

CHAPTER 11

Electrical and Mechanical Services Department

Wider use of water-cooled air-conditioning systems

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WIDER USE OF WATER-COOLED AIR-CONDITIONING SYSTEMS

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PART 1: INTRODUCTION

1.1 This PART describes the background to the audit and outlines the audit objectives and scope.

Electricity consumption of air-conditioning systems

1.2 According to the Electrical and Mechanical Services Department (EMSD), electricity consumed by air-conditioning systems accounts for about one-third of the total electricity consumption in Hong Kong. The air-conditioning system of a typical office building may account for more than 50% of its total electricity consumption. With increasing population and development, the use of air conditioning and the electricity demand for air conditioning will continue to increase. Therefore, significant energy saving can be achieved by adopting energy-efficient air-conditioning systems and good energy management practices.

Air-cooled and water-cooled air-conditioning systems

1.3 Central air-conditioning systems used in non-domestic buildings can be broadly categorised by their heat rejection methods as:

- (a) air-cooled air-conditioning systems (AACS); or
- (b) water-cooled air-conditioning systems (WACS).

For the same cooling capacity, WACS generally consume 20% to 30% less electricity than AACS. The reduction in electricity consumption will bring about environmental benefits, e.g. conservation of fossil fuels and reduction in emission of carbon dioxide. WACS also operate at lower noise levels.

1.4 Both sea water and fresh water can be used for heat rejection in WACS. When sea water is used, WACS usually operate in the form of a once-through direct cooling system (Note 1). When fresh water is used, WACS usually operate in the form of an evaporative cooling tower system. Because of its corrosive effect, sea water is seldom used in WACS with evaporative cooling towers.

Note 1: *This type of WACS usually uses the once-through design in which the sea water enters the condenser, carries away the heat and is then discharged back to the sea. Water consumption is very high for the once-through system.*

Use of water-cooled air-conditioning systems

1.5 WACS are widely used in many cities including those in the Mainland. However, the use of WACS in Hong Kong is limited despite their benefits. For water conservation, the Water Supplies Department (WSD) used to disallow the use of mains water for air-conditioning purposes, except for industrial processes or essential uses. Despite this, there have been cases of unauthorised use of mains water for air-conditioning purposes. In 1996, an EMSD survey found that there were cooling towers scattered in the territory, the vast majority of which were without the WSD's authorisation for connection to the mains.

Health concerns over cooling towers

1.6 The installation and maintenance of cooling towers require special care because they have been found to be associated with the spread of Legionnaires' Disease (LD — see paras. 5.2 and 5.3), which is caused by human inhalation of contaminated aerosols dispersed from cooling towers or other sources. In Hong Kong, sporadic cases of LD have been reported without any outbreak. In 1985, the Government established the Prevention of Legionnaires' Disease Committee (PLDC — Note 2) to advise the Government, from the public health, microbiology and engineering services perspectives, on the minimisation of the risk of LD, and on the promotion of good practices to building owners and associated practitioners to prevent the outbreak of LD. In 1994, the PLDC issued the Code of Practice for Prevention of Legionnaires' Disease (CoP(PLD)) for the proper design, operation and maintenance of air-conditioning and water systems. In 2006, the EMSD issued the Code of Practice for Water-cooled Air-conditioning Systems (CoP(WACS)) providing guidelines on the proper design, operation and maintenance of cooling towers to promote the proper use of WACS to meet the energy efficiency objective with due consideration of the environment and health issues.

Note 2: *The PLDC is currently chaired by a medical professor from a local university. Members of the Committee include representatives from the EMSD, the Department of Health, the Development Bureau, the Architectural Services Department, the WSD, the Buildings Department, and professionals from the medical and engineering fields.*

Administrative framework

1.7 The Environment Bureau (ENB — Note 3) is responsible for policy matters on energy efficiency and conservation. Since LD is an illness connected with the improper operation and maintenance of evaporative cooling towers in air-conditioning systems, the Development Bureau (DEVB — Note 3) is responsible for policy matters related to the prevention and control of LD with assistance from the Department of Health (DH) and the EMSD. In August 1994, the EMSD set up the Energy Efficiency Office to spearhead and coordinate the Government's efforts to promote energy efficiency and conservation. Since then, the EMSD has developed standards and guidelines on energy management, and implemented various programmes to achieve energy saving. The EMSD also provides services to government departments on the operation and maintenance of air-conditioning systems through the Electrical and Mechanical Services Trading Fund (EMSTF). The Architectural Services Department (ArchSD) is responsible for designing and constructing building services installations, including air-conditioning systems, of government buildings for which the ArchSD is the works agent.

Director of Audit's Report on energy-efficient air-conditioning systems

1.8 In Chapter 2 of the Director of Audit's Report No. 33 of October 1999, the Audit Commission (Audit) reported observations on the use of energy-efficient air-conditioning systems in Hong Kong. Audit made a number of recommendations for improvement. The Administration accepted the audit recommendations and subsequently implemented them.

Audit review

1.9 Audit has recently conducted a review to examine the Government's efforts and progress in promoting the wider use of WACS in Hong Kong to identify room for improvement. The review focused on the following areas:

- (a) measures to promote wider use of water-cooled air-conditioning systems (PART 2);

Note 3: *In July 2007, the Environment Bureau and the Development Bureau were formed to take up the environmental policy portfolio and works policy portfolio respectively of the former Environment, Transport and Works Bureau. For simplicity, the Environment, Transport and Works Bureau is also referred as either the Environment Bureau or the Development Bureau, as appropriate, in this Audit Report.*

- (b) use of water-cooled air-conditioning systems in hospitals (PART 3);
- (c) development of district cooling systems (PART 4);
- (d) health concerns over cooling towers and water-using apparatus (PART 5);
- (e) inspection of cooling towers (PART 6); and
- (f) control measures on unauthorised cooling towers (PART 7).

Audit has found that there are areas where improvements can be made and has made a number of recommendations to address the issues.

General response from the Administration

1.10 The **Secretary for the Environment** and the **Director of Electrical and Mechanical Services** generally agree with the audit recommendations. They have said that the ENB and the EMSD will work closely with relevant bureaux and departments to implement the audit recommendations.

1.11 The **Secretary for Development** agrees with the audit recommendations. She has said that, given the energy efficiency benefits of WACS and the health concerns connected with improper operation and maintenance of cooling tower systems, the DEVB will work closely with the ENB and the Food and Health Bureau respectively to implement the audit recommendations. Any regulatory action to promote the use of WACS or to tackle unauthorised cooling tower systems would have to take account of the environment, economic and resource implications.

Acknowledgement

1.12 Audit would like to acknowledge with gratitude the full cooperation of the staff of the EMSD, the ArchSD, the DH, the WSD, the ENB, and the DEVB during the course of the audit review.

PART 2: MEASURES TO PROMOTE WIDER USE OF WATER-COOLED AIR-CONDITIONING SYSTEMS

2.1 This PART examines the measures taken to promote the wider use of WACS in Hong Kong with a view to identifying areas for improvement.

Use of mains water for air conditioning

2.2 According to Regulation 13 of the Waterworks Regulations (Cap. 102A), except with the permission of the WSD, mains water is not allowed for air-conditioning purposes. Under this arrangement, the use of mains water in WACS for **human comfort** is usually not permitted. Exemptions may be granted to use mains water for air-conditioning systems which are essential to **industrial processes** or for **essential uses** (e.g. air conditioning for operating theatres in hospitals, and cold storage), provided that water losses arise from evaporation only.

1999 audit review

2.3 In the 1999 audit review (see para. 1.8), Audit examined the WSD's ban on the use of mains water for air-conditioning purposes. Audit found that the ban was imposed a long time ago when there was a shortage of water supply and air conditioning was considered a luxury. In view of the ample capacity in the water supply system and the benefits of adopting WACS, Audit has recommended that the Administration should consider formulating a plan to relax the ban on the use of mains water for air-conditioning purposes at an early date.

2.4 In its report of February 2000, the Public Accounts Committee (PAC) of the Legislative Council (LegCo) recommended that the WSD should relax the ban on the use of mains water for air-conditioning purposes, and urged the Administration to expedite efforts in promoting and facilitating the wider use of WACS in Hong Kong.

Scheme for wider use of water-cooled air-conditioning systems

2.5 In early 2000, the Administration set up an interdepartmental Working Group (Note 4) to look into the possibility of relaxing the ban on the use of mains water for air conditioning and to review the requirements associated with the wider use of fresh water cooling towers.

2.6 In June 2000, the Working Group launched a “Scheme for Wider Use of Fresh Water in Evaporative Cooling Towers for Energy-efficient Air-conditioning Systems” (the FWCT Scheme). The FWCT Scheme was launched as a pilot scheme with a term of two years, covering six designated areas (Note 5) where the water supplies and sewerage network would be adequate to meet the additional water demand. The FWCT Scheme aims to:

- (a) promote the wider use of energy-efficient WACS;
- (b) monitor additional water demand;
- (c) monitor the quality and quantity of effluents discharged from cooling tower installations;
- (d) assess the health and environmental effects arising from the wider use of cooling towers; and
- (e) facilitate the territory-wide implementation of WACS.

Designated areas under FWCT Scheme

2.7 The FWCT Scheme was implemented on a district basis. The Working Group designated an area for inclusion under the FWCT Scheme according to the following criteria:

Note 4: *The interdepartmental Working Group, chaired by a Chief Engineer of the EMSD, comprises members from the DEVB, the ENB, the EMSD, the WSD, the DH, the Buildings Department, the Drainage Services Department, the Lands Department and the Planning Department.*

Note 5: *The six designated areas were in Wan Chai, Pok Fu Lam, Hung Hom, Tai Po, Yuen Long and Mong Kok.*

- (a) the area should be primarily non-domestic;
- (b) there was demand for using fresh water for air conditioning in the area; and
- (c) the existing water supply systems should have adequate capacity or very little work needed to be done to provide additional fresh water for air conditioning.

Owners of non-domestic buildings (Note 6) within the designated areas could apply for approval to use fresh water for WACS using evaporative cooling towers.

2.8 For buildings located outside the designated areas, applications for joining the FWCT Scheme would also be considered. Consideration will be given to the need to add a new designated area or expand an existing one to facilitate the applications on a case-by-case basis.

2.9 If an application for WACS is supported by the EMSD, the applicant can then submit the related plumbing proposals to the WSD for approval, and submit details of the evaporative cooling towers to the EMSD for registration. If supporting frameworks are involved in the installation of the cooling towers, the applicant is required to obtain approval from the Buildings Department on the construction plans of the supporting frameworks.

Requirements under FWCT Scheme

2.10 Participants of the FWCT Scheme are required to follow:

- (a) relevant statutory regulations, e.g. Waterworks Ordinance (Cap. 102), Buildings Ordinance (Cap. 123) and Sewage Services Ordinance (Cap. 463); and
- (b) requirements laid down under the Scheme, in particular, compliance with the CoP(PLD) and CoP(WACS) for the proper design, installation, operation and maintenance of cooling towers.

Note 6: *Domestic buildings (i.e. buildings for residential uses) are usually not designed to use central air-conditioning systems. They usually adopt AACCS in the form of window-type room coolers. WACS are usually used in non-domestic buildings as central air-conditioning systems.*

2.11 Participants of the FWCT Scheme are required to take the following actions as evidence of compliance with the requirements of the Scheme:

- (a) submitting monthly returns to provide information on the operating conditions, including conditions of each cooling tower shell and its supporting framework, energy consumption, water consumption and effluent discharge volume;
- (b) collecting water samples from cooling towers and conducting tests on the quality of cooling water, including monthly testing of total bacteria count and quarterly testing of Legionella bacteria count, and taking necessary action for cleansing and disinfection if the test results indicate that the cooling towers are contaminated;
- (c) reporting the test results to the EMSD in the monthly returns, and the remedial actions, if any, taken to bring the system back to normal; and
- (d) engaging independent and competent professionals to conduct annual examinations of the operation and maintenance records of the cooling tower installations, their operating conditions and the operation and maintenance programme, and submitting the examination reports to the EMSD. The examinations serve to verify whether the scheduled operation and maintenance work has been properly carried out, and whether appropriate remedial actions have been taken.

Approval of water supplies for WACS may be revoked for non-compliance with the requirements of the FWCT Scheme.

Progress in wider use of water-cooled air-conditioning systems

2.12 Since June 2000, the FWCT Scheme had been extended three times for two years each, and expanded to include more designated areas. In the reviews of the FWCT Scheme conducted in 2005 and 2007, the Working Group found:

- (a) substantial energy savings from the wider use of WACS under the FWCT Scheme;
- (b) no significant impact on the water supply and sewerage infrastructures; and
- (c) no adverse reports on health and environmental issues.

