Legislative Council
Panel on Environmental Affairs
Subcommittee on Issues Relating to Air, Noise and Light Pollution

Cost-Benefit Analysis of the Various Measures Taken to Improve Air Quality for the meeting of 16 April 2013

The Administration is requested to provide a cost-benefit analysis of the various measures taken to improve air quality. The format should be similar to the one given in Appendix II to Annex B of the paper on "Review of Hong Kong's Air Quality Objectives and Development of Long-term Air Quality Management Strategy".

As part of the review of Hong Kong's Air Quality Objectives (AQOs), the Environment Bureau appointed a consultant in June 2007 to assist in the review. Amongst various tasks, the consultant conducted a crude cost-benefit analysis for various air quality improvement measures to provide a broad indication on their relative cost-effectiveness. The relevant analysis was published in Annexes E and F of the "AQO Review Public Consultation document issued in July 2009. An extract of the two annexes are attached.

2. The consultant conducted a cost-benefit analysis to provide an indication of the cost-effectiveness of the proposed emission control measures. In the analysis, the estimated principal costs include the administrative costs of the Government in pursuing the required policies and any other incidental capital and operational costs on the entire community as a consequence of implementation. It should be stressed that the analysis focuses mainly on the "social costs" to be borne by the entire community. It makes no distinction as to whether the costs would at the end of the day be borne by the Government, power companies, transport operators or consumers. The benefits could be sub-divided into those of a direct nature (principally short and long-term health related cost savings, including the reduced costs of illness and reduced premature mortality, and savings in electricity costs) and indirect nature (principally impacts on the workforce and costs of maintenance and repair to buildings and structures and some lesser items). As the proposed measures are still at a conceptual stage, the estimates on costs and benefits are subject to a great deal of uncertainties and variations depending on the timing and details of implementation, market situations and community's responses, etc. Nonetheless, the cost-benefit analysis does provide a systematic framework for comparing the relative cost-effectiveness of different proposed measures. It should also be stressed that the findings of the cost-benefit analysis should not be considered as the only criterion for considering whether any of the proposed emission control measures should be implemented. Any decision on implementation of the proposed measures should be taken and balanced against different considerations, including emission reduction potential, costs and benefits, acceptance by the stakeholders, etc.

Environment Bureau / Environmental Protection Department
April 2013

Annex E

Proposed Phase I Emission Control Measures and Their Respective Emission Reduction Potential and Cost-Benefit Analysis

		Emission Reduction Potential (t)				Cost – Benefit Analysis[1]		
		SO_2	NOx	RSP / PM_{10}	VOCs	Cost ($M)	Benefit ($M)	B/C Ratio[2]
Emission Capping and Control								
1.	Increasing the ratio of natural gas in local electricity generation to 50% together with additional emission abatement measures[3]	13,402	25,225	523	0	2,032[4]	1,803	0.9[4]
2.	Early retirement of aged / heavily polluting vehicles (pre-Euro, Euro I and Euro II commercial diesel vehicles and franchised buses)	0	3,102	300	184	3,882[5]	24,344	6.3
3.	Earlier replacement of Euro III commercial diesel vehicles with models meeting latest Euro standards	0	743	75	24	2,668[5]	6,134	2.3
4.	Wider use of hybrid / electric vehicles or other environment-friendly vehicles with similar performance (20% private cars and 10% franchised buses)	15	216	7	173	4,326[5]	2,417	0.56
5.	Ultra low sulphur diesel (SCR) for local vessels	675	0	18	0	378	6,331	16.7
6.	Selective catalytic reduction for local vessels	0	304	0	0	249	74	0.30
7.	Electrification of aviation ground support equipment	85	759	21	67	1,449	3.8	0.003
8.	Emission control for off-road vehicles / equipment	4	950	239	326	845	2,123	2.5
9.	Strengthening volatile organic compounds control	0	0	0	700	18	124	6.9
Transport Management								
10.	Low emission zones	Note [6]	Note [6]	Note [6]	Note [6]	3,696	2,586	0.7
11.	Car-free zone / pedestrianisation scheme	Note [6]	Note [6]	Note [6]	Note [6]	42	400	10
12.	Bus route rationalization	4	156	7	9	14	548	39
Infrastructure Development and Planning								
13.	Expand rail network	17	501	46	207	Note [7]	3,850	Note [7]
14.	Cycling network to major public transport hubs	0.1	2.3	0.1	0.1	836	8	0.01
Energy Efficiency Measures [8]								
15.	Mandatory implementation of Building Energy Codes	151	256	8	3	95	2,634	28
16.	Energy efficiency standards for domestic electrical appliances	84	142	4	1	84	2,277	27
17.	Light-emitting diode or equivalent alternatives for traffic signal / street lighting	3	5	0.1	0	47	105	2.2
18.	Tree planting / roof-top greening [9]	Note [9]	Note [9]	Note [9]	Note [9]	6,357	1,603	0.3
19	District cooling system for Kai Tak Development	6	16	0.5	0.2	2,788[10]	4,047	1.5

