to 27% (Garthwaite, 2011) for a reduction of 10 miles per hour (mph). It has been found that fuel economy of medium- to heavy-duty trucks carrying heavy loads (with a total vehicle weight of greater than 65 000 lbs or about 29.5 t) on highway operations reaches its maximum from about 80 km/hr to 105 km/hr, and that the optimal speed within this range is, in fact, around 95 km/hr (Franzese, Davidson, 2011). **Cooper et al. (2009) estimate that reducing speeds by 1 mph would result in an average 0.7% reduction in fuel consumption**. Most European countries mandate the use of speed governors on trucks, i.e. devices that limit truck speed.

Urban consolidation centres

Various cities, most of which are located in Europe), have effectively reduced local traffic and emissions by setting up urban consolidation centres (UCCs). By grouping shipments from multiple shippers and retailers and consolidating them onto a single truck for delivery to a particular geographic region, vehicle activity and CO_2 emissions within urban centres can be reduced by an estimated 30-80% (Allen et al., 2012). It must be noted that by adding a link to the supply chain, UCCs may increase delivery costs (Cherrett et al., 2012), but that UCCs have been able to improve their fiscal viability by incorporating value-adding activities, such as store preparation and waste packaging collection (IEA, 2017).

Further short-term solutions can include:

- Aerodynamic retrofits
- Low rolling resistance (LRR) tyres
- Lightweighting

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BUILDINGS

BACKGROUND ON HONG KONG

"Saving energy is not only possible but profitable. Energy saving is the most critical means for Hong Kong to continuously reduce carbon emissions where there will also be an air quality benefit."
– 2015 Energy Saving Plan

Why do we need energy efficiency in buildings?

"achieving energy saving in the buildings sector is our primary target for the short and long term"
– HK Climate Action Plan 2030+

Globally, buildings account for 40% of the entire world's energy use. In Hong Kong, buildings account for 90% of the city's electricity usage and are responsible for almost two thirds of the city's emissions. In London that figure is closer to 80%. As such, addressing energy efficiency in buildings will be crucial in reaching Hong Kong's climate targets.

Hong Kong vs London

There are several fundamental differences between Hong Kong and London that affect how policy in London's building sector might be effectively adapted for implementation in Hong Kong:

Climate

Hong Kong has a sub-tropical climate which is much warmer and more humid than London (average annual temperatures range from 16℃ to 29℃ in Hong Kong, compared to 5℃ to 18℃ in London). Hong Kong therefore has a very different energy demand profile to London: most notably, Hong Kong needs cooling whereas London predominantly requires heating.

Population density

Only one fifth of Hong Kong's land mass is used for living on, with the remaining four fifths being hilly terrain. As such, despite having comparable average population densities, Hong Kong has a much more localised population which is up to 8 times more dense than London. Hong Kong has only a fraction of the number of buildings as in London, with much of the population living in high-rise buildings.

Proportion of population renting

Hong Kong has a much higher proportion of its population renting than London (50% vs 25%) therefore has a lower building ownership rate than London.

Climate affects the energy demand differences between Hong Kong and London, however this is not in itself a barrier to implementing London's policy, provided that heating and cooling networks are sufficiently similar. Points **II** and **III** both concern the fundamental differences in the building stocks of the two cities and will be more instrumental in deciding how Hong Kong can successfully adapt some of London's successful emissions reduction policies into its own building sector.

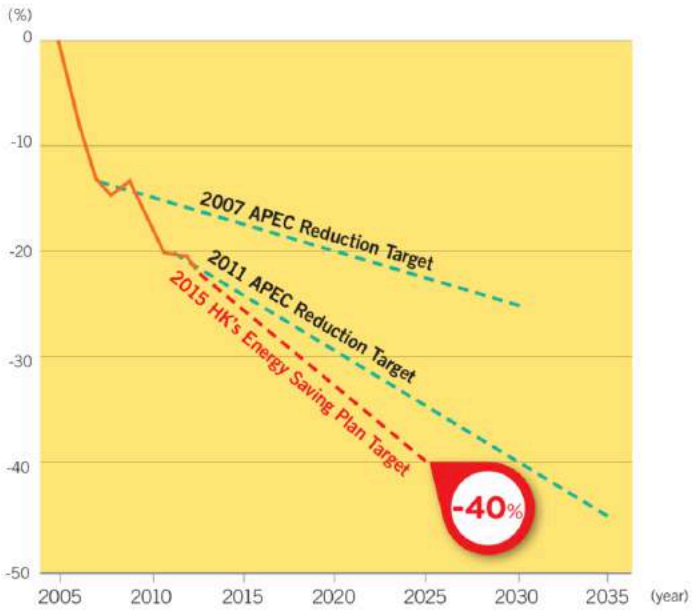
Hong Kong's current commitments to reduce emissions

As set out in its Climate Action Plan 2030+, Hong Kong has pledged to reduce emissions by 65-70% of 2005 levels by 2030, equivalent to a 40% reduction in per capita emissions from 6.2 tonnes per person per year to roughly 3.5 tonnes. While a step in the right direction, this is still a way off the 2 tonnes per capita annual carbon allowance, in a world where every person on the planet has an equal share of global carbon emissions, required to limit global warming to 2℃ as set out in the Paris Agreement.

The Climate Action Plan also states Hong Kong's desire to move towards consumption-based emissions, a system which accounts for the carbon footprint of products imported from outside one's home country. Currently most emissions accounting processes do not take this into account, with the result that wealthy, more developed countries such as Hong Kong, who import much of their food, energy and goods, have artificially depressed per capita emissions. One of the ways Hong Kong wants to address this problem is to increase consumer awareness in the products they buy, promoting an ethical consumerism culture.

In line with its target for emissions reduction, Hong Kong intends to reduce its carbon intensity, which is the units of CO_2 produced per kW of energy generated, by 70% by 2030, relative to 2005 levels. Whilst a step in the right direction, the bulk of this reduction will be achieved by shifting from coal to gas as its primary energy source. While cleaner than coal, burning gas still releases CO_2 into the atmosphere and this is not therefore a long-term solution. In addition, Hong Kong will import most of this gas, simply shifting the carbon emissions associated with producing the gas onto other countries. Besides energy, Hong Kong is looking to reduce emissions in the building and transport sectors.

Figure 31 Energy intensity, 2005-2035 (2005 as base year)



(Sources: Hong Kong Energy End-use Data, EMSD and C&SD)

As a member of Asian Pacific Economic Cooperation (APEC), Hong Kong is required to reduce its energy intensity (energy demand per unit GDP) by at least 25% by 2030, using 2005 as a base. In fact, HK has pledged in its 2015 Energy Saving Plan to slash its energy intensity by 40% by 2025 relative to 2005 levels. While this exceeds the target set by APEC, it is worth noting that London has already exceeded a 40% reduction since 2005, and that the measure itself depends on a country's GDP, such that a decreasing energy intensity may in fact be more attributable to rising GDP than falling energy demand.

