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For Discussion

Strategic Environmental Assessment of Territory-wide Implementation Study for Water-cooled Air Conditioning Systems in Hong Kong

Purpose

This paper presents the findings and recommendations of the Territory-wide Implementation Study for Water-cooled Air Conditioning Systems in Hong Kong" (hereunder referred as "this Study"), and the environmental issues and mitigation measures revealed from the Strategic Environmental Assessment (SEA); and invites Members' views on the implementation of Water-cooled Air Conditioning Systems (WACS) in Hong Kong.

Need for the Study

2. WACS is not a new technology. Utilizing seawater for condenser cooling in air-conditioning system has already been adopted by some individual buildings along the seafront. Pursuant to the current Waterworks Regulations, except with the permission in writing of the Water Authority, no person shall use water from waterworks for air-conditioning use. Evaporative type cooling towers (i.e. those to be used under the Cooling Tower Scheme) are only permitted to use for industrial or essential purposes and seldom permitted for comfort air-conditioning in commercial buildings.

3. In 2000, the air conditioning loads associated with the non-domestic premises was 8,090,000 kW with an electricity consumption of 8,400 millions kWh per year, 23% of the territory electricity consumption.[1] It was further estimated that the then electricity consumption by air-conditioning systems for non-domestic premises could be translated into greenhouse gas emission in the order of 5,880,000 tonnes annually.

4. At the meetings of the Legislative Council Panel on Environmental Affairs held on 10 February 2000 and 2 March 2000, the Panel was informed that the Administration supported the findings and recommendations of the "Preliminary Phase Consultancy Study on Wider Use of Water-cooled Air Conditioning Systems in Hong Kong". Subsequently, with the support of the Panel, we obtained the funding approval of the Finance Committee for conducting this Study.

[1] According to the Hong Kong Energy Statistics Annual Report, there was a territorial electricity consumption of 36,328 millions kWh in Year 2000.

Description of the Study

5. This Study aims to formulate plans, programmes and control requirements for the phased implementation of WACS in the whole territory and examine in detail the relevant environmental, health, regulatory, institutional, financial, technical and land administration issues. It has also explored various technologies and three strategic WACS schemes (Details refer to **Annex A**), namely, the Centralised Piped Supply System for Cooling Towers (CPSSCT or Cooling Tower Scheme), the more energy-efficient District Cooling Scheme (DCS) and Centralised Piped Supply System for Condenser Cooling (CSS or Central Seawater Scheme).

Key Findings of the Study

6. The key findings are as follows -

(a) The projected air conditioning loads for non-domestic premises in the whole territory were estimated to be 13,348,500 kW by 2020[2];

(b) By switching from an Air-cooled Air Conditioning System (AACS) to the DCS, CSS, or Cooling Tower Scheme, it is possible to achieve energy savings of up to 35%, 28% and 20% respectively;

(c) The wider-adoption of the Cooling Tower Scheme and the District Cooling Scheme in the territory will reduce our electricity consumption on air-conditioning systems3 by 1,360 millions kWh or about $1.2 billion saving4 per year. Moreover, the energy conserved can also be translated into reduction in greenhouse gas emission by 950,000 tonnes annually.

Cooling Tower Scheme

(d) Studies on the demand for water supply and sewerage arising from the Scheme revealed the following -

(i) Additional fresh water demand generated by the Scheme could largely be met by the existing fresh water supply infrastructure in the short to medium term by taking up the supply capacity for planned developments yet to be completed. In the long run, the water supply system should be upgraded at an estimated cost of $1.1 billion to meet the demand arising directly from the Scheme;

[2] According to the Hong Kong Energy Statistics Annual Report and the Energy Modelling of the Study, there was 8,090,000 kW non-domestic air conditioning load in Year 2000. The Consultants estimated that for a mean annual growth of 2.5% in air conditioning load, the non-domestic air conditioning load in Year 2020 will become 13,348,500kW.

[3] The estimation assumes different penetration of DCS in newly developed and existing DCS zones.

[4] Assuming $0.9 per kWh.