In June 2008, the Administration decided that the FWCT Scheme should continue as a standing scheme with no termination date.


2.13 Up to April 2009, the FWCT Scheme had been in operation for about nine years. The progress of the FWCT Scheme can be summarised as follows:

- (a) 86 designated areas were included under the FWCT Scheme, covering about 74 million square metres of non-domestic gross floor area (GFA), or 75% of the total non-domestic GFA in Hong Kong;
- (b) 14% of the non-domestic GFA in the designated areas had joined the FWCT Scheme. This accounted for 11% of the GFA of all non-domestic buildings in the territory;
- (c) for new non-domestic buildings in the designated areas, 97% (in terms of GFA) joined the FWCT Scheme. For existing buildings, only 5% (in terms of GFA) joined the Scheme;
- (d) 396 applications for installation of WACS were received under the FWCT Scheme, of which 333 had been approved;
- (e) among the approved applications, 162 WACS installations (comprising 578 cooling towers) were completed and commissioned, with a total cooling capacity of 889,000 kilowatts (kW);
- (f) the estimated electricity saving of the 162 completed WACS installations amounted to 129 million kilowatt-hours (kWh) a year, with a corresponding reduction in carbon dioxide emission of 90,000 tonnes a year. The average rate of energy saving was higher than that originally estimated; and
- (g) the additional water consumption arising from the completed WACS installations was about 2 million cubic metres a year, or about 0.2% of the annual water consumption of Hong Kong. The average rate of water consumption was well below that originally estimated.

2.14 Photographs 1 and 2 show two examples of WACS installations under the FWCT Scheme.

Photograph 1


WACS installation of a restaurant in Mong Kok

<p>Floor area served: 1,300 square metres Commissioning date: January 2002</p> <p>Cooling tower equipment: 1 x 683 kW</p> <p>Water consumption: 10 cubic metres/day Electricity saving: 15,600 kWh/year</p>	
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Source: EMSD records

Photograph 2

WACS installation of a commercial building in Wan Chai

	<p>Floor area served: 23,683 square metres Commissioning date: December 2001</p> <p>Cooling tower equipment: 3 x 2,000 kW + 1 x 1,480 kW</p> <p>Water consumption: 36 cubic metres/day Electricity saving: 1,079,251 kWh/year</p>
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Source: EMSD records

Audit observations and recommendations

Need for sustained efforts to promote wider use of WACS

2.15 According to the EMSD, assuming that 50% of all non-domestic buildings (in terms of GFA) in Hong Kong would adopt WACS instead of AACS by 2020, the anticipated energy saving would be about 1,000 million kWh a year, with a corresponding reduction in carbon dioxide emission of 700,000 tonnes a year (Note 7).

2.16 Up to April 2009, only 11% of all non-domestic buildings (in terms of GFA) in the territory had joined the FWCT Scheme (see para. 2.13(b)). **Audit considers that there is scope for the Administration to step up efforts in promoting the wider use of WACS.**

Need to extend coverage of FWCT Scheme

2.17 As at April 2009, there were 86 designated areas under the FWCT Scheme. About 25% of the GFA of non-domestic buildings in the territory was not yet covered under the Scheme. Under the existing practice, the EMSD would start to assess the demand for WACS in a new area upon receiving requests and enquiries for extending the Scheme to that area. If there are no requests and enquiries, no action will be taken to assess whether an area could be included under the FWCT Scheme. In this connection, Audit noted that:

- (a) up to July 2009, some areas with high density of non-domestic buildings, such as parts of Central, Sheung Wan and Sai Wan, were not included under the FWCT Scheme; and
- (b) it took time to consider requests for including a new area under the Scheme. In some cases, the potential applicants had switched to using AACS before the area was designated.

2.18 In response to Audit's enquiry, in August 2009, the EMSD said that it had liaised with the WSD in respect of the addition/extension of designated areas. In September 2009, in response to Audit's enquiry, the WSD said that the capacity of the water supply infrastructure serving parts of Central and Western areas was not adequate to cater for the cooling water demand. Spare capacity could be made available for the purpose in 2010 upon the completion of improvement works.

Note 7: *On the same assumption, in 2020, the water consumption arising from WACS would be 20.6 million cubic metres, or about 1.8% of the annual water consumption of Hong Kong. According to the WSD, the fresh water supply would be adequate for meeting the additional water demand.*

2.19 **In Audit's view, the EMSD and the WSD need to adopt a more proactive approach in extending the FWCT Scheme to new areas.**

Need to review basis for assessing peak daily water demand of WACS

2.20 In considering a new area for inclusion under the FWCT Scheme, the EMSD would estimate the peak daily water demand of cooling towers in that area for the WSD's consideration. The WSD would check if there is surplus water supply in that area to meet the estimated peak daily demand. The EMSD would estimate the peak daily water demand on the basis of a full conversion of all the non-domestic buildings in the area to WACS. However, Audit noted that, in all existing designated areas, the conversion to WACS proceeded rather slowly. Up to April 2009, only 14% of the non-domestic buildings (in terms of GFA) in the designated areas had joined the Scheme. **Audit considers that the EMSD needs to review the basis for estimating the peak daily water demand of WACS in determining whether an area should be designated under the FWCT Scheme.**

Need to encourage conversion of AACS to WACS

2.21 Both new and existing non-domestic buildings could join the FWCT Scheme. As at April 2009, while 97% of the new buildings (in terms of GFA) joined the FWCT Scheme, only 5% of the existing buildings (in terms of GFA) joined the Scheme. As most existing buildings are still using AACS, it appears that there are ample opportunities for energy saving in existing buildings from conversion to WACS.

2.22 In this connection, in a discussion paper submitted to the LegCo Panel on Environmental Affairs (EA Panel) in March 2000, the Administration said that one of the future directions of adopting the wider use of WACS was implementing measures to encourage the conversion of AACS to WACS in existing buildings.

2.23 Audit notes that there are practical difficulties associated with the conversion of AACS to WACS in existing buildings. These include:

- (a) interruption to existing air-conditioning systems and the operations of the building;
- (b) physical/space and structural constraints of individual buildings (e.g. availability of suitable and adequate floor space, and floor loading capacity); and
- (c) the capital cost involved.

2.24 In response to Audit's enquiry, in August 2009, the EMSD said that:

- (a) the constraints and difficulties varied from case to case and were all under the responsibilities of the owners; and
- (b) the role of the Government should be to facilitate the owners to understand the benefits of WACS. In this connection, the Government had regularly issued guidelines and information leaflets, and arranged seminars for building owners/property operators to promote the use of WACS.

2.25 **Audit considers that the EMSD needs to continue to provide the necessary assistance and incentives to facilitate conversion of AACS in existing buildings to WACS.**

Need to ensure compliance with scheme requirements

2.26 To evaluate the compliance of scheme participants with the reporting requirements of the FWCT Scheme (see para. 2.11), Audit selected 30 WACS installations to examine the progress (as at May 2009) of submission of the required monthly returns for the period from January to December 2008. The audit findings are as follows:

- (a) submission of all 12 returns: 7 cases (23%);
- (b) submission of 7 to 11 returns: 12 cases (40%);
- (c) submission of 0 to 6 returns: 11 cases (37%); and
- (d) submission of annual independent examination reports: nil.

2.27 The audit findings indicate that most of the scheme participants did not fully comply with the reporting requirements. Audit is concerned about whether the scheme participants had complied with the scheme requirements for the prevention of LD. Audit also noted that the EMSD did not vigorously follow up outstanding returns from scheme participants. **There is a need for the EMSD to take measures to strengthen controls over the participants' compliance with the requirements under the FWCT Scheme.**

Need to strengthen controls over approved WACS not under the FWCT Scheme

2.28 From 1979 to June 2009, the WSD granted 136 permissions for using fresh water in WACS installation for industrial processes or essential uses (see para. 2.2). These cases were directly approved by the WSD without the involvement of the EMSD. The approved WACS installations were not subject to the conditions of the FWCT Scheme, in particular, the compliance with the CoP(PLD) and CoP(WACS) for the proper design, operation and maintenance of cooling towers.

2.29 **In Audit's view, there is a need to include all applications for using fresh water for WACS, including those approved by the WSD direct, under the FWCT Scheme.**

Audit recommendations

2.30 **Audit has recommended that the Secretary for the Environment should, in collaboration with the Secretary for Development and the Director of Electrical and Mechanical Services, step up efforts in promoting the wider use of WACS in Hong Kong (see para. 2.16).**

2.31 **Audit has recommended that the Director of Electrical and Mechanical Services should:**

- (a) **in consultation with the Director of Water Supplies,**
 - (i) **consider adopting a more proactive approach in extending the FWCT Scheme to new areas (see para. 2.19); and**
 - (ii) **review the basis for estimating the peak daily water demand of WACS in determining whether an area should be designated under the FWCT Scheme (see para. 2.20);**
- (b) **continue to provide the necessary assistance and incentives to facilitate conversion of AACS in existing buildings to WACS (see para. 2.25); and**
- (c) **strengthen controls over the participants' compliance with the requirements under the FWCT Scheme (see para. 2.27).**

2.32 **Audit has recommended that the Director of Electrical and Mechanical Services and the Director of Water Supplies should consider working out an arrangement to include all applications for, and approved cases of, using fresh water in air-conditioning systems under the FWCT Scheme (see para. 2.29).**

Response from the Administration

2.33 The **Secretary for the Environment** agrees with the audit recommendation in paragraph 2.30. He has said that the ENB will work with the DEVB and the EMSD to step up efforts in promoting the wider use of WACS in Hong Kong.

2.34 The **Secretary for Development** agrees with the audit recommendation in paragraph 2.30.

2.35 The **Director of Electrical and Mechanical Services** generally agrees with the audit recommendations in paragraphs 2.30 to 2.32. He has said that:

- (a) the EMSD will work with concerned bureaux and departments to review the current application procedures and Codes of Practice to facilitate the wider use of WACS. At present, all WACS applications from buildings in designated or non-designated areas are welcome. Those applications in non-designated areas will be considered on a case-by-case basis with regard to the adequacy of water supply in the areas. The EMSD will enhance the publicity and promotion programmes for the FWCT Scheme, and issue invitation letters to owners of cooling towers, trade associations and other stakeholders to invite them to join the Scheme;
- (b) the EMSD will continue to provide necessary assistance and technical advice as in the past to the owners of cooling towers and to facilitate the conversion of AACS in existing buildings to WACS;
- (c) the Building Energy Efficiency Funding Scheme, established under the Environment and Conservation Fund and launched by the ENB in 2009, provides subsidies to private building owners for implementing energy efficiency projects, such as installation of WACS in place of AACS. As subsidies under the Funding Scheme are granted on a matching basis (i.e. up to 50% of the project expenditure), they should provide substantial financial incentive for building owners to switch to WACS. The EMSD will promulgate this message by sending the promotional leaflet of the Funding Scheme in the invitations to the building owners to join the FWCT Scheme;

- (d) the procedures to handle non-compliance with the requirements under the FWCT Scheme have been reviewed and strengthened. The owners of cooling towers will first receive a reminder letter to rectify non-compliance. A warning letter will be issued if they still fail to do so within a prescribed period. Following the implementation of the enhanced procedures, compliance with the requirements has shown improvement. More returns from the owners are being received. As at 24 September 2009, for the 30 cases mentioned in paragraph 2.26, the compliance rate has been improved as shown below:
- (i) submission of all 12 returns: 18 cases (60%);
 - (ii) submission of 7 to 11 returns: 11 cases (37%);
 - (iii) submission of 0 to 6 returns: 1 case (3%); and
 - (iv) submission of annual independent examination reports: 27 cases (90%).

The EMSD will bring the audit recommendation in paragraph 2.31(c) to the attention of the interdepartmental Working Group to consider further measures to strengthen control over the compliance with the requirements under the Scheme; and

- (e) the EMSD and the WSD will invite owners of the cases approved by the WSD to join the FWCT Scheme if they agree to comply with requirements under the FWCT Scheme. The EMSD will bring the audit recommendation in paragraph 2.32 to the attention of the interdepartmental Working Group to review and consider the practicability of including all approved cooling towers under the FWCT Scheme.

2.36 The **Director of Water Supplies** has said that:

- (a) the capacity of waterworks infrastructure is seldom a constraint to the extension of the FWCT Scheme to new areas. In case capacity is an issue in a particular area, the cooling water demand will be taken into account in planning for new waterworks projects to meet growth or other purposes in the concerned areas; and
- (b) the WSD will provide information of those WACS installations directly approved by it to the EMSD for consideration of necessary follow-up actions for inclusion under the FWCT Scheme.