Hong Kong's 4T framework

Hong Kong has put in place its 4Ts framework (timeline, targets, together, transparency) to encourage transparency and cooperation between stakeholders in the building sector. It hopes this will stimulate the energy efficiency market for existing buildings by encouraging stakeholders to participate in:

I. *Sharing information*
II. *Setting energy saving targets*
III. *Carrying out building energy audits*
IV. *Implementing recommendations*
V. *Endorsing green schemes such as HK G-Pass*
VI. *Applying Beam Plus rating to existing buildings*
VII. *Outperforming Building Energy Code where possible*
VIII. *Carrying out periodic retro-commissioning to identify energy saving measures in existing buildings*

2015 Energy Saving Plan

2 goals for the buildings sector

I. **Trigger private sector action in private buildings**

II. **Trigger a local energy efficiency market**

"being energy aware to become energy wise" as well as developing an energy saving culture encouraging companies to share energy saving practices and be transparent"

Expects a 2 stage transformation:

I. **Establishment by 2025 of a reporting system for energy-related information, including retrocommissioning and benchmarking**

II. **Delivery of retrocommissioning and retrofitting schemes by 2035**

The majority of the energy saving would occur in second stage, which will also require the bulk of investment. However for the success of the first stage, stakeholder cooperation is required across the whole building sector.

Hong Kong's building stock

The bulk of Hong Kong's building stock is made up of existing buildings with a large number of them built before 1995. These older buildings cannot achieve same levels of efficiency as newer buildings and are typically the most inefficient in their energy usage as they lack the technology of new builds, and they were built at a time when energy regulations were less stringent. As in London, most of the current building stock will still exist in the next 50-100 years, therefore it is vital that Hong Kong devises a clear plan of action to retrofit these existing buildings.

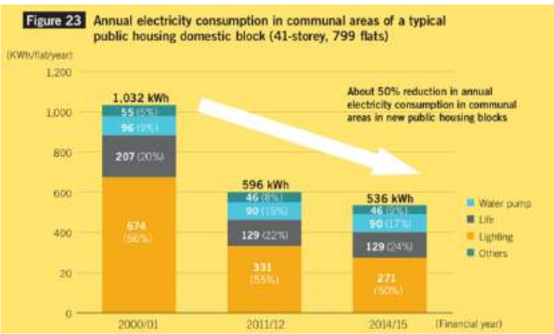
The majority of Hong Kong's 42,000 buildings are private or commercially owned, however the government is a major building manager and manages more than 8,000 buildings and facilities. Therefore it is well placed to lead the way in retrofitting as well as new builds, and doing so will not only set an example for the private sector to follow but will also have a significant positive impact on Hong Kong's emissions.

Almost half of the population live in public housing, either renting or under subsidised ownership, and accordingly public housing accounts for 45% of all energy consumption in residential buildings. However, as in London, we see the commercial building sector accounting for a disproportionate amount of energy usage, this time making up two thirds of the building sector's total energy usage or 60% of Hong Kong's electricity demand. <u>This highlights the importance of implementing a RE:FIT-like scheme in Hong Kong.</u>

Year	2006	
	Population	
	Number of Persons	Percentage
Type of Housing		
Public rental housing	2 129 252[(2)]	31.0
Subsidised home ownership housing	1 221 221[(2)]	17.8
Private permanent housing	3 383 890[(2)]	49.3
Non-domestic housing	81 413[(2)]	1.2
Temporary housing[(1)]	48 570[(2)]	0.7
Total	**6 864 346**	**100.0**

HKHA and the government leading the way

The Hong Kong Housing Authority, HKHA, is a major developer of affordable housing and plans to build 200,000 public rental housing units and 90,000 subsidised sale flats between 2015 and 2025. It aims for all these new builds to achieve at least BEAM Plus Gold rating, an example of where the government is leading the way towards a greener building sector. In addition, HKHA is already doing well in terms of reducing energy consumption in its existing public housing. By focusing on lighting, lifts and water pumps (which collectively make up over 90% of communal energy usage) they have achieved a 50% reduction in electricity consumption within communal areas of their public housing blocks (2015 Energy Saving Plan), **showing that there is a business case for retrofitting in Hong Kong**.



In general, the Hong Kong government aspires to be an example of best practice and inspire the private sector to follow suit. It follows the following sequence of objectives which it hopes will provide a framework to the private sector:

I. Set building energy reduction targets
II. Give specific energy saving responsibility to a senior level official
III. Audit and benchmark
IV. Re-commission to ensure buildings perform to their design standards
V. Retrofit energy-related systems to reduce energy consumption

In addition, the government has set out the following targets for its buildings:

I. 5% reduction of electricity usage in all government buildings by 2020 (estimated saving of 70 million kWh per year)
II. All new government buildings with floor area greater than 5,000 m^2 and with central air-conditioning, or floor area greater than 10,000 m^2, to achieve at least BEAM Plus Gold rating
III. All new government buildings/retrofit projects are required to consider adoption of RE technologies
IV. All new government buildings since 2009 required to meet at least Beam Plus Gold rating

Government buildings are well set to achieve significant energy efficiency improvements with minimal expense because 90% of the electricity consumed by government buildings is with annual electricity consumption over 500,000 kWh account for about 90% of total electricity consumption of all government buildings. Therefore by making use of economies of scale in retrofitting its largest existing buildings the government will achieve significant improvements in energy efficiency.

Air conditioning

One of the biggest differences in energy demand between London and Hong Kong is heating vs cooling.

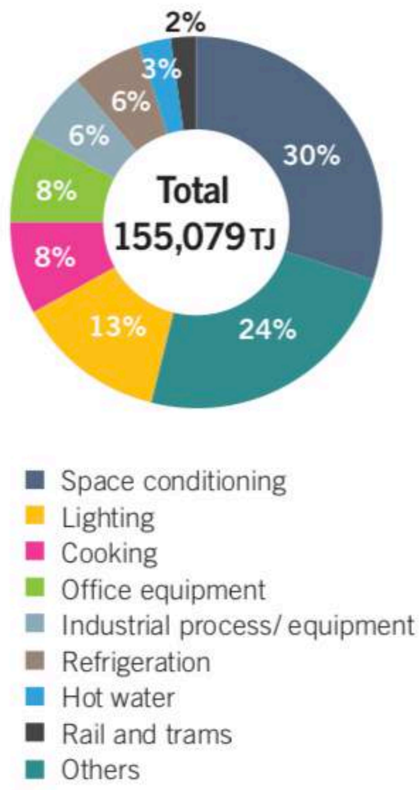
Air conditioning is Hong Kong's largest source of electrical consumption, accounting for 30% of the city's electricity end-use, and it is by far the largest energy usage in both public and private buildings (Energy Saving Plan, 2015). Given that global temperatures are on track to rise by at least 2℃ by the second half of the century, the demand for cooling will only increase. As such it is imperative that action be taken to improve the energy efficiency of air conditioning units in place throughout the city.

FWCT and DCS

The government launched the Fresh Water Cooling Towers Scheme in 2000 to promote the wider use of these water cooling towers for air-conditioning systems in non-domestic commercial buildings, as they are up to 20% more energy efficient than conventional air-cooled systems. By the end of 2016, over 2,200 fresh water cooling towers had been installed with an estimated annual saving of 460 million kWh. The number of designated areas approved for FWCT implementation has now increased to 114 as of 2016.