(ii) In most situations, all wastewater from cooling towers could be used for toilet flushing and zero additional discharge could be achieved provided that the required additional facilities could be accommodated; and

(iii) Use of fresh water, rather than seawater, by cooling towers is preferable due to the high corrosive effect of seawater and insufficient capacity of existing seawater supply infrastructure;

(e) From a survey conducted on existing fresh water cooling towers in the Study, the cooling tower water quality was found suitable for reuse as flushing water and discharging into foul sewers leading into Government sewage treatment plants due to the fact that the cooling water meets the existing water quality requirements for flushing water and standards for effluent discharged into foul sewers leading into Government sewage treatment plants;

(f) Proper control of residual chemicals in the wastewater from the cooling towers is necessary to prevent undermining the effectiveness of standard sewage treatment processes. In the near term, the use of chemicals for the water treatment of cooling towers can still be accommodated and the reuse of cooling water for flushing purpose should be promulgated. A more stringent legislative control as a contingency approach may be established in the long term for regulating potentially toxic substances which may pose an unreasonable risk to public health or the environment when all existing legislative and administrative measures have been exhausted and found ineffective for control of residual chemicals in the wastewater from the cooling towers;

(g) The Health Risk and Control assessment concluded that the requirements stipulated in the existing "Code of Practice for Prevention of Legionnaires' Disease" and the application procedures/guidance document for the "Pilot Scheme for Wider Use of Fresh Water in Evaporative Cooling Towers for Energy-efficient Air Conditioning Systems" issued by Electrical and Mechanical Services Department (EMSD) should be supplemented by a standing surveillance programme to prevent the breeding of Legionella bacteria;

District Cooling Scheme and Central Seawater Scheme

(h) In order to avoid overloading the existing infrastructure, dedicated supply and discharge pipelines independent from the existing government seawater supply and sewerage infrastructure are required for DCS adopting the once-through seawater cooling system[5] and CSS;

[5] The once-through seawater cooling system means an open loop system with seawater passing through the condenser and returning the warmed seawater back to the sea.

(i) The implementation of either DCS or CSS should not cause any insurmountable traffic problems. However, detailed traffic impact assessment should be conducted and proper mitigation measures should be implemented when large water pipes are to be laid under major roads with heavy traffic;

(j) It is not suitable to locate the intakes and outfalls of a DCS adopting the once-through seawater cooling system or a CSS in sensitive marine areas such as Deep Bay, Tolo Harbour and near fish culture zones;

(k) Proper control of residual chemicals in the wastewater from DCS adopting once-through seawater cooling system or CSS is necessary; and

(l) There would be no significant air quality and noise problems during implementation of DCS or CSS.

(m) The WACS schemes of relatively small scale will not constitute Designated Project. Nonetheless, SEA recommended a strategic environmental monitoring & auditing (SEM&A) system to ensure that the required environmental protection measures are instituted and the level of environmental benefits achieved by their implementation is validated.

Environmental Issues and Mitigation Measures

7. The environmental issues and mitigation measures are as follows -

(a) Cooling Tower Scheme

(i) Environmental Benefits - The Scheme is more energy-efficient than the conventional air-cooled air conditioning scheme and the additional demand of fresh water can be accommodated within the existing and planned water supply infrastructure;

(ii) Environmental Impacts – Residual chemicals in the wastewater discharged from the Scheme may have impact on the effectiveness of the standard sewerage treatment process, and the potential growth of Legionella bacteria in the warmed cooling water stream and undesirable aerosol transmission may pose risk to the public health;

(iii) Environmental Impact Mitigation Measures – The environmental impact control measures outlined in paragraph 6(f) above should be stipulated as the conditions for permission to use fresh water by cooling towers. In addition, a code of practice would be compiled on the use of proven technology and acceptable chemicals for controlling the cooling water quality. A register of acceptable

chemicals would be established by the approving authority, and the use of unregistered chemicals would be subject to the permission of the approving authority based on the environmental impact assessment of the chemicals to be carried out by the project proponent.

(iv) Health Risk Mitigation Measures – The health risk control measures outlined in paragraph 6(g) above should be stipulated as the conditions for permission to use fresh water by cooling towers, and a standing surveillance programme to ensure proper implementation of the required control measures by the owners or operators of the cooling towers should be set up by the approving authority.

