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Emission Reduction Estimation on Proposed New Air Quality Improvement Measures Confirmed by Air Quality Objectives (AQO) Review Working Group

Emission reduction potential assessment of marine emission control measures

List of Proposed Measures Confirmed by Marine Transportation Sub-group

Measure	Code	Practicability	Approach
Ocean-going vessels (OGVs) at berth to use marine fuel with lower fuel sulphur content, e.g. not exceeding 0.1%.	I-A-4	Short-term	Quantitative
Local vessels to use electricity from the power grid while at berth	I-A-5	Short-term	Quantitative
Impose emission standards on outboard engines of local vessels	I-B-1#	Medium-term	Quantitative
Explore financial incentive and disincentive schemes to encourage liners to use less polluting OGVs calling Hong Kong ports	I-C-1#	Medium-term	Quantitative
Explore the use of Liquefied Natural Gas (LNG) for marine vessels	I-A-1	Long-term	Quantitative
Explore the use of hybrid, diesel electric and electric vessels	I-A-3	Long-term	Quantitative
OGVs to use on-shore power supply (OPS) while at berth for Kai Tak cruise terminal only)	I-A-7	Long-term	Quantitative
Explore the use of biofuel (e.g. B5), fuel cell, Liquefied Petroleum Gas (LPG), compressed natural gas (CNG), methanol, nuclear and renewable energy, e.g. wind and solar energy,etc. for marine vessels	I-A-2	Long-term	Qualitative

Measure	Code	Practicability	Approach
Encourage academia to carry out studies on fuel and energy efficient measures in terms of operation and maintenance for local vessels; and collaboration between academia and local marine trade for the development of best practice guidelines and award system to facilitate adoption of the measures	I-C-4	Long-term	Qualitative
Optimize port efficiency to shorten waiting and turnaround time of OGVs and river trade vessels at container terminals, river trade terminals and public cargo working areas (PCWA)	I-C-2	Others	Qualitative
River trade vessels to use OPS while at berth at terminals	I-A-6	Others	--
Install emission reduction device (e.g. particulate filters) to reduce particulate matters (PM) emitted from local vessels	I-B-2	Others	--
Impose control on nitrogen oxides (NOx) emissions from engines of local vessels	I-B-3	Others	--
Slow-steaming of OGVs in Hong Kong waters	I-C-3	Others	--
Remove floating rubbish for smooth operation of small local vessels.	I-D-1	Others	--
Government to expedite the approval process of new local vessels	I-D-2	Others	--

[#] Subject to the endorsement from the Subgroup, the practicability for implementation of the measure is under re-consideration and could be revised.

Emission Reduction Estimation on Proposed New Air Quality Improvement Measures Confirmed by Air Quality Objectives (AQO) Review Working Group

Emission reduction potential assessment of energy & power generation emission control measures

(I) List of Proposed Measures Confirmed by Energy & Power Generation Sub-group

Measure	Code	Practicability	Approach
Replacement of coal-fired generation units by gas-fired units	III-C-1	Short-term	Quantitative
Encourage stakeholders in the commercial sector and the non-government sector, e.g. universities and hospital to adopt demand-side management (SDM) measures	III-A-1	Short-term	Quantitative for these measures as a whole in term of the achievable improvement in building energy efficiency
Explore building energy efficiency measures for old existing buildings which are not covered by the Building Energy Efficiency Ordinance	III-A-2	Short-term	
Encourage or provide incentives for the private sector to develop distributed renewable energy (RE)	III-B-1	Short-term	Quantitative for these measures as a whole in term of the achievable increase in the use of RE
Facilitate distributed RE systems to connect to the power grid	III-B-2	Short-term	
Encourage the development of more waste-to-energy facilities, such as waste incinerators, organic waste treatment plants, etc. for waste disposal as well as recovering energy for local use	III-B-3	Short-term	
Increase the use of wind and solar energy in electricity generation	III-B-4	Short-term	

Measure	Code	Practicability	Approach
Explore the use of waste materials such as corncobs, waste wooden pallets (i.e. biomass) as fuel	III-F-1	Short-term	
Upgrade burners of gas-fired generating units to improve fuel efficiency and emission performance	III-D-1	Short-term	Quantitative
Review operations of gas-fired power generating units with a view to identifying further emission reduction potential	III-D-2	Short-term	Qualitative
Encourage major electricity users to reduce peak load demand so as to reduce the operation and emissions from coal-fired generation units for coping with peak local demand	III-A-3	Long-term	Qualitative
Explore the use of old EV batteries as an electrical energy storage system for the power grid	III-G-2	Long-term	Qualitative
Consider importing more nuclear electricity from the Mainland.	III-C-2	Others	Would not be evaluated
Explore the idea of "SolarRoad" for promoting the use of solar energy	III-E-1	Others	Would not be evaluated
Explore the feasibility of using electric vehicles (EV) as electrical energy storage for power grid	III-G-1	Others	Would not be evaluated

(II) Detailed Emission Reduction Estimation Approach

The Environment Bureau (ENB) published in May 2015 the first-ever Energy Saving Plan for Hong Kong's Built Environment 2015~2025+ which calls for the Hong Kong community to reduce energy wastage and pollution so as to achieve a new target of reducing energy intensity by 40 per cent by 2025. As undertaken in the Energy Saving Plan, ENB would engage built environment stakeholders and power companies to discuss energy saving in the private sector.

