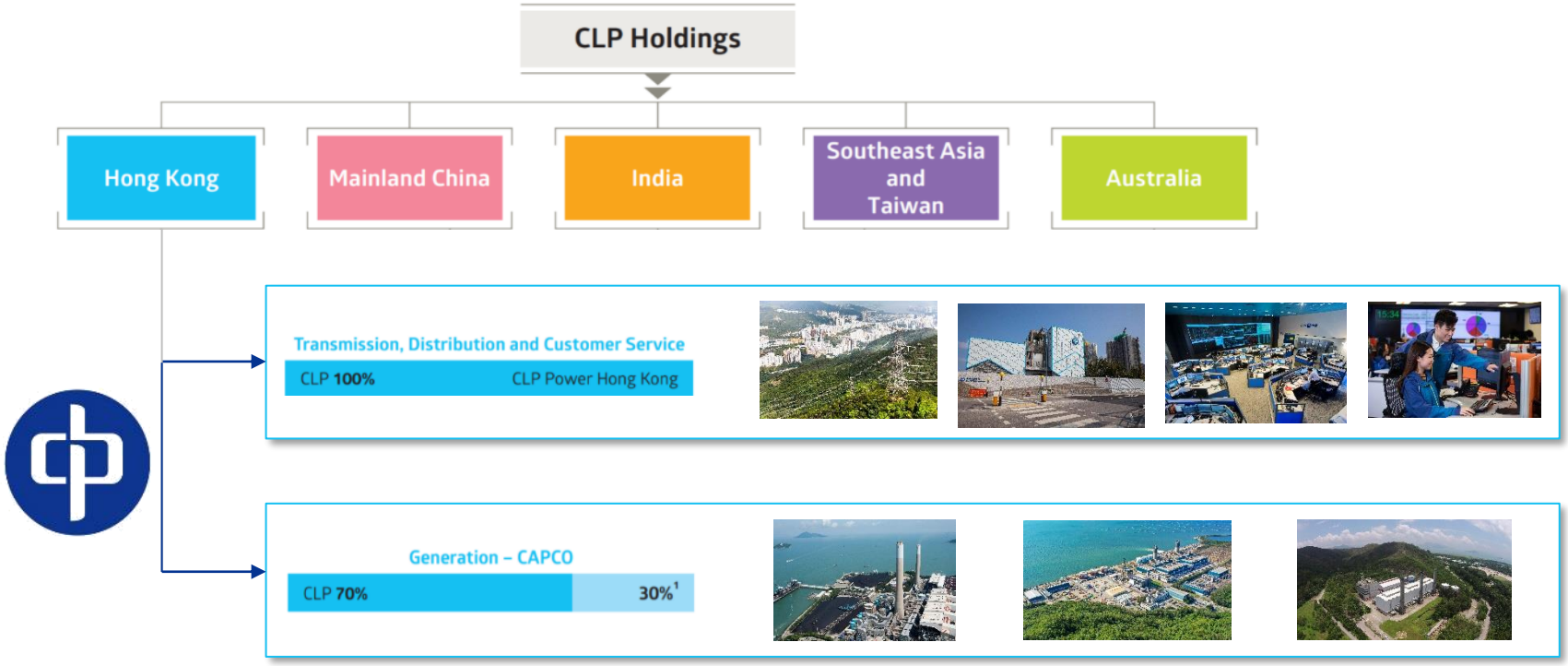
Powering a Carbon Neutral Hong Kong

Thomas Lui
Associate Director – Decarbonisation Architecture

10 May 2024

Energy for Brighter Tomorrows

CLP serves more than 80% of HK's population



CLP 中電

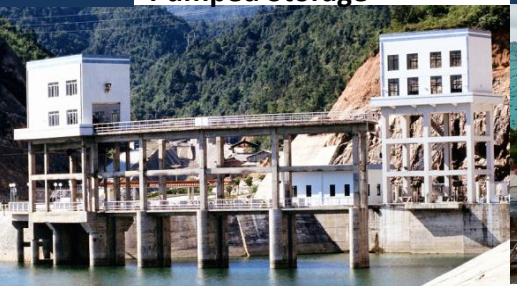
(1) 30% of CAPCO is held by China Southern Grid International HK Ltd.

CLP's diversified power generation fuel mix for HK

Nuclear Daya Bay Nuclear Station

Natural Gas Black Point Power Station

Hydro Guangzhou Pumped Storage



Landfill Gas WE Station

Coal Castle Peak Power Station

Oil Penny's Bay Power Station

Electricity fuel types

Coal

Public concerns

CO_2 & air emissions

Price today

Reliability

Natural Gas

Price today

CO_2 & air emissions

Public concerns

Reliability

Nuclear

Public concerns

CO_2 & air emissions

Price today

Reliability

RE

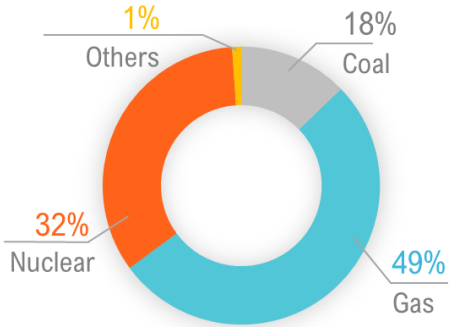
Price today

Reliability

CO_2 & air emissions

Public concerns

Fuel Mix in 2023



Note: Others include oil, energy from waste and electricity generated under FiT Scheme

CLP significantly improved environmental performance in HK

1994
Nuclear Power from Daya Bay

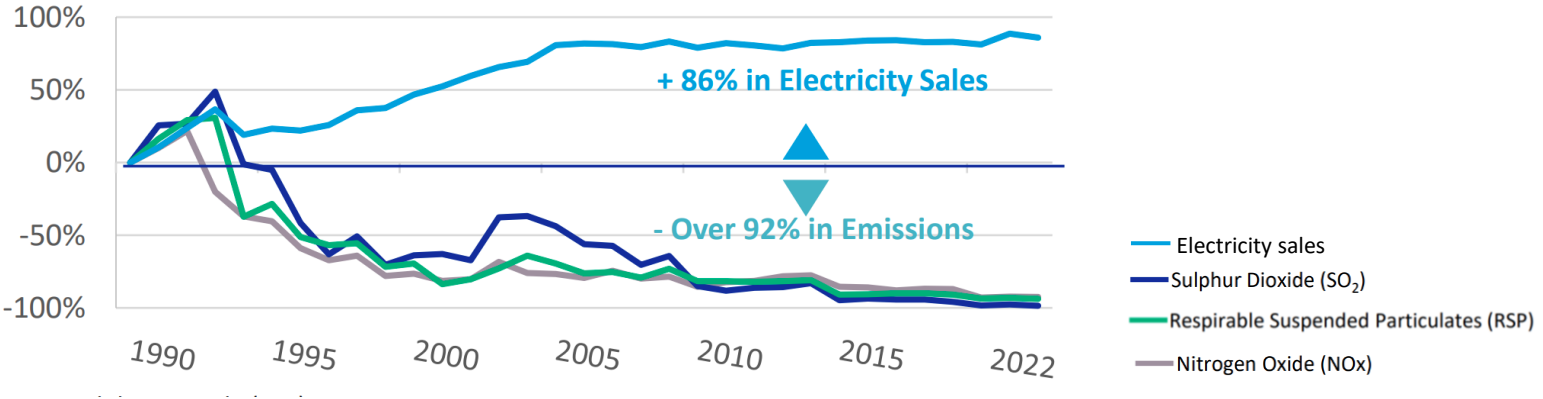
1996
Natural Gas at Black Point Power Station