(b) District Cooling Scheme and Central Seawater Scheme

(i) Environmental Benefits – The Scheme is more energy-efficient than the conventional air-cooled air conditioning scheme and the Cooling Tower Scheme;

(ii) Environmental Impacts – Noise and air quality impacts are not expected during operation of DCS and CSS. The wastewater discharged from the DCS adopting once-through seawater cooling and CSS would cause temperature rise and residual chemicals to the receiving water. The impacts were assessed by a hydrodynamic model and it was confirmed that the situation is environmentally acceptable in all 15 potential district cooling zones; and

(iii) Mitigation Measures – The adoption of the once-through seawater cooling system in sensitive marine areas such as Deep Bay, Tolo Harbour and near fish culture zones should be avoided.

8. In light of the above, the following implementation strategies of WACS were highlighted -

(a) For the Cooling Tower Scheme,

(i) the Scheme should be accorded with higher priority than other Schemes, given that it requires relatively less substantial initial investment in infrastructure and relatively short planning lead-time;

(ii) the Scheme could first be implemented in those zones with adequate fresh water supply capacities provided that the supply capacity taken up by the Scheme would be re-provided when the planned developments are completed;

(iii) the environmental and health risk control measures outlined in

paragraphs 6(f) and 6(g) above should be stipulated as the conditions for permission to use fresh water by cooling towers; and

(iv) a standing surveillance programme to ensure proper implementation of the required control measures by the owners or operators of the cooling towers should be set up by the approving authority.

(b) For the District Cooling Scheme,

(i) suitable zones should be selected for detailed studies and pilot implementation; and

(ii) the rights to implement and operate a DCS in a designated area can be granted through either a contractual agreement or a statutory licensing agreement[6]. The environmental and regulatory control measures described in paragraph 6(k) above should be stipulated as the contract conditions or licensing conditions;

(c) The CSS, being less energy efficient than the DCS and mutually exclusive with the latter in the same district, should be considered when DCS is not practicable;

(d) A Regulator Office should be set up to oversee the above key implementation issues of Cooling Tower Scheme, District Cooling Scheme and Central Seawater Scheme.

Strategic Environmental Monitoring and Auditing (SEM&A)

9. SEA sets out a SEM&A schedule, to provide a clear direction to implement the recommended WACS schemes progressively in a long term. The details of which are given in **Annex B.**

10. The outlines of the monitoring and auditing actions are as follows -

(a) There will be zero net additional wastewater drainage loading from the Cooling Tower Scheme;

(b) Chemicals with acceptable environmental impact can only be used in the WACS schemes; and

(c) The thermal effect and the decay of residual chemicals associated with DCS adopting once-through seawater cooling and CSS will not exceed the scenario case of 30% penetration of projected air conditioning loads for non-domestic premises in the whole territory and in case of exceeding the

[6] The Contract Approach can only govern the rights and obligations of the Government and the DCS operator. The Statutory Licensing Approach is necessary if the rights and obligations of third parties are affected.

set point, it shall trigger an Environmental Review on the WACS implementation; and

(d) The actual energy savings arising from implementation of the recommended WACS schemes will be monitored and compared with the estimated environmental benefits and in case of significant deviation, the implementation strategies shall be reviewed for future decision on remediation.

Public Consultation

11. The Executive Summary of the Study was posted on the EMSD website on 11 August 2003 and a consultation exercise of the Study was conducted from August to November 2003. The major stakeholders were invited to give their views and comments. A total of twenty-four submissions were received. Sixteen submissions supported the implementation of WACS in Hong Kong. Others did not express any explicit support, but their views and opinions were positive.

Proposed Way Forward

12. With the encouraging feedback from the public consultation and earlier support from the Legislative Council Panel on Environmental Affairs and the Energy Efficiency and Conservation Subcommittee, consideration will be given to lift the restriction on the use of fresh water for cooling towers in areas where the fresh water supply capacities are adequate. The development programme of the areas recommended for implementing district cooling schemes will be monitored.