A. Projection of Electricity Demand in 2025

$$Total\ Energy\ Demand_{2025} = EI_{2025} \times GDP_{2025}$$

Estimated energy intensity in 2025

i. Assuming the Hong Kong's energy intensity in 2025 will be reduced 40% by 2025 using 2005 as base year as stated in the "Energy Saving Plan for Hong Kong's Built Environment 2015~2025+"[1].

ii. Extracting from the "EMSD Energy end use data 2016" report[2] , the Energy Intensity, GDP and Energy End-use in 2005 are **170**, **HK$1,651 billion dollars** and **280,537 TJ** respectively.

iii. The energy intensity in the year 2025 is:

$$\begin{aligned} EI_{2025} &= EI_{2005} \times (1 - 0.4) \\ &= 170 \times 0.6 \\ &= 102\ TJ/GDP\ HK\$\ billion \end{aligned}$$

Estimated GDP in 2025

iv. The GDP estimation is based on the latest Hong Kong Economic report,"2016 Economic Background and 2017 Prospects"[3], published by the Financial Secretary's office of HKSAR government.

[1] http://www.enb.gov.hk/sites/default/files/pdf/EnergySavingPlanEn.pdf
[2] http://www.emsd.gov.hk/filemanager/en/content_762/HKEEUD2016.pdf
[3] http://www.hkeconomy.gov.hk/en/pdf/er_16q4.pdf

v. The reported annual GDP for HK in 2016 is HK$2,489 billion. It is forecasted that there would be an increase of 2-3% in 2017 and 3% per annum for the years 2018 – 2021. Assuming the GDP growth rate from 2016 to 2025 as 3% per annum, the GDP for year 2025 can be projected as:

$$GDP_{2025} = GDP_{2016} \times \left(1 + GDP_{growth\ percentage}\right)^9$$
$$= 2{,}489 \times (1 + 0.03)^9$$
$$= 3{,}248\ HK\$\ billion$$

Electricity demand in 2025

vi. The total energy end use for the year 2025 therefore can be calculated as:

$$Total\ Energy_{2025} = EI_{2025} \times GDP_{2025}$$
$$= 3{,}248 \times 102 = 331{,}296\ TJ$$

vii. Assume the percentage electricity accounted for the total end use energy has an average percentage of approximately 54% [1], therefore the electricity demand for the year 2025 is:

$$Electricity\ \ Demand_{2025} = Total\ Energy_{2025} \times 0.54$$
$$= 178{,}900\ TJ = 49{,}694\ GWh$$

Table 1 Summary Table of Energy Intensity, GDP and Total Energy End Use of year 2005 and 2025

Year	Energy Intensity (Energy End Use/GDP HK $ billion)	GDP (HK $ billion)	Total Energy End Use (TJ)
2005	170	1,651	280,537
2025	102	3,248	331,296

B. Estimation of Fuel mix for electricity generation in 2025

i. According to "Hong Kong Climate Action Plan 2030+" [2] the Fuel mix for electricity by 2020 will be:
Natural gas: 50%
Non-fossil fuels including nuclear: 25%
Coal: 25%

ii. The basis and assumptions taken for estimating the fuel mix for electricity generation in 2025:

Natural gas:

- To meet the 2020 fuel mix target, CLP has committed to install a 550 MW gas-fired unit (D1) at Black Point Power Station and put it into service by 2020. By 2020, CLP's gas generation ratio will increase to 49% [4].

  To meet the 2020 fuel mix target and to replace some old power generating units which are due to retire, HEC has committed to install two 380 MW gas-fired units (L10 and L11) and put them into service by 2019 and 2022 respectively. HEC's gas generation ratio will increase to 50% in 2020 and 55% by 2022 [5].

- The Government has announced that to meet the new carbon intensity reduction target of 65% to 70% by 2030, Hong Kong will continue to phase down the remaining coal plants as they reach their normal retirement life in the next decade and replace them with natural gas and non-fossil fuel sources.

- With a view to achieving this carbon reduction target progressively, assume **One** 550 MW gas-fired unit (D2) and **One** 380 MW gas-fired unit (L12) will be installed by CLP and HEC by 2025 respectively. Taking account of inspection and maintenance time, seasonal and diurnal variation in load demand, etc., the gas-fired units are assumed to have a capacity factor of around 0.7. Gas generation ratio in total fuel mix will then be increased by :

[4] http://www.info.gov.hk/gia/general/201612/13/P2016121300652.htm
[5] http://www.info.gov.hk/gia/general/201609/20/P2016092000796.htm

$$\frac{Capacity\ of\ the\ gas\ units\ \times\ opertion\ time\ \times capacity\ factor}{Total\ Energy_{2025}}$$

$$= \frac{(550MW + 380MW)\ \times (24 * 365) \times 0.7}{49694 * 1000}$$

$$= 11.5\%$$

- Assume the new gas-fired units (D2 and L12) will displace the existing coal-fired units

Nuclear:

- Current agreement to import electricity from Daya Bay Nuclear Power Station (DBNPS) runs up until 2034.
- The DBNPS is capable of producing some 14 billion kWh of electricity per year, of which a portion has already been imported by CLP into its system in Hong Kong [6].
- It is outlined in Hong Kong's climate action plan 2023+ that we will continue to have around 25% of our electricity coming from nuclear energy for the medium term, it is therefore assumed that imported nuclear for electricity generation could be maintained at about 25% of fuel mix in 2025.
- The estimated electricity demand in 2025 is 49694 GWh and 25% of electricity demand is equal to 12423 GWh, in which falls within the production capacity (i.e. 14000 GWh) of the Daya Bay Nuclear Power Station.