PART 3: USE OF WATER-COOLED AIR-CONDITIONING SYSTEMS IN HOSPITALS

3.1 This PART examines the use of WACS in hospitals with a view to identifying areas for improvement.

Use of evaporative cooling towers in public hospitals

3.2 The ArchSD is responsible for the design and installation of air-conditioning systems in government buildings and public facilities for which the ArchSD is the works agent. The ArchSD has laid down guidelines that energy-efficient air-conditioning systems should be used in government buildings. Before the launch of the FWCT Scheme, the ArchSD adopted WACS using sea water in some government building projects including public hospitals. For locations where sufficient sea water could not be provided economically, the ArchSD would adopt AACS for the buildings.

3.3 Since the launch of the FWCT Scheme in June 2000, the ArchSD has obtained approval under the Scheme for the use of fresh water in WACS in some government buildings and public hospitals (e.g. the EMSD Headquarters Building, the ICAC Building and the Castle Peak Hospital).

2004 review by Architectural Services Department

3.4 In view of the outbreak of Severe Acute Respiratory Syndrome (SARS) in Hong Kong and the outbreaks of avian flu in Asian countries, in 2004, the ArchSD carried out a review on the use of fresh water cooling towers in the new Infectious Disease Block of the Princess Margaret Hospital. The review found that:

- (a) overseas practices did not impose any restrictions on using cooling towers in any particular types of buildings, including hospitals. However, preventive measures on the use of cooling towers were recommended for reducing the risk of an outbreak of LD;
- (b) after reviewing research findings about the outbreaks of SARS and avian flu, there was a possibility that:

- (i) the discharge of water mist from cooling towers would enhance the spread of airborne diseases; and
- (ii) new airborne diseases associated with the evaporative process of cooling towers might be found in future;
- (c) the risk of the cooling towers spreading airborne diseases could not be fully eliminated in the new hospital block for treating highly infectious diseases; and
- (d) new recommendations from international institutions might impose restrictions on the use of cooling towers in hospitals.

3.5 Taking into account the possibility of spreading airborne diseases from cooling towers and the risk of interruption to hospital operation due to suspension of water supply, the ArchSD considered that using cooling towers in the Infectious Disease Block of the Princess Margaret Hospital would not be appropriate. As there was no economical supply of sea water for WACS using direct sea water cooling, the ArchSD adopted AACS for this hospital project.

2005 review by Working Group

3.6 In March 2005, the Working Group discussed applications under the FWCT Scheme for use of fresh water in WACS in hospitals and healthcare premises. The DH said that:

- (a) occupants in hospitals and healthcare premises were in general more vulnerable to contracting LD. These premises should therefore avoid using WACS with cooling towers as far as possible;
- (b) the proponents of projects involving these premises had final discretion on whether fresh water cooling towers should be used for energy-efficient air-conditioning systems, having evaluated the risk of LD; and
- (c) apart from adhering to the CoP(PLD), these systems were expected to adopt a higher standard of maintenance, which would be covered by the new CoP(WACS) then under preparation.

3.7 At the meeting, the EMSD referred to an overseas practice where proponents of projects involving cooling tower installations would submit a risk management plan providing information about the risks associated with the system, and measures to be taken to manage the risks. The meeting agreed that:

- (a) submission of a risk management plan should accompany any applications received from hospitals and healthcare premises for participating in the FWCT Scheme; and
- (b) the PLDC should be consulted on the issue.

3.8 In May 2005, the PLDC discussed the use of fresh water cooling towers in healthcare premises. The PLDC had no objection to the use of such towers in healthcare premises, and agreed that a risk management plan should be prepared for these premises, and any other establishments considered prone to higher risk of LD.

3.9 The requirement to submit a risk management plan for installing cooling tower systems in hospitals and healthcare premises was incorporated in the CoP(WACS) issued in July 2006 as an additional requirement for the prevention of LD in healthcare facilities.

2006 review by Architectural Services Department

3.10 In 2006, the ArchSD conducted a further review before letting the contract for constructing the Extension Block of the Prince of Wales Hospital. The review concluded that, to prevent the spreading of infectious diseases, **no cooling towers should be used in acute or infectious disease hospitals**, and that only WACS using direct sea water cooling or AACS should be used. Following the recommendation of this review, the ArchSD adopted AACS in the Extension Block of the Prince of Wales Hospital and the Tseung Kwan O Hospital Extension.

Audit observations and recommendation

3.11 Audit noted that:

- (a) apart from LD, the ArchSD was concerned about the risk of spreading SARS, avian flu as well as **new airborne diseases** in acute and infectious disease hospitals associated with the evaporative process of cooling towers (see para. 3.4);

- (b) the ArchSD's practice on selecting air-conditioning systems for acute and infectious disease hospitals, as stated in its 2006 review, was determined in-house on a case-by-case basis;
- (c) there were cases of adopting WACS with cooling towers in public hospitals:
 - (i) projects undertaken by the EMSD for replacement of air-conditioning systems in public hospitals adopted WACS with cooling towers (e.g. the Queen Elizabeth Hospital); and
 - (ii) in July 2009, the Hospital Authority (HA) discussed with the EMSD about energy-saving retrofit projects for replacing AACS in public hospitals with WACS using cooling towers; and
- (d) for energy efficiency, a number of public and private hospitals used WACS with cooling towers (either fresh water or sea water).

3.12 Audit considers that there is a need to review the use of cooling towers in hospitals and healthcare premises with a view to formulating guidelines for the adoption of WACS in such premises.

Audit recommendation

3.13 Audit has recommended that the Director of Architectural Services and the Director of Electrical and Mechanical Services should, in consultation with the Director of Health and the Chief Executive, Hospital Authority, conduct a review on the use of cooling towers in hospitals and healthcare premises with a view to formulating guidelines for the adoption of WACS in such premises (see para. 3.12).

Response from the Administration

3.14 The Director of Architectural Services has said that the ArchSD will liaise with the EMSD, the DH and the HA to conduct a review on the use of cooling towers in hospitals and healthcare premises with a view to formulating guidelines for the adoption of WACS in such premises.

3.15 The **Director of Electrical and Mechanical Services** generally agrees with the audit recommendation in paragraph 3.13. He has said that the ArchSD and the EMSD will consult with the DH and the HA to conduct a review on the use of cooling towers in hospitals and healthcare premises. The findings will be considered by the ArchSD and the EMSD with a view to formulating guidelines for the adoption of WACS in such premises.

3.16 The **Chief Executive, Hospital Authority** agrees that there is a need to review the use of cooling towers for WACS in hospitals and healthcare premises. He has said that:

- (a) in April 2009, the HA commissioned a consultancy study involving the participation of a microbiologist to study the cost-effectiveness of WACS using cooling towers and to assess how the associated risks might be managed;
- (b) the study aims to provide a holistic view on the application of AACS and WACS in acute and non-acute hospitals. It is anticipated that the consultancy study will be completed by the end of 2009. The outcome of the consultancy study will form the basis for the HA to establish guidelines for the wider use of WACS in hospital projects;
- (c) interim findings of the study have revealed that:
 - (i) there is no evidence that the use of cooling towers in healthcare settings is considered too risky by international health authorities and experts; and
 - (ii) the use of cooling towers should entail careful design considerations and rigorous monitoring and maintenance; and
- (d) the HA will continue to work with both the ArchSD and the EMSD to formulate necessary guidelines on the use of AACS and WACS in hospitals and healthcare premises.

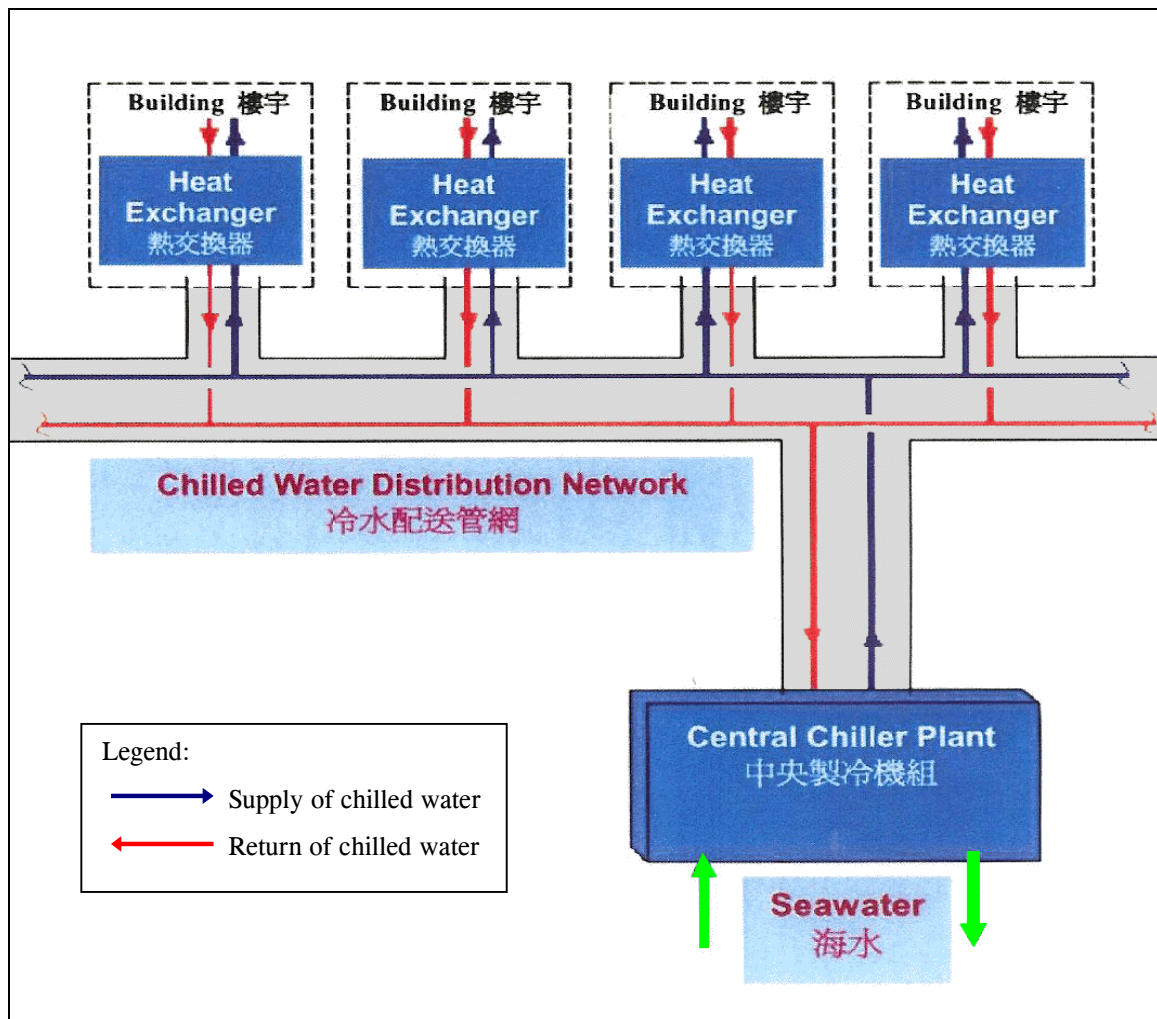
PART 4: DEVELOPMENT OF DISTRICT COOLING SYSTEMS

4.1 This PART examines the development of district cooling systems in Hong Kong with a view to identifying areas for improvement.

District cooling systems

4.2 A district cooling system (DCS) is a centralised WACS on a mega scale, comprising one or more chiller plants to produce chilled water, and a closed loop network of underground pipes for distributing the chilled water to buildings within its service area for air-conditioning purposes. Heat rejected from the chilled water network is carried away either by sea water pumped into the chiller plant through a pump house near the seafront, or through cooling towers using fresh water. Figure 1 shows a schematic diagram of a DCS.

Figure 1
Schematic Diagram of a DCS



Source: EMSD records

4.3 A DCS service is usually provided by an operator who supplies chilled water to users at a fee based on the cooling capacity demand and chilled water energy consumption.

Benefits of district cooling systems

4.4 A DCS is a form of WACS with the highest energy efficiency. Its electricity consumption is 35% and 20% lower than that of AACS and individual WACS using cooling towers respectively. It takes advantage of the economy of scale, and diversity in cooling demand of different buildings. The user buildings do not need to install their own chiller plants. Instead, DCS sub-stations with heat exchangers which occupy much less floor space than chiller plants will be required. The construction cost of the building can be reduced and additional floor areas can be released.

Studies on water-cooled air-conditioning systems and district cooling systems

4.5 The EMSD conducted five consultancy studies relating to the implementation of WACS and DCS between 1998 and 2007. Details are shown in Table 1.