More efficient than FWCT is DCS (district cooling system), which is 35% more efficient than conventional cooling systems. Hong Kong is trialling DCS at the Kai Tak Development area, a 320 hectare development project at the site of an old airport, incorporating residential, commercial and tourist developments.[1] The system will serve about 50 buildings, using sea water to deliver roughly 280 mega Watts of refrigeration serving over 1.7 million m^2 of floor space.[2] It is expected to save 85 million kWh and 60,000 tonnes CO_2 per year compared to conventional air conditioning systems. If successful, the government aims to implement DCS more widely.

Figure 4 End-uses of electricity in Hong Kong, 2012[7]



(Source: Hong Kong Energy End-use Data, EMSD)

1 https://www.epd.gov.hk/eia/register/profile/latest/esb152.pdf

2 https://www.emsd.gov.hk/en/energy_efficiency/district_cooling_system_at_kai_tak_development/introduction/index.html

Both FWCT and DCS suit Hong Kong's planned high-rise developments, however they would be difficult to incorporate into existing buildings as they require a connected network of underground pipes between buildings and the connection of air conditioning units within buildings. As such, the energy efficiency of air-conditioning within existing buildings will have to be dealt with in other ways, for example encouraging consumers to buy more efficient A/C units via product labelling schemes, and by changing consumer attitudes to energy conservation.

Changing consumer behaviour: Energy Saving Charter and MEELS

In this regard, the Electrical and Mechanical Services Department (EMSD) launched its Energy Saving Charter in 2012, which aims to build closer partnerships with business and community organisations. Initially, companies within the building and property management sectors pledged to reduce electricity consumption by air-conditioning during the summer by maintaining the indoor temperature at their premises between 24˚C and 26˚C. In 2016 the Charter was extended such that signatories also pledged to switch off electrical appliances when not in use and to only procure energy efficient appliances, including electrical appliances with MEELS Grade 1 Energy Label. This updated Energy Saving Charter now has over 3,300 signatories.

The Mandatory Energy Efficiency Labelling Scheme (MEELS) aims to encourage consumers to buy more energy efficient household appliances by displaying energy efficiency information on major domestic electrical appliances. MEELS now covers 60% of residential electricity usage and the government continues to tighten standards of these products and to add more products to the scheme. The scheme is estimated to save 300 million kWh per year, increasing to 500 million kWh per year after the extension of the product line in 2018. <u>This scheme aligns well with the values of a RE:NEW type retrofitting scheme.</u>

Raising awareness of climate change

Hong Kong Green Building Council (HKGBC) have a number of initiatives for promoting sustainable building practices, including HK G-PASS (Green Product Accreditation and Standards Scheme), BEAM Plus, MEELS and GIS.

HK G-PASS:

Labelling scheme rating building materials, products and building services components in terms of their ecological footprint.
Officially endorsed by GIS scheme (see below) and also HKGBC's own BEAM Plus scheme

GIS (Green Item Subsidy):

The Urban Renewal Authority introduced the GIS in July 2015 to encourage property owners to use environmentally friendly building materials and energy-saving facilities when carrying out any building rehabilitation works. The maximum amount of GIS is HK$1,500 per property unit subject to a cap of HK$600,000 per Owners' Corporation.

To be eligible for the subsidies, building materials and household items must achieve sufficiently green labels according to labelling schemes such as G-PASS or the Green Labelling Scheme run by Green Council and Hong Kong Ecolabelling Scheme run by Hong Kong Federation of Environmental Protection (HKFEP).

BEAM Plus (Building Environmental Assessment Method):

Recognised and certified by the HKGBC, BEAM Plus offers a comprehensive set of performance criteria for a wide range of sustainability issues relating to the planning, design, construction, commissioning, management, operation and maintenance of a building. A building's overall performance is independently assessed throughout its life cycle, enabling organisations and companies to demonstrate their commitment to sustainable development.

Since 2010, over 880 projects with nearly 26 million m^2 of floor space were registered under BEAM Plus, roughly 40% of all new buildings completed up until September 2016.

BEAM Plus is an economic incentive to new buildings, as, since 2011, Beam Plus certification has been a pre-requisite to gross floor area (GFA) concessions in development projects (other prerequisites include supplying energy efficiency data on project and complying with sustainable building design guidelines).

Owners of existing buildings can voluntarily have their buildings assessed and rated by HKGBC, but currently there is no economic incentive to do so, since GFA concessions only work for new builds. <u>Therefore we recommend the government implements financial incentives to encourage homeowners to retrofit their existing buildings</u>.

Building Energy Efficiency Fund Scheme (BEEFS)

BEEFS was a programme that ran from 2008-2012 providing funds for building energy efficiency upgrades, ranging from replacing lighting to replacing lifts and central air conditioning systems.
1/7th of Hong Kong's buildings (about 6,400 buildings) participated in the programme, collectively receiving $450 million in funding. The estimated total combined energy saving is 180 million kWh per year, or 216,000 tonnes CO_2 per year.[3]
BEEFS was intended to promote building owners' awareness of the benefits of building energy efficiency and encourage them to actively seek improvements. The scheme has been moderately successful in motivating relevant sectors to grasp the business opportunities brought about by improving building energy efficiency.

Since the termination of BEEFS, Hong Kong's two major power companies, CLP Power and Hong Kong Electric, have put in place their own schemes for subsidising retrofit projects of non-governmental buildings:

CLP's Eco Building Fund ran between 2014-2018 with total value of HK$70

3 https://www.info.gov.hk/gia/general/201306/19/P201306190385.htm

million over the 5-year period, and granted subsidies for retrofit projects on a 50/50 matching basis, subject to a cap of HK$500,000 per project.4 As of March 2018, 428 buildings had made use of the subsidy with the total approved funding amount exceeding HK$64 million.5

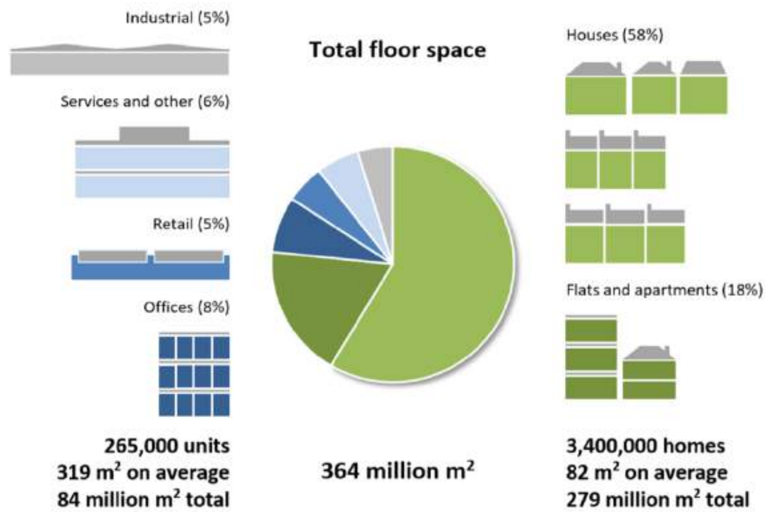
HK Electric's ***Power Smart Building Fund*** *has a value of HK$25 million and is running as of January 2019. This will operate on a similar matching scheme as the Eco Building Fund, and have similar caps.*

These schemes prove that there is demand for retrofit projects in Hong Kong, and that such projects can be delivered successfully. They are similar in some ways to phase one of London's RE:NEW scheme in that they offer grants for retrofit projects but do not offer an expert support team to assist with project planning. However this method of financing is not suitable for the bulk of Hong Kong's retrofitting requirements and we recommend implementation of a similar support team as with the RE:NEW and RE:FIT programmes, with funding from the Hong Kong government as well as an external source such as the Asian Development Bank, to support a wider market delivery of retrofitting projects.