Renewable energy:

- Renewable energy will account for 1% of fuel mix by 2025 [7,8].

6 https://www.clp.com.hk/en/about-clp/power-generation/infrastructure-and-fuel-mix/guangdong-daya-bay-nuclear-power-station

7 https://www.clpgroup.com/en/Media-Resources-site/Current%20Releases%20Documents/20170125%20Factsheet_B_en.pdf

8 http://www.enb.gov.hk/sites/default/files/en/node3450/fcq_1516e.pdf

iii. The Fuel mix for electricity in 2025 will be assumed as :

Gas: 50% + 11.5% = 61.5%

Nuclear: 25%

Renewable energy: 1%

Coal: 100% - 25% -1% - 61.5% = 12.5%

Table 2 Summary Table of the fuel mix for electricity generation in 2020 & 2025

Type of fuel \ Year	2020	2025
Natural gas	50%	61.5%
Nuclear	25%	25%
Coal	25%	12.5%
Renewable energy	0%	1%

C. Estimation of the emission performance of the power generation unit in 2025

i. As Castle Peak Power Station is the larger coal-fired plant that supplies more coal-fired generation, the overall emission performance of **coal-fired units** is based on castle peak's emission factor given in the 6th TM [9].

ii. The overall emission performance of the **existing gas-fired units** is derived from the information extracted from the discussion paper for the "Review of the 4th Technical Memorandum for Allocation of Emission Allowances for Power Plants"[10]. Given gas-fired units have negligible emissions of SO_2 and RSP, new gas-fired units which installed both dry Low-NOx combustion system and Selective Catalytic Reduction had a 90% reduction in NOx emission. As such, it is assumed that the emission factors for SO_2 and RSP of the existing gas-fired plant is same as the new gas-fired plants. The NOx emission factor of the existing gas-fired plants should be 10 times (1/(1-90%)) of the new gas-fired plant.

iii. The overall emission performance of **new gas-fired units** are based on New Electricity Works given in the 6th TM [9]

[9] http://www.legco.gov.hk/yr16-17/english/subleg/negative/2016ss_no5-3-e.pdf

[10] http://www.legco.gov.hk/yr15-16/english/subleg/brief/2015ss_no5-4_brf.pdf

Table 3 Summary Table of the emission factors of the power generation units in 2025

	Emission factors (tonnes/GWh)		
	SO_2	NOx	RSP
Coal-fired plant[a]	0.407	1.062	0.031
Existing gas-fired plant[b]	0.018	0.28	0.007
New gas-fired plant[a]	0.018	0.028	0.007

Notes:

[a] : quoted from 6th Technical Memorandum for Allocation of Emission Allowances in Respect of Specified Licences, with consideration of the best available air pollution control technologies applied

[b]: derived from the information extracted from the discussion paper for the "Review of the 4th Technical Memorandum for Allocation of Emission Allowances for Power Plants"

D. Emission reduction potential estimation for the proposed measures

Measure III-C-1 - Replacement of coal-fired generating units by gas-fired units

Practicability for implementation: Short-term

Approach of Emission Reduction Estimation

1. Background of the proposed measure

The Government has banned the use of coal for power generation since 1997 and that new generating units shall be gas-fired units. Most of the existing local coal-fired generating units came into operation in the 1980s and are scheduled to retire progressively from 2017. Having regard to the views received in the Public Consultation on Future Fuel Mix for Electricity Generation conducted in 2014 (the 2014 Public Consultation), the Government announced in 2015 its plan to increase the share of natural gas electricity generation to around 50% of the total fuel mix in 2020, and maintain the current nuclear import at around 25% of our fuel mix. The remaining demand will be met by coal-fired generation and renewable energy (RE). Following the adoption of the Paris Agreement in December 2015, the Government established the Steering Committee on Climate Change (SCCC) to examine experience outside Hong Kong in combating climate change and review the scope for enhancing our mitigation, adaptation and resilience actions. The SCCC recommended setting a target to reduce our carbon intensity by 65-70% by 2030 compared with the 2005 level. The SCCC also recommended a number of measures to achieve the target. The Chief Executive accepted the SCCC recommendations the gist of which were covered in his Policy Address on 18 January 2017. As electricity generation accounts for almost 70% of our carbon emissions, to achieve the new target, we need to phase down coal-fired electricity generation, i.e. replace the majority of the coal plants which are due to retire by cleaner energy sources by 2030 to reduce carbon emissions.