Notes:

[1] In its simplest form, the costs and benefits of each policy are quantified and valued in monetary terms. The cost-benefit analysis is subject to a wide range of assumptions used by the consultant for compiling the assessment of different proposed emission control measures. As these assumptions are subject to change, the findings of the cost-benefit analysis should be read with caution. Nonetheless, it provides a systematic framework to compare the potential cost-effectiveness of different measures.

[2] A benefit-cost ratio above one indicates that the overall monetized benefits of the proposed measure are expected to be higher than the costs to be borne by the society. A ratio below one indicates the otherwise.

[3] Possible additional emission abatement measures include enhancing the SCR systems of the existing coal-fired units. However, the technical feasibility and financial viability of retrofitting the existing coal-fired units with enhanced SCR systems are not yet established and subject to more detailed examination with the concerned power company.

[4] The figure includes estimated costs due to increasing the ratio of natural gas in local electricity generation to 50%. It does not cover the costs of the additional emission abatement measures, such as enhancing the SCR systems of the existing coal-fired units, the technical feasibility and financial viability of which would be subject to further examination.

[5] The cost of early retirement of the concerned vehicles is calculated based on the residual value foregone of these vehicles over the remaining period of their normal serviceable life. The upfront capital costs required for procuring the replacement vehicles would be higher than the figures set out in the table.

[6] Emission reduction potential would not be substantial as it involves mainly transferring emission from one place to another.

[7] The railway strategy includes the Express Rail Line, the Sha Tin to Central Link (the Tai Wai to Hung Hom section), the West Island Line, the South Island Line (East), the Kowloon Southern Link and the Kwun Tong Line Extension. The railway strategy will have additional ride-on effect on improvement of air quality. Only benefits are presented.

[8] Benefits include material damage, energy saving as well as acute and chronic health benefits. For strategies 15, 16, 17 and 19, the majority of benefits are due to energy savings, not health benefits. Emission reduction of energy efficiency measures is generated from less electricity demand. To be conservative, they have not been included in the net total emission reduction.

[9] The proposed measures help reduce urban heat island effect and improve air pollution dispersion. No local emission and cost data are available. Estimates are based on overseas data for roof top greening of 10% of the urban area.

[10] The figure includes both the capital and operational costs of the plant for the coming 50 years.

Total Emissions (Tonnes) With and Without Proposed Phase I Emission Control Measures

	Without Proposed Measures				With Proposed Meaures			
Sector	**SO_2**	**NOx**	**RSP / PM_{10}**	**VOCs**	**SO_2**	**NOx**	**RSP / PM_{10}**	**VOCs**
Power	25,120	42,600	1,260	420	11,718	17,375	737	420
Transport	5,706	43,832	2,407	6,705	4,910	38,048	1,933	6,040
Vehicles	*299*	*14,075*	*1,697*	*5,854*	*263*	*9,354*	*1,262*	*5,257*
Marine (Figure in brackets for local vessels)	*4,938 (682)*	*21,684 (3,994)*	*676 (179)*	*436 (91)*	*4,263 (7)*	*21,380 (3,690)*	*658 (161)*	*436 (0)*
Aviation	*469*	*8,073*	*34*	*415*	*384*	*7,314*	*13*	*348*
Industry and Others	16	4,608	624	24,131	12	3,658	385	23,104
Total	**30,842**	**91,040**	**4,291**	**31,255**	**16,640**	**59,080**	**3,055**	**29,564**