London and the benefit of retrofit

In its 2011 Climate Change and Energy Strategy, London set a target of a 60% reduction in carbon emissions by 2025 with a view to being net carbon-zero by 2050. It aims to do so in part by retrofitting, by 2025, 2.9 million homes as well as two thirds of its existing non-domestic building stock (11 million m^2 of public buildings and 44 million m^2 private sector workplaces). It will do this through several schemes, including the RE:NEW and RE:FIT retrofitting schemes for domestic and non-domestic buildings respectively, which are themselves part of the city's £34 million 2018 Energy for Londoner's Scheme.

Figure 4: Breakdown of London's building floor-space by use[10]



In order to understand how to go about retrofitting its building stock, it is useful to understand the breakdown of London's floor space. Every year the English Housing Survey publishes a breakdown of London's floor space by category, which is helpful in understanding the nature of the retrofit projects required and formulating

[4] https://www.clp.com.hk/en/community-and-environment-site/green-service-site/clp-eco-building-fund-site/Documents/EBFund_eng/CLP%20Launches%20Fund%20to%20Create%20Greener%20Buildings_Eng.pdf

[5] https://www.clp.com.hk/en/community-and-environment/green-service/clp-eco-building-fund/latest-news

retrofit schemes accordingly. We expect that an analogous survey of Hong Kong's floor space would be similarly helpful. Domestic housing makes up three quarters of London's floor area and together account for almost half of the city's CO_2 emissions.[6] Combine this with the fact that as much as 80% of this stock will still exist well into the second half of this century and it is clear to see the importance of retrofitting this stock through the RE:NEW scheme. Also evident from the survey is the importance of the RE:FIT scheme to address energy performance in non-domestic buildings. Despite numbering just 265,000 and making up roughly one quarter of London's floor area, non-domestic buildings account for over 40% of the city's carbon emissions.

The benefits of retrofitting are wide-ranging:

Financial:

I. Improved energy efficiency means reduced future energy bills
II. Money saved on bills is spent in economy instead
III. Carrying out other essential repairs or other work, such as installing solar PV, alongside retrofit projects makes use of building synergies
IV. Installing newer, more efficient devices should decrease ongoing maintenance costs
V. Financial case strengthened by external funding/grants as well as by scaling up operations. As such, RE:NEW is especially effective for housing organisations and local councils, which is where it has seen many of its successes.[7]

Environmental:

I. reduced energy use means smaller carbon footprint
II. retrofitting raises environmental profile of home owners and encourages them to be more energy efficient

Social:

I. Retrofitting creates jobs for the community
II. Encourages community to engage in becoming more energy efficient

When retrofitting large numbers of houses at once, additional financial benefits can be realised through making use of economies of scale. This is the case for Orbit Housing, one of UK's largest housing organisations, who found they could save £4 million in management costs over a 20 year period by investing in the energy performance of their homes. Specifically, the report found that the majority of savings were to be found by retrofitting the worst performing houses – those with EPC rating C and below.[8]

[6] https://www.ukace.org/wp-content/uploads/2016/07/Energy-Efficiency-in-London.pdf

[7] https://www.london.gov.uk/sites/default/files/renew_brochure_jun_2017.pdf

[8] https://www.london.gov.uk/sites/default/files/renew_positive_energy_-_the_business_case_for_retrofit-_online_0.pdf

2018 Energy for Londoner's Scheme

In addition to the RE:NEW and RE:FIT schemes, London has put in place various policies to help meet its energy saving targets within the buildings sector:

Energy Leap

£450,000 pilot project to radically retrofit at least 10 domestic homes to become carbon neutral

Energy Planning Monitoring Report

Annual publication detailing current efforts to reduce CO_2 emissions

Be Lean, Be Clean, Be Green energy hierarchy

Including significant investment in each stage:

Be Lean – investment in energy demand reduction measures resulting in an 8.4% reduction in CO_2 emissions compared with relevant Building Regulations in force through energy efficiency measures alone

Be Clean – £139 million in heat network infrastructure and associated combined heat and power (CHP)

Be Green – £15 million in PV panels and additional investment in other renewable energy technologies

London Plan, Policy 5.2 for major new developments

All major new developments must

I. Publish an energy strategy detailing how CO_2 emissions will be minimised according to the lean/clean/green energy hierarchy
II. Include proposals to further reduce emissions through the use of decentralised energy where feasible, such as district heating/cooling and combined heat and power (CHP)
III. Include proposals to further reduce emissions through the use of on-site renewable technologies where feasible
IV. Meet the following minimum improvements over the base target emissions rate (TER) that is set in Part L of the National Building Regulations

Residential buildings:

Year	Improvement on 2010 Building Regulatons
2010 – 2013	25 per cent (Code for Sustainable
2013 – 2016	40 per cent
2016 – 2031	Zero carbon

Non-domestic buildings:

Year	Improvement on 2010 Building Regulatons
2010 – 2013	25 per cent
2013 – 2016	40 per cent
2016 – 2019	As per building regulations requirements

For developments that do not achieve the required CO_2 emission reduction targets on-site, the shortfall must be provided off-site or through a cash in-lieu contribution to the relevant borough that is ring-fenced to secure delivery of CO_2 savings elsewhere.

RE:NEW

Established in 2009 to cut carbon emissions and reduce fuel poverty, RE:NEW works with London boroughs, housing associations and universities to assist them in all stages of retrofitting their housing stock.

Implemented in a two-phase process, phase one lasted until June 2013, comprising a pilot stage and limited subsequent roll-out projects. During this first phase, RE:NEW provided local authorities with grants and an easy to use procurement framework of certified suppliers. Over 100,000 homes were retrofitted, saving 22,000 tonnes of CO_2 per year.