Table 1
Consultancy studies on WACS and DCS

Item	Consultancy study	Started	Completed	Cost (\$ million)
1	Preliminary Phase Consultancy Study on Wider Use of WACS in Hong Kong	10/1998	4/1999	3.2
2	Territory-wide Implementation Study for WACS in Hong Kong	10/2000	6/2003	13.6
3	Implementation Study for a DCS at South East Kowloon Development	1/2001	12/2003	6.6
4	Implementation Study for WACS in Wan Chai and Causeway Bay	12/2001	9/2005	5.5
5	Implementation Assessment Study for Kai Tak Development DCS	4/2007	10/2007	0.8

Source: EMSD records

Preliminary Phase Consultancy Study

4.6 The Preliminary Phase Consultancy Study (see Item 1 in Table 1 of para. 4.5), completed in April 1999, found that:

- (a) the wider use of WACS in Hong Kong was viable with significant economic and environmental benefits;
- (b) the implementation of DCS in Hong Kong was economically and financially viable, but there were two major technical concerns:
 - (i) the need to lay large-diameter pipelines; and
 - (ii) the need to use sea water for once-through cooling in DCS chiller plants; and
- (c) further detailed studies should be conducted to examine the technical, financial, institutional and control requirements for DCS implementation in:
 - (i) an existing developed area; and
 - (ii) a new development area.

Subsequently, the EMSD conducted three detailed studies (see Items 2 to 4 in Table 1 of para. 4.5).

Territory-wide Implementation Study for WACS

4.7 The Territory-wide Implementation Study (see Item 2 in Table 1 of para. 4.5), completed in June 2003, found that:

- (a) wider adoption of WACS in the territory could significantly help reduce electricity consumption, and priority should be given to WACS using cooling towers for territory-wide implementation;
- (b) the development of DCS would need to lay large pipes under major roads with heavy traffic. There was a need to conduct detailed traffic impact assessment and implement proper mitigation measures to minimise the disruption to the traffic and pedestrians; and

- (c) suitable sites should be selected for detailed studies and pilot implementation of DCS.

4.8 The territory-wide study identified 15 potential areas for the implementation of DCS, comprising 5 developed areas (including Wan Chai District and Causeway Bay District) and 10 new development areas (including South East Kowloon District (SEKD)).

Study on district cooling system in Wan Chai and Causeway Bay

4.9 The Implementation Study for WACS in Wan Chai and Causeway Bay (see Item 4 in Table 1 of para. 4.5) was intended for the implementation of DCS in the two areas. The two areas were divided into five zones (Note 8) for detailed assessment of DCS implementation. The study, completed in September 2005, found that:

- (a) it was technically feasible to implement DCS in all the five zones;
- (b) it was commercially viable to implement DCS in three out of the five zones without government concession on land cost. Another zone would become viable if concessions on land cost were granted; and
- (c) it was, however, difficult to find suitable sites for DCS chiller plants and pump house since Wan Chai and Causeway Bay were developed areas. Unallocated government land could not be identified. Implementation of DCS was possible only when there were redevelopment projects in the district.

4.10 Owing to the lack of suitable sites for accommodating the DCS plants, the plan for implementing DCS in Wan Chai and Causeway Bay areas was eventually shelved.

District cooling system at Kai Tak Development

4.11 The SEKD has a total site area of 461 hectares including the former Kai Tak Airport. As it is a new district under planning, it offers a good opportunity for implementing DCS to meet the air conditioning demand in the area.

Note 8: *The five zones were: Wan Chai Gloucester Road Area, Wan Chai South Area, Causeway Bay Area, Fortress Hill Area and Wan Chai Waterfront Area.*

4.12 The Implementation Study for a DCS at SEKD (see Item 3 in Table 1 of para. 4.5), completed in December 2003, found that:

- (a) implementing DCS at SEKD was technically viable and would bring about significant benefits in electricity saving and reduction in carbon dioxide emission;
- (b) the financial viability of the project was sensitive to the overall percentage of users opting for the service (i.e. the subscription rate), the pace of development of SEKD, and the land costs for the facility;
- (c) the Government could involve the private sector in taking forward the project;
- (d) for the DCS operator, the major risks were the uncertainty in the subscription rate, the intensive upfront capital outlays, and the long payback period; and
- (e) for DCS users, the main concerns were their limited bargaining power and control over the services provided by the DCS operator.

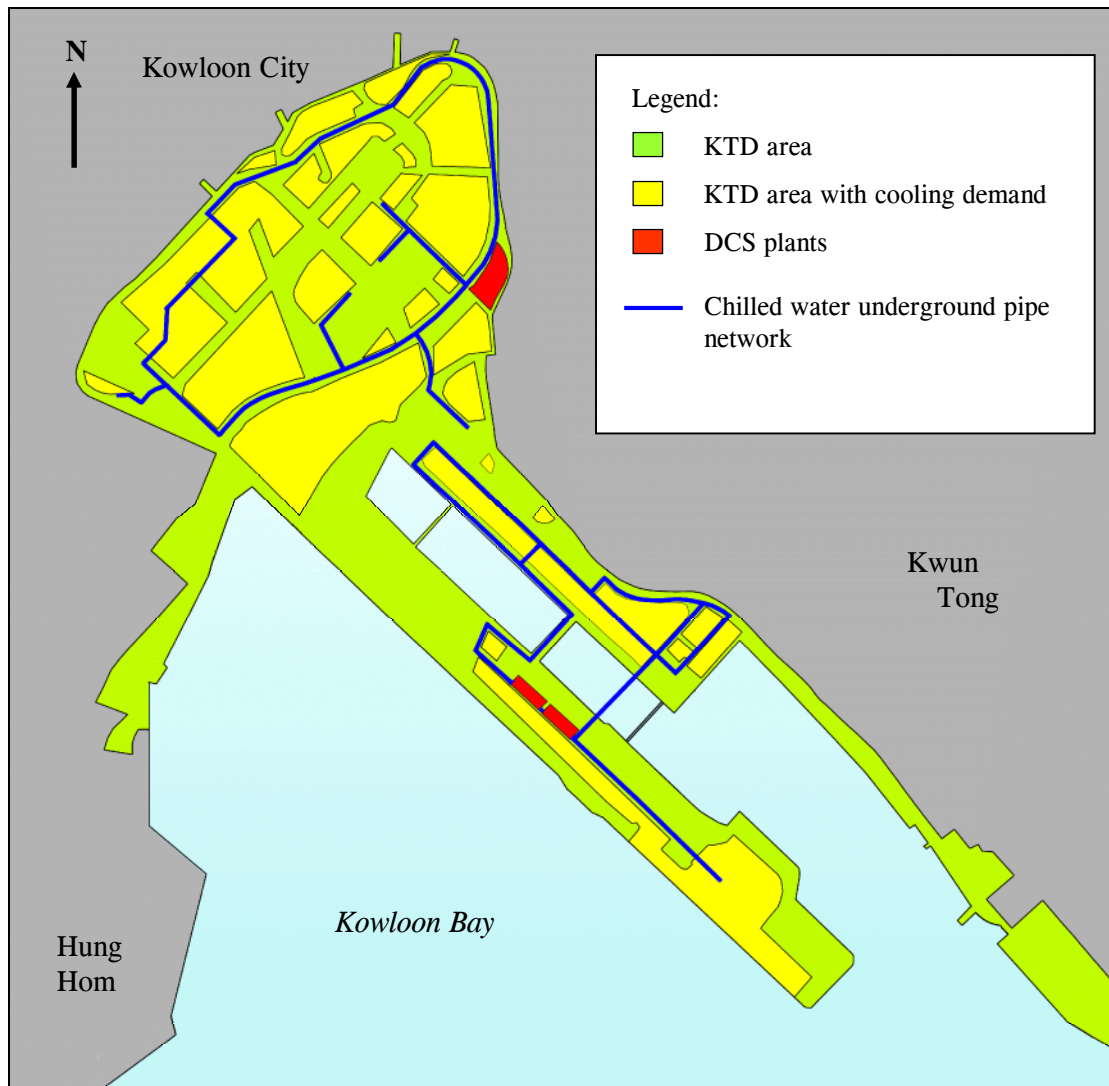
4.13 Due to various planning and development issues, the development of SEKD was not pursued and replaced by the Kai Tak Development (KTD) in early 2007. In October 2007, the EMSD completed an updated study for the development of DCS at KTD (see Item 5 in Table 1 of para. 4.5).

4.14 In December 2008, the Administration consulted the EA Panel of LegCo about implementing a DCS at KTD. In May 2009, the Administration submitted a paper seeking funding for the project. The Public Works Subcommittee (PWSC) supported the funding application. In June 2009, the Finance Committee approved funding of \$1,671 million for implementing a DCS at KTD. The scope of the project included:

- (a) constructing a northern chiller plant and a southern underground chiller plant;
- (b) constructing an underground sea water pump house and laying of sea water intake and discharge pipelines; and
- (c) laying of chilled water distribution pipe networks.

4.15 Figure 2 shows a layout plan of the proposed DCS at KTD.

Figure 2
Layout plan of the DCS at KTD



Source: EMSD records

- 4.16 According to the information provided to the PWSC in May 2009:
- (a) the estimated cooling capacity of the proposed DCS was 284 megawatt cooling energy, based on a total planned non-domestic air-conditioned floor area of about 1.73 million square metres;
 - (b) the maximum estimated annual saving in electricity consumption by adopting the proposed DCS (instead of AACCS) was up to 85 million kWh, equivalent to a saving of \$76.5 million for users, and a reduction of 59,500 tonnes of carbon dioxide emission a year;
 - (c) of the 1.73 million square metres of non-domestic air-conditioned floor area in KTD, 35% would be in public developments and 65% in private developments;
 - (d) as a demonstration of the Government's determination to reduce energy consumption, all public developments in KTD would be connected to the DCS provided that their implementation programme could match the development schedule of DCS;
 - (e) for private developments, the connection to the proposed DCS would be on a voluntary basis. It was envisaged that the DCS would have a high subscription rate from private developments given its benefits to users;
 - (f) the provision of DCS service to users would be subject to payment of a tariff set at a competitive level comparable to the charge of individual WACS using cooling towers; and
 - (g) based on an assumed overall subscription rate of 50%, the capital and operating costs could be recovered from users over the project life of 30 years. The cost-recovery period would be shortened and the tariff level would be lowered if the subscription rate exceeded 50%.

4.17 The private sector would be engaged for the design, construction and operation of the DCS under a Design-Build-Operate contract (Note 9). The project would be developed and commissioned for operation in three phases by 2013, 2017 and 2022 respectively to match the phased developments at KTD. According to the EMSD, the

Note 9: *Under this contract arrangement, the contractor will be responsible for the design and construction of the DCS at KTD. The Government will bear the construction cost and retain ownership of the facility. After completing the works, the contractor will operate the facility on behalf of the Government at a service fee.*

construction and installation schedule of the component equipment would be adjusted to suit the progress of development at KTD and the actual subscription rate for the DCS service. In July 2009, the EMSD invited tenders for the Design-Build-Operate contract of the DCS at KTD. Up to September 2009, the tender exercise was in progress.

Audit observations and recommendations

Room for improvement in estimating energy saving

4.18 According to the consultancy study commissioned by the EMSD, the estimated annual electricity consumption of the non-domestic floor area at KTD for air-conditioning purposes would be:

- (a) 243 million kWh for AACS;
- (b) 197 million kWh for WACS using cooling towers; and
- (c) 158 million kWh for DCS.

4.19 In the paper submitted to the PWSC in May 2009, it was estimated that the development of DCS at KTD could bring about a maximum annual saving in electricity consumption of up to 85 million kWh (see para. 4.16(b)). Audit noted that this estimated saving was the difference between adopting AACS (243 million kWh) and DCS (158 million kWh) based on a 100% subscription rate for the DCS service.

4.20 Audit considers that the estimated electricity saving of 85 million kWh mentioned above may not be attainable for the following reasons:

- (a) **KTD is one of the designated areas under the FWCT Scheme. Private developers may choose between the proposed DCS service and installing WACS in their new buildings.** If the developers choose not to subscribe to the DCS service, they will more likely install the more energy-efficient WACS (instead of AACS) in their buildings. Audit noted that, under the FWCT Scheme, 97% of new non-domestic buildings (in terms of GFA) in designated areas participated in the Scheme; and

- (b) **while the EMSD estimated that the DCS would have a high subscription rate from private developers (see para. 4.16(e)), a 100% subscription rate might not be achieved.** As private developers are allowed to subscribe to the DCS service on a voluntary basis, some developers may, for some reasons, choose not to subscribe to it.

4.21 In response to Audit's enquiry, in August 2009, the EMSD said that:

- (a) the estimated electricity saving of 85 million kWh was the maximum possible saving of energy consumption which was the target to be achieved; and
- (b) given various benefits enjoyed by the private building owners, it was expected that a high subscription rate reaching 100% would be likely.