2. Assumptions and data adopted for emission reduction estimation

a. The assumed fuel mix in 2025 and emission factor of the power generation units can be referred to previous sections B and C.

b. The Business-As-Usual (BAU) case is assumed other than those committed gas-fired units, no more additional gas-fired units will be built to further displace coal-fired generation, and the fuel mix remains at the level of the 2020 fuel mix target.

c. The following table summarizes the fuel mix for the BAU case and the fuel mix for 2025.

Type of fuel \ Year	BAU Case	2025
Natural gas	50%	61.5%
Nuclear	25%	25%
Coal	25%	12.5%
Renewable energy	0%	1%

3. Approach to estimate emission reduction

The total electricity demand in 2025 is 49694 GWh.

Emission of air pollutants in power generation

a. From Coal-fired units

- The electricity generated by coal-fired units in 2025 would be:
  49694 x 12.5% = 6212 GWh
- SO_2 emission
  = 6212 GWh x 0.407 = 2528 tonnes
- NOx emission
  = 6212 GWh x 1.062 = 6597 tonnes
- RSP emission
  = 6212 GWh x 0.031 = 193 tonnes

b. From New Gas-fired units

- The electricity generated by new gas-fired units in 2025 would be:
  (550 x 2 + 380 x 3) x 0.7 x 24 x 365 = 13736 GWh which is around 28% of the electricity demand in 2025.
- SO_2 emission

= 13736 GWh x 0.018 = 247 tonnes

- NOx emission

  = 13736 GWh x 0.028 = 385 tonnes

- RSP emission

  = 13736 GWh x 0.007 = 96 tonnes

c. From Existing Gas-fired units

- The electricity generated by existing gas-fired units in 2025 would be:

  (49694) x (61.5% -28%) = 16647 GWh

- SO_2 emission

  = 16647 GWh x 0.018 = 300 tonnes

- NOx emission

  = 16647 GWh x 0.28 = 4661 tonnes

- RSP emission

  = 16647 GWh x 0.007 = 117 tonnes

Total emission of in 2025 of SO_2 = 2528+247+300 = 3075 tonnes

NOx = 6597+385+4661 = 11643 tonnes

RSP = 193+96+117 = 406 tonnes

BAU case

a. From Coal-fired units

- The electricity generated by coal in 2025 would be:

  49694 x 25% = 12424 GWh

- SO_2 emission

  = 12424 GWh x 0.407 = 5057 tonnes

- NOx emission

  = 12424 GWh x 1.062 = 13194 tonnes

- RSP emission

  = 12424 GWh x 0.031 = 385 tonnes

b. From New Gas-fired units

- The electricity generated by new gas-fired units in 2025 would be:
  (550 x 1 + 380 x 2) x 0.7 x 24 x 365 = 8033 GWh which is around 16% of the electricity demand in 2025.
- SO_2 emission
  = 8033 GWh x 0.018 = 145 tonnes
- NOx emission
  = 8033 GWh x 0.028 = 225 tonnes
- RSP emission
  = 8033 GWh x 0.007 = 56 tonnes

c. From Existing Gas-fired units

- The electricity generated by existing gas-fired units in 2025 would be:
  (49694) x (50% -16%) = 16896 GWh
- SO_2 emission
  = 16896 GWh x 0.018 = 304 tonnes
- NOx emission
  = 16896 GWh x 0.28 = 4731 tonnes
- RSP emission
  = 16896 GWh x 0.007 = 118 tonnes

Total emission of in 2020 of SO_2 = 5057+145+304 = 5506 tonnes
NOx = 13194+225+4731 = 18150 tonnes
RSP = 385+56+118 = 559 tonnes

The following table summarize the emission reduction due to *replacement of coal-fired generating units by gas-fired units*:

Pollutants	Emission reduction (tonnes)
SO_2	2431
NOx	6507
RSP	153

Measures on Building energy efficiency

Measure III-A-1 - Encourage stakeholders in the commercial sector and the

non-government sector, e.g. universities and hospital to adopt demand-side management (DSM) measures

Measure III-A-2 - Explore building energy efficiency measures for old existing buildings which are not covered by the Building Energy Efficiency Ordinance

Practicability for implementation: Short-term

Approach of Emission Reduction Estimation

1. Background of the proposed measure

In Hong Kong, more than half of the energy use (~55%) is in the form of electricity consumption in 2014, with buildings accounting for about 90 per cent of the city's electricity use. Promoting green buildings and enhancing building energy saving has been one of the priority tasks in the Government's attempt to achieve energy saving. The Buildings Energy Efficiency Ordinance (BEEO) requires new buildings and existing buildings undergoing major retrofitting to comply with minimum energy efficiency standards as specified in the Building Energy Code in respect of air-conditioning, electrical, lift and escalator and lighting installations, regardless of age. In addition, commercial buildings are required to conduct energy audits once every ten years.

The Government has established dialogue platforms with relevant stakeholders in the built environment to discuss ways to promote green buildings and to explore energy saving targets and measures. So far the results have been encouraging and some potential measures have been come up through active discussions and group meetings with relevant stakeholders.

The Government has formulated various policy measures to engage various sectors of the community, including the commercial and non-government sectors to work together for energy saving.