After the success of phase one, RE:NEW moved toward a more strategic delivery model through the creation of its Expert Support Team for wider market delivery during phase two. In its maturity the scheme now works on a two-pronged strategy:

Expert Support Team

This is a free service, co-funded by the Greater London Authority and the European Investment Bank, assisting all aspects of retrofit projects such as:

i. Advising on retrofit potential
ii. Assisting with budgeting, including providing investment modelling and feasibility studies
iii. Providing technical risk analysis
iv. Assisting with funding procurement
v. Formulating retrofit projects
vi. Offering ongoing support

The RE:NEW Framework

This is a streamlining mechanism designed to reduce the total time taken for the retrofitting process, as well as assure buyers through pre-qualification of suppliers. The framework is fully integrated with the support team, thus playing an essential role in helping home owners realise the retrofit potential of their houses. Currently there are 9 certified suppliers designed to supply a wide range of domestic retrofit projects who are frequently price-checked to ensure buyers are receiving the best value for money.

Typical retrofit measures encouraged through the RE:NEW scheme range from small energy saving measures such as insulation and draught proofing, to more significant works such as heating upgrades or installation of solar PV.

Since its inception, over 130,000 homes have been retrofitted through the RE:NEW scheme, decreasing CO_2 emissions by more than 46,000 tonnes per year. As of 2016, 119,000 homes received free advice from the expert support team, 19,000 homes installed solar panels, and 400 homes installed low-carbon heating systems.

It is worth noting that the Feed In Tariff (FiT) was a significant factor in helping homeowners finance their domestic solar (and other renewable) generation projects, a large part of RE:NEW's initial focus. Homes with renewable generation capacity below 5MW would receive from their energy supplier a generation tariff (payment per kWh electricity generated) and an export tariff (payment for any electricity you sell back to the supplier). This provided homeowners with a guaranteed source of income from their future energy generation, thus de-risking their investment and reducing the payback period.

As of March 2019 the FiT is no longer in place, and as such the payback period on domestic renewables is longer and the uptake of solar PV is expected to fall as domestic consumers must bear more of the risk of investing in renewables. However as the price of solar technology continues to fall, the payback period will decrease which in turn will encourage more homeowners to invest in renewable technology again.

RE:NEW fits into London's wider push for increased energy efficiency, and since 2005 an estimated 1,430,000 significant energy performance improvements have been undertaken in London homes (350,000 loft insulations, 260,000 cavity wall insulations and 800,000 efficient boilers installations).

Crucially, the success of the RE:NEW scheme shows that the home owners' demand for retrofitting exists, but it needs support to enable action. The use of a multi-phase process has been crucial in the scheme's success, with the pilot phase highlighting the need for the expert support team without which the scheme would be less effective.

London refit

Background

Section 2.1.3 of the 1st Report "Shaping Sustainable Urban Futures" (p.19) gives an overview of the RE:FIT program in London. This section aims to provide a more comprehensive analysis of RE:FIT and discuss the possibility of implementing a similar framework in Hong Kong.

In gist, RE:FIT is a procurement framework developed by the Greater London Authority (GLA) for energy performance contracting (EPC) between Energy Service Companies (ESCOs) and owners of non-domestic public buildings (e.g. central and local government, education, health care, cultural organisations, charities, and museums). It covers a variety of projects, including building large infrastructure, optimizing existing buildings, reducing maintenance backlog, reducing maintenance costs and doing quick fixes.

The pilot stage of RE:FIT commenced in London in 2009, during which 42 public buildings underwent retrofitting. Its success led to the launch of the second and third stages of the framework (with more ESCOs and retrofitting buildings), which will drive the RE:FIT program until 2020.[9] This program successfully reduced carbon emissions by more than 21,000 tonnes and energy expenses by £8 million in non-domestic public buildings.[10]

London's RE:FIT

Financing of the installations

RE:FIT is a two stage process, with associated two stage finance requirements. First, engaging the Program Delivery Unit[11] for their services throughout the entire process (from management buy-in to performance monitoring); second, engaging ESCOs for assessing, designing, and installing energy conservation measures.

Until the end of 2019, service of the Program Delivery Unit is fully funded by the GLA and the European Regional Development Fund.[12] The costs for ESCOs are borne by building owners in the following ways:

- Funding by building owners
- Loan from banks
- Loan from public financial institutions or funds such as Public Works Loan Board,[13] Salix[14] or London Energy Efficiency Funds[15]
- Financed through a third party (e.g. ESCOs)

[9] https://www.c40.org/case_studies/re-fit-programme-cuts-carbon-emissions-from-london-s-public-buildings

[10] https://www.london.gov.uk/sites/default/files/achievments_0.pdf

[11] Program delivery unit is the delivery vehicle of RE:FIT, acting as projects facilitator, marketer, aggregator and financial advisor.

[12] https://www.london.gov.uk/what-we-do/environment/energy/energy-buildings/refit/what-refit-london#acc-i-56486

[13] PWLB is a statutory body which lends money to local authorities.

[14] Salix delivers interest-free loans to the public sector for energy efficiency projects.

[15] LEEF provides low interest loans for energy efficiency retrofit.

Alleviating the financial burden of building owners and making RE:FIT financially attractive is the mechanism of EPC with ESCOs. Upon pre-selection by the GLA, there are numerous ESCOs available to be engaged for EPC. They guarantee to produce certain level of energy efficiency improvements on the buildings in return for investments from the building owners in installing energy conservation measures. EPC provides incentives far greater than free refurbishments and the reduction of backlog maintenance issues. Building owners actually receive cash-positive benefits by enjoying full energy savings for the lifespan of the works done by the ESCOs. During the pilot stage of RE:FIT, retrofitting projects yielded an average payback period of seven years.[16]

Maintenance of energy efficient installations

Regular maintenance of existing and new installations can be a heavy financial burden to building owners. Consequently, public buildings in the UK often face a backlog of maintenance works. The lack of maintenance undercuts energy efficiency of the installations and in turn increases energy expenses of building owners.

By participating in RE:FIT, building owners have the opportunity of negotiating with ESCOs and putting on them the responsibility of maintenance. As energy savings only arrive from properly maintained installations, building owners and ESCOs would need to negotiate and agree on the period and standard of maintenance expected. As a result, participation in RE:FIT's retrofitting projects could relieve building owners of the backlog of maintenance work in public buildings.

Improvements for Building Management System

Building Management System (BMS) is a computer-based central control system which is installed within a building to manage the operation of its service, such as heating, cooling, ventilation, hot water, lighting, and the integration of these services into the building envelope.

There are numerous advantages for installing or upgrading BMS. First of all, BMS has low running costs and maintenance requirements. A correctly set up and well-managed BMS could reduce energy consumption and expenses up to 30%. On the contrary, an improperly configured BMS could waste up to 20% of the building's energy and affect the operation and energy saving capacity of other installations. Moreover, installation of BMS will allow the building to adopt new technologies such as wireless control

[16] http://localpartnerships.org.uk/our-expertise/refit/refit-background/

platforms and new protocol system, which facilitates the collection of data and use of automated rules for enhancing energy efficiency.[17]

Overall, since the cost of installing or retrofitting a BMS will be outweighed by return in the long run,[18] BMS improvement is often carried out in retrofitting projects under RE:FIT. For examples, the New County Offices under Buckinghamshire County Council has utilised the retrofitting process to identify issues with inefficient setup of its existing BMS and strategy scripts, and to address these issues to ensure its good working order for the duration of the payback period under the monitoring of the ESCO.[19] The London School of Economics and the London Fire Brigades also carried out retrofitting measures to optimise and improve their BMS.