2010-2011
Castle Peak Power Station Emissions Control Enhancement

2013
West-East Pipeline Gas for Black Point Power Station

2020 - 2024
New gas-fired generation units at Black Point Power Station commissioned
Hong Kong offshore liquefied natural gas (LNG) terminal went into operation

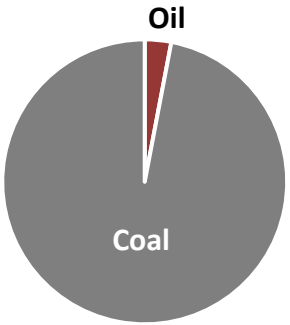
Environmental Improvement of CLP



Transition from coal to nuclear and natural gas reduces carbon emission

CLP Electricity Fuel Mix Evolution

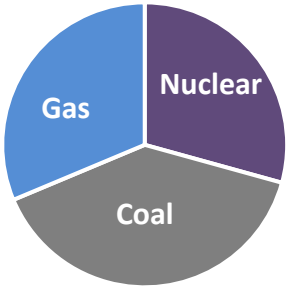
1990
~ 0.9 kg CO_2/kWh



import nuclear power

develop gas power

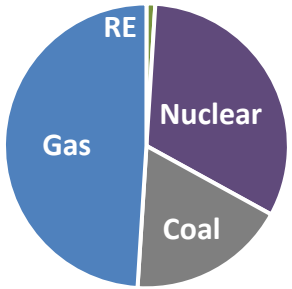
2005
~ 0.5 kg CO_2/kWh



increase nuclear power

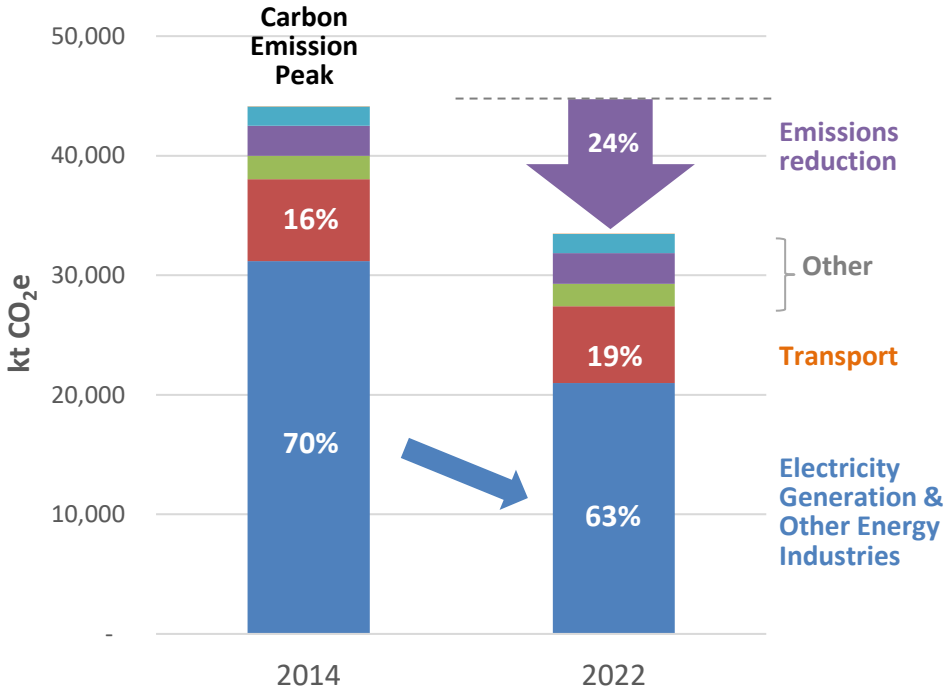
increase gas power

Today
< 0.4 kg CO_2/kWh



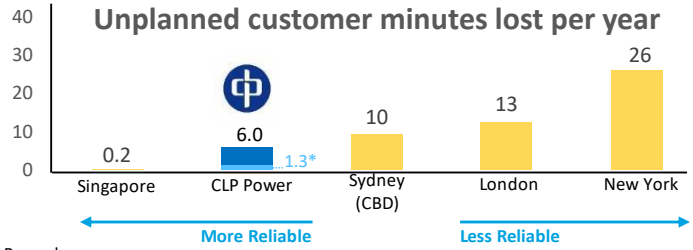
HK reducing carbon emission with high reliability and reasonable tariff

HK's Greenhouse Gas Emissions are reducing…

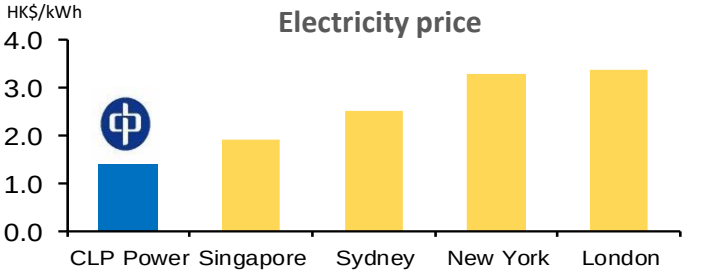


SOURCE: Greenhouse Gas Emissions in HK (by Sector) up to 2022, EPD, Nov 2023

…with high reliability and reasonable tariff



Remarks:
(1) *2021-2023 average for CLP Power was 6.0 minutes; Taking out the impact due to cable bridge fire incident in Yuen Long, the three-year average was 1.3 minute
(2) 2020-2022 average for all other cities
(3) There are no overhead lines in Singapore



Remarks:
Comparison based on monthly domestic consumption of 275kWh
Tariff and exchange rate in Jan 2024

Carbon emission is increasingly a global concern due to worsening climate change

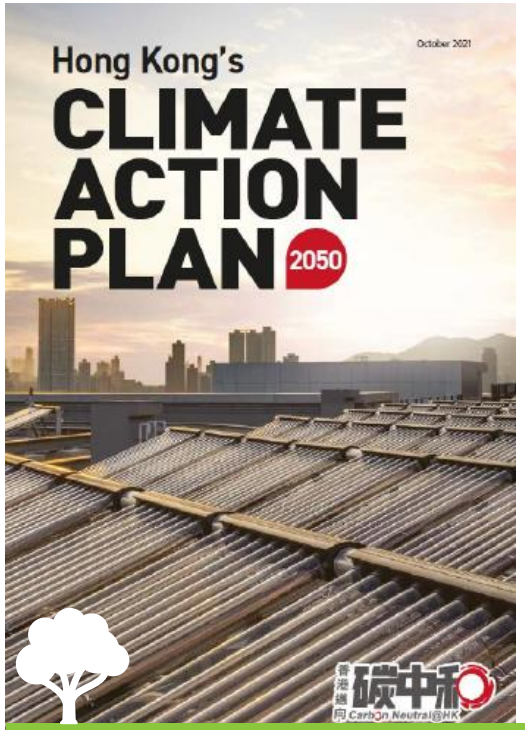
China

- CO_2 emissions peak before **2030**
- Achieve carbon neutrality before **2060**

Hong Kong

- Reduce carbon emissions by 50% before **2035** (from 2005 level)
- Achieve carbon neutrality before **2050**

Power sector plays a key role in HK's decarbonisation targets



No Coal for Electricity Generation

2035

Cease using coal for daily electricity generation, to be replaced by low to zero-carbon energy

Zero-carbon Energy

2035 60-70%

Trial of new energy and closer cooperation with neighbouring areas to increase the supply of zero-carbon electricity

Electricity Saving in Buildings

2035

Electricity consumption (Compared with 2015)