4.22 **Audit considers that there is a need to estimate electricity saving arising from DCS development based on realistic assumptions.**

Need to keep LegCo informed of project progress

4.23 At the meetings of the EA Panel and the PWSC held in December 2008 and May 2009 respectively, questions were raised about:

- (a) the increase in the estimated capital cost from its original estimate of \$655 million prepared in 2001 to the estimate of \$1,402 million (excluding provision for price adjustments) in the funding submission of 2009;
- (b) the subscription rate of the DCS service as compared with the assumed subscription rate of 50%;
- (c) the financial viability of the DCS and competition from the traditional AACs and individual WACS using cooling towers;
- (d) the tariff level of the DCS service; and
- (e) the design capacity of the DCS plants in view of the voluntary connection and uncertain subscription rate.

4.24 **Audit noted that the Administration had provided information on the above issues at the meetings. Nevertheless, as the DCS project at KTD is the first of its kind in Hong Kong and there are risks and uncertainties to be addressed, Audit considers that the EMSD needs to regularly review the progress of the DCS project and keep LegCo informed of the up-to-date position.**

Need to take proactive action to increase the subscription rate

4.25 As stated in the PWSC paper of May 2009, all public developments in KTD would be connected to the DCS as far as practicable. Audit notes from the EMSD records that some of the public facilities to be developed at KTD are often installed with stand-alone room coolers (e.g. classrooms of primary schools and secondary schools). Connection to the DCS may require changes in the design of these facilities.

4.26 In response to Audit's enquiry, in September 2009, the EMSD said that:

- (a) it had already started liaison with the ArchSD and other government departments on the use of DCS in their projects. For example, the EMSD had meetings with:
 - (i) the ArchSD and the Government Property Agency in April 2008 on the use of DCS in Kai Tak Government Offices project;
 - (ii) the Housing Department in May 2008 on the use of DCS in commercial centres in public housing projects;
 - (iii) the ArchSD and the Education Bureau in May 2008 on the use of DCS in school projects;
 - (iv) the ArchSD in October 2008 on the use of DCS in the Cruise Terminal project; and
 - (v) the ArchSD and the Hong Kong Police Force in November 2008 on the use of DCS in the Kowloon East Police Headquarters project.

The EMSD would continue to work closely with them on the adoption of DCS in their projects; and

- (b) the earliest private developments at KTD were planned for Phase 2 and would only be completed by 2016. At present, the developers were not known. For the time being, the DCS at KTD was publicised through various channels. When the developers were known, the EMSD would liaise with them to promote the DCS.

4.27 In response to Audit's enquiry, in September 2009, the ArchSD said that it had discussed with the Education Bureau and the EMSD on the availability of DCS for the air conditioning of schools at KTD in May 2008. The ArchSD would continue to advise the Education Bureau on the DCS.

4.28 Audit considers that the EMSD needs to continue to liaise with the ArchSD and other relevant departments at the early stage of development of public facilities at KTD. The EMSD also needs to liaise with private developers at an early stage to promote the DCS as connection of private developments to the DCS is voluntary.

Need to focus on new development areas for future DCS

4.29 The setting up of a DCS involves complicated technical and administrative issues, and has to be incorporated into the development plan of a district at an early stage. Thus, it may not be feasible to implement DCS for existing developed areas. The main technical constraints include:

- (a) the availability of land for constructing pumping stations and chiller plants; and
- (b) the disruption to traffic during works for laying large-diameter underground pipes.

4.30 Moreover, for AACS users in designated areas under the FWCT Scheme, they may switch to WACS using cooling towers to achieve energy saving, instead of waiting for the development of DCS. This would further affect the subscription rate and financial viability of DCS in a developed area.

4.31 Audit noted that Wan Chai (a developed area) was one of the designated areas when the FWCT Scheme was first launched in June 2000. In 2001, the EMSD commissioned a consultancy study for the development of a DCS at Wan Chai and Causeway Bay. The proposal was eventually shelved for lack of sites for plant development (see paras. 4.9 and 4.10).

4.32 **Audit considers that it is more cost-effective to focus on new development areas or redevelopment areas for implementing a DCS in future.**

Potential reduction in project scope

4.33 The capital funding of \$1,671 million was intended for the full development of the DCS at KTD at a 100% subscription rate. However, if the actual subscription rate falls below 100%, not all the chiller plants would be required to meet the reduced demand. As such, there might be a possible reduction in the scope of the project, necessitating a reduction in the approved funding. **Audit considers that there is a need to monitor the progress of the DCS at KTD according to the actual scale of development and the DCS subscription rate, and to revise the project scope and funding, where appropriate.**

Audit recommendations

4.34 **Audit has recommended that the Director of Electrical and Mechanical Services should:**

- (a) **state clearly the basis of estimates and estimate electricity saving arising from DCS development based on realistic assumptions in future submissions to LegCo (see para. 4.22);**
- (b) **regularly review the progress of the DCS project at KTD and keep LegCo informed of the up-to-date position (see para. 4.24);**
- (c) **continue to liaise with the ArchSD and other relevant departments at the early stage of development of public facilities at KTD to facilitate connection of such facilities to the DCS (see para. 4.28);**
- (d) **liaise with private developers at an early stage to promote the DCS service with a view to increasing the DCS subscription rate (see para. 4.28);**
- (e) **focus efforts on new development areas or redevelopment areas for implementing a DCS in future (see para. 4.32); and**
- (f) **closely monitor the progress of the DCS at KTD according to the actual scale of development and the DCS subscription rate, and revise the project scope and funding, where appropriate (see para. 4.33).**

Response from the Administration

4.35 The **Director of Electrical and Mechanical Services** generally agrees with the audit recommendations in paragraph 4.34. He has said that:

- (a) in future submissions to LegCo on the DCS project, the ENB and the EMSD will continue to state clearly the basis of estimates and the estimated electricity saving arising from DCS development based on realistic assumptions. The ENB and the EMSD have stated clearly in the papers to the EA Panel and the PWSC that the estimated electricity saving of 85 million kWh is the maximum annual saving in electricity consumption arising from the use of DCS, and that DCS consumes 35% and 20% less electricity as compared with traditional AACs and individual WACS respectively;
- (b) the EMSD will regularly review the progress of the DCS project at KTD and keep LegCo informed of the updated position as necessary;
- (c) the EMSD will continue to provide professional advice to bureaux on the feasibility of implementing DCS in new and redeveloped areas; and
- (d) the EMSD will closely monitor the progress of the DCS at KTD according to the actual scale of development and subscription rate for the DCS service, and will revise the project scope and funding where appropriate.

PART 5: HEALTH CONCERNS OVER COOLING TOWERS AND WATER-USING APPARATUS

5.1 This PART examines the health concerns over cooling towers and other water-using apparatus (e.g. humidifiers) with a view to identifying areas for improvement.

Legionnaires' Disease

5.2 The installation and maintenance of cooling towers require special care because they have been found to be associated with the spread of LD (Note 10). LD is an acute pneumonic illness with symptoms of malaise, muscle pains, cough, breathlessness, headache and fever, often culminating in respiratory failure. According to research findings, the infection rate of LD in an outbreak was less than 5% and the fatality rate was about 10% to 15%. Many antibiotics are effective for treating LD.

5.3 The LD bacteria (i.e. the Legionella bacteria), are ubiquitous in natural fresh water sources such as rivers, streams, ponds, mud and soil, as well as man-made water systems (e.g. cooling towers, architectural fountains and spa pools). Transmission of the bacteria to human bodies is mainly through inhalation of airborne droplets (i.e. aerosols) or particles in fine mist containing the bacteria into the lungs.

Code of Practice for Prevention of Legionnaires' Disease

5.4 In November 1994, the PLDC (see para. 1.6) issued the CoP(PLD) with reference to similar codes of practice in overseas countries. The CoP(PLD) was revised in 2000 and 2007.

5.5 According to the CoP(PLD), the first option to be considered for preventing LD is to avoid, where reasonably practicable, the use of equipment which can create a spray of contaminated water. Where the use of such equipment cannot be avoided, the risk should be prevented or controlled by measures to reduce exposure to contaminated water droplets and to prevent conditions which allow the proliferation of Legionella bacteria.

Note 10: *The disease was named after an outbreak of pneumonia in Philadelphia of the United States, during the American Legion Convention in 1976. More than 200 cases were reported and 34 people died. The cooling towers of the hotel where the convention was held were found to be the source of infection.*

- 5.6 The CoP(PLD) provides guidelines on the following areas:
- (a) a water safety plan for water-using apparatus (e.g. cooling towers and spa pools) to manage health risk of exposure to Legionella bacteria;
 - (b) precautions on design, operation and maintenance of cooling towers and other water-using apparatus;
 - (c) regular collection of water samples from water-using apparatus for testing of bacterial content; and
 - (d) keeping of a formal design, operation and maintenance record for water-using apparatus.

Code of Practice for Water-cooled Air-conditioning Systems

5.7 In July 2006, the EMSD issued the CoP(WACS) to promote the proper use of WACS with detailed guidelines and technical reference on the design, installation, operation and maintenance of fresh water cooling towers, including:

- (a) prescriptive design requirements for effective operation of cooling towers (e.g. the installation of drift eliminators to reduce the discharge of aerosols);
- (b) minimum separation distance between a cooling tower and the nearby facilities (e.g. pedestrian thoroughfare and area of public access);
- (c) water sampling frequencies for testing the bacterial content of cooling water;
- (d) control limits and action levels for bacterial content of cooling water;
- (e) procedures for conducting cleansing, disinfection and decontamination of cooling towers;
- (f) conduct of annual independent examination of operation and maintenance records; and
- (g) water treatment methods.

5.8 **Owners of cooling towers under the FWCT Scheme (see para. 2.6) are required to comply with the CoP(PLD) and CoP(WACS).**

Investigation of reported Legionnaires' Disease cases

5.9 Since 1994, LD has become a statutory notifiable disease. When an LD case is reported, the DH, with technical support from the EMSD, conducts an investigation to identify the source of infection and takes steps to prevent the spread of LD. The home, workplace and other places visited by the patient during the incubation period are investigated. **The investigation focuses on identifying aerosol-generating water systems (such as cooling towers, showers and fountains) and other water-using apparatus which may be a source of infection.** The maintenance records of the relevant systems are examined, and water samples are taken for laboratory testing.

5.10 The DH prepares a situation report on the case under investigation. The EMSD prepares a field visit report with details including the locations and number of water samples collected for testing. The DH notifies the EMSD of the test results. The EMSD provides advice and supervision on the cleansing and disinfection process to the owners or operators of water systems or apparatus found with Legionella bacteria, and the DH carries out follow-up investigations after disinfection of the system. The DH compiles investigation reports and informs the PLDC of the investigation results.

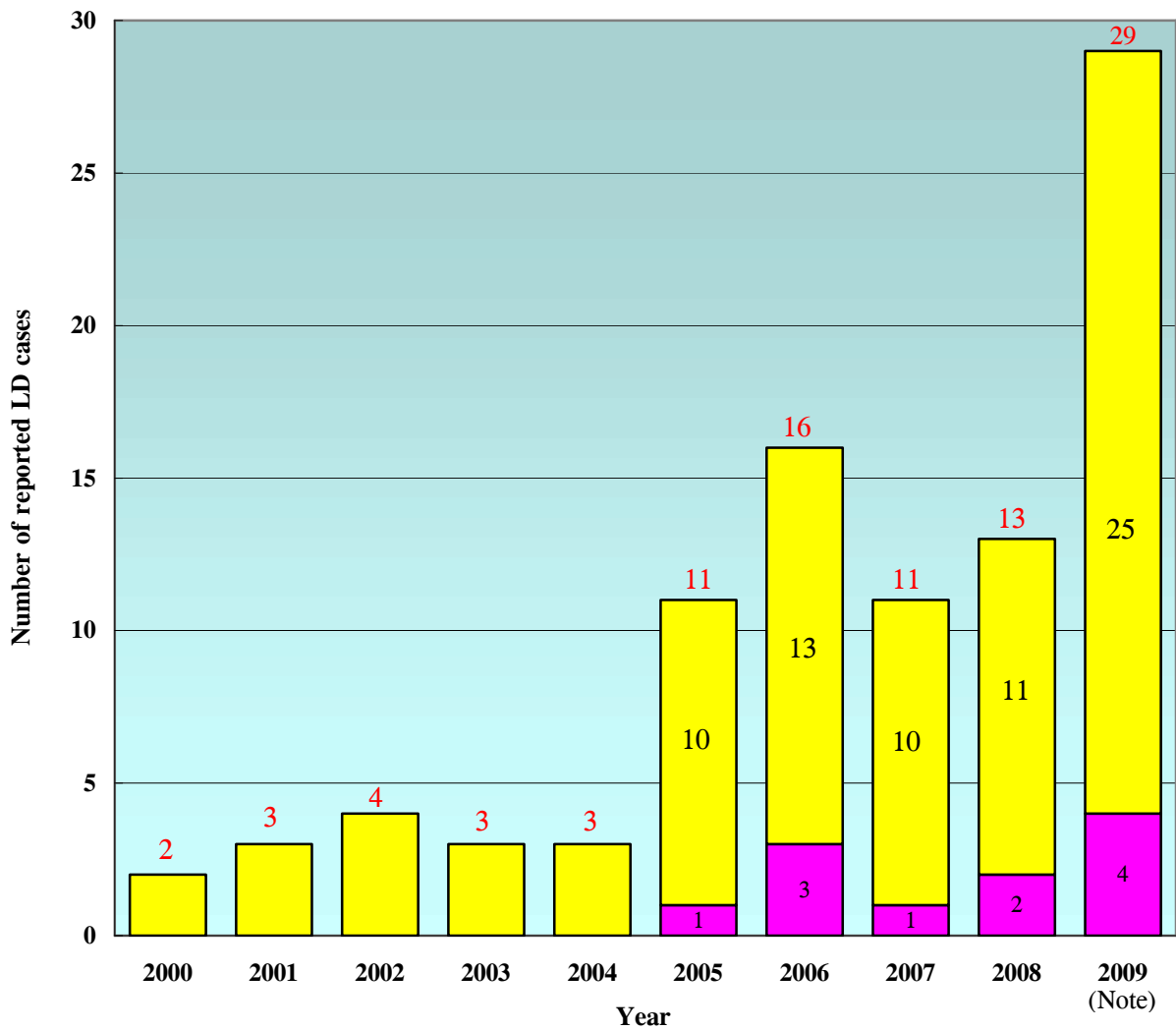
Legionnaires' Disease cases in recent years