Feed-in tariffs

The UK government (Office of Gas and Electricity Markets) subsidises the generation of renewable energy through the feed-in tariff scheme. Depending on the size of the system, the degree of energy efficiency, the type of technology and the time of installation, building owners will be paid for the electricity they generate. They can also sell any extra units of electricity to their supplier under the scheme.

Participants of RE:FIT, such as West London Alliance,[20] London School of Economics[21] and London Borough of Hounslow[22] installed solar photovoltaic systems in their retrofitting projects and benefitted from the feed-in tariff. The feed-in tariff is believed to have financed many retrofitting projects, as over 1.9GWh annual PV output has been generated through RE:FIT[23].

However, the feed-in tariff scheme will cease to operate in April 2019. This brings about immediate negative impact on the operation of RE:FIT, as at least one well-advanced £2-million solar project is now being reconsidered.[24]

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[17] https://www.fairbanksenergy.com/our-services/building-management-services/;https://relayr.io/retrofitting-smart-buildings-and-smart-cities/

[18] http://advancedcontrolcorp.com/blog/2019/01/retrofit-install-intelligent-building-management-systems/

[19] (http://localpartnerships.org.uk/wp-content/uploads/2016/08/Refit-Bucks-CC-New-County-Offices-Aug-16.pdf).

[20] (https://www.ukace.org/wp-content/uploads/2016/07/Energy-Efficiency-in-London.pdf)

[21] (https://www.current-news.co.uk/news/london-school-of-economics-makes-sustainability-progress-with-solar-5648)

[22](https://www.lps.lv/uploads/docs_module/7_REFIT_General_Presentation_Citynvest%20v2.pdf

[23](https://www.lps.lv/uploads/docs_module/7_REFIT_General_Presentation_Citynvest%20v2.pdf

[24]https://www.london.gov.uk/sites/default/files/mol_fit_consultation_response_cover_v2_22.10.15.pdf

Analysis of RE:FIT's framework in the context of Hong Kong

First of all, RE:FIT targets non-domestic public buildings, the retrofitting of which would contribute heavily to the reduction of carbon emission in Hong Kong. In the city, there is a high ratio of existing buildings to new buildings hence existing buildings will dominate the building stock of Hong Kong for many years to come.[25] Moreover, many existing buildings have great potentials to perform better through retrofitting. By 2020, it is envisaged that 14% (5,600) of the existing buildings will require refurbishment or replacement, rising to 26% (10,400) in 2030 and 44% (17,600) in 2050.[26] The building sector consumes over 90% of the territory-wide electricity generation, 66% of which are consumed in the commercial (non-domestic) sector.[27] Hence, the retrofitting of non-domestic buildings would be essential to achieving carbon reduction in Hong Kong.

In recent years, retrofitting has increasingly been recognised as a means to achieve energy efficiency in Hong Kong. There is a clear social consensus that retrofitting existing buildings is necessary for reducing electricity consumption and carbon emissions (figure 1).

Figure 1: Social consensus

The government[28]	"The Environment Bureau has made energy saving in buildings a target area for long-term stakeholder engagement, and our major focus is to work with existing building owners in both the public and private sectors." They will also work built environment and financing professionals to enhance their knowledge about energy saving.
Non-profit organisation	Hong Kong Green Building Council has advocated for its HK3030 initiative, which targets at a reduction of the building energy consumption by 30% in 2030. It suggests that to realise this target, there needs to be substantial improvement on energy efficiency by retrofitting existing buildings.[29]
Building owners	Non-domestic public institutions, such as the University of Hong Kong[30] and disciplinary buildings of the government[31] launched retrofitting to enhance energy efficiency.

[25] (https://www.beamsociety.org.hk/files/PPT/31st%20BPT/pdf/03_TT_EU_20160622.pdf)

[26] http://global.ctbuh.org/resources/papers/download/2381-climate-change-in-hong-kong-mitigation-through-sustainable-retrofitting.pdf

[27] EMSD, 'Hong Kong Energy End-use Data 2013', Electrical and Mechanical Services Department, Government of Hong Kong Special Administrative Region, 2013.

[28] (https://www.enb.gov.hk/sites/default/files/pdf/EnergySaving_EB_EN.pdf)

[29] https://www.hkgbc.org.hk/ebook/hkgbc_roadmap/files/assets/common/downloads/hkgbc_roadmap.pdf

[30] https://www.sustainability.hku.hk/report/2013-2015/sustainability-indicators/carbon

[31] https://www.emsd.gov.hk/filemanager/conferencepaper/en/upload/60/cnfrnc-paper-20150705-09-2.pdf

However, the current conditions in Hong Kong pose certain difficulties for retrofitting work to be carried out extensively. (Figure 2)

Figure 2: Current conditions for retrofitting in Hong Kong[32]

Problems	Explanations
Lack of financial support	As most leases contain reinstatement clauses requiring tenants to restore premises to their original condition upon expiration of leases, there is little motive for tenants to retrofit the buildings. On the part of landlords, they are often unwilling to invest in costly retrofitting. Any decision to retrofit are made after careful cost-benefit analyses, taking into account considerations such as payback period and financial risks, including both initial up-front costs as well as ongoing maintenance costs. Against these concerns, subsidies or other forms of financial assistance would be an important factor in favour of retrofitting. At present, as far as retrofitting of non-domestic public buildings is concerned, there are some forms of financial support, for examples: a) Eco Building Fund offered by the CLP to subsidise retrofitting projects including lighting, air-conditioning, lift, escalator, and electrical installations (not available for buildings directly owned and operated by the government);[33] b) Smart Power Building Fund offered by Hong Kong Electric to subsidise projects including retrofitting building services installations (e.g. air-conditioning, lift, electrical installations, lighting) and building-based smart technologies (not available for building directly owned and operated by the Government except housing estates of Hong Kong Housing Authority and Hong Kong Housing Society);

32 https://www.climateready.gov.hk/files/report/en/5.pdf

33 https://www.clp.com.hk/en/community-and-environment/community-funds/eco-building-fund

	c) Feed-in tariffs offered by both CLP and Hong Kong Electric for users' generation of electricity through solar photovoltaic and/or wind power system; d) Tax deduction for expenses incurred on the construction of energy efficient building installations where energy performance of the building has reached specified standard.[34] These financial incentives, which mainly assist building owners to gather capital for retrofitting, failed to address their concerns over the uncertainties of energy saving and payback period.
Lack of benchmarking data	Under Energy Building Efficiency Ordinance and Energy Audit Code, energy audit reports are only submitted to the government every 10 years, making it difficult to compare the latest energy performance between buildings. As a result, there is no updated benchmark available to assist building owners in their decision on whether to invest more in energy efficiency and carry out retrofitting projects.
No mandatory regulation for retrofitting	Currently, the Energy Audit Code only recommends that building owners implement 'energy management opportunities', such as retrofitting. The Code does not mandate any building to carry out the same.
Lack of procurement policies	The Urban Renewal Authority hosted an e-tendering platform, 'Smart Tender' to facilitate private building owners to procure consultants and registered contractors for carrying out retrofitting works[35] – no similar or other procurement policies are in place for public building owners.