COMMERCIAL BUILDINGS 15-20%

(Reduce by 30-40% subsequently)

RESIDENTIAL BUILDINGS 10-15%

(Reduce by 20-30% subsequently)

Renewable Energy (RE)

2035 7.5-10%

(Increase to 15% subsequently)

Public and private sectors to develop RE proactively to increase its share in the fuel mix for electricity generation

Cooperation and Innovation

Seek investment and development opportunities, participate in and operate zero-carbon energy projects near Hong Kong

RE Potential (Until 2035)

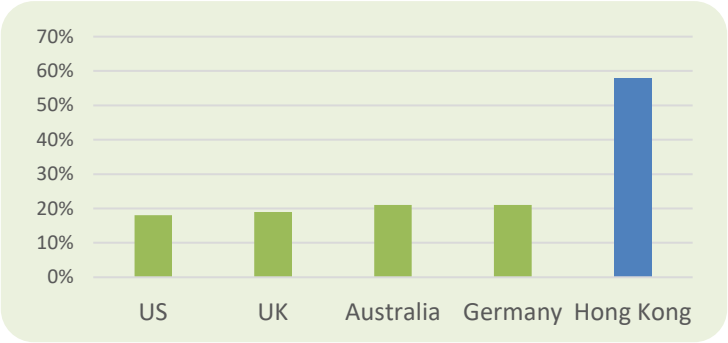
Wind 3.5-4% + Waste-to-energy 3-4% + Solar 1-2% = 7.5-10% (Increase to 15% subsequently)

Net zero electricity generation by 2050

SOURCE: Hong Kong's Climate Action Plan 2050, Oct 2021

HK requires extra high level of electricity supply reliability

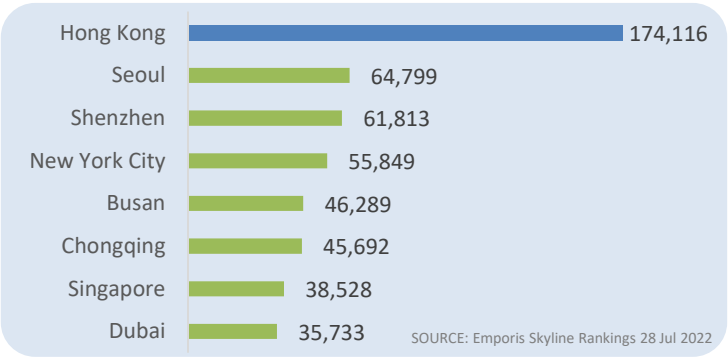
Electricity in Final Energy Consumption



6 million

passenger trips every day on electrically powered transport

Emporis Skyline Ranking



50%

or more of the population live or work above the 15th floor

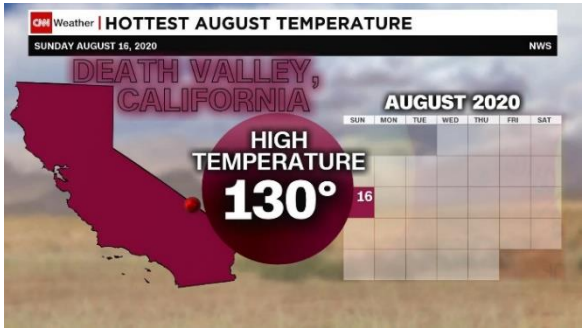
70,000

lifts in use every day

Migration from fossil fuels to new energy hasn't come easy

Windfarm settings triggered South Australia blackout on 28 Sep 2016

Source: Guardian News & Media



Death Valley recorded 54°C on 16 Aug 2020

Source: CNN

Prolonged heatwave resulted in rolling blackout in California in Aug 2020, despite heavy investment in renewable energy

Fossil fuel phase-out and RE phase-in increase volatility to supplies and prices

- In 2018, Australia's energy prices were among the highest in the world, despite the country's substantial energy resources
- Rocky transition from coal to renewable energy was often blamed

Closure of the Hazelwood coal power station in Victoria prompted a price surge of 85% compared to 2016 prices

South Australia is Australia's leading wind power-producing state

International Energy Agency appealed for stabilizing power supply

IEA Executive Director Fatih Birol

‘Avalanche’ of renewables threatens power grid

- In Dec 2018, IEA opined Australia needed to ensure an **“avalanche” of clean energy supply is backed up by firm generation to keep the lights on**
- **Power systems without back-up have accidents in terms of security of supply**. It’s definitely not good news for citizens

SOURCE: The Australian, 5 Dec 2018

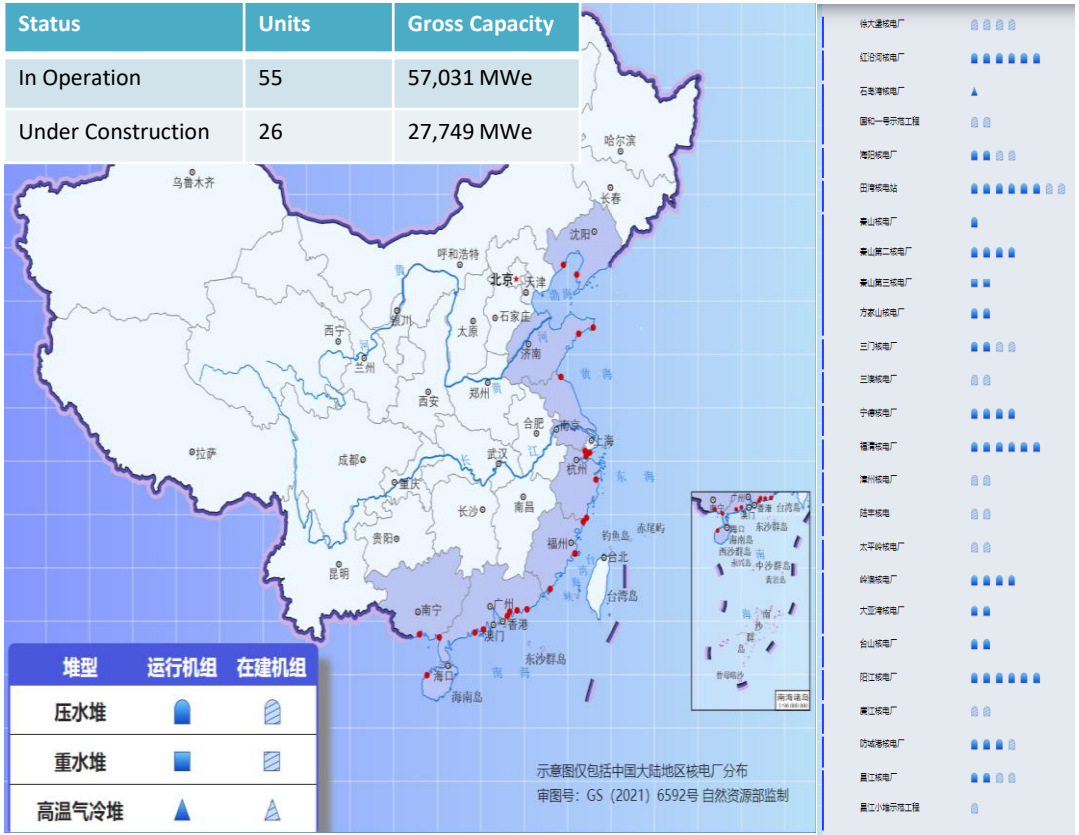
Achieving net zero globally will be harder without nuclear