2. Assumptions and data adopted for emission reduction estimation

a. The potential saving of 3,600 TJ would be achieved by 2025 through reviewing the Building Energy Code every 3 years. There will be a total of 4 reviews to be conducted before the year 2025 among which two of them will be completed by 2020 and the remaining two will be completed by 2025. Assume the potential saving in energy for each round of the review would be around 1,800 TJ (i.e. 3,600 TJ/4).

b. The potential energy saving for Mandatory Energy Efficiency Labelling Scheme (MEELS) upgrading/extension would be about 2,880 TJ by 2025. There will be two reviews to be conducted before 2025 of which one will conducted at the year of 2020 and the other will be conducted at the year of 2025. Assume the potential saving in energy for each round of the review would be around 1,440 TJ (i.e. 2,880TJ/2).

c. The potential electricity saving from the new 5% electricity saving target for government buildings from 2015 to 2020 would be about 252TJ by 2020. If another round of 5% electricity saving target to be arranged from 2020 to 2025, the potential additional saving is assumed to be about another 252TJ by 2025.

d. Assuming energy saved are distributed according to the fuel mix at the year of 2020 and 2025 which listed in the previous sections. The emission performance of the power generation plants can be referred to previous sections.

3. Approach to estimate emission reduction

Total energy saving resulted from Measures A1 and A2 would be approximately 6984 TJ (1940 GWh) by 2025 and assumed there will be around 3492 TJ (970 GWh) can be saved by the year 2020. Thus, the energy saved by 2025 compared to 2020 would be another 3492 TJ (970 GWh). The emission reduction can be achieved through the savings in the electricity use.

Emission of air pollutants reduction in power generation in 2025

a. From Coal-fired units

- The reduction in energy needs to generated electricity by coal in 2025 would be:
  970 x 12.5% = 121 GWh
- SO_2 emission reduction
  = 121 GWh x 0.407 = 49 tonnes
- NOx emission reduction
  = 121 GWh x 1.062 = 129 tonnes
- RSP emission reduction
  = 121 GWh x 0.031 = 4 tonnes

b. From New Gas-fired units

- The Energy used to generated electricity by new gas-fired units in 2025 would be around 28% of the electricity demand in 2025. In this aspect, the reduction of energy needed from new gas unit would be:
  970 x 28% = 272 GWh
- SO_2 emission reduction
  = 272 GWh x 0.018 = 5 tonnes
- NOx emission reduction
  = 272 GWh x 0.028 = 8 tonnes
- RSP emission reduction
  = 272 GWh x 0.007 = 2 tonnes

c. From Existing Gas-fired units

- The reduction of energy needed from existing gas-fired units in 2025 would be:
  970 x (61.5% -28%) = 970 x (33.5%) = 325.0 GWh
- SO_2 emission
  = 325.0 GWh x 0.018 = 6 tonnes
- NOx emission
  = 325.0 GWh x 0.28 = 91 tonnes
- RSP emission
  = 325.0 GWh x 0.007 = 2 tonnes

Total emission reduction in 2025 of SO_2 = 49+5+6 = 60 tonnes
NOx = 129+8+91 = 228 tonnes
RSP = 4+2+2 = 8 tonnes

The following table summarize the emission reduction due to *building energy efficiency measures*:

Pollutants	Emission reduction (tonnes), 2025 (with base year 2020)
SO_2	60
NOx	228
RSP	8

Measures on Renewable Energy application:

Measure III-B-1-Encourage or provide incentives for the private sector to develop distributed renewable energy (RE)

Measure III-B-2 - Facilitate distributed RE systems to connect to the power grid

Measure III-B-3 - Encourage the development of more small scale waste-to-energy facilities, such as waste incinerators, organic waste treatment plants, etc. for waste disposal as well as recovering energy for local use

Measure III-B-4 - Increase the use of wind and solar energy in electricity generation

Measure III-F-1- Measure Explore the use of waste materials such as corncobs, waste wooden pallets as fuel

Practicability for implementation: Short-term

Approach of Emission Reduction Estimation

1. Background of the proposed measure

Renewable energy (RE) systems can be designed either as standalone systems or grid-connected systems, many people prefer the advantages that grid connection offers. A grid-connected system allows RE producers to power their facilities with renewable energy during those periods RE resources (e.g. sunlight, wind) are plentiful. Any excess electricity the RE system produce is fed back into the grid. When renewable resources are unavailable, electricity from the grid will always make up for the loss of power output from the RE system to ensure the stability of power supply. This also can eliminate the expense of electricity storage devices like batteries. In the spirit of sustainable use of resources, it has been the Government's strategy to accord priority to the promotion of waste reduction and recycling thus minimizing the amount of waste that requires end-of-pipe treatment.

Notwithstanding the efforts in waste reduction, the Government at the same time aims to maximize the potential to recover energy from unavoidable waste, which is a source of renewable energy (RE) and can help reduce carbon emissions. In this regard, the Government

has covered in its major waste management work plans, namely the "Hong Kong: Blueprint for Sustainable Use of Resources 2013-2022" and "A Food Waste & Yard Waste Plan for Hong Kong 2014-2022" (the Food waste Plan) a number of waste-to-energy (WtE) facilities including sludge treatment facilities (STF), integrated waste management facilities (IWMF) Phase I, and a network of organic waste treatment facilities (OWTF).