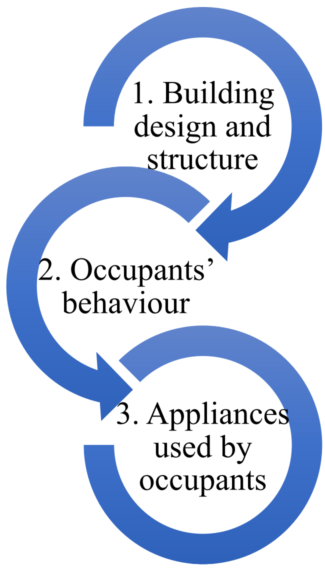
Against this background, the case of developing a RE:FIT-like framework in Hong Kong is strong.

[34] https://www.emsd.gov.hk/en/energy_efficiency/energy_efficiency_registration_scheme_for_building/index.html

[35] (http://www.buildingrehab.org.hk/Rehabilitation-Resources/Smart-Tender)

More importantly, the RE:FIT framework chimes with existing policies. In 2017, the Business Environment Council Limited, with the support of the government, launched the Retrofit Guide and Retrofit Calculator. They provide building owners information such as mature energy efficient technologies, net costs, and payback periods to facilitate their decisions and business case to retrofit.[36] Moreover, the aforesaid financial support, while they alone are insufficient incentives, could facilitate the implementation of a RE:FIT framework. They provide the capitals for individual building owners to participate in retrofitting, lest retrofitting is limited to wealthy owners. RE:FIT's compatibility with current policies is also demonstrated by the fact that it aligns with the government's Energy Saving Priorities (Figure 3).[37] Given the government's recognition of the importance of retrofitting towards energy saving, there is a high chance in lobbying the government to launch and support RE:FIT.

Figure 3: HK Government's relative energy saving priorities for commercial and institutional buildings



The availability of ESCOs renders RE:FIT framework possible in Hong Kong.[38] ESCO business exists in Hong Kong in the way provided by individual building services contractors.[39] As their counterparts in the UK, they sign agreements with building owners through EPC, under which they design, install, and maintain retrofit projects to improve energy efficiency of buildings. As early as in 2009, there were about 13 EPC projects being conducted in public buildings in Hong Kong for the retrofitting of energy efficient installations.[40] According to surveys conducted with practitioners of ESCOs in

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[36] http://bec.org.hk/newsroom/bec-launches-the-energy-efficient-retrofit-guide--calculator

[37] https://www.enb.gov.hk/sites/default/files/pdf/EnergySaving_EB_EN.pdf

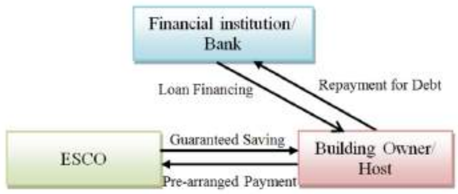
[38] for a detailed analysis of EPC in Hong Kong, see Lee Pan, 'A model for energy performance contracting (EPC) in Hong Kong' The Hong Kong Polytechnic University

[39] https://ee.emsd.gov.hk/english/general/gen_other/gen_other_esco.html

[40] Lee Pan, 'A model for energy performance contracting (EPC) in Hong Kong' The Hong Kong Polytechnic University, 24

Hong Kong, around 35% of respondents have hands-on experience in EPC projects and among them, over half implemented 4 or more EPC projects.[41] To further promote the concept of EPC and develop EPC market in Hong Kong, the Hong Kong Association of Energy Service Companies was founded in 2008. With well-established banking structure and project financing, coupled with the availability of financial subsidies, EPC in Hong Kong may follow the successful model (Figure 4) that is currently adopted in RE:FIT (as opposed to the sharing savings model that is normally adopted in developing countries) to protect ESCOs from any credit risks.[42] EPC also addresses the problem of a lack of talents on the part of building owners.[43] Not only will ESCOs offer technologies and expertise to implement energy improvement projects, they will also provide staff training on system operation and control to ensure that newly installed equipment operate at their optimal efficiency. Thus, EPC could save up building owners' expenses for engaging experts and provide financial incentives to building owners who do not have or cannot afford any experts.

Figure 4: Relationships of stakeholders under the guaranteed saving models[44]



The case of implementing a RE:FIT framework is strengthened by its side benefit of fostering the development of renewable energy in Hong Kong. At present, only about one per cent of Hong Kong's electricity is generated from renewables whilst they have the potential to provide 3-4 per cent of energy in the city.[45] Given currently available subsidies (e.g. feed-in tariffs), the payback period for renewable energy system owners is estimated to be about 10 years.[46] As building owners in retrofitting projects also make other installations (in addition to renewables) which have shorter payback periods, they would have shorter payback period as a whole. The relatively expensive maintenance costs for renewable energy installations would also be borne by ESCOs during the payback period. As far as technologies are concerned, installation of solar panels has been identified by the government and researchers as possible in

41 Lee Pan, 'A model for energy performance contracting (EPC) in Hong Kong' The Hong Kong Polytechnic University, 67

42

42 Lee Pan, 'A model for energy performance contracting (EPC) in Hong Kong' The Hong Kong Polytechnic University, 18-19

43 https://www.hongkongfp.com/2018/12/25/bright-future-solar-energy-hong-kong-still-long-way-go/

44 Lee Pan, 'A model for energy performance contracting (EPC) in Hong Kong' The Hong Kong Polytechnic University, 19

45 https://www.scmp.com/news/hong-kong/health-environment/article/2142101/proposal-hong-kongs-renewable-energy-producers

46 https://www.legco.gov.hk/yr17-18/english/panels/ea/papers/ea20180423cb1-809-3-e.pdf

Hong Kong.[47] For instance, the government found the installations of solar water heating system and solar lights practical, and has installed them on some of its disciplinary buildings.[48]

Finally, technologies in Hong Kong are sufficiently mature to support the comprehensive retrofitting of buildings.

Figure 5: Technologies identified by researchers/government as practicable in Hong Kong[49]

Air-conditioning • Replace air-cooled chiller with water-cooled type • Upgrade to oil-free/magnetic bearing chiller • Use variable-speed primary chiller pump station • Use fan coil unit with variable-speed-drive fan • Add CO_2 sensor to reduce fresh air rate • Adopt ductwork pressure optimization
Lighting • Replace light tubes by T5 or LED fixtures • Adopt lighting with motion/ occupancy sensor controls • Add daylight sensor with/without dimming effect
Lift and escalators • Use lift motor with variable-voltage-variable-frequency drives and/or regenerative power • Service on demand escalators
Others: • Add heat pump to domestic hot water supply • Building-based smart/IT technologies (e.g. building management system) • Install solar collectors: thermal or photovoltaic

47 http://www.bsomes.org.hk/upload_pdf/GPRD2016_S1-1.pdf

48 https://www.emsd.gov.hk/filemanager/conferencepaper/en/upload/60/cnfrnc-paper-20150705-09-2.pdf

49 http://www.bsomes.org.hk/upload_pdf/GPRD2016_S1-1.pdf; https://www.enb.gov.hk/sites/default/files/pdf/EnergySaving_EB_EN.pdf; https://web.wpi.edu/Pubs/E-project/Available/E-project-030217-213321/unrestricted/Energy-EfficientSolutions_HongKong2017.pdf

Conclusion

As outlined above, the Hong Kong government has rolled out a patchwork of policies on enhancing energy efficiency in existing buildings, including Building Energy Codes, Reporting and Benchmarking of Energy Performance Data, and Mandatory Auditing. However, there is not yet a framework putting together those policies for promoting green retrofit of existing non-domestic public buildings in Hong Kong.