- As an established large-scale low emissions energy source, nuclear is well placed to help decarbonise electricity supply
- Extending nuclear plants’ lifetimes is an indispensable part of a cost-effective path to net zero by 2050
- Nuclear power plays a significant role in a secure global pathway to net zero
- Less nuclear power would make net zero ambitions harder and more expensive

SOURCE: Nuclear Power and Secure Energy Transitions, IEA, June 2022

Nuclear power has been developing in China safely, reliably and cost effectively

Status	Units	Gross Capacity
In Operation	55	57,031 MWe
Under Construction	26	27,749 MWe



- China approved 10 new nuclear power units in 2023
- Expect to approve 6-8 new units per year
- Advanced nuclear power plants could be built in China at much lower cost than those in US and Europe, due to well developed and low cost manpower resources and supply chains
- Target to reach 120 GW* by 2035 (~10% of electricity generation)

* HK's electricity demand ~10GW

Source:國家核安全局網站 *As of March 2024*

HK has 25 years to phase out fossil fuel with zero-carbon energy

Typical Power Generation Carbon Emission (kg CO_2/kWh)

Coal
~ 1

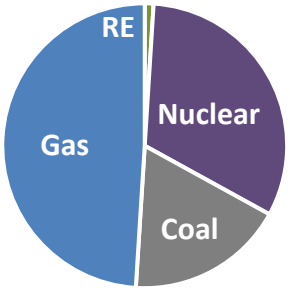
Natural Gas
~ 0.4

RE, Nuclear, Hydrogen* (H_2)
0

* H_2 produced from zero-carbon sources

CLP Electricity Fuel Mix Projection and Average Carbon Intensity (kg CO_2/kWh)

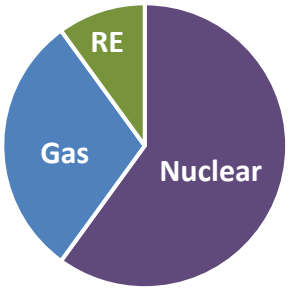
Today
< 0.4



increase RE and nuclear power

phase out coal and phase down gas

2035
~ 0.1

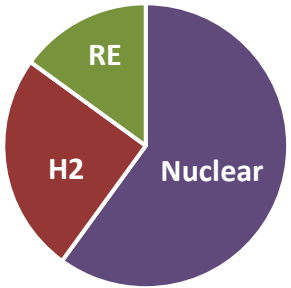


increase RE

repurpose gas to zero-carbon hydrogen

(may also retrofit carbon capture to natural gas power generators)

2050
0



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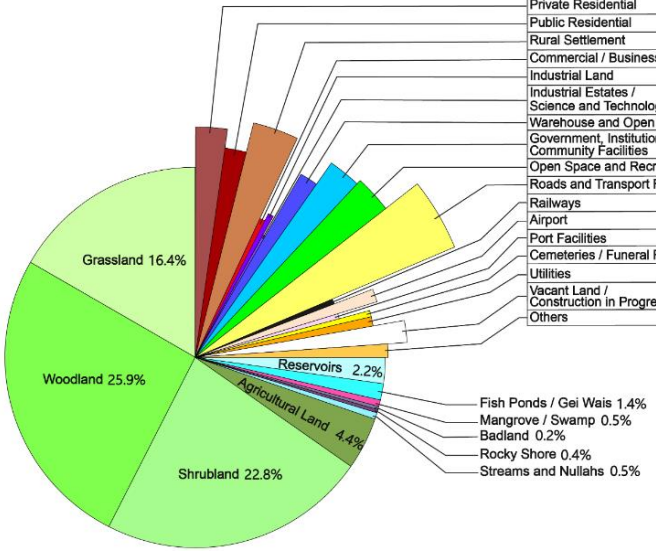
HK has limited RE potential for fully decarbonising power generation

Land Area Analysis

SOURCE: Planning Department



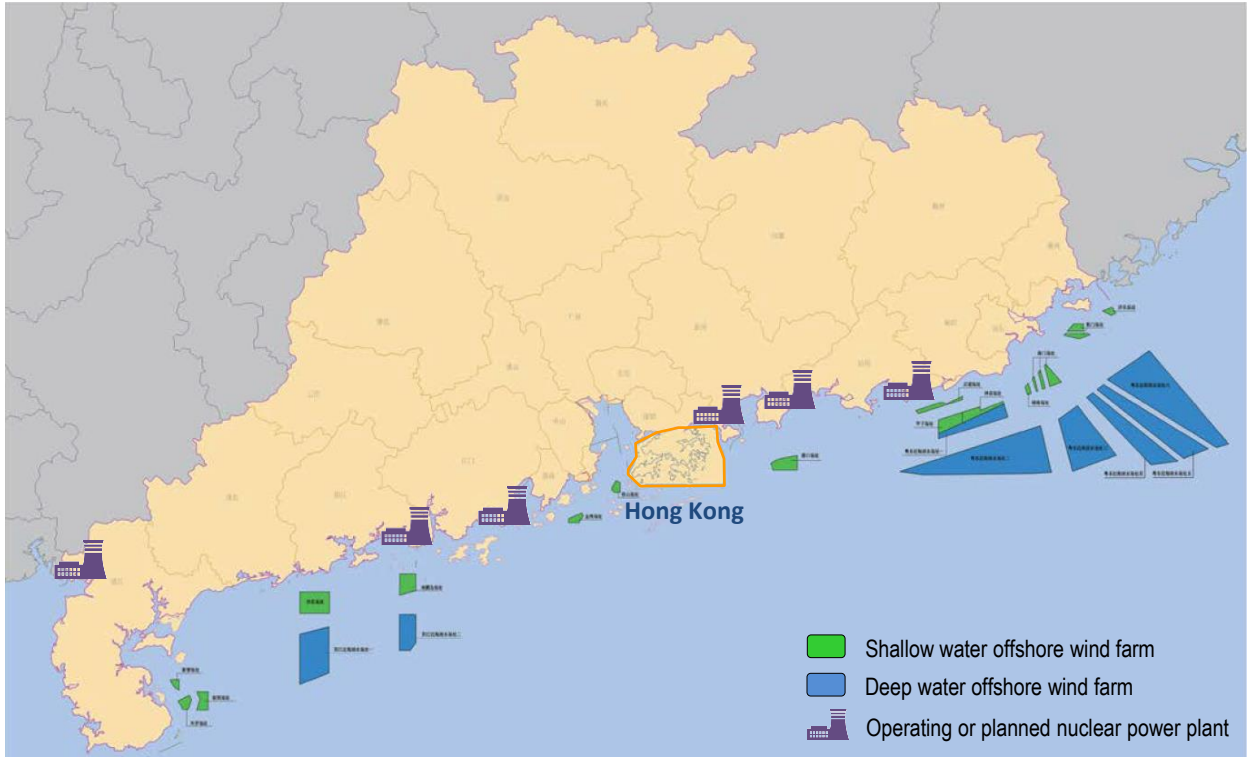
TOTAL AREA OF URBAN OR BUILT-UP LAND = 25.1%	
Land Uses	%
Private Residential	2.4
Public Residential	1.5
Rural Settlement	3.1
Commercial / Business and Office	0.5
Industrial Land	0.6
Industrial Estates / Science and Technology Parks	0.3
Warehouse and Open Storage	1.5
Government, Institutional and Community Facilities	2.2
Open Space and Recreation	2.5
Roads and Transport Facilities	4.2
Railways	0.4
Airport	1.2
Port Facilities	0.4
Cemeteries / Funeral Facilities	0.8
Utilities	0.8
Vacant Land / Construction in Progress	1.6
Others	1.1

Total land area = 1,114 km^2 (including about 4 km^2 of Mangrove and Swamp below the High Water Mark).
Country Parks, Special Areas and Mai Po Ramsar Site cover about 41.6% of the land area of Hong Kong.