To meet Hong Kong's long term needs for proper handling of solid waste, the Government in 2015 commenced a study for planning of future waste management and transfer facilities (the Study). The Study is to formulate, develop and produce a territory-wide plan and strategy on the provision of waste treatment and bulk waste transfer facilities for handling solid waste in an environmentally acceptable, sustainable and cost-effective manner. The Study will explore a variety of issues, including types and requirements, technology choices, optimal scales, spatial distribution, siting principles, site requirements, selection criteria, procurement options and indicative timing of the additional waste treatment and bulk waste transfer facilities. If additional WtE facilities are to be identified, it will help reduce carbon emission.

2. Assumptions and data adopted for emission reduction estimation

a. The potential energy saved by implementing renewable energy application [7,8] are as follows:

- Landfill Gas generation at West New Territories (WENT) landfill will account for 95GWh energy
- Waste-to-energy facilities in Integrated Waste Management Facilities (IWMF) will account for 480 GWh energy
- Waste-to-energy facilities in Sludge Treatment Facility (STF) will account for 19.2 GWh energy
- Waste-to-energy facilities in Organic Waste Treatment Facilities (OWTF) phase 1 and 2 will account for 37 GWh energy
- Renewable energy from solar and winds would generate another 2 GWh of energy

b. Assume the energy generated by renewable energy is to displace the power from coal-fired generation.

3. Approach to estimate emission reduction

a. The electricity generated by renewable energy would be 633GWh and lead to an emission reduction through savings in the electricity generated by the coal-fired units.

- SO_2 emission reduction

  = 633 GWh x 0.407 = 258 tonnes

- NOx emission

  = 633 GWh x 1.062 = 672 tonnes

- RSP emission

  = 633 GWh x 0.031 = 20 tonnes

The following table summarize the emission reduction due to *application of renewable energy*:

Pollutants	Emission reduction (tonnes)**
SO_2	258
NOx	672
RSP	20

***Note: The energy generated by Waste to Energy facilities are counted as the renewable energy. However, the facilities would also emit certain pollutant amount during the operation process. The estimation of emission reduction in the above table does not take into account of the emission during the operation process of the Waste to Energy facilities.*

Measure III-D-1 - Upgrade burners of gas-fired generating units to improve fuel efficiency and emission performance

Practicability for implementation: Short-term

Approach of Emission Reduction Estimation

1. Background of the proposed measure

Some existing gas-fired generating units were built around 20 years ago. The technology advancement of combustion system can facilitate the improvement in generation efficiency and emission performance of gas-fired generating units. New gas-fired generating units to be installed by power companies use more advanced type of combustion system to reduce emissions. Technology is also available to upgrade the combustion systems of some existing gas-fired units so as to improve their emission performance. . One gas-fired unit in Black Point Power Station was upgraded in early 2016.

2. Assumptions and data adopted for emission reduction estimation

a. Reference to the development plan of the Two Power companies [11], we assumed 3 of the existing gas-fired units at Black Point Power Station (BPPS) will be upgraded by 2025

b. The existing gas-fired unit model is GE 9FA gas-fired generating unit and its original emission performance of NOx is 25ppm[12].

c. The new technology can help the upgraded GE 9FA gas-fired unit to reduce the NOx emission from 25 ppm to 15ppm[13] .The potential reduction is around 40%.

d. Upgrading the gas-fired unit expected to have improvement in energy efficiency by more than 6% of the power output[14]

11 http://www.legco.gov.hk/yr13-14/english/panels/edev/papers/edev1210-enbcr145760813pt14_enbcr245760813pt10-e.pdf

12 https://www.environmental-expert.com/products/model-9fa-heavy-duty-gas-turbine-309019

13 https://www.ge.com/sites/default/files/LifeMax_DLN_Fact_Sheet.pdf

14 https://powergen.gepower.com/services/upgrade-and-life-extension/gas-turbine-upgrades/gas-turbine-upgrades-catalog/9fa-advanced-gas-path.html

3. Approach to estimate emission reduction

a. Maximum achievable emission reduction due to *improvement of energy efficiency* of the unit:

- The electricity to be generated by existing gas-fired units (9 existing gas units in total, 8 units in BPPS and 1 unit in Lamma Power Station) in 2025 would be about 16447 GWh
- The improvement in power output due to upgrading **Three** existing gas-fired unit at BPPS:

  16647/9*3x (6%) = 333 GWh
- Assume this additional capacity in gas generation to displace that from coal generation. The potential reduction in emission would be:
- SO_2 emission reduction

  = 333 GWh x (0.407-0.018) = 130 tonnes
- NOx emission reduction

  = 333 GWh x (1.062-0.28) = 260 tonnes
- RSP emission reduction

  = 333 GWh x (0.031-0.007) = 8 tonnes

b. Maximum achievable emission reduction due to *improvement of NOx emission performance*

- The electricity generated by existing gas-fired units in 2025 would be 16447 GWh which is around 33.5% of the electricity demand in 2025
- NOx emission reduced

  =16647/9*3 x 0.28 x (40%) = 62 tonnes

The following table summarize the maximum emission reduction due to *Upgrade burners of gas-fired generating units*:

Pollutants	Emission reduction (tonnes)
SO_2	130
NOx	322
RSP	8

Measure III-D-2 - Review operations of gas-fired power generating units with a view to identifying further emission reduction potential

Practicability for implementation: Short-term (Qualitative)

Approach of Emission Reduction Estimation

1. Background of the Measure

Currently, there is a mix of coal-fired generating units and gas-fired generating units in power plants in which their operations are scheduled for meeting the electricity demand. Among the two types of generating units, coal-fired generating units have higher emissions.

