Long Term Decarbonisation Strategy for Hong Kong

Climate change is here in Hong Kong NOW and it's going to get worse!

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1 Executive Summary

Climate change is happening and getting worse—Hong Kong has to act NOW.

Climate change is threatening people's livelihood with heatwaves, storm surges, heavy precipitation, and more. For every tonne of carbon put into the atmosphere unmitigated, the world is pushed closer to the point of no return. Global emissions need to be cut by 45% from 2010 levels by 2030 and to reach net zero by 2050 to limit global warming to 1.5°C. Hong Kong's current climate targets are far from sufficient in meeting its responsibilities towards the Paris Climate Agreement.

Energy generation accounts for the largest portion of Hong Kong's locally produced greenhouse gas emissions. The Government must target to completely phase out fossil fuels by 2050. The gap should be covered by the uptake of renewable energies like solar and wind power—met locally or through regional collaborations.

The building sector accounted for about 60% of the city's total GHG emissions. The Government must continue to update and tighten the building energy codes to reduce energy use in both new and existing buildings, targeting to reach net zero emissions by 2050. Energy management system installation must be mandated in all buildings to enhance energy performance. All buildings should include embedded carbon into considerations and be obligated to perform life cycle assessments.

For the transportation sector, the Government must curtail the city's dependence on private cars and be electrified. Hong Kong must align with international cities to retire and ban all vehicles with internal combustion engines by 2030. The Government must support the transition by improving walkability and cycling within the city. Further, maritime and aviation emissions within Hong Kong space must be included as part of the city's carbon footprint.

The city's consumption emission is a major aspect that also cannot be ignored. The Government must promote healthier and sustainable diets as part of their decarbonisation strategy. At the other end, the Government must scale up efforts on food waste reduction, recycling, and recovery. Water consumption likewise must be

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tackled through repairing public and private mains and encouraging better consumption behaviours.

Hong Kong must invest into sustainable infrastructures and technologies. The Government must capture the potential of green finance and solidify Hong Kong as the regional leader in the area. The Government should scale up ESG requirements and mandate investors to adopt the *Principles of Responsible Ownership*. At the same time, the Government must implement carbon pricing and take the lead to divest the city from fossil fuels.

Beyond decarbonising human activity, the world must remove excess anthropogenic carbon from the atmosphere. The Government should explore the various avenues for carbon sequestration including reforestation, mangroves, algae, and other technological solutions.

Most importantly, the Government needs a paradigm shift in setting policy objectives. Decarbonisation requires cross-bureaux collaboration; it cannot be the priority and responsibility of just one bureau. Climate change is happening and getting worse—Hong Kong has to act NOW.

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2 Introduction

Climate change is happening and getting worse—Hong Kong has to act NOW.

With just a 1°C warming, heatwaves, storm surges, heavy rainfall, and more have become more frequent and severe. Existing socioeconomic vulnerabilities are also exacerbated – such as food and water insecurity, spread of vector-borne diseases, and the elderly and the poor in coping with climate-related stresses.[1]

When the Paris Agreement was adopted in 2015, the intended contributions initially submitted by the countries were acknowledged as insufficient in limiting global warming to 2°C, let alone 1.5°C. All parties reached a consensus that they should scale up their ambitions and review their contributions by 2020. The Paris Agreement applies to Hong Kong as well; it is time for the city to develop stronger climate targets.

Young people around the world fear for their futures. The perceived lack of urgency from national governments and world leaders triggered a wave of movements like school strikes for climate and Extinction Rebellion.[2]

Many global cities have taken matters into their own hands and have already peaked their emissions,[3] while others have pledged to reach net zero emissions by 2050.[4] If Hong Kong is to maintain its high standard of living, it must reduce its emissions by at least 45% by 2030 and 100% by 2050.[5]

3 The Cost of Inaction

It is estimated that the cost to mitigate climate change requires the world to invest US$220-390 billion per year by 2030.[6] By comparison, climate change inaction will cost over US$16 trillion—around US$400 per tonne of CO_2.[7]

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1 Pielke, R.A., Climate Vulnerability
2 BBC, Extinction Rebellion: Climate protesters march on Parliament
3 C40, 27 Cities Have Reached Peak Greenhouse Gas Emissions whilst Populations Increase and Economies Grow
4 C40, 19 Global Cities Commit to Make New Buildings "Net-Zero Carbon" by 2030
5 IPCC, Global Warming of 1.5°C
6 Our World in Data, How much will it cost to mitigate climate change?
7 Nature, The costs of climate inaction

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These costs come in many forms. The increased frequency and severity of storms and floods destroying properties and displacing people;[8] rising sea levels leading to land loss in coastal regions;[9] warming temperatures devastating agricultural crop yields and fishery production;[10] heatwaves hospitalising the more vulnerable populace and more.[11]

Hong Kong has already seen some of these costs in the form of Typhoon Hato and Mangkhut. The two super typhoons led to property damage, business interruptions, and injuries, causing HK$8 billion and HK$3 billion in 2017 and 2018 respectively.[12] [13] Hong Kong must play an active role in combating climate change.