- 42% land reserved for country parks and special areas
- 25% developed area, strong demand on housing and commercial development

Local RE Developments

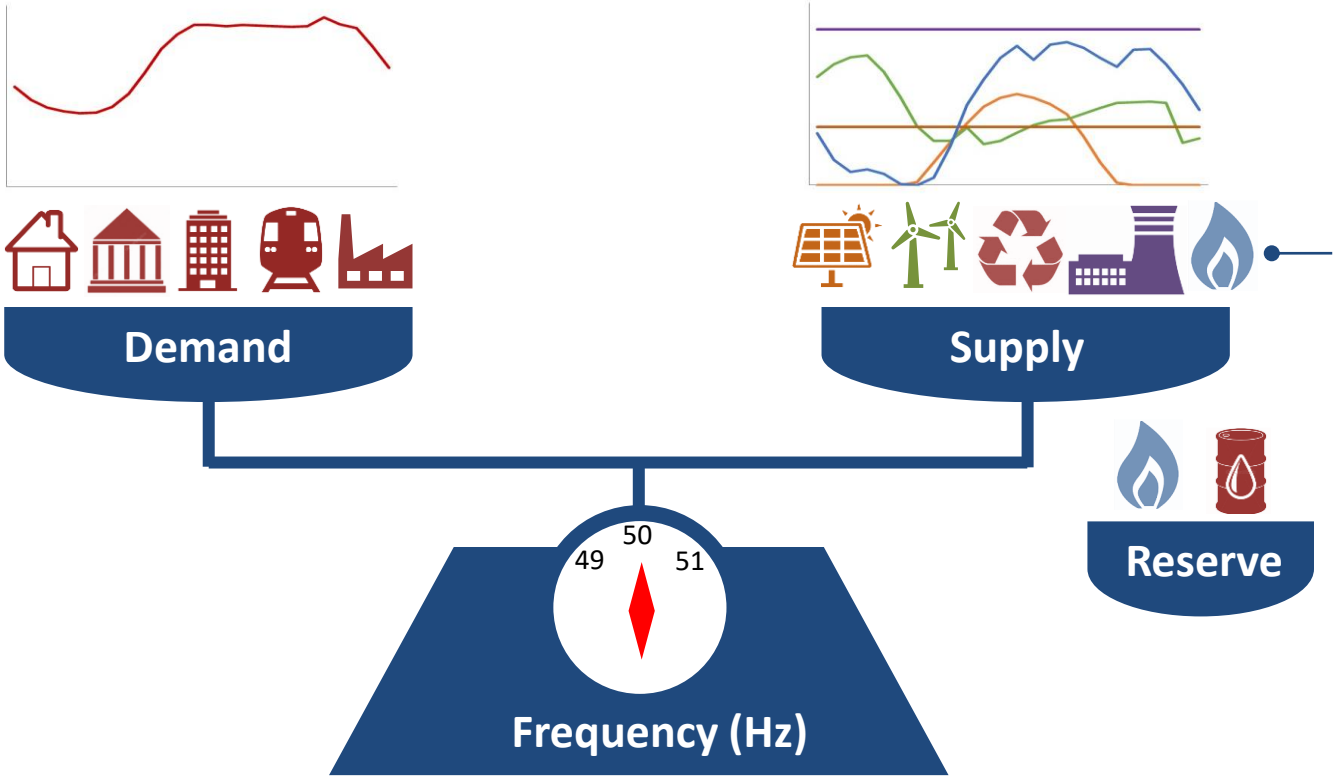
Strengthening regional cooperation for reliable decarbonisation



- Power interconnection between HK and GD being upgraded to enable more zero-carbon energy for HK
- Nuclear power would have an important role in HK's long-term power generation mix

SOURCE: Guangdong Offshore Wind Development Plan (2017-2030) 广东省海上风电发展规划 (2017-2030年)
World Nuclear Association, updated October 2022

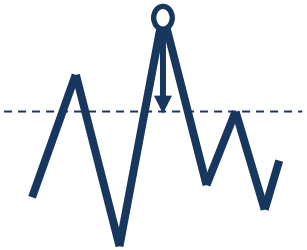
Balancing demand and supply would become challenging



Phasing out fossil fuel would reduce flexibility in coping with varying demand and intermittent RE

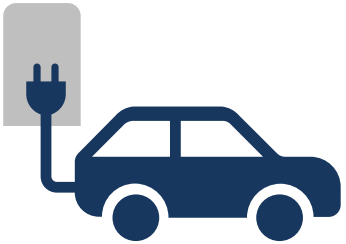
Leveraging distributed energy resources could enhance system flexibility

Demand Response



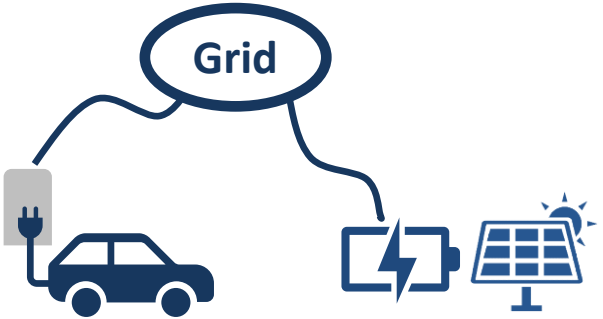
Reduce electricity consumption during peak demand hours

Load Shifting



Shift load to off peak hours when supply is abundant at lower cost and lower carbon

Distributed Energy Resources



Potential future option on leveraging customers' energy storages such as EV batteries

Deploying energy storages could stabilize power system

Pumped Storage

- Large storage capacity
- Relatively low cost
- Accessible through regional cooperation

Lithium Ion Battery

- Quick response
- High round-trip efficiency
- Local installation of different scales feasible

Emerging Long-duration Storages

Flow Battery

Source: Sumitomo Electric

Liquid Air Energy Storage

Source: Highview Power

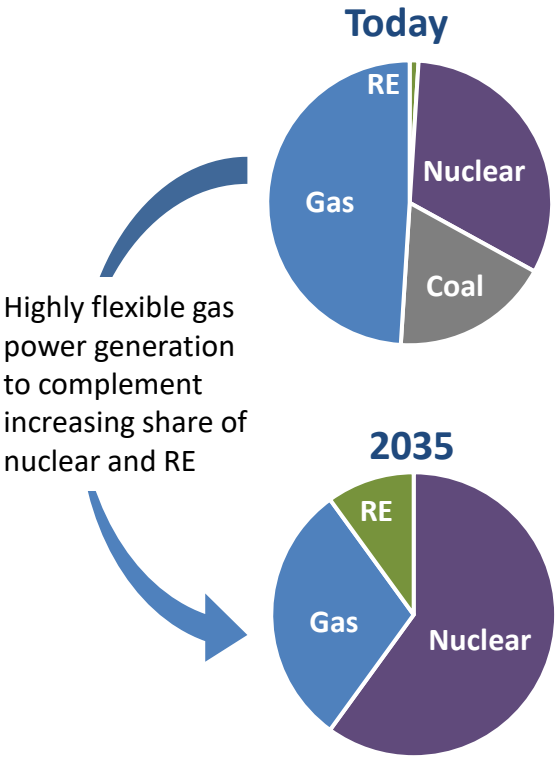
Potential future options on local installation if scale and cost approaching parity with pumped storage

Flexible natural gas power generation balances system and maintains security

Black Point Power Station

- Primary fuel – natural gas
  Secondary fuel – ultra low sulphur diesel
- 2 pipeline gas supplies from Mainland China
- Liquefied natural gas supply through offshore terminal