5.11 In Hong Kong, there have been no outbreaks of LD. All the reported LD cases were classified as sporadic cases with no evidence of linkage. Some of the reported cases were diagnosed as imported cases as the patients had a travel history during the incubation period. During case investigations, Legionella bacteria were found in some of the cooling towers and potable water systems. Nevertheless, in most cases, a definitive linkage between positive environmental samples and sporadic cases could not be established (Note 11). Thus, the investigation results usually indicated that the source of infection was uncertain.

Note 11: *In all the reported cases, the likely source of infection could only be identified in one case which was associated with the use of a respiratory therapy device.*

5.12 According to the DH, although the number of notified LD cases in Hong Kong is not high, there is always the possibility of under-reporting. Figure 3 shows the number of reported LD cases in Hong Kong from 2000 to 2009 (up to September).

Figure 3
Number of reported LD cases
(2000 to 2009)



Legend: LD cases not causing deaths
 LD cases causing deaths

Source: *DH records*

Note: *The data for 2009 were up to September 2009.*

Audit observations and recommendations

Need to closely monitor the increasing trend in LD cases

5.13 Audit notes that the Administration has taken a proactive approach on the prevention and control of LD. While only sporadic LD cases had been found in the past, the Administration, as early as in 1985, set up the PLDC to advise the Government on matters relating to prevention and management of the possible outbreaks of LD (see para. 1.6). **In Audit's view, it is important to make sustained efforts in the prevention and control of LD in Hong Kong.**

5.14 As shown in Figure 3, there was an increasing trend of LD cases in recent years, in that:

- (a) there were less than 5 cases a year in 2004 and before;
- (b) there were over 10 cases a year in 2005 and afterwards; and
- (c) there were 29 cases in 2009 (up to September).

Audit considers that there is a need to closely monitor the increasing number of LD cases, and examine the underlying reasons so that appropriate prevention and control measures can be formulated.

Impact of contaminated aerosols on public health

5.15 According to records of the DH, the Legionella bacteria may, in addition to LD, induce a milder form of infection called Pontiac fever (Note 12). The main characteristics of LD and Pontiac fever are shown in Table 2.

Note 12: *Pontiac fever is so named because of an outbreak in 1968 in Pontiac, Michigan of the United States.*

Table 2

Main characteristics of LD and Pontiac fever

Characteristic	LD	Pontiac fever
Incubation period	Long (2 to 10 days)	Short (A few hours to 3 days)
Infection rate	Up to 5%	Up to 95%
Duration	Weeks	2 to 5 days
Average fatality rate	10% to 15%	Nil
Symptoms	Principally manifested as pneumonia	Non-pneumonic illness with flu-like symptoms
Medical treatment	Antibiotics	Self-healing

Source: *DH and the World Health Organisation*

5.16 Reports of Pontiac fever were rare, possibly because of the similarity of the symptoms to the flu and the spontaneous recovery of the illness. However, Pontiac fever has a high infection rate and the source of infection is usually not identified. The guidelines issued by the PLDC have not mentioned Pontiac fever. **Audit considers that there is a need to provide more information about Pontiac fever to the public.**

Guidelines on using water-using apparatus other than cooling towers

5.17 Based on investigation reports submitted to the PLDC about LD cases from 2006 to early 2009, Audit noted that Legionella bacteria were found in the following water-using apparatus:

- (a) cooling towers in 4 cases;
- (b) shower heads and water taps in 12 cases;
- (c) the water treatment plant of the mist generation facility in a theme park in 1 case;

- (d) the respiratory therapy device of a patient in 1 case; and
- (e) a spa pool in a private clubhouse in 1 case.

The results of investigations indicated that many types of water-using apparatus could be a potential source of infection.

5.18 In early 2009, subsequent to an LD case in which Legionella bacteria were found in a spa pool of a private clubhouse, there were enquiries from the public on whether guidelines were available for the operation and maintenance of spa pools. In March 2009, at a meeting of the PLDC, members agreed to review whether the guidelines on the operation and maintenance of spa pools in the CoP(PLD) needed further elaboration. As at September 2009, the review was in progress.

5.19 Audit conducted a research of overseas reports about the outbreaks of LD and found that:

- (a) in 2007, there was an LD case in Japan associated with the use of domestic humidifiers. In January 2009, in a press release about health care measures, the DH advised the public that domestic humidifiers should be cleaned and maintained regularly to avoid the growth and spread of harmful bacteria, like Legionella bacteria; and
- (b) in 1997 and 1998, there were six LD cases (involving two deaths) in the Netherlands associated with the use of a sauna.

5.20 Audit notes that the CoP(PLD) provides general guidelines on a wide range of water-using apparatus and the CoP(WACS) provides detailed guidelines on cooling towers. However, there is little information about the LD risk of certain water-using apparatus (e.g. shower heads and domestic humidifiers) in the publications of the PLDC. **Audit considers that there is a need to keep in view the LD risks of water-using apparatus.**

Audit recommendations

5.21 **Audit has recommended that the Director of Health and the Director of Electrical and Mechanical Services should:**

- (a) **make sustained efforts in the prevention and control of LD in Hong Kong (see para. 5.13);**

- (b) **closely monitor the increasing number of LD cases and examine the underlying reasons with a view to formulating appropriate measures to minimise the spread of LD (see para. 5.14);**
- (c) **examine the need to provide more information about Pontiac fever to the public (see para. 5.16); and**
- (d) **keep in view the LD risks of water-using apparatus, with a view to providing more comprehensive guidelines for the prevention of LD (see para. 5.20).**

Response from the Administration

5.22 The **Director of Health** has said that:

- (a) LD is a statutory notifiable disease in Hong Kong. The DH has all along been maintaining high vigilance against LD and working closely with the EMSD in the prevention and control of LD in Hong Kong; and
- (b) the DH has provided information on Pontiac fever on its website and education leaflet. LD and Pontiac fever are different manifestations of the infection by Legionella bacteria. Pontiac fever is a milder, flu-like illness with much less public health significance than LD. Patients suffering from Pontiac fever recover spontaneously without treatment. This clinical syndrome may represent reaction to inhaled antigen rather than bacterial invasion. The DH will continue to put emphasis on LD, the more severe form of the infection, and consider the need to provide more information on Pontiac fever should the need arise.

5.23 The **Director of Electrical and Mechanical Services** generally agrees with the audit recommendations in paragraph 5.21. He has said that:

- (a) the EMSD will continue to promote the proper maintenance and operation of cooling towers;
- (b) the EMSD will continue to support the DH in the investigation of LD cases and the PLDC in the prevention of LD; and
- (c) the audit recommendations will be brought to the attention of the PLDC for advice and follow-up action as necessary.

PART 6: INSPECTION OF COOLING TOWERS

6.1 This PART examines the EMSD cooling tower inspection programmes with a view to identifying areas for improvement.

Surveys of cooling towers

6.2 The EMSD conducted two surveys of cooling towers in 1996 and 1999 and found that there were about 12,000 cooling towers scattered in the territory. The vast majority of these cooling towers did not have WSD authorisation for the use of mains water. The surveys also found that many of these cooling towers were not properly installed or maintained.

1999 audit review

6.3 In the 1999 audit review (see para. 1.8), Audit recommended that the EMSD should conduct regular surveys of cooling towers to ascertain and monitor their operating conditions, particularly those which were not properly installed or maintained. In its report of February 2000, the PAC recommended that the Administration should ensure that, as a matter of urgency, the operation and maintenance of the then 12,000 cooling towers were closely monitored, in order to minimise the risk of LD. The Administration accepted the recommendations for implementation.

Inspection programme from 2001 to 2005

6.4 The EMSD launched a large-scale cooling towers inspection programme from 2001 to 2005 with earmarked funding of \$9 million. The EMSD employed contractors to:

- (a) record the physical data of cooling towers and the owners' details;
- (b) assess and record the general conditions of the cooling towers and their components;
- (c) conduct on-site tests on cooling water quality parameters (e.g. water temperature, residual chlorine content and conductivity); and

- (d) collect water samples from cooling towers for testing of bacterial content (Note 13) in an accredited laboratory.

6.5 According to an EMSD report of January 2006 on the results of the 2001 to 2005 inspection programme:

- (a) the number of cooling towers in the territory had reduced to about 10,700;
- (b) 8,387 cooling towers were inspected with 10,057 water samples collected for testing of bacterial content;
- (c) 30% of the cooling towers were in good conditions, while 66% and 4% of them were in fair and poor conditions respectively;
- (d) about 80% of the cooling towers were found with biofilm (biological growth) or scale (mineral build-up) in their water basins, which were conducive to bacteria growth; and
- (e) 93% of the cooling towers were not installed with drift eliminators (Note 14) and 95% not installed with fill packs (Note 15). According to the CoP(WACS), both devices should be installed in a cooling tower.

Inspection programme from 2006 to 2008

6.6 The EMSD carried out an inspection programme of a smaller scale from 2006 to 2008. A total of 631 inspections were carried out which involved mainly the collection of water samples for testing of bacterial content.

Note 13: *From 2001 to 2005, water samples were tested for Legionella bacteria count only. From 2006 to 2008, water samples were tested for both Legionella bacteria count and total bacteria count.*

Note 14: *A drift eliminator is a grid-like arrangement of physical barriers located before the cooling tower exhaust designed to minimise water loss as liquid droplets or aerosols from the cooling tower.*

Note 15: *A fill pack is the material placed within a cooling tower to increase heat and mass transfer between the circulating water and the air flowing through the tower.*