Advice Sought

13. Members are invited to comment on the findings and recommendations of the Study and offer views on the implementation strategies of the WACS schemes.

Attachments

Attachment 1 : Strategic Environmental Assessment Report of the "Territory-wide Implementation Study for Water-cooled Air Conditioning Systems in Hong Kong"

Attachment 2 : Executive Summary of the "Territory-wide Implementation Study for Water-cooled Air Conditioning Systems in Hong Kong"

Environment, Transport and Works Bureau
Electrical and Mechanical Services Department
October 2004

BASIC FEATURES OF DISTRICT COOLING SCHEME, CENTRAL SEAWATER SCHEME, AND COOLING TOWER SCHEME

The basic features of the three WACS schemes, namely the District Cooling Scheme, the Central Seawater Scheme, and the Cooling Tower Scheme, are summarized below :-

- The District Cooling Scheme **generates chilled water centrally** and supplies chilled water to the connected building groups for air-conditioning through a closed loop of distribution pipeline network. This Scheme is suitable for large developments, where a large central chiller plant is normally located in close proximity to user buildings. It may employ seawater cooled once through condenser, or fresh water or sea water cooling towers for heat ejection.

- The Central Seawater Scheme supplies sea water from a central pumphouse through an open loop of distribution pipeline network to individual buildings' air-conditioning systems, which generate their own chilled water and employ **once through sea water condensers** for heat ejection. Due to the need to consume a large volume of seawater, this Scheme is most suitable for buildings near the sea front.

- The Cooling Tower Scheme, unlike the two Schemes above, does not have centralized components and requires no pipeline network. Individual buildings are installed with their own **evaporative cooling towers** for heat ejection by their own chiller plants. Cooling towers may use seawater or fresh water. Water may be recycled for a number of times before being discharged into the sewerage system. As the Cooling Tower Scheme does not require a new distribution network, the investment in infrastructure would be minimal.

ANNEX B

SEM&A Schedule for Environmental Protection Measures – Assumptions

SEA Report Ref.	Assumption	Environmental Protection Measures	Implementation Agent	Implementation Phase	Rationale/ Relevant Legislation/ Guidelines
14.4	No elements in WACS implementation constitute Designated Project	Review particulars of the specific WACS schemes against EIAO* to determine whether the statutory EIA* process is required	Project Proponent	Planning Design	EIAO*
8.3	Zero discharge to existing sewerage system	1. For freshwater cooling tower, re-use of discharge as toilet flushing along with the use of cooling water storage tank at the buildings concerned as necessary 2. For DCS and CSS**, dedicated pipework for discharge into the sea 3. Obtain Consent of Discharge from Regulator Office on a case by case basis for any surplus discharge to the existing sewerage system	1 & 2: Project Proponent 3: Project Proponent Regulator Office	Design Operation	DSD Technical Circular No. 4/94 (C.E.O. Instruction No. 9/71; H.O. Instruction No. 8/71)
12.7.94	30% of territory-wide WACS(DCS) with once-through seawater cooling penetration for future scenario	1. Regular monitoring and audit of the 30% of territory-wide WACS(DCS) with once-through seawater cooling penetration for future scenario 2. In case of exceeding 30% penetration for future scenario, trigger Environmental Review on the WACS implementation for future decision and remediation	1 & 2: Regulator Office	Design Operation	Assumption of the Delft3D water quality modeling
12.2	Environmental benefits to the society in terms of energy conservation and the associated reduction of power plant emission	1. Regular monitoring and audit of the estimated environmental benefits to the society in terms of energy conservation. 2. In case of significant deviation from the estimated environmental benefits, review the WACS methodologies for future decision and remediation	1 & 2: Regulator Office	Design Operation	Assumption of the WACS Study