Highly flexible gas power generation to complement increasing share of nuclear and RE



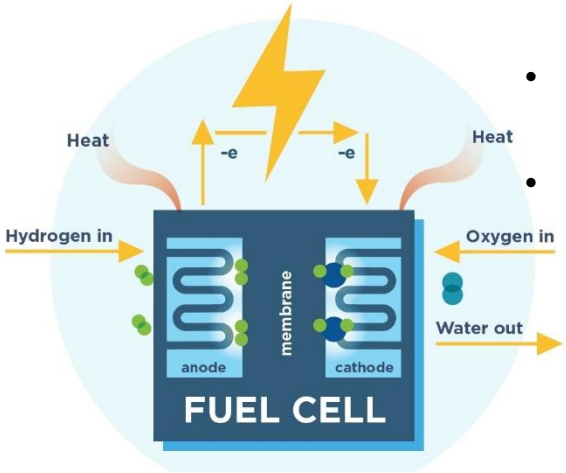
Hydrogen can be used for producing energy

- Hydrogen (H_2) can be produced as a gas or liquid, or made part of other materials (e.g. water H_2O, methane CH_4, methanol CH_3OH, ammonia NH_3, etc.)
- H_2 is a raw material in industrial and chemical processes. H_2 can also be used as energy storage, or as fuel for transport, heating and power generation through combustion turbine or fuel cell

Hydrogen Combustion

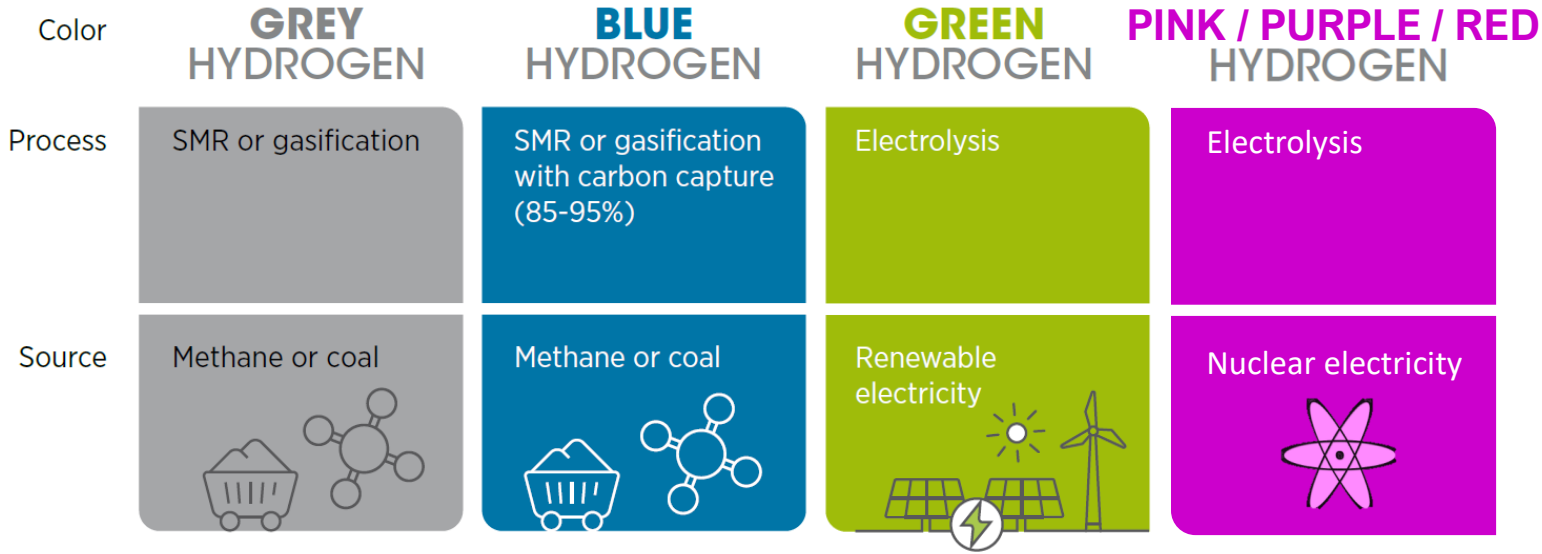
$$2\,H_2 + O_2 \longrightarrow 2\,H_2O$$

- Produce heat and water
- Without CO_2 emission
- Emit NO_x due to thermal process



- Produce electricity, heat and water
- Without CO_2 and NO_x

Hydrogen could potentially enable deep decarbonisation



SMR – Steam Methane Reforming

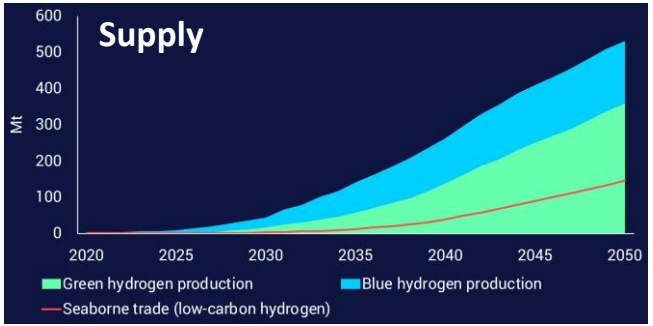
SOURCE: Green Hydrogen: A Guide to Policy Making, IRENA (2020)

For decarbonisation, H_2 must be produced from low / zero carbon processes

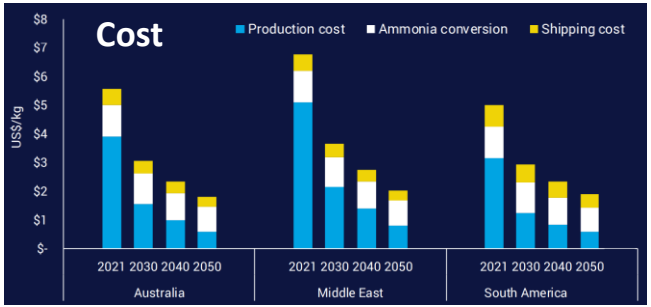
Zero-carbon hydrogen supply and cost would improve towards 2050

Technology - “In the power sector, gas turbine manufacturers are confident they can provide gas turbines that run on pure hydrogen by 2030.”