Tests for Legionella bacteria during inspections

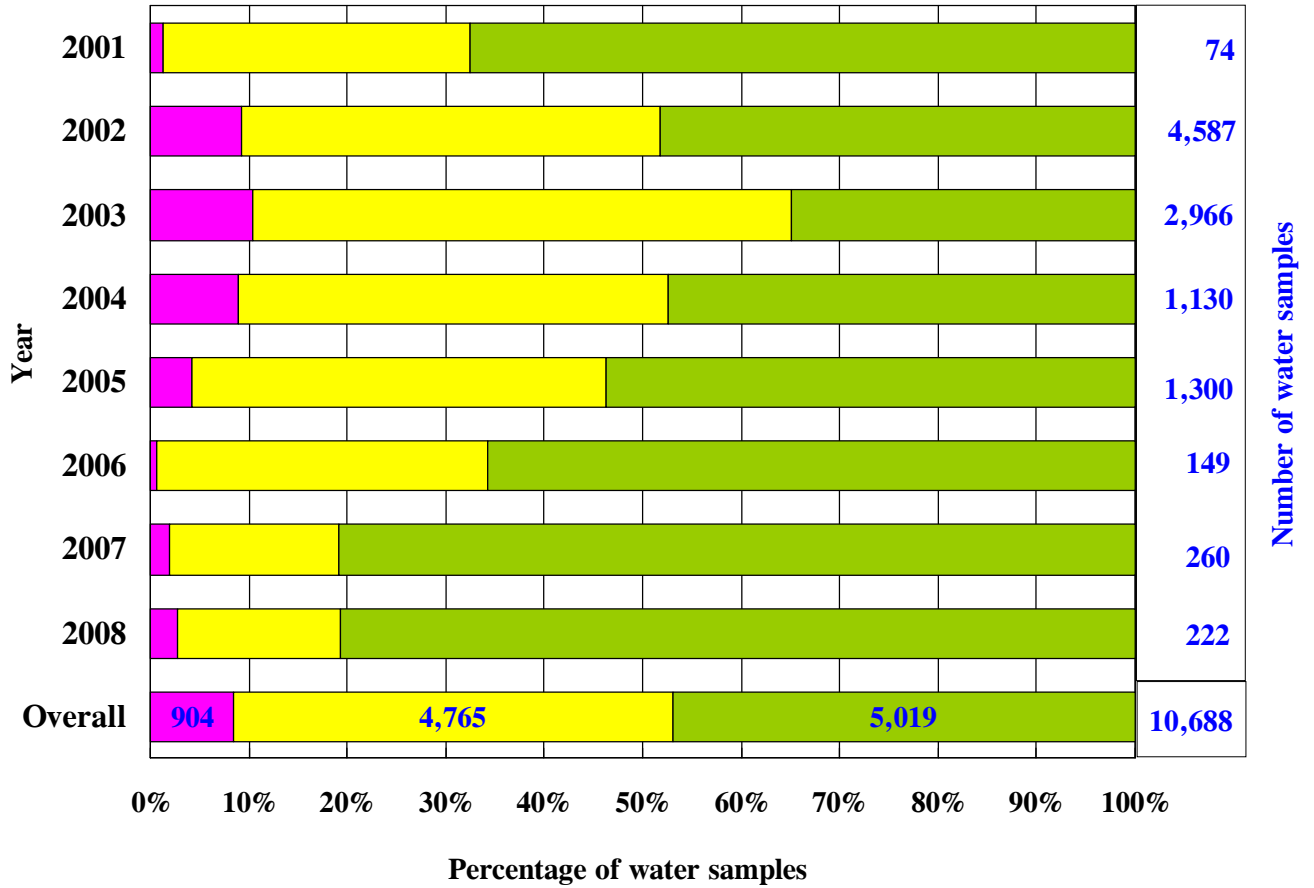
6.7 During the inspections, the EMSD collected water samples from cooling towers for testing of Legionella bacteria. The test results were expressed in colony forming units per millilitre (cfu/ml) which represented the number of bacteria in the water sample. According to the CoP(WACS), cooling towers detected with a Legionella bacteria count of 10 cfu/ml or more are considered to have problems within the systems. In such cases, the EMSD would require owners of the cooling towers to take the following control measures:

- (a) ***Legionella bacteria count of 10 to 1,000 cfu/ml.*** Owners would be requested to review the water treatment programme, take necessary remedial actions, including immediate disinfection of the cooling towers, and conduct further testing of water samples after disinfection; and
- (b) ***Legionella bacteria count of over 1,000 cfu/ml.*** Owners would be requested to review the water treatment programme, take necessary remedial actions, including suspending the operation of cooling towers for emergency decontamination, and conduct further testing of water samples after decontamination.

The pertinent cooling tower owners were required to complete a reply slip to inform the EMSD of the date of completion of the necessary disinfection or decontamination, and the results of subsequent tests of water samples.

6.8 The results of tests for Legionella bacteria in water samples collected from cooling towers by the EMSD are shown in Figure 4.

Figure 4
Results of tests for Legionella bacteria in water samples
(2001 to 2008)



Legend: ■ Legionella bacteria count of over 1,000 cfu/ml
■ Legionella bacteria count of 10 to 1,000 cfu/ml
■ Legionella bacteria not detected (i.e. less than 10 cfu/ml)

Figures in blue denote number of water samples.

Source: EMSD records

Audit observations and recommendations

Need to conduct more inspections of cooling towers

6.9 During the inspection programme from 2001 to 2005, the EMSD found that there were about 10,700 cooling towers in the territory. However, the EMSD was unable to inspect all the 10,700 cooling towers, and water samples were only collected from 8,387 cooling towers (78%) for testing of Legionella bacteria. This was because:

- (a) the owners of some cooling towers could not be identified;
- (b) some owners denied EMSD's access to the cooling towers; and
- (c) some cooling towers were installed at locations out of reach for inspection or water sampling.

6.10 The inspection programme from 2006 to 2008 was substantially reduced in scale. The EMSD only completed 631 inspections with an average of 210 inspections a year. In response to Audit's enquiry, in August 2009, the EMSD said that funding had been earmarked for conducting another round of inspections of cooling towers on a larger scale. **In view of the potential health hazards posed by cooling towers, especially those with unauthorised connection to water mains, the EMSD needs to consider conducting more inspections on such cooling towers.**

Need to strengthen controls over cooling towers

6.11 Audit noted that the EMSD's inspections found that many cooling towers were not properly installed or maintained (see para. 6.5) and many were detected with Legionella bacteria in the water samples (see para. 6.8).

6.12 For cooling towers detected with Legionella bacteria in the water samples, the EMSD would inform the owners of the test results in writing and request them to take necessary remedial actions (see para. 6.7). Audit noted that in many cases the owners did not respond to the EMSD's instructions. From 2006 to 2008, the EMSD issued 216 letters to owners of contaminated cooling towers with instructions for remedial actions. Of these 216 letters, 109 (50%) reply slips were received confirming completion of remedial actions.

6.13 **In Audit's view, there is a need to consider ways to deal with cooling towers found not properly installed or maintained, and those found contaminated.**

Need to prioritise inspection of cooling towers

6.14 Audit notes that the following groups of cooling towers may pose a higher risk to public health:

- (a) cooling towers with a record of repeated contamination;
- (b) cooling towers located near elderly homes, hospitals and healthcare facilities. According to the CoP(PLD), elderly people and patients who have low resistance to infection are more vulnerable to contracting LD; and
- (c) cooling towers located near pedestrian thoroughfares or fresh air intakes of a building.

6.15 **Audit considers that the EMSD, in devising cooling tower inspection programmes, needs to give priority to those cooling towers which may pose a higher risk to public health.**

Contamination of cooling towers under the FWCT Scheme

6.16 Owners of cooling towers approved under the FWCT Scheme are required to comply with the CoP(PLD) and CoP(WACS) for proper operation and maintenance of their cooling towers. They are also required to carry out regular tests on water samples from cooling towers for bacterial content and to submit regular returns to the EMSD as evidence of compliance (see para. 2.11). These cooling towers are expected to be properly maintained without contamination.

6.17 The EMSD's inspection programmes also covered cooling towers approved under the FWCT Scheme. From 2001 to 2008, of the 541 water samples collected from cooling towers under the FWCT Scheme, 97 (18%) were detected with Legionella bacteria count of 10 cfu/ml or more (Note 16), and 50 (9%) were detected with total bacteria count of 100,000 cfu/ml or more (Note 17). The EMSD requested the responsible owners to conduct cleansing and disinfection of the contaminated cooling towers. However, the EMSD had not examined the reasons for contamination. It appears that some scheme

Note 16: *There were 85 cases detected with Legionella bacteria count of 10 to 1,000 cfu/ml, and 12 cases with Legionella bacteria count of over 1,000 cfu/ml.*

Note 17: *Total bacteria count is another indicator of the water quality of cooling towers. A total bacteria count of 100,000 cfu/ml or more indicates that the system could support Legionella bacteria growth if action is not taken. The EMSD would request owners of cooling towers to carry out cleansing and disinfection if water samples are detected with a total bacteria count of 100,000 cfu/ml or more.*

participants might not have properly maintained their cooling towers, resulting in contamination. **Audit considers that the EMSD needs to conduct a review and take measures to ensure that cooling towers approved under the FWCT Scheme are properly maintained and not contaminated.**

Contamination of cooling towers in government premises

6.18 Among the approved cooling towers with water samples collected for testing (see para. 6.17), some were installed in government premises. Of the 14 government premises involved, test results revealed that the cooling towers in 10 premises were contaminated. Table 3 shows the details.

Table 3
Contaminated cooling towers in government premises
(2006 to 2008)

	Name of building	Number of water samples	
		Tested	Contaminated (Note)
1	Centre Street Cooked Food Centre	3	3
2	EMSD Headquarters Building	5	3
3	Immigration Tower (17/F)	2	1
4	ICAC Building	2	1
5	Joint-user Complex at Tseng Choi Street, Tuen Mun	2	1
6	Kowloon Public Library	4	3
7	Kwun Chung Municipal Services Building	2	1
8	Lo Wu Cross Boundary Footbridge	4	1
9	New Territories South Police Headquarters	5	3
10	Tuen Mun Children and Juvenile Home	4	2
	Total	33	19

Source: EMSD records

Note: The 19 water samples found contaminated included 8 cases with *Legionella* bacteria count of 10 cfu/ml or more, and 11 cases with total bacteria count of 100,000 cfu/ml or more (see Note 17 to para. 6.17).

6.19 The cooling towers in the 10 government premises shown in Table 3 were maintained by the EMSTF. The EMSTF operating units were notified of the test results and were requested to carry out cleansing and disinfection of the contaminated cooling towers. After cleansing and disinfection, further testing of water samples was conducted confirming that the bacterial content of the cooling towers were satisfactory. **Audit considers that there is a need to review the programme for the operation and maintenance of cooling towers in government premises with a view to identifying improvement measures.**

Presentation of cooling tower water quality test results

6.20 The Hong Kong Productivity Council (HKPC) is one of the accredited laboratories in Hong Kong providing services for testing water samples for Legionella bacteria. In March 2007, the HKPC said in a press release that:

- (a) from 2004 to 2007, among the 3,685 water samples referred to it for testing, 29% were found to contain Legionella bacteria (Note 18); and
- (b) the water samples found contaminated had an average Legionella bacteria count of about 140 cfu/ml. The highest level was 14,000 cfu/ml.

6.21 In May 2007, a written question was raised at a LegCo meeting, citing the HKPC's test results, about the measures taken by the Administration to enhance the prevention of LD. The Administration's reply was that:

- (a) according to inspections conducted by the EMSD from 2001 to 2005, covering 10,057 water samples, 892 (9%) of them were found to have exceeded the acceptable level in terms of their Legionella bacteria content;
- (b) the EMSD and the HKPC presented in different ways the discovery of Legionella bacteria in water samples taken from cooling towers; and
- (c) the HKPC published the number of all water samples containing the Legionella bacteria while the EMSD considered that only water samples with Legionella bacteria concentration exceeding 1,000 cfu/ml should be regarded as exceeding the acceptable level. This resulted in the disparity in their findings.

Note 18: *This refers to a Legionella bacteria count of 10 cfu/ml or more.*

6.22 Audit noted that:

- (a) according to the CoP(WACS), the cooling water quality criterion for Legionella bacteria was 10 cfu/ml;
- (b) during the EMSD inspection programme, when water samples were detected with a Legionella bacteria count of 10 cfu/ml or more, the EMSD would request the owners of the cooling towers to carry out cleansing and disinfection;
- (c) a Legionella bacteria count of over 1,000 cfu/ml was considered as a high contamination level calling for emergency decontamination; and
- (d) during the EMSD's investigations of reported LD cases, cooling towers detected with a Legionella bacteria count of 10 cfu/ml or more were required to be disinfected.

6.23 **In Audit's view, in reporting the relevant test results, consideration needs to be given to reporting all contamination cases with a Legionella bacteria count of 10 cfu/ml or more, apart from those over 1,000 cfu/ml.**

Need for compilation of comprehensive records of cooling towers

6.24 In January 2006, the EMSD reported to the PLDC that:

- (a) an enhanced cooling tower database system was completed in December 2005;
- (b) the new database system could provide enhancement features with the use of electronic maps to facilitate the positioning of cooling towers and analysis of nearby site information; and
- (c) the location of hospitals, clinics and elderly homes could be indicated on the electronic maps to facilitate locating cooling towers near these facilities.

6.25 In June 2009, the enhanced cooling tower database system had been reverted to a text-based spreadsheet format, with the enhancement features removed. **In view of the benefits of the enhancement features of the system, Audit considers that the EMSD needs to revisit the need for the continued development of the enhanced cooling tower database system.**

6.26 As at April 2009, the EMSD maintained information of cooling towers in three categories:

- (a) the 10,700 cooling towers recorded upon completion of the 2001 to 2005 inspection programme (see para. 6.4);
- (b) the 578 cooling towers approved under the FWCT Scheme (see para. 2.13(e)); and
- (c) the 60 cooling towers registered under the Voluntary Registration Scheme (see para. 7.4).