Annex F

Proposed Phases II and III Emission Control Measures and Their Respective Emission Reduction Potential and Cost-Benefit Analysis

Proposed Phases II Emission Control Measures and Their Respective Emission Reduction Potential and Cost-Benefit Analysis

		Emission Reduction Potential (t)				Cost – Benefit Analysis[1]		
		SO_2	NOx	RSP / PM_{10}	VOCs	Cost ($M)	Benefit ($M)	B/C Ratio[2]
Emission Capping and Control								
20.	Increasing the ratio of natural gas in local electricity generation to 75% with additional abatement measures (Additional to Phase I measure)	5,163	5,761	178	0	1,702	383	0.2
21.	Increasing the ratio of renewable energy (2% wind energy)	502	852	25	8	13,069	206	0.02
22.	Wider use of hybrid / electric vehicles or other environment-friendly vehicles with similar performance [30% private cars, 15% buses (including franchised buses), 15% light goods vehicles (LGVs) plus 15% heavy goods vehicles (HGVs)] (Additional to Phase I measure)	40	849	79	174	9,026	14,447	1.6
23.	Ultra low sulphur diesel for ocean-going vessels and local vessels (Additional to Phase I measure)	2,392	1,145	15	0	4,563	15,087	3.3
24.	Selective catalytic reduction for ocean-going vessels and local vessels (Additional to Phase I measure)	0	7,153	0	0	1,333	1,173	0.9
25.	Electrification of on-shore power supply	377	2,361	297	404	1,579	6,243	4.0
26.	Tightening aviation emission standards	0	3,587	0	0	Note [3]	12	Note [3]
27.	Further strengthening volatile organic compounds control	0	0	0	4,870	37	634	17.2
Transport Management								
28.	Electronic road pricing (ERP) / congestion charging scheme for Hong Kong Island North	Note [4]	Note [4]	Note [4]	Note [4]	Note [4]	577	Note [4]
29.	Reduce parking provision (25%) to restrain car usage for Central	Note [5]	Note [5]	Note [5]	Note [5]	757	18	0.02
Energy Efficiency Measures [8]								
30.	District cooling system (35% in existing areas and 90% in other new development areas)	120	197	5.5	1.9	19,347	11,578	0.6

Proposed Phases III Emission Control Measures and Their Respective Emission Reduction Potential and Cost-Benefit Analysis

Emission Capping and Control								
31.	Increasing the ratio of natural gas in local electricity generation to 100% (Additional to Phase II measure) [7]	6,553	7,430	270	0	348	255	0.7
32.	50% nuclear power and 50% natural gas (Alternative Case compared to Base Case of 75% natural gas) [7]	6,554	8,422	381	210	-2,894	91	–
33.	Wider use of hybrid / electric vehicles or other environment- friendly vehicles with similar performance (50% private cars, 50% buses (including franchised buses), 50% HGVs plus 50% LGVs) (Additional to Phase II measure)	63	789	42	232	8,530	7,751	0.91
34.	Vehicle permit quota system (to reduce around 50% private cars and 50% motorcycles)	28	93	3	119	691	251	0.4
35.	Use of hydrogen fuel cell vehicles or equivalent alternatives (40% penetration)	140	2,778	94	1,453	Note [8]	10,420	Note [8]
Infrastructural Development and Planning								
36.	Rail for transport of cross-boundary goods	1	11	1	9	Note [9]	115	Note [9]

Notes:

[1] In its simplest form, the costs and benefits of each policy are quantified and valued in monetary terms. The cost-benefit analysis is subject to a wide range of assumptions used by the consultant for compiling the assessment of different proposed emission control measures. As these assumptions are subject to change, the findings of the cost-benefit analysis should be read with caution. Nonetheless, it provides a systematic framework to compare the potential cost-effectiveness of different measures.