SOURCE: Global Hydrogen Review 2021, International Energy Agency, Oct 2021



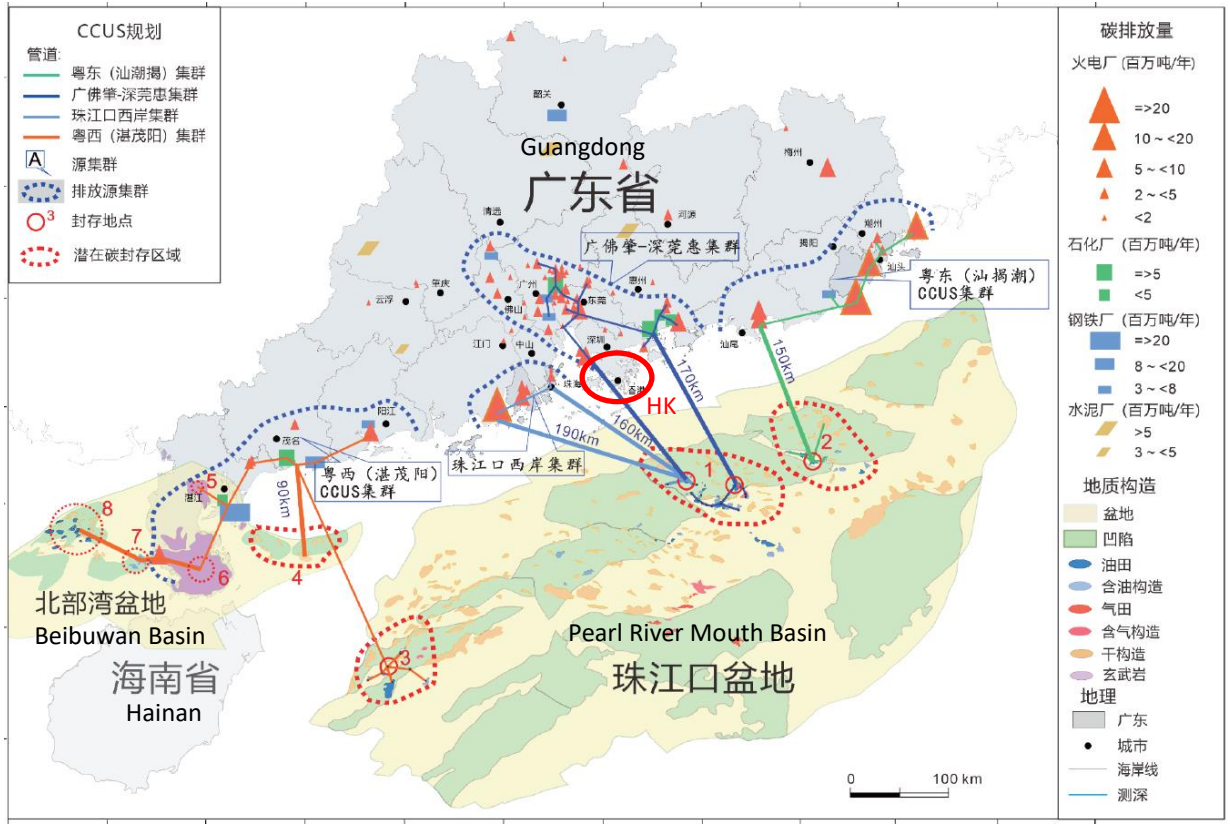
Global Hydrogen Production and Trade (million tonne)



Delivered Cost of Green Hydrogen to Northeast Asia (US$/kg)

SOURCE: The blue-green planet: How hydrogen can transform the global energy trade, Wood Mackenzie, Oct 2021

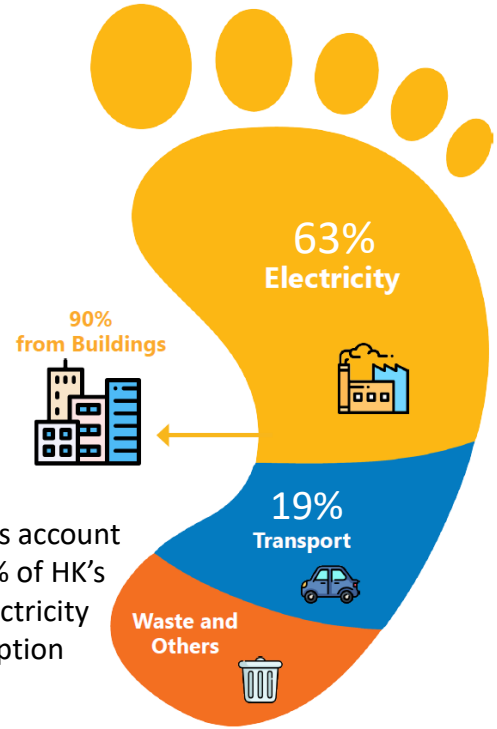
Carbon Capture Utilisation and Storage may be an alternative to hydrogen



- Continuation of fossil fuel power generation and industrial applications is possible with CCUS
- Carbon capture removes ~90-95% of emission. Carbon offset would be required for residual emission
- HK does not have large industries that use carbon dioxide
- New pipeline may be built to transmit carbon dioxide to GD offshore for permanent storage
- Pearl River Mouth Basin (~100km from HK) is a potential carbon dioxide storage site

SOURCE: 广东省二氧化碳捕集利用运输与封存规划研究报告 Guangdong CCUS Study Report, Sep 2022

CLP's programmes to help customers save energy



Buildings account for ~90% of HK's total electricity consumption

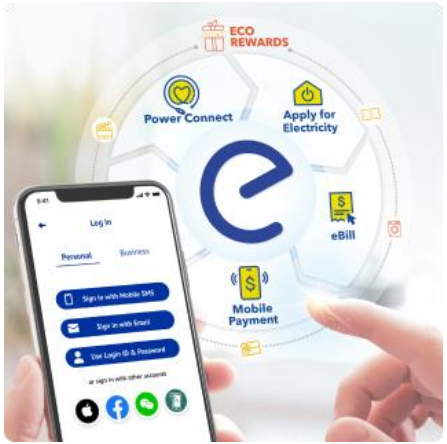
Energy Audit	Free energy audit service to identify energy management opportunities of customers
Eco Building Fund	Subsidy for energy-saving improvement works in communal areas of buildings
Electrical Equipment Upgrade Scheme	Subsidy for business customers for purchase of energy efficient electrical equipment

SOURCE: Long-term Decarbonisation Strategy Public Engagement, Council for Sustainable Development, June 2019
(Sector GHG emission ratios updated with 2022 data)

Information and tools to engage and empower the community

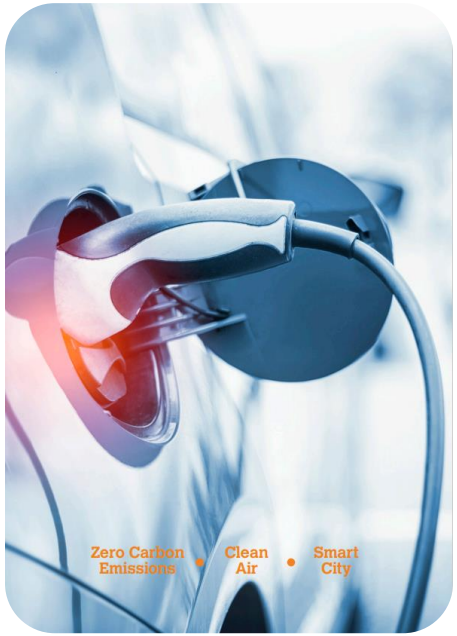
Progressively roll-out smart meters to all customers

Customers enjoy instant access to consumption data anytime, anywhere, and use app to budget for next bill