4 Why Set Targets Now?

The world is being pushed closer to several tipping points that could lead to abrupt and irreversible climate change. The runaway melting of glaciers and sea ice can upset or even stop the ocean current.[14] The warming and drying climate will cause dieback in the Amazon Rainforest and boreal forests.[15] Other important carbon sinks, such as peatlands and permafrost tundra, are also threatened by climate change to release their large stores of greenhouse gases into the atmosphere.[16]

Hong Kong's current targets are insufficient to achieve the 2°C scenario. The Intergovernmental Panel on Climate Change stated with high confidence that a half-degree difference between 1.5°C and 2°C will significantly magnify climate risks.[17] As a coastal city, Hong Kong is particularly vulnerable to climate change threatening people's health, livelihood, economic development, and more. To limit global warming

[8] National Oceanic and Atmospheric Association, Hurricane Florence
[9] World Bank, Risk of sea-level rise: high stakes for East Asia & Pacific region countries
[10] The Guardian, Heatwave in Europe set to push up UK food prices
[11] BBC, Europe heatwave: Why are temperatures on the continent soaring?
[12] SCMP, Typhoon Hato could cause HK$8 billion in losses after No 10 signal storm brought Hong Kong to standstill
[13] Insurance Asia News, Typhoon Mangkhut: Hong Kong's claims breakdown
[14] UCAR Center for Science Education, Melting Arctic Sea Ice and Ocean Circulation
[15] FAO, Climate-induced forest dieback: an escalating global phenomenon?
[16] Voigt *et al.*, Ecosystem carbon response of an Arctic peatland to simulated permafrost thaw
[17] IPCC, Global Warming of 1.5°C

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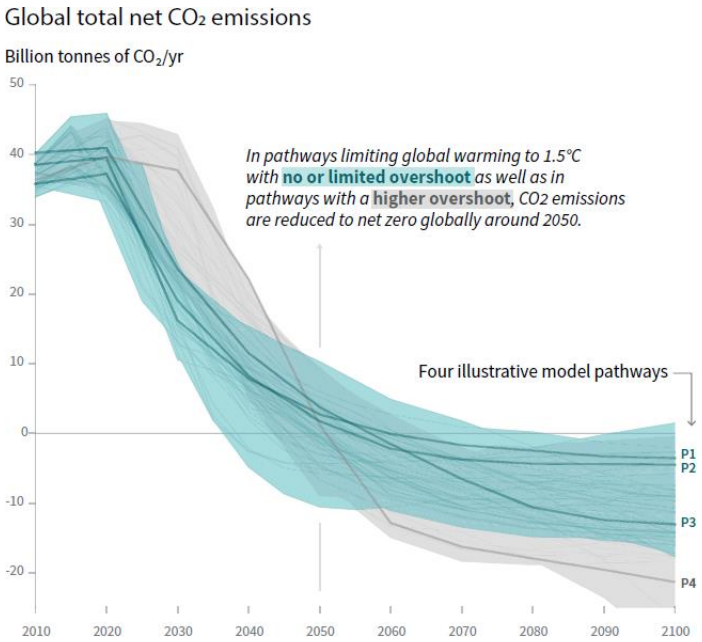
to 1.5°C, global emissions need to be cut by 45% from 2010 levels by 2030 and to reach net zero by around 2050.

In the longer term, the world has to remove excess anthropogenic greenhouse gas emissions from the atmosphere to limit the effects of runaway climate change. Pathways limiting global warming to 1.5°C with no or limited overshoot would require rapid and far-reaching mitigation measures. The Government must adopt the targets from the *Special Report on Global Warming of 1.5°C* and prepare a long-term strategy for rapid and deep decarbonisation before 2050.



Source: IPCC, Global Warming of 1.5°C

5 Emission Accounting

The Kyoto Protocol uses a production-based accounting framework for greenhouse gas emissions.[18] Internationally, greenhouse gas inventories also follow the guidelines and methodologies of the IPCC production-based GHG accounting framework.[19]

[18] Boitier, B., CO2 emissions production-based accounting vs consumption: Insights from the WIOD databases

[19] IPCC, Overview of the IPCC guidelines

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Production-based greenhouse accounting however is limited in addressing emissions embodied in international trade.[20]

A consumption-based accounting of carbon emissions shares responsibility amongst producers and consumers and facilitates dialogue that is hindered by concerns over inequity.[21] Assessing greenhouse gas emission across the entire value chain is essential to formulate climate mitigation measures. The Greenhouse Gas Protocol defines the accounting standard and classifies greenhouse gas emissions into three 'scopes'.[22] It provides an effective alternative in determining reduction opportunities, facilitating effective climate policies, and tracking performance.[23]

6 Barriers to Change

6.1 People

Hong Kong is a materialistic society. There is an overemphasis in Hong Kong on the prestige of material consumption—such as shopping, eating, driving, and more. The per-capita carbon footprint of Hong Kong is ranked second globally due to our overconsumption patterns.[24]

There is still a gap in consensus in public opinion and the scientific community on climate change. The lack of or poor understanding of climate change hinders mitigation and adaptation planning.

The individuals that constitute governments and institutions would reflect this knowledge and cultural bias in the decision-making process, limiting the effectiveness of climate policies and strategies. At the same time, the society may oppose proposed solutions if they believe climate risks are exaggerated. Knowledge alone may not be enough to spur action; cultural, institutional, and infrastructural changes are also needed to drive sustainable choices.[25]

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[20] Afionis, S. *et al.*, Consumption-based carbon accounting: does it have a future?
[21] Steven J. Davis and Ken Caldeira, Consumption-based accounting of CO_2 emissions
[22] World Resources Institute, Greenhouse Gas Protocol
[23] Davis, S.J. & Caldeira, K., Consumption-based accounting of CO_2 emissions
[24] Hong Kong's carbon footprint second highest in world
[25] European Commission, Emerging Visions for Future Sustainable Lifestyles

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6.2 Government

Of the three stakeholders, the government is the key and most influential actor by being able to set policies and legislations. The Hong Kong Government prefers to take a passive approach—using knowledge to create spillover in the community and letting the industry to manage themselves.