The Air Pollution Control Ordinance (APCO) empowers the Government to cap the emission of power plants for improving air quality through issuing a Technical Memorandum (TM). When setting the emission caps, the Government would give due regard to, amongst other things, the best practicable means for preventing the emission pollutants.

2. Potential benefits of the measures

Normally, the gas-fired units will emit less air pollutants than the coal-fired unit. More operation of the gas-fired units indicate potential emission reduction.

Other measures (C1 and D1) also reflected the potential emission reduction by implementing this measure.

3. Limitation

Given the technical and operational constraints, there is limited scope to further increase the operation of gas-fired units so as to reduce emissions from power plants

Measure III-A-3 - Encourage major electricity users to reduce peak load demand so as to reduce the operation and emissions from coal-fired generation units for coping with peak load demand

Practicability for implementation: Long-term (Qualitative)

1. Background of the Measure

Advanced Metering Infrastructure ("AMI", also known as smart meters) provides two way meter communications between utilities and consumers, allowing commands to be sent toward the consumer for multiple purposes, including "time-of-use" pricing information, demand-side response, etc. Some overseas utilities have adopted AMIs to help consumers using information provided by the system to change their normal consumption patterns to take advantage of lower prices offered for different time periods. Incentive pricing may be used to curb growth of peak consumption.

2. Potential benefits of the measures

Peak demand reductions, load shifting, and electricity conservation are demand-side resources that can be used by system planners and operators to increase system reliability and reduce costs. When cost-effective, demand-side resources can provide benefits such as lower capital costs from deferral of supply-side capacity additions, lower fuel costs from reductions in electricity demand, and reduced environmental emissions from reduced levels of fossil-fuel generation. Demand reductions can also result in lower bills for customers.

3. Limitations

As the development of AMI technologies in Hong Kong is still at initial stage, the Government and the power companies would have to carry out more in-depth studies and tests on its application in Hong Kong. It would be unlikely for this proposed measure to be widely implemented within the time horizon of the AQO Review.

Measure G2 - Explore the use of old EV batteries as an electrical energy storage system for the power grid

Practicability for implementation: Long-term (Qualitative)

1. Background of the Measure

With increasing numbers of electrical vehicle (EV) battery used in these years, the possibility of old EV battery to work as an electrical energy storage system for the power grid is being explored. EV batteries may retain around 70% or more of their original storage capacity after 10 years usage but are no longer strong enough to provide a sufficient electric driving range. Draining as much useful storage capacity as possible by using the second life of these retired EV batteries as stationary grid storage not only would increase the lifetime value of the batteries and reduce their overall cost, but also improve the stability of power supplies by balancing power supply and demand through storing excess power generation for use when high load occurs.

2. Potential benefits of the measures

Since excess power generation (e.g. Renewable Energy) can be stored in the old EV batteries for use when high load occurs, this would reduce the supply with power generated by fossil fuel to meet the peak demand, thus save the fuel consumption, reduce the air pollution emission and benefit the air quality improvement. However, further study is needed to quantify the replacement of power generation by fossil fuel with energy stored in the old EV batteries to meet the need of peak demand.

3. Limitations

As the use of old EV batteries as an electrical energy storage system for the power grid is still at pilot stage all over the world and only few small scale pilot studies were/are being conducted in the advanced countries, exploring the application of this technology in Hong Kong is needed. It would be unlikely for this proposed measure to be widely implemented within the time horizon of the AQO Review.

Reference

[1] EMSD (2017). Hong Kong Energy End-use Data 2016. Available at http://www.emsd.gov.hk/filemanager/en/content_762/HKEEUD2016.pdf

[2] ENB (2017). Hong Kong's Climate Action Plan 2030+. Available at http://www.enb.gov.hk/sites/default/files/pdf/ClimateActionPlanEng.pdf

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Emission Reduction Estimation on Proposed New Air Quality Improvement Measures Confirmed by Air Quality Objectives (AQO) Review Working Group

Emission reduction potential assessment of road transportation emission control measures

List of Proposed Measures Confirmed by Road Transportation Sub-group

(The estimation approach will be deliberated in the coming task force meeting)