As retrofitting projects are widely implemented in public buildings around the world,[50] this report recommends that a RE:FIT like framework should also be put forward in Hong Kong for three major reasons:

1. It is compatible with current policies in enhancing energy efficiency and reducing carbon emission;

2. EPC framework provides huge financial incentives and technological supports to building owners;

3. Technologies are available in Hong Kong to support green retrofitting. The implementation of a city-wide EPC framework also benefits the development of new green technologies for building retrofit and even renewable energy.

With all merits of implementing RE:FIT in Hong Kong being said, there are some foreseeable challenges.

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50 http://www.annex46.de/pdf/brosch_BRITAinPuBs.pdf

Figure 6: Challenges and their possible solutions

Challenges	Possible solutions
Insufficient public awareness	It was found that that a major obstacle of extensive green retrofitting framework is the lack of awareness of stakeholders. For example, owners and investors may not know of the benefits of green buildings or financial institutions may refuse provide funding for building owners because of their unawareness of returns under EPC green retrofitting. [51] In response to this obstacle, some researchers have suggested that building green retrofit in Hong Kong can be divided into three stages, namely pilot stage, promotion stage and full implementation stage. During the pilot and promotion stages, it was recommended to roll out direction-based and training measures to equip stakeholders with knowledge and skills in arranging retrofitting.[52] This would resemble RE:FIT, which was also implemented with a 2-year pilot stage.
Fiscal burden on the government	While some researchers recommended that financial support policies should be in place for the whole process of implementation,[53] this will impose heavy fiscal burdens on the government. We propose that the government may reconsider the amounts of subsidies after pilot stage. Once building owners have noted that pilot retrofitting projects yield certain return of investment, they would have the incentive to retrofit even though they need to borrow loan for capital investments. This approach is adopted by the UK government, which will soon withdraw its subsidies for engaging program delivery unit in RE:FIT. Moreover, in the long run, government's funding may be focused on research, tax reduction and interest rate reduction for using new retrofit technologies. This encourages the development and use of new technologies which yield better energy saving outcomes, allowing building owners to secure higher return and be less dependent on government's funding for upfront investment.

[51] Jagarajan and Asmoni et al., 'Green retrofitting – a review of current status, implementations and challenges' 67 *Renewable and Sustainable Energy Reviews* 1360, 1364

[52] Tan, Liu et al., 'green retrofit of aged residential buildings in Hong Kong: a preliminary study' 143 (2018) *Building and Environment* 89, 95-96

[53] Tan, Liu et al., 'green retrofit of aged residential buildings in Hong Kong: a preliminary study' 143 (2018) *Building and Environment* 89

Complexities relating to the procurement of EPC[54]	Complexities of procurement process was found to be a main concern shared by building owners and ESCOs. As against conventional retrofitting projects, EPC projects entail a larger work scope, including the arrangement of financing, measure and verification process, and the allocation of maintenance responsibilities. Despite that every EPC project is likely to be unique in its scope of work, the government may provide template contracts. The government may also provide information of ESCOs to building owners such as the number of EPC projects they undertook or their ratings/reviews to assist building owners to select ESCOs that are more likely to be helpful and collaborative during procurement negotiations.
Relatively long payback period[55]	For both building owners and ESCOs, the longer the payback period, the greater the project risks. For ESCOs, long payback period entails the risk of bearing increasing costs of installations and labour. Long payback period also restricts the flexibility of building owners in changing their building structures and operations to suit future business needs. Therefore, the concern of long payback period deters building owners from making large investment in retrofitting. To encourage investment in retrofitting, we propose that the government may raise the amounts of financial subsidies according to level of energy efficiency attained by the buildings. Thus, building owners could undergo a larger-scale of retrofit or to make more expensive but energy efficient installations without the fear of suffering a longer payback period.

Finally, there are two things to note.

First, a host of factors have been identified by researchers as important for the success of the implementation of green retrofitting framework, for examples green knowledge and awareness of stakeholders, green development quantification, green building professionals, and green technologies.[56] These factors are, however, not fully analysed in this report. It would be

[54] Lee Pan, 'A model for energy performance contracting (EPC) in Hong Kong' The Hong Kong Polytechnic University, 78
[55] Lee Pan, 'A model for energy performance contracting (EPC) in Hong Kong' The Hong Kong Polytechnic University, 78
[56] Jagarajan and Asmoni et al., 'Green retrofitting – a review of current status, implementations and challenges' 67 *Renewable and Sustainable Energy Reviews* 1360, 1364

desirable for further research to be carried out, in the light of these factors, to identify appropriate support policies for a RE:FIT like framework in Hong Kong.

Second, experiences of building retrofit throughout the world can be used as references when implementing green retrofit of existing buildings in Hong Kong. However, such experience may be unsuitable or unfeasible in Hong Kong because of its distinctive climatic features, architectural characteristics, and construction standards. It is important to identify the technologies and policies which are in line with the local situation.

KEY TAKEAWAYS

"The challenge is how to achieve integrated actions from across the building sector – from policy-makers to property developers to building designers, building managers and other built environment professionals – and also building inhabitants, whether they are owners, tenants or users... To speed up [energy saving advances], however, it requires everyone's willingness to act in a coordinated way."

– Hong Kong Energy Saving Plan, 2015

- **There is strong potential and need for the implementation of a RE:FIT-like framework in Hong Kong, deliverable through a scaling up of the BEAM Pus scheme. The potential for a RE:NEW-type scheme is lower, however the use of financial incentives will be crucial in encouraging private retrofit projects.**
- **There are defects with current policies that deter non-domestic public building owners from engaging in retrofitting works.**
- **A RE:FIT-like framework can provide greater incentives for building owners to retrofit, such that saving energy is not only possible but profitable.**
- **There are certain degrees of resemblence between London's and Hong Kong's conditions for retrofitting projects, thus London's RE:FIT model is illustrative in many respects.**
- **An implementation of such a framework will face multi-faceted challenges, such as lack of awareness, lack of skilled contractors or a heightened fiscal burden on the government. A possible solution is for the government to implement the framework in multiple stages.**
- **There will be an important and continuous role of the government in the process of implementation, from providing financial support at pilot stage, monitoring the Energy Performance Markets, and formulating new policies and regulations (e.g. more stringent audit requirements)**
- **–**