Climate change however requires governments to take proactive actions and to make ambitious, bold, and sometimes controversial changes. Businesses and industries rely on the local government's policies and targets in setting their own strategies.

The use of GDP and economic growth to measure prosperity and well-being also undermines long-term decarbonisation and sustainable development planning.

6.3 Industries and commerce

The current economic model prioritises short-term profit to maximise shareholder value, with little regards for long-term sustainable performance. Environmental matters are still not integral to many C-suite decision makers, and climate change is not an essential material aspect in business considerations. Although more organisations are now taking into account of how climate change will affect future business operations, these are usually restricted to industries where climate change has an imminent and direct impact. Moreover, the high investment and capital expenditure of developing green solutions deter organisations from adopting them.

7 Opportunities for Change

7.1 Energy supply

7.1.1 Smart Grid

Smart grids integrate information technology into the electricity transmission and distribution network to provide two-way communication. Real-time feedback of demand allows grid operators to make significant efficiency improvements and empower end-users to make informed decision on their energy use.[26] Smart grids

[26] Global Intelligent Utility Network Coalition, The Impact of Smart Grid on Climate Change

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further enable the use of complementary solutions such as smart meters and time-of-use rates. The Government currently only plans to explore the feasibility of smart grids in the long term.[27]

- **The Government must fast track the transformation of Hong Kong's electricity grid into a smart grid**

7.1.2 Develop renewable energy

Over 66% of Hong Kong's emission comes from electricity generation. [28] Decarbonising the electricity grid is thus one of the most direct and effective means for Hong Kong to reduce its carbon footprint. While the Government aims to replace coal with natural gas, it is not a climate-friendly substitute. Methane, the main ingredient in natural gas and a potent greenhouse gas, can leak into the atmosphere during extraction, transportation, and storage processes.[29] It is estimated that a 2-3% leakage rate would offset any benefits of replacing coal.[30] Using natural gas as a bridge fuel only prolongs the process of decarbonisation and delays the adoption of renewable energy.[31]

Hong Kong benefits from a fair amount of wind and solar resources as a coastal city near the equator. Many government facilities and public spaces, such as rooftops, parks and reservoirs, treatment plants and more, would benefit from the creative deployment of solar panels. Solar energy is already cost competitive with fossil fuels in 2017 and is predicted to halve by 2020.[32] Moreover, the city particularly has a high potential for onshore and offshore wind farms, of which the technology is maturing and has become viable for Hong Kong.[33]

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27 GovHK, Consultancy Study Report

28 EPD, Greenhouse Gas Emissions in Hong Kong by Sector

29 The New York Times, The Natural Gas Industry Has a Leak Problem

30 Wigley, T.M.L., Coal to gas: the influence of methane leakage

31 Zhang, X., *et al.*, Climate benefits of natural gas as a bridge fuel and potential delay of near-zero energy systems

32 IRENA, Onshore Wind Power Now as Affordable as Any Other Source, Solar to Halve by 2020

33 Lo, K., Renewable Energy Development in Hong Kong: Potential, Progress, and Barriers

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Beyond public land, home-scale renewable energy should be promoted by removing technical and policy barriers.[34] For example, Minor Works limits the maximum height of solar panels to no more than 1.5 meters above rooftops. The lack of a strong government target on renewable energy also dampens public enthusiasm.

- **The Government must target to completely phase-out fossil fuels by 2050**
- **The Government must facilitate the uptake for solar energy by removing regulatory barriers and providing incentives**
- **The Government must expedite the development of wind farms in Hong Kong**

7.1.3 Hydrogen

Full electrification of energy consumption may be difficult, particularly with some industrial processes and transportation modes.[35] Hydrogen can provide flexibility in decarbonising the energy sector. Both the European Union and Japan have laid out roadmaps to develop the hydrogen economy to replace natural gas.[36] [37]

- **The Government should develop a roadmap for a hydrogen economy**

7.1.4 Enhance regional collaboration

Hong Kong and Guangdong have a long-term strategic partnership in energy supply.[38] It is however restricted to conventional energy sources such as natural gas and nuclear power. China has showed sustained rapid growth in renewable energy development. The total installed capacity of renewables in China exceeded 720 gigawatts by the end of 2018, more than 11% year-over-year increase.[39] Since China will likely exceed the target of obtaining 20% of its energy from renewables by 2030[40], they stepped up

[34] Asian Energy Studies Centre, Hong Kong's Solar PV Future
[35] Totten, M.P., Flourishing Sustainably in the Anthropocene? Known Possibilities and Unknown Probabilities
[36] European Commission, Hydrogen Roadmap Europe
[37] Ministry of Economy, Trade and Industry, Base Hydrogen Strategy
[38] Hong Kong: The Facts, Power and Gas Supplies
[39] ECNS, Renewable energy powers up in 2018 with fast growth
[40] SCMP, China steps up green energy push with revised renewable target of 35 per cent by 2030

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renewable energy push with a revised target of 35% by 2030. China clearly shows its ambition to become a global leader in clean energy shift.