6.27 Audit noted that the EMSD database system did not capture information about the cooling towers of the 136 WACS installations approved directly by the WSD for industrial processes or essential uses (see para. 2.28). **Audit considers that the EMSD needs to include information about these cooling towers in the enhanced cooling tower database system.**

Audit recommendations

6.28 **Audit has recommended that the Secretary for Development and the Director of Electrical and Mechanical Services should, in consultation with the Director of Health and the Director of Water Supplies, consider ways to deal with cooling towers found not properly installed or maintained, and those found contaminated (see para. 6.13).**

6.29 **Audit has recommended that the Director of Electrical and Mechanical Services should:**

- (a) **consider conducting inspections of cooling towers on a regular basis as far as practicable (see para. 6.10);**
- (b) **consider adopting a risk-based approach in the inspections of cooling towers by giving priority to those which may pose a higher risk to public health (see para. 6.15);**
- (c) **conduct a review and take measures to ensure that cooling towers approved under the FWCT Scheme are properly maintained and not contaminated (see para. 6.17);**

- (d) review the programme for the operation and maintenance of cooling towers in government premises with a view to identifying effective measures for improvement (see para. 6.19);
- (e) continue with the development of an enhanced and updated cooling tower database system (see para. 6.25); and
- (f) include information about cooling towers directly approved by the WSD in the cooling tower database system (see para. 6.27).

6.30 Audit has *recommended* that the Secretary for Development and the Director of Electrical and Mechanical Services should, in reporting test results for Legionella bacteria in water samples in future, consider providing information on contamination cases with a Legionella bacteria count of 10 cfu/ml or more, apart from those over 1,000 cfu/ml (see para. 6.23).

Response from the Administration

6.31 The Secretary for Development agrees with the audit recommendations in paragraphs 6.28 and 6.30.

6.32 The Director of Electrical and Mechanical Services generally agrees with the audit recommendations in paragraphs 6.28 to 6.30. He has said that:

- (a) the EMSD will work closely with relevant bureaux and departments to implement the audit recommendation in paragraph 6.28;
- (b) the EMSD will continue to carry out regular inspections of cooling towers as far as practicable;
- (c) in selecting cooling towers for inspection, priority will be given to cooling towers that may pose a higher risk to public health;
- (d) the procedures to handle non-compliance with the requirements under the FWCT Scheme have been revised. The owners of cooling towers will first receive a reminder letter to rectify the non-compliance. A warning letter will be issued if they still fail to rectify within a prescribed period. The EMSD will bring the audit recommendation in paragraph 6.29(c) to the attention of the interdepartmental Working Group to consider measures to strengthen control over the compliance with the requirements under the Scheme;

- (e) the programme for the operation and maintenance of cooling towers in government premises has already been reviewed and improvement works have been immediately undertaken. From January to July 2009, a total of 95 water sampling tests were conducted for the cooling towers in the ten government premises mentioned in paragraph 6.18. No water sample was found contaminated. The EMSD will continue to closely monitor the situation and take improvement measures where appropriate;
- (f) the DEVB has already allocated resources to the EMSD to enhance the cooling tower database system, and to carry out data updating work in 2009-10 and after;
- (g) the EMSD will work together with the WSD to include information about cooling towers directly approved by the WSD into the database system; and
- (h) the EMSD will follow the audit recommendation in paragraph 6.30 in reporting test results for Legionella bacteria in water samples in future.

6.33 The **Director of Health** has said that the DH will continue to contribute to the prevention and control of LD through detailed case investigations, public education, and professional health advice on LD risk in connection with cooling towers and other water-using apparatus.

6.34 The **Director of Water Supplies** has said that the WSD will provide information about WACS installations directly approved by it to the EMSD for inclusion in the cooling tower database system.

PART 7: CONTROL MEASURES ON UNAUTHORISED COOLING TOWERS

7.1 This PART examines control measures on unauthorised cooling towers with a view to identifying areas for improvement.

1999 audit review

7.2 In the 1999 audit review (see para. 1.8), Audit commented that, as the connections of the unauthorised cooling towers (see para. 6.2) to the mains were illegal in the first place, the willingness of these operators to comply with the requirements laid down in the CoP(PLD) for proper operation and maintenance was questionable. Audit considered that there was an urgent need to regulate the operation of unauthorised cooling towers for the sake of public health, with reference to practices of other countries adopting mandatory controls by requiring registration or licensing of cooling towers. In its report of February 2000, the PAC recommended that, in order to minimise the risk of LD, the Administration should:

- (a) consider ways, including the setting up of a registration and licensing system, of requiring operators and owners of fresh water cooling towers to comply with the CoP(PLD) on the proper operation and maintenance of cooling towers; and
- (b) ensure that there would be a smooth transition to bring these cooling towers under the regulation of the future registration and licensing system.

7.3 In May 2000, the Administration said that it would step up the monitoring of operation and maintenance of the existing cooling towers, and take into account the findings of a territory-wide implementation study (see para. 4.7) then in progress to set up a registration and licensing system to ensure proper design, operation and maintenance of cooling towers.

Voluntary Registration Scheme for cooling towers

7.4 In September 2000, the EMSD launched the Voluntary Registration Scheme for Cooling Towers (VRS). Upon registration under the VRS, the EMSD would provide owners of cooling towers with advice and assistance on the prevention of LD, aiming to minimise the risk in spreading LD from the cooling towers. Participants would be advised to comply with the CoP(PLD) for proper operation and maintenance of cooling towers to minimise the risk of bacterial growth.

- 7.5 Upon registration, the owners of cooling towers agree to:
- (a) allow EMSD staff to enter their premises for conducting site checks and water sampling of the cooling towers; and
 - (b) submit monthly returns to the EMSD on the operation and maintenance information of the cooling towers.

7.6 In September 2000, the EMSD issued letters to owners of unauthorised cooling towers identified in the 1999 survey inviting them to participate in the VRS. As at September 2009, there were 61 cooling towers in 18 premises (out of about 10,000 unauthorised cooling towers) registered under the VRS.

Consideration of further controls on unauthorised cooling towers

7.7 In April 2004, the Working Group of the FWCT Scheme (see para. 2.5) discussed the feasibility of a transition plan for controlling the unauthorised cooling towers scattered in the territory. The meeting resolved that ways to extend the registration, regulatory, monitoring and control measures should be included in the comprehensive review of the FWCT Scheme.

- 7.8 In March 2005, the Working Group considered that:
- (a) the task of working out a feasible transition for controlling the 12,000 unauthorised cooling towers was not within the purview of the Working Group; and
 - (b) there would be a need to revise the terms of reference of the Working Group to incorporate this new task.

In March 2006, the Working Group decided that it should not pursue the issue.

7.9 At a LegCo meeting in May 2007, a question was raised as to whether the Administration had plans, including enacting legislation, to require owners of cooling towers to cleanse and disinfect their facilities on a regular basis. In response, the Administration said that:

- (a) it had no plan to enact legislation that would require owners of cooling towers to cleanse and disinfect the facilities regularly;

- (b) there had not been an outbreak of LD in Hong Kong;
- (c) the reported cases of LD in Hong Kong were sporadic, rendering it very difficult to confirm the sources of infection;
- (d) no cooling tower had been identified as the source of LD infection; and
- (e) self-regulation of professionals to follow the Codes of Practice and to conduct inspections was more effective than enacting legislation.

Invitation to join Fresh Water Cooling Towers Scheme

7.10 In November 2006, the EMSD sent out about 8,000 letters to the owners of unauthorised cooling towers inviting them to join the FWCT Scheme on a voluntary basis. Up to September 2009, the EMSD had received 15 applications.

Audit observations and recommendations

Need to review effectiveness of voluntary compliance measures

7.11 Despite the efforts made since 2000, the Administration has not been able to put in place an effective system that could require owners of unauthorised cooling towers to properly operate and maintain their cooling towers. The EMSD's measures so far, appealing for voluntary compliance, reaped little results:

- (a) only 18 unauthorised WACS installations (including 61 cooling towers) joined the VRS since its launch in 2000 (see para. 7.6); and
- (b) only 15 unauthorised WACS installations joined the FWCT Scheme in response to the invitation in 2006 (see para. 7.10).

7.12 The EMSD records showed that, in 2005, there were about 10,700 unauthorised cooling towers in the territory. However, as shown in paragraph 7.11 above, only a very small number responded positively to the voluntary compliance measures. **Audit considers that there is a need to critically review the effectiveness of the voluntary compliance measures for controlling unauthorised cooling towers. It is also necessary to keep in view the need to introduce alternative strategies and additional measures to bring unauthorised cooling towers under control in the long term.**

Need to ensure no unauthorised cooling towers in government buildings

7.13 From the EMSD's records, Audit noted that it was maintaining two fresh water cooling towers installed in the Civil Engineering and Development Building in Ho Man Tin for air-conditioning purposes. In response to Audit's enquiry, in May 2009, the WSD said that it had no records of approving the use of mains water for air-conditioning purposes in this government building.

7.14 As this government building was situated in a designated area of the FWCT Scheme, in July 2009, Audit suggested that the EMSD should liaise with the Civil Engineering and Development Department to include these unauthorised cooling towers under the control of the FWCT Scheme. In August 2009, the EMSD said that the WACS with cooling towers in the Civil Engineering and Development Building would be replaced in 2009-10. Application for the new WACS using fresh water under the FWCT Scheme was made in July 2009 and approved in August 2009. **Audit considers that there is a need to introduce control measures to ensure that unauthorised cooling towers are not installed in government premises in future.**

Need to identify target groups of cooling towers for further action

7.15 Audit noted that some unauthorised cooling towers were located in:

- (a) shopping centres of housing estates;
- (b) premises owned by major property developers;
- (c) premises managed by major property management agents; and
- (d) premises operated by reputable chain stores and restaurant groups.

7.16 **In Audit's view, the landlords/property management agents/tenants of the above premises may be more forthcoming in joining the FWCT Scheme or the VRS. The EMSD needs to consider identifying target groups of cooling tower owners with a view to encouraging them to join either the FWCT Scheme or the VRS.**

Audit recommendations

7.17 **Audit has recommended that the Secretary for Development and the Director of Electrical and Mechanical Services should, in consultation with the Director of Water Supplies, keep in view the need for introducing alternative strategies and**

additional measures for controlling unauthorised cooling towers in the long term (see para. 7.12).

7.18 Audit has *recommended* that the Director of Electrical and Mechanical Services should:

- (a) critically review the effectiveness of the voluntary compliance measures for controlling unauthorised cooling towers (see para. 7.12);**
- (b) introduce control measures to ensure that unauthorised cooling towers are not installed in government premises in future (see para. 7.14); and**
- (c) consider identifying target groups of owners of unauthorised cooling towers with a view to encouraging them to join either the FWCT Scheme or the VRS (see para. 7.16).**

Response from the Administration

7.19 The Secretary for Development agrees with the audit recommendation in paragraph 7.17.

7.20 The Director of Electrical and Mechanical Services generally agrees with the audit recommendations in paragraphs 7.17 and 7.18. He has said that:

- (a) the EMSD will bring the audit recommendations to the attention of the interdepartmental Working Group to:**
 - (i) review and consider measures to be taken for controlling unauthorised cooling towers; and**
 - (ii) consider measures to be taken to encourage owners of unauthorised cooling towers to join the FWCT Scheme; and**
- (b) the EMSD will liaise with relevant bureaux and departments to ensure that all cooling towers installed in government premises are duly authorised.**

Acronyms and abbreviations

AACS	Air-cooled air-conditioning system(s)
ArchSD	Architectural Services Department
Audit	Audit Commission
cfu/ml	Colony forming units per millilitre
CoP(PLD)	Code of Practice for Prevention of Legionnaires' Disease
CoP(WACS)	Code of Practice for Water-cooled Air-conditioning Systems
DCS	District cooling system(s)
DEVB	Development Bureau
DH	Department of Health
EA Panel	Panel on Environmental Affairs
EMSD	Electrical and Mechanical Services Department
EMSTF	Electrical and Mechanical Services Trading Fund
ENB	Environment Bureau
FWCT Scheme	Scheme for Wider Use of Fresh Water in Evaporative Cooling Towers for Energy-efficient Air-conditioning Systems
GFA	Gross floor area
HA	Hospital Authority
HKPC	Hong Kong Productivity Council
KTD	Kai Tak Development
kW	Kilowatts
kWh	Kilowatt-hours
LD	Legionnaires' Disease
LegCo	Legislative Council
PAC	Public Accounts Committee
PLDC	Prevention of Legionnaires' Disease Committee
PWSC	Public Works Subcommittee
SARS	Severe Acute Respiratory Syndrome
SEKD	South East Kowloon District
VRS	Voluntary Registration Scheme for Cooling Towers
WACS	Water-cooled air-conditioning system(s)
WSD	Water Supplies Department