SEM&A Schedule for Environmental Protection Measures - Environmental Impacts

SEA Report Ref.	Environmental Impacts	Environmental Protection Measures	Implementation Agent	Implementation Phase	Rationale/ Relevant Legislation/ Guidelines
	Water Quality / Ecology				
12.7.99-101	Corrosion, scaling and sediment fouling	Good treatment practice, in particular the use of proven technologies e.g. corrosion resistant materials, physical and environmentally friendly techniques. Use of approved chemicals approved by Regulator Office	Project Proponent Operator	Design, Construction & Operation	EMSD: Guidance of Pilot Scheme** Code of Practice for Prevention of Legionnaires' disease Recommendations of the WACS Study
	Biofouling and *Legionella*	Disinfection with environmentally friendly techniques including UV, Ozone and peroxide for fresh water cooling water Compliance with *Legionella* control requirements as recommended in Health Risk and Control Strategy Use of approved chemicals by Regulator Office. If chlorine based chemicals were used, the total residual chlorine concentration of the discharge should not exceed 0.3 mg/L		Design & Operation	
12.7.94 – 97	Discharge	Implementation of once-through seawater cooling system according to the prioritization of the prospective zones, in particular avoidance of the once-through seawater cooling system in ecologically sensitive zones e.g. Tolo Harbour, Deep Bay, etc. Compliance with the conditions of Consent of Discharge by Regulator Office for any surplus discharge to the existing sewerage system	Project Proponent Operator Regulator Office	Design, Construction & Operation	Recommendations of the WACS Study
	Air Quality				
12.2.15 – 18	Global warming and Ozone depletion refrigerants	Selecting appropriate refrigerants, in particular those with zero Ozone Depletion Potential (ODP) and Global Warming Potential (GWP); and code of practice for leakage prevention, recovery, re-use and recycle of the refrigerants	Project Proponent Contractor Regulator Office	Planning; Design; Construction; Operation & Decommissioning	
	Noise				
12.10.42 – 43	Operational noise	1. Use of acoustic enclosure and silencer 2. Proper orientation and configuration of vent	Project Proponent	Design & Operation	NCO, HKPSG, NQO*

SEM&A Schedule for Environmental Protection Measures - Environmental Impacts

SEA Report Ref.	Environmental Impacts	Environmental Protection Measures	Implementation Agent	Implementation Phase	Rationale/ Relevant Legislation/ Guidelines
	Heritage Resources				
12.12.4	Underground works	Carry out detailed heritage assessment to confirm the presence of heritage resources in the construction sites	Project Proponent	Planning; Design; Construction; Operation & Decommissioning	Antiquities and Monuments Ordinance
	Maintenance of underground facilities	AMO* guidelines for protection of heritage resources	Project Proponent	Design & Operation	AMO* guidelines
	Landscape & Visual				
12.13.1-3	Construction	1. Planning to install WACS facilities underground at seafront areas and inside existing urban parks to minimize inconvenience to the public 2. Avoidance of removal of existing vegetation 3. Installation of adequate hoarding to minimize visual effects	Project Proponent Contractor	Planning Design Construction Decommissioning	HKPSG, Section 10: Guidelines for Landscape and Visual Impact Assessment; Government General Regulation 740; TMEIAP*
12.13.4 - 5	Operation	Careful integration of the design of ventilation outlets of the underground plant room with the existing landscape, such as by planting vegetation around this structure, and by the use background-compatible colour	Project Proponent	Planning Design	

Notes

*	EIA	= Environmental Impact Assessment
	EIAO	= Environmental Impact Assessment Ordinance
	TMEIAP	= Technical Memorandum on Environmental Impact Assessment Process
	APCO	= Air Pollution Control Ordinance
	OLPO	= Ozone Layer Protection Ordinance
	AQO	= Air Quality Objectives
	NSRs	= Noise Sensitive Receivers
	NCO	= Noise Control Ordinance
	HKPSG	= Hong Kong Planning Standards and Guidelines
	WCPO	= Water Pollution Control Ordinance
	WDO	= Waste Disposal Ordinance
	AMO	= Antiquities and Monuments Office

**	CPSSCT	= Cooling Tower System
	DCS	= District Cooling System
	CSS	= Centralized Piped Seawater Supplies for Condenser Cooling or Central Seawater Scheme
	Pilot Scheme	= Pilot Scheme for Wider Use of Fresh Water in Evaporative Cooling Towers for Energy-efficient Air Conditioning Systems