Cross-border collaboration could make better use of resources and lower the cost of renewable energy development. For example, Australia's Northern Territory plan to develop the world largest 10 gigawatts solar farm near Tennant Creek to power Singapore via 3800 km subsea cables.[41]

- **At a regional scale, Hong Kong Government must consider collaborating with the Greater Bay Area to gain access to the abundant renewable energy sources nearby**

- **Hong Kong can serve as the technology and green finance hub for renewable energy development[42]**

7.1.5 Market liberalisation

Over the past few decades, the electricity market has been liberalised in many countries. The reform involves the key element of introducing competition in traditionally state-owned and/or monopolies sectors. [43] Market liberalisation empowers alternative energy suppliers to enter the market, allowing for more decentralised energy generation and sustainable renewable energy to thrive.[44] It has shown to have increased public support for renewable energy in OECD countries.[45]

A greater level of interconnection between the two power utilities will enable exchange of peak load and increase generation capability, efficiency and reliability.[46] It also reduces capital cost for building new capacity through the sharing of reserve capacity. Moreover, increasing interconnection facilitates new entrants into future market development and make it easier to manage variable renewable energy sources like solar and wind.[47]

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41 Reuters, Australian territory gives major status to solar plan by Singapore's Sun Cable
42 Daphne M., *et al*., Managing the transition towards a low-carbon economy
43 Paul L. Joskow, Lessons Learned From Electricity Market Liberalization
44 Nicolli, F., Vona, F., Energy market liberalization and renewable energy policies in OECD countries
45 Francesco N., Francesco V., Energy market liberalization and renewable energy policies in OECD countries
46 Mohammad A.S. Masoum, Ewald F. Fuchs, Power Quality Solutions for Renewable Energy Systems
47 European Commission, Electricity interconnection targets

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- **The Government should liberalise the market to create opportunities for new competition, technologies and sustainable renewable energy**

7.2 Buildings

7.2.1 Building energy codes and design

The building sector is the major source of carbon emission in Hong Kong. About 90% of electricity generated goes to meet building energy demands. Space conditioning is the largest end-use, followed by lighting.[48] High demand for space conditioning is attributed to both the local climate and the generally poor building envelope in Hong Kong; this results in excessive heat gain during summertime and heat loss during winters.[49]

Climate change is also making heatwaves more intense and frequent, driving up the demand for air conditioning.[50] Building envelopes play a significant role in reducing building energy consumption. A high-performance building envelope for a hot and humid climate should harvest daylight, block unwanted solar gain, improve heat dissipation, and enhance natural ventilation.[51]

The Overall Thermal Transfer Value (OTTV) and Residential Thermal Transfer Value (RTTV) need to be reviewed and tightened in order to control the amount of heat transferred through the building envelope.[52] [53] A more stringent U-value should encourage the use of more thermal insulation and double-glazed windows.

Green financing can also be set up to encourage building owners to renovate existing buildings.[54] Many cities provide grants or low-interest loans to both homeowners and

[48] EMSD, Hong Kong Energy End-use Data 2018
[49] Kwok, Y.T. *et al.*, The influence of building envelope design on the thermal comfort of high-rise residential buildings in Hong Kong
[50] Nature, Climate change made Europe's mega-heatwave five times more likely
[51] Attia, S., A Tool for Design Decision Making Zero Energy Residential Buildings in Hot Humid Climates
[52] Hui, S.C.M., Overall Thermal Transfer Value (OTTV): How to Improve Its Control in Hong Kong
[53] Buildings Department, Design and Construction Requirements for Energy Efficiency of Residential Buildings
[54] European Bank for Reconstruction and Development, Scaling Up Finance for Energy Efficiency Refurbishments of Buildings:

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companies to install renewable energy facilities and pursue energy efficiency retrofits.[55]

- **The Government must update and strengthen the building energy codes regularly to ensure a continual reduction in building energy use and to reach zero emission by 2050**

- **The Government must tighten the building energy codes for all new buildings and mandate renovation and retrofit of existing buildings to enhance their energy efficiency**

7.2.2 Building operation

Beyond more energy-efficient building designs, building energy management system and smart meter integration can enable finer control over consumption patterns.[56] Paired with time-of-use rates, smart meters enable end-users to better budget their electricity use, avoid price volatility and enjoy electricity savings.

Moreover, the electricity tariff system should be reformed with progressive pricing to better moderate use and peak loads.[57] These measures allow Hong Kong to transition towards an electricity grid that is reliant on variable energy sources.[58]

- **The Government must work with the power companies to expedite the installation of smart meters in all residences**

- **The Government must mandate buildings to install a building energy management system**

7.2.3 Energy utilisation index

Real estate listings should incorporate information on the building's energy efficiency to enable transparency and drive demand for greener homes.[59] Although building

[55] ACEEE, Incentives and Financing for Efficient Buildings and Renewable Energy
[56] Albadi, M.H. & El-Saadany, E.F., A summary of demand response in electricity markets
[57] Centrum Wiskunde & Informatica, Balancing supply and demand in future energy systems
[58] Sinn, H.-W., Buffering volatility: A study on the limits of Germany's energy revolution
[59] CNT Energy and the National Home Performance Council, Unlocking the Value of an Energy Efficient Home