Measure	Code	Practicability
Establish a maintenance information database of vehicle tailpipe emission system	II-B-4	Short-term
Raise awareness on the importance of vehicle maintenance and repair.	II-B-5	Short-term
Foster "pedestrian-friendly" environment (such as widening of footpaths, construction of covered walkways and enhancing the pedestrian connections) to encourage people to walk	II-C-1	Short-term (for existing towns and urban areas)
Foster “bicycle-friendly” environment and study into the provision of ancillary facilities for cycling (such as provision of cycling track network and bicycle parking spaces, park-and-ride facilities at public transport interchanges and bike-friendly policies to facilitate carriage of bicycles on public transport)	II-C-2	Short-term (for existing towns and urban areas)
Launch one-stop mobile app for the public to access real-time information on car parking vacancies which helps them choose the best parking location and shortening the driving distance	II-E-2	Short-term
Introduce intelligent transport systems (e.g. manage traffic flow by traffic signal control, install smart sensors and surveillance cameras for illegal parking enforcement)	II-E-4	Short-term

Measure	**Code**	**Practicability**
Use urban planning and design solutions together with transport management to improve air ventilation in high density development	II-F-2	Short-term
Enhance district-based publicity on bus route rationalization	II-F-5	Short-term
Enhance enforcement against illegal parking	II-G-2	Short-term
Raise public awareness on environmental protection, promote green living and encourage the public to use public transport systems as well as low emission transportation options	II-H-8	Short-term
Launch one-stop mobile app for the public to choose the most time-saving, economical and low-emission transportation mode	II-E-1#	Medium-term
Conduct comprehensive review on the development of road transportation infrastructure and networks (such as construction of new tunnels and roads) to cope with population growth and to tackle road traffic congestion	II-F-3#	Medium-term
Raise the first registration tax of highly polluting vehicles and impose higher licence fees for more polluting vehicle licences to manage the growth of vehicles	II-G-1#	Medium-term
Review on-street metered parking fees	II-G-3#	Medium-term
Address the personal and operational needs of heavy vehicle drivers, such as provision of parking space and arrangement of meal and rest breaks at the Kwai Chung Container Terminals area, so as to reduce air pollution arising from idling engines	II-H-4#	Medium-term
Review the tunnel toll policy and level (e.g. the Government to buy back the tunnels, tunnel toll subsidy pilot scheme)	II-A-1	Long-term
Set up cycling and walking shared space at harbourfront areas	II-C-3	Long-term

Measure	**Code**	**Practicability**
Electric vehicles pilot schemes - switching the existing vehicle fleet of selected routes to electric vehicles. - Targeting green minibus or franchised bus routes -With the support of vehicle supplier, work out the best configurations for electric vehicles of the selected routes for the trial -The scale of the pilot scheme must be large enough to attract vehicle suppliers to provide comprehensive technical and maintenance support	II-D-2	Long-term
Implement electronic road pricing scheme to tackle road traffic congestion at busy roads	II-E-3	Long-term
Through proper land use planning to redress the current imbalance in home-job distribution and bring jobs closer to home so as to reduce commuting time and private car usage	II-F-1	Long-term
Provide low-emission transport mode to the residents of new development areas	II-F-4	Long-term
Foster "pedestrian-friendly" environment (such as widening of footpaths, construction of covered walkways and enhancing the pedestrian connections) to encourage people to walk	*II-C-1*	*Long-term* *(for new towns and New Development Areas (NDAs))*
Foster "bicycle-friendly" environment and study into the provision of ancillary facilities for cycling (such as provision of cycling track network and bicycle parking spaces, park-and-ride facilities at public transport interchanges and bike-friendly policies to facilitate carriage of bicycles on public transport)	*II-C-2*	*Long-term* *(for new towns and New Development Areas (NDAs))*

Measure	**Code**	**Practicability**
Consider replacing the existing system with complete automatic toll collection system	II-A-2	Others
Propose to use chassis dynamometer for testing vehicle tailpipe emissions	II-B-1	Others
Tighten the annual vehicle examination for private cars from over six years old to over three years old (or consider adopting vehicle kilometres travelled as the vehicle examination criterion)	II-B-2	Others
Provide vehicle tailpipe emission testing equipment for rent by small and medium-sized vehicle repair workshops	II-B-3	Others
Establish lower vehicle speed limits zones (e.g. 30km/h) in community roads, school zone and areas with elderly centres, to foster pedestrian environment	II-C-4	Others
Tram or electric bus interchange schemes at busy road sections (e.g. Nathan Road) to replace the franchised bus services so as to reduce the number of buses and boarding/alighting passengers on the road section. - Consider using electric buses with ultra-fast charge or super-capacitor models for the interchange schemes - Set up priority lanes for trams/electric vehicles within the pilot areas	II-D-1	Others
Promotion of hybrid private cars	II-D-3	Others
Exploring the use of new-energy vehicles	II-D-4	Others
Provide information on the energy efficiency, emission performance and noise level of vehicles, etc. to facilitate the public to make a more environmentally-friendly choice	II-H-1	Others

Measure	**Code**	**Practicability**
Set out objectives/policies to support the use of cleaner vehicle fuels	II-H-2	Others
Extend the coverage areas of the existing low emission zones and its restriction to other vehicle types	II-H-3	Others
Set up priority lanes for public vehicles	II-H-5	Others
Review the policy on replacement of franchised buses	II-H-6	Others
Provide funding to support District Councils for implementing air quality improvement projects	II-H-7	Others

[#] Subject to the endorsement from the Subgroup, the practicability for implementation of the measure is under re-consideration and could be revised.