[2] A benefit-cost ratio above one indicates that the overall monetized benefits of the proposed measure are expected to be higher than the costs to be borne by the society. A ratio below one indicates the otherwise.

[3] Costs for this proposed measure will be borne by the aircraft industry (and hence consumers) worldwide and only air quality benefits to Hong Kong have been calculated.

[4] The ERP strategy will have additional ride-on effect on improvement of air quality. The overall emission reduction potential would not be substantial. The ERP measure will have incidental improvements to air quality. Only these benefits have been calculated here. The estimated cost for the proposed ERP scheme is about $1 billion (including the cost of in-vehicle units for existing vehicles) with an annual recurrent cost of about $200 million.

[5] Emission reduction potential would not be substantial as it involves mainly transferring emission from one place to another.

[6] Emission reduction of energy efficiency measure is generated from less electricity demand. To be conservative, they have not been included in the net total emission reduction.

[7] The “increase ratio of natural gas in local electricity generation to 100%” scenario and “50% nuclear power and 50% natural gas” scenario are either-or case. Adoption of only one of these proposed measures would be expected.

[8] Fuel cell technology has not yet matured, and there are no local cost data. Hence only the likely air quality improvement benefits have been calculated.

[9] Only the air quality improvement benefits have been calculated. The capital cost of the freight rail would be about $5 billion to $9 billion.

Total Emissions (Tonnes) With and Without Proposed Phase I and II Emission Control Measures

	Without Proposed Measures				With Proposed Meaures			
Sector	**SO_2**	**NOx**	**RSP / PM_{10}**	**VOCs**	**SO_2**	**NOx**	**RSP / PM_{10}**	**VOCs**
Power	25,120	42,600	1,260	420	6,053	10,762	534	412
Transport	6,451	45,133	2,244	6,304	2,861	28,317	1,760	5,442
Vehicles	*331*	*11,231*	*1,416*	*5,290*	*270*	*9,722*	*1,284*	*4,900*
Marine (Figure in brackets for local vessels)	*5,569 (682)*	*24,412 (3,994)*	*788 (179)*	*526 (91)*	*2,124 (7)*	*13,450 (3,690)*	*457 (161)*	*122 (0)*
Aviation	*552*	*9,490*	*40*	*488*	*466*	*5,145*	*19*	*421*
Industry and Others	15	4,632	625	24,761	11	3,682	386	18,865
Total	**31,586**	**92,365**	**4,129**	**31,485**	**8,925**	**42,761**	**2,679**	**24,719**

Total Emissions (Tonnes) With and Without Proposed Phase I, II and III Emission Control Measures

	Without Proposed Measures				With Proposed Meaures			
Sector	**SO_2**	**NOx**	**RSP / PM_{10}**	**VOCs**	**SO_2**	**NOx**	**RSP / PM_{10}**	**VOCs**
Power	25,120	42,600	1,260	420	0	2,340	153	202
Transport	7,734	49,154	2,438	6,501	3,952	29,515	1,894	4,000
Vehicles	*353*	*9,797*	*1,388*	*5,306*	*101*	*5,466*	*1,195*	*3,276*
Marine (Figure in brackets for local vessels)	*6,829 (682)*	*29,866 (3,994)*	*1,010 (179)*	*707 (91)*	*3,385 (7)*	*18,904 (3,690)*	*680 (161)*	*303 (0)*
Aviation	*552*	*9,490*	*40*	*488*	*466*	*5,145*	*19*	*421*
Industry and Others	14	4,720	629	25,980	10	3,770	391	20,083
Total	**32,868**	**96,474**	**4,327**	**32,900**	**3,962**	**35,626**	**2,437**	**24,285**