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owners in Hong Kong are mandated to conduct regular energy audits, the building's performance is not made easily available for public reference. Buildings in the European Union countries are obligated to show their energy performance certificates to prospective tenants and buyers.[60]

- **The Government must mandate building owners to show greater transparency with their building energy performance**

- **The Government must mandate building owners to take remedial measures after auditing to enhance building energy performance**

7.2.4 Embedded carbon

Building materials such as steel, glass and concrete are carbon-intensive but often not accounted for. Embedded carbon in building materials makes up for 20% of a building's lifecycle emission and as much as a-half in low-energy buildings.[61] Given the degree of rapid urbanisation planned for Hong Kong, it is imperative that the Government acknowledge the embedded carbon hidden within buildings. Low-carbon materials such as recycled metals and green concrete using recycled waste aggregate are available on the market.[62] [63] Carbon sink building materials like wood and bamboo products can also replace some of the demand for steel and concrete.[64]

- **The Government must obligate all building to perform life cycle assessments, including embedded carbon and building operations**

7.3 City transportation

7.3.1 Develop green transport

[60] European Commission, Certificates and inspection

[61] Williams, D. *et al.*, Climate change influence on building lifecycle greenhouse gas emissions: Case study of a UK mixed-use development

[62] Martchek, K.J., The Importance of Recycling to the Environmental Profile of Metal Products

[63] D'Alessandro, A., *et al.*, Innovative concretes for low-carbon constructions: a review

[64] Lou, Y., *et al.*, Bamboo and Climate Change Mitigation

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Transportation contributes to around 18% of the local greenhouse gas emission in Hong Kong.[65] Private cars in particular make up for 25% of the sector's energy demand, and increasing to 37% when considering for passenger movement purposes only and excluding freight.[66] Despite the energy demand, private cars only account for 12% of passenger trips of all kinds, making them an inefficient transportation mode.[67] Private cars also lower the fuel efficiency of other vehicles by congesting traffic and taking up as much as 70% of road space on major roads.[68]

There have been a number of recent railway system failures with serious repercussions.[69] The Government should continue to work with public transport operators to strengthen the public transportation system. Road transportation should be electrified to reduce the demand for fossil fuel, which will come with the additional benefit of reducing roadside air pollution emission.[70]

Hydrogen vehicles are an alternative to be considered. Hydrogen fuel cells have higher energy density than lithium ion batteries in electric vehicles, making them suitable for heavier commercial duties.[71] As mentioned in Section 7.1.3, both the European Union and Japan have prepared a roadmap for developing hydrogen energy infrastructure within their respective regions.[72] [73]

- **The Government must curtail the city's dependence on private cars through policies such as implementing congestion pricing and low-emission zones and capping private car ownership**

- **The Government should expand electric vehicle incentives for public transportation and extend it to commercial light goods vehicles**

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65 EPD, Greenhouse Gas Emissions in Hong Kong by Sector
66 EMSD, Hong Kong Energy End-use Data 2018
67 TD, Travel Characteristics Survey 2011 Final Report
68 Transport Advisory Committee, Report on Study of Road Traffic Congestion in Hong Kong
69 SCMP, Signalling system blamed for Hong Kong MTR collision was also behind 2017 crash at Joo Koon station on Singapore MRT
70 Techcrunch, First buses, now Shenzhen has turned its taxis electric in green push
71 The International Council on Clean Transportation, Developing hydrogen fueling infrastructure for fuel cell vehicles: A status update
72 European Commission, Hydrogen Roadmap Europe
73 Ministry of Economy, Trade and Industry, Base Hydrogen Strategy

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- **The Government should explore the feasibility of hydrogen vehicles**

- **The Government must align with international cities to plan for the retirement and banning of all vehicles with internal combustion engines by 2030[74] [75]**

7.3.2 Promote walking and cycling

Walking and cycling are environmentally friendly ways to get around the city. They help complement public transportation by connecting the first and last mile of the journey.[76] In addition to being low-carbon and healthy, both walking and cycling provide indirect benefits by alleviating transport demand. Fewer vehicles on the road will reduce road network strain, road maintenance and repair cost, and roadside air and noise pollution.

Although Hong Kong is considered very efficient to walk,[77] the walking experience is generally uncomfortable and uninteresting.[78] Walkability in Hong Kong can be improved by installing amenities like soft landscaping, shading, seating areas, and water fountains; widening footpaths where possible; planting street trees to block roadside pollution and more. The pedestrian network should be well connected. Footbridges and underpasses should not be relied as a primary means for pedestrian access, as they are unfriendly to the elderly and disabled.

Cycling is a commuting option overlooked by city planners and treated mostly as a recreational activity.[79] Dedicated cycling lanes should be planned in all areas; a comprehensive cycling network should be set up to connect districts; bicycle-parking, showering and changing facilities should be integrated into the building code.