Low-carbon electricity and electrification reduce fossil fuels consumption

Electric Mobility

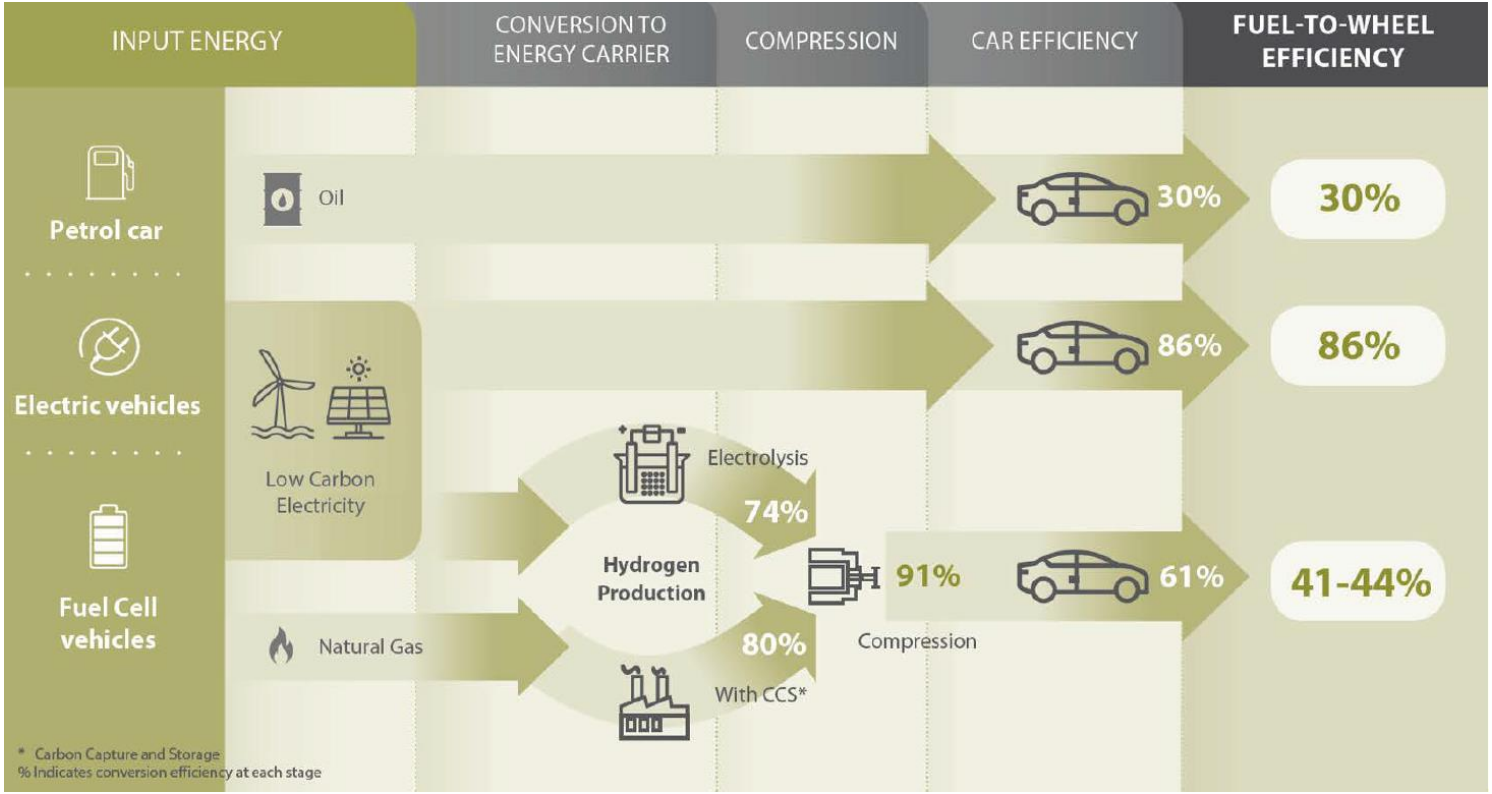


Electric Home

Electric C&I

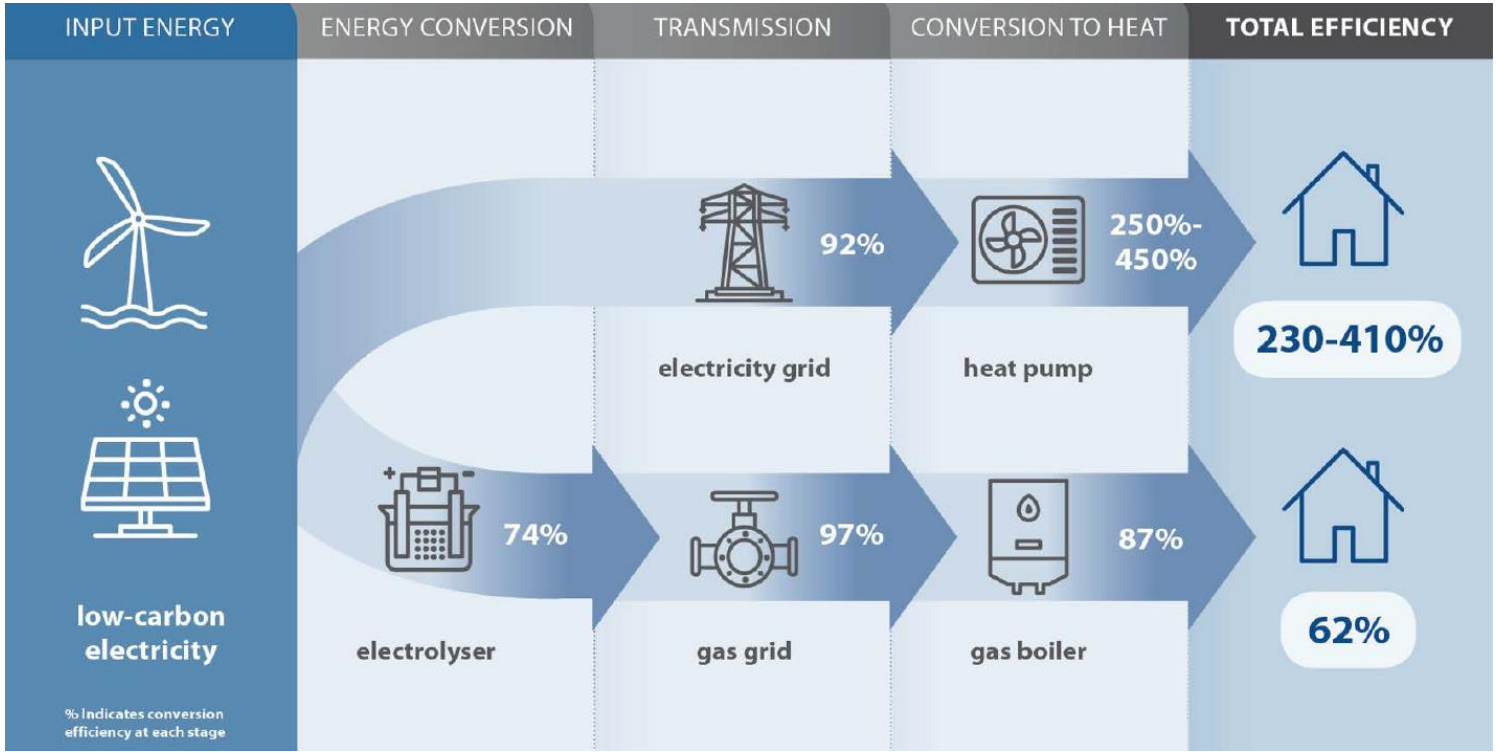
SOURCE: Hong Kong Roadmap on Popularisation of Electric Vehicles, Mar 2021

Electric vehicles have the highest energy chain efficiency for transportation



SOURCE: Hydrogen in a Low-carbon Economy, UK Committee on Climate Change, Nov 2018

Electric heat pump can efficiently decarbonise water heating

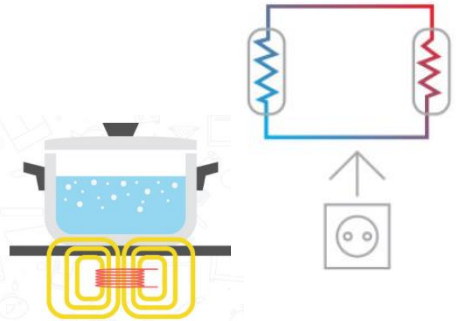


SOURCE: Hydrogen in a Low-carbon Economy, UK Committee on Climate Change, Nov 2018

Multipronged approach in decarbonisation

Energy Efficiency

Electrification



Zero-carbon Electricity