- **The Government should improve the city's accessibility via enabling more street-level walking**

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[74] The Guardian, Amsterdam to ban petrol and diesel cars and motorbikes by 2030

[75] BBC, Ireland to ban new petrol and diesel vehicles from 2030

[76] Chidambara, C., Pedestrian Environment Influence on 'Walk' As A Choice For Last Mile Connectivity (LMC) To Transit Stations: A Case of Delhi Metro

[77] SCMP, Global study on walking puts Hong Kong a step ahead

[78] Civic Exchange, Measuring and Improving Walkability in Hong Kong

[79] TD, Cycling Study

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- **Hong Kong can become a bicycle-friendly city, but it requires the Government to change its policies and recognise cycling as a legitimate transportation mode**

7.4 Maritime shipping

As the world becomes increasing interconnected and globalised, the carbon footprint of international trade will grow. Maritime shipping is the dominant mode for trading international goods and responsible for around 3% of global greenhouse gas emission.[80] Hong Kong is one of the major and busiest ports in the world. Although the Government cannot regulate ships while they are in international waters, they can still control portside emissions. Ships should use shore-side electricity to reduce emissions while at berth.[81]

- **The Government must include the emission of marine vessels moving within Hong Kong waters as part of the city's carbon footprint**

- **The Government should follow international practice and develop shore-side electricity infrastructure**

7.5 Aviation

Aviation emissions account for more than 2% of global emissions and are expected to grow as much as 700% from 2005 by 2050.[82] The aviation sector cannot be excluded in developing the long-term decarbonisation strategy.

While it is difficult to regulate emissions coming from outside of Hong Kong, there are still avenues for decarbonisation. The HKIA can reduce aviation emission by providing sustainable biofuels to refuel aircrafts.[83] Aircrafts with electric taxiing systems can reduce fuel consumption on the ground.[84]

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80 International Maritime Organization, Third IMO GHG Study 2014

81 NOW, Support for Environmentally Friendly On-board and Mobile Shore-Side Power Supply For Inland and Seagoing Vessels

82 European Commission, Reducing emissions from aviation

83 Swedavia Airports, Biofuel used for refuelling at five Swedavia airports

84 Lukic, M., *et al.*, State of the Art of Electric Taxiing Systems

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- **The Government must include the carbon emission of aircraft within Hong Kong airspace into their scope of emissions**

- **The Government should also enable and encourage local airlines to adopt electric taxiing systems to reduce emissions from taxiing airplanes**

7.6 Waste management

Waste is the third largest source of Hong Kong's local greenhouse gas emissions. Food waste accounts for over one-third of the city's municipal solid waste disposed of at landfills, but just one percent is collected for recycling.[85] Food waste not only produces methane in landfills; they also contribute to inefficiencies in carbon-emitting activities throughout the entire food supply chain.[86] O·PARK1, which went into operation late last year, can only handle a fraction of the food waste produced.[87]

- **The Government must ramp up the scale of food waste reduction, recycling and recovery in the city, including food redistribution, bioconversion, and energy recovery**

7.7 Water

The Water Supplies Department is a major consumer of electricity in Hong Kong—around 1% of local electricity demand comes from supplying the city with freshwater.[88] It is estimated that about 15% of freshwater is lost to leakage in public mains, creating excessive resource waste.[89] Hong Kong's per-capita water consumption is also well above the global average.[90]

- **The Government must expedite replacement of aged public distribution pipework while enforcing building owners to repair or upgrade private pipework and fittings**

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85 EPD, Monitoring of Solid Waste in Hong Kong; Waste Statistics for 2017
86 FAO, Food wastage footprint & Climate Change
87 EPD, O.PARK
88 WSD, Water Supplies Department Annual Report 2017/18
89 WSD, Leakage Rate of Government Mains
90 Hong Kong Free Press, Why Hong Kong urgently needs to tackle its water problem

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- **The Government must make the Water Efficiency Labelling Scheme mandatory and obligate the use of certified appliances and tapware**

- **The Government should encourage better water consumption behaviours through education and tariff reforms**

7.8 Food

Food comprises of a significant portion of Hong Kong's invisible emission. Hong Kong is highly dependent on imports to satisfy its high-consumption lifestyle,[91] relocating carbon-intensive production beyond its borders. Under a consumption-based approach, the city's per-capita emission is comparable to that of the United States.[92]

Hong Kong's consumption-based greenhouse gas emission largely comes from the populace's heavy meat and dairy consumption; pursuing a dietary change to a healthier diet could cut livestock-related emissions by almost 70%.[93] In fact, a group of experts published a set of dietary guidelines early this year, recommending a switch to a plant-based diet to feed 10 billion people healthily and sustainably.[94] Eating less meat also provides significant health benefits of reducing the risk of stroke, coronary diseases, type-2 diabetes, and colorectal cancer and avoiding as much as 2.4 million deaths worldwide.[95]

- **The Government must strongly promote more healthy and sustainable dietary patterns as part of its long-term decarbonisation strategy**

7.9 People

Green technologies and policy strategies will enable individuals and organisations to decarbonise. However, their effectiveness depends on the society's acknowledgement of climate change–whether it is the policymakers writing the laws and regulations, the

[91] Audit Commission, Centre for Food Safety: Import control of foods
[92] Our World in Data, Global inequalities in CO_2 emissions, based on consumption
[93] Yau Y.Y. *et al.*, Impact of cutting meat intake on hidden greenhouse gas emissions in an import-reliant city
[94] Willett, W., *et al.*, Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems
[95] Springman, M., *et al.*, Health-motivated taxes on red and processed meat: A modelling study on optimal tax levels and associated health impacts

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institutions adapting to new environmental policies, or people adopting sustainable lifestyles. People are also more likely to take climate actions if it aligns with their worldview.[96] Paris recently announced it would create a "climate academy" to educate the public on climate change.[97] The Government should not just rely on outreach to raise public awareness but also educating the next generation at a young age.

The growth in the environmental sector and greening of existing industries are unlocking new job opportunities. A shift to a greener economy could create 24 million jobs worldwide by 2030.[98] The nature and scope of existing jobs may evolve, requiring new skills and competencies.[99] The Government should raise interest amongst the younger generation of green career opportunities.[100]

- **The Government must implement climate and sustainability education in schools to complement technological solutions and policy interventions**
- **The Government should offer vocational training and certification programmes to prepare skilled labour for the green transformation**
- **The Government should develop its own "climate academy", addressing:**
  - **The impact and geopolitical implication of climate change on the society**
  - **Changes needed to transition to a low-carbon world (sustainable fuels, renewable energies, alternative transport modes, etc.)**
  - **New opportunities and careers in a zero-carbon economy**
  - **Measures to encourage sustainable behaviours (carbon labelling, incentives, etc.)**

[96] Hornsey, M.J., *et al.*, Meta-analyses of the determinants and outcomes of belief in climate change
[97] France24, Paris declares 'climate emergency'
[98] UN Sustainable Development Goals, Green economy could create 24 million new jobs
[99] European Centre for the Development of Vocational Training, Green skills and environmental awareness in vocational education and training
[100] UNIDO, Green Industry: Policies for supporting Green Industry

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7.10 Carbon pricing

Carbon-emitting activities are often subsidised directly by financial instruments like tax credits or indirectly by neglecting the negative externalities of climate change. It is estimated that fossil fuels are subsidised at US$5.2 trillion globally.[101] Further, technology-driven solutions may create a rebound effect when people believe they now have a moral license to consume more.[102]

Carbon pricing implements the polluter pays principle for greenhouse gases, which can act as a corrective measure and internalise the cost of not mitigating climate change. Today, around 40 countries and over 20 states and cities have implemented some form of carbon pricing.[103] In British Columbia, the carbon tax has helped reduced the province's carbon emissions by 5-15% over a four-year period with little impact on economic performance.[104] The Government could consider including revenue-recycling mechanisms – such as tax rebates or funding green investments – to improve its desirability and sustainability.[105]

- **The Government must urgently develop and implement a carbon pricing system**

7.11 Carbon reporting

The Government requires accurate data to assess the city's decarbonisation progress. Today, more than 40 countries have introduced mandatory carbon reporting which allows policymakers to trace greenhouse gas emissions sources and trends.[106] The Hong Kong Exchanges and Clearing currently required listed companies to disclose

[101] IMF, Global Fossil Fuel Subsidies Remain Large: An Update Based on Country-Level Estimates
[102] European Council for an Energy Efficient Economy, Energy sufficiency and rebound effects
[103] World Bank, Pricing Carbon
[104] Murray, B.C. and Rivers, N., British Columbia's revenue-neutral carbon tax: A review of the latest "grand experiment" in environmental policy
[105] International Council on Mining & Metals, Options in recycling revenues generated through carbon pricing
[106] World Resources Institute, A Global Look at Mandatory Greenhouse Gas Reporting Programs

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their environmental, social, and governance performance under a "comply or explain" approach.[107] [108]

- **The Government must mandate the disclosure of greenhouse gas emissions from all sources to guide Hong Kong's decarbonisation strategy**

7.12 Continuing Mitigation

In addition to above recommendations, the Government should continue to enhance the following ongoing mitigation measures:

- Strengthen the building energy codes;
- Mandate and publicise the reporting of Energy Utilisation Index for all buildings;
- Install charging stations for EVs;
- Retrofit air-conditioning systems with variable speed drives;
- Replace street lamps and traffic signals with LEDs;
- Install distributed RE generation in all public premises;
- Expand the food waste-sewage sludge anaerobic co-digestion system in sewage treatment plants;
- Expand the scope of the green procurement list and promote to business sectors;
- Expedite the urban forestry and ecological management strategy;
- Promote sustainable agricultural development through the new agricultural policy;
- Retro-commission existing building to optimise energy efficiency

[107] HKEX, Listing Rules, Interpretation & Guidance - Appendix 27 Environmental, Social and Governance Reporting Guide

[108] Downar, B. *et al.,* Fighting Climate Change with Disclosure? The Real Effects of Mandatory Greenhouse Gas Emission Disclosure

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8 Green finance

Decarbonising Hong Kong requires significant investments into new infrastructures and technologies. The world is expected to invest about US$90 trillion on climate mitigation and adaptation measures by 2030.[109] The launch of the HK$100 billion green bond programme and the signing of the Green Bond Pledge is a big step forward for Hong Kong's green financial market.[110] [111]

High-profile fossil fuel divestments by large institutional actors are essential to shift towards a low or zero carbon economy.[112] Today, over 1,000 institutions with portfolios worth almost US$8 trillion have committed to divest from fossil fuel companies.[113] The Hong Kong Monetary Authority Investment Portfolio alone commands around US$450 trillion of assets;[114] it would send a strong signal to other asset owners and asset managers if it were to divest.

The green financing and investing ecosystem is driven by readiness of asset owners to integrate ESG considerations in their strategies. All asset owners, endowments, charities and foundations need to align their investment policies with the *Principles of Responsible Ownership* by the Securities and Futures Commission (SFC).

- **The Government should capture the green finance potential from the Belt and Road Initiative to solidify Hong Kong as the regional leader in green finance**
- **The Government must take the lead on fossil fuel divestments**
- **The Government must enable green subsidies, low-interest loans or tax breaks to incentivise business to reduce carbon emissions**

[109] The New Climate Economy, The New Climate Economy 2016
[110] GovHK, Gov't backs green financing
[111] Climate Bonds Initiative, HKSAR Government signs the Green Bond Pledge: First signatory from Asia
[112] Royal Dutch Shell, Annual Report 2018, Risk factors
[113] Fossil Free, 1000 Divestment Commitments and Counting
[114] Willis Towers Watson, Thinking Ahead Institute reveals the "most influential capital on the planet"

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- **The Government—specifically the Financial Secretary Office—should fully adopt the *Environmental, Social and Governance (ESG) Strategy for Hong Kong* by the Financial Services Development Council**

- **SFC should take a 'comply or explain' approach for the *Principles of Responsible Ownership* in the near-term and mandating its adoption in the longer term**

- **The Hong Kong Monetary Authority must scale up the ESG requirements for their external investment managers**

- **The Government should budget for green finance training and education for industry practitioners and the general public**

9 Beyond Zero Carbon - Carbon Removal

9.1.1 Reforestation

Large-scale restoration of forests is one of the most effective means to capture atmospheric carbon; it may remove as much two-thirds of all anthropogenic carbon emissions produced since the industrial revolution.[115] Although Hong Kong's countryside is covered by swathes of forests, it is dominated by a small variety of exotic species with low ecological value from early afforestation efforts.[116]

- **The Government should devote more resources to expand and promote healthy forests to aid in decarbonisation efforts**

9.1.2 Mangrove restoration

Hong Kong possesses a little over 500 hectares of mangroves.[117] Mangroves are highly productive, carbon-rich biomes. Besides the numerous ecological services they already provide, they store several times more carbon than other forest types, playing an important role as carbon sinks.[118]

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115 Bastin, J.-F. *et al.*, The global tree restoration potential

116 AFCD, Country Parks Plantation Enrichment Programme

117 AFCD, Distribution

118 Donato, D.C. *et al.*, Mangroves among the most carbon-rich forests in the tropics

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- **The Government should play an active role in conserving and rehabilitating mangroves**

9.1.3 Algae farms

Algae are another means for biosequestration. Microalgae in particular are more efficient than land plants in fixing carbon.[119] Harvested algae can be converted into food ingredients, pharmaceutical products or biofuels—substituting fossil fuels.[120] In addition, algae bioreactors have a relatively small footprint, allowing to be installed creatively such as the building façade.[121]

- **The Government should promote the use of algae to capture carbon**

9.1.4 Carbon capture and storage

Besides tree planting, bio-energy with carbon capture and storage, direct air capture through engineered chemical reactions, seawater capture, and enhanced weathering of rocks can also absorb and bind carbon dioxide chemically.[122] For instance, the Northern South China Sea is assessed to be suitable for sub-seafloor carbon capture and storage.[123] Different carbon removal technologies have different risks and benefits.

- **The Government should invest in research and development to explore the different carbon removal strategies to address climate change without unintended consequences**

10 Policy Orientation

The Government is the biggest and most significant player in driving large-scale changes. Policymakers and legislators have the tools in place to facilitate

[119] Bhola, V. *et al.*, Overview of the potential of microalgae for CO^2 sequestration
[120] Khan, M.I. *et al.*, The promising future of microalgae: current status, challenges, and optimization of a sustainable and renewable industry for biofuels, feed, and other products
[121] ARUP, SolarLeaf, the world's first bio-reactive façade
[122] World Resources Institute, Carbon Removal
[123] Li, P. *et al.*, Potential of Sub-seafloor CO2 Geological Storage in Northern South China Sea and its Importance for CCS Development in South China

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decarbonisation strategy, but the traditional emphasis on business and economic growth hinders policymaking and implementation. This laissez-faire approach is reflected in Hong Kong's other environmental policies—a reliance on voluntary actions from businesses and individuals. Societal shifts however are difficult if climate change is not regarded as an urgent problem and if the new practices are not comfortable, safe and/or desirable. The Government needs to intervene and make sustainable living the social norm.

The Government needs a paradigm shift in setting policy objectives, with an emphasis on environmental protection as an overarching goal. Decarbonisation requires cross-bureaux collaboration; it should not be the priority of just one bureau. The Government needs to reorient themselves to enable decarbonisation and not restrain it.

11 Conclusion

Climate change is threatening people's livelihood right now. Heatwaves, storm surges, heavy rainfall, and more have become more frequent and severe. Hong Kong is particularly vulnerable to the impacts of climate change as a coastal city.

For every tonne of carbon put into the atmosphere unmitigated, the world moves closer to the point of no return. Global emissions need to be cut by 45% from 2010 levels by 2030 and to reach net zero by around 2050 to limit global warming to 1.5°C. Hong Kong's current climate targets are far from sufficient in meeting its share of responsibilities.

Many global cities have already peaked their emissions, while others have pledged to reach net zero emissions by 2050. If Hong Kong is to maintain its high standard of living, it must adopt the targets from the *Special Report on Global Warming of 1.5°C* and prepare a long-term strategy for rapid and deep decarbonisation before 2050.

Climate change is happening and getting worse—Hong Kong has to act NOW.

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