CHAPTER 2

Environment Bureau
Electrical and Mechanical Services Department

Kai Tak District Cooling System

Audit Commission
Hong Kong
30 November 2021

This audit review was carried out under a set of guidelines tabled in the Provisional Legislative Council by the Chairman of the Public Accounts Committee on 11 February 1998. The guidelines were agreed between the Public Accounts Committee and the Director of Audit and accepted by the Government of the Hong Kong Special Administrative Region.

Report No. 77 of the Director of Audit contains 8 Chapters which are available on our website at https://www.aud.gov.hk

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KAI TAK DISTRICT COOLING SYSTEM

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Executive Summary

1. A district cooling system (DCS) is a centralised air-conditioning system of a very large scale. According to the Government, DCSs are a very energy-efficient cooling solution and a typical saving of around 35% and 20% can be achieved when compared with traditional air-cooled and individual water-cooled air-conditioning systems respectively. To further promote energy efficiency and conservation, and to reduce carbon dioxide emissions substantially, the Government announced in October 2008 that it would implement a DCS at the Kai Tak Development (KTD) (i.e. Kai Tak District Cooling System — KTDCS) to supply chilled water to buildings in the new development area for centralised air-conditioning. KTDCS is the first of its kind in Hong Kong. The Electrical and Mechanical Services Department (EMSD) is responsible for the planning, design, construction, operation and maintenance of KTDCS. The Environment Bureau (ENB) is responsible for policy matters on energy efficiency and conservation, and for overseeing the operation of EMSD on the implementation of KTDCS.

2. To match the schedules of development projects at KTD, KTDCS project was implemented in three phases (Phases I, II and III). A total funding of $4,945.5 million was approved by the Finance Committee (FC) of the Legislative Council (LegCo) for KTDCS project between June 2009 and January 2019. EMSD awarded four consultancies for KTDCS project to two consultants (Consultants X and Y) between February 2008 and January 2014. Between February 2011 and August 2020, EMSD awarded 11 works contracts (Contract A under Phase I, Contract B under Phase II and Contracts C to K under Phase III) to 9 contractors for the implementation of KTDCS project. Phases I to III works commenced between February 2011 and July 2013 and the works under Phases I and II were completed in January 2013 and September 2014 respectively. For Phase III, three of the four works packages were completed in phases between September 2017 and April 2020, and the remaining one is scheduled for completion by December 2025. As of August 2021, the Government had incurred $4,120.1 million (83% of $4,945.5 million) for KTDCS project.

3. EMSD adopted a design-build-operate (DBO) contract arrangement for implementing KTDCS. In February 2011, EMSD awarded a DBO contract (Contract B) to a contractor (Contractor B) for the design, construction, operation and maintenance of KTDCS. The operation of KTDCS commenced on 29 January 2013 and the provision of district cooling services to user buildings within KTDCS's service area had commenced progressively since February 2013. Under Contract B, the operation period was 6.5 years (i.e. expiry in July 2019) and EMSD had an option to extend the operation period for a further 8 years. In July 2018, EMSD extended the operation period for 8 years from July 2019 to July 2027. The total operation payment to Contractor B since commissioning of KTDCS and up to 31 March 2021 was about $374 million.

4. All public developments (i.e. all government premises and facilities of public bodies which are not for domestic use) at KTD are mandated to connect and subscribe to the district cooling services and all private non-domestic developments at KTD are required to connect to KTDCS. As of August 2021, there were 11 DCS consumers under KTDCS and all were public developments. The provision of district cooling services of KTDCS is governed by the District Cooling Services Ordinance (Cap. 624). The Audit Commission (Audit) has recently conducted a review to examine EMSD's work in managing the implementation and operation of KTDCS.

Administration of Kai Tak District Cooling System project

5. ***Scope for conducting more thorough pre-tender site investigations on underground utilities.*** Under Contract A, Contractor A was required to construct chilled water pipes at four locations by open-cut method. During the pipe laying works, congested underground utilities (e.g. electricity cables and telecom cables) were found at the four locations. In the event, Consultant X (i.e. the Engineer of Contract A) issued four variation orders (later valued at a total cost of $6.4 million) to instruct Contractor A to change the pipe laying method to trenchless method to cater for the existing site constraints at the four locations. According to EMSD, before the tender exercise of Contract A, it had coordinated with the relevant interfacing parties and utility undertakings to obtain the latest information on site conditions. In Audit's view, in implementing DCS projects in future, EMSD and its consultants need to continue to improve the pre-tender site investigations on underground utilities (paras. 2.4, 2.5, 2.7 and 2.8).

6. ***Scope for improvement in phasing arrangement of construction works.*** Of the three phases (Phases I, II and III) of works under KTDCS project, Contract B was for implementing Phase II works. Audit noted that, during the construction stage, Consultant X (i.e. the Supervising Officer of Contract B) instructed Contractor B to carry out some builder's works originally scheduled under Phase III. Consultant X considered it more appropriate to carry out such works at an early stage (i.e. under Phase II) before the operation of DCS plants. Due to carrying out the additional builder's works, Consultant X instructed Contractor B to carry out mitigation measures to catch up with the works programme and minimise further delay of Contract B. Contractor B submitted claims for additional costs for carrying out the additional builder's works and implementing the delay mitigation measures. In the event, $47.2 million was paid to Contractor B to settle the claims. In Audit's view, there is scope for improvement in phasing arrangement of construction works for DCS projects in future (paras. 2.17, 2.18 and 2.20).

7. ***Malfunction of some water leakage detection cables.*** Contract D mainly involved chilled water pipe laying works, which included the construction of a water leakage detection system for chilled water pipes. Contract D was substantially completed in October 2016 and the maintenance period expired in October 2017. Audit noted that there was malfunction of water leakage detection cables for all three sections of pipeline under Contract D. As of September 2021 (i.e. about 4 years after the expiry of the maintenance period), the related defects rectification works had not been completed. According to EMSD, after further testing and review in 2016 and 2017, Consultant Y (i.e. the Engineer of Contract D) concluded in mid-2018 that the water leakage detection cables were defective due to poor workmanship. In May 2019, Contractor D worked out a remedial proposal by using noise logger system, which was subsequently agreed by EMSD based on the recommendations of Consultant Y. Installation works were expected to be completed by December 2021. According to EMSD, it updated in 2019 the relevant technical specifications of water leakage detection cables to prevent occurrence of similar defects in future (including strengthening site supervision and training to workers). In Audit's view, EMSD needs to complete the defects rectification works of installing the noise logger system on schedule and keep under review its performance (paras. 2.23 to 2.27).

Monitoring of operation of Kai Tak District Cooling System

8. The operation of KTDCS is as follows: (a) chilled water is produced at two chiller plants (the northern and southern chiller plants). The chilled water is distributed through the distribution network to substations at user buildings where cooling energy is transferred for user buildings' use, and is then returned to the chiller plants for re-chilling; (b) each user building has its own chilled water distribution network, which is separated from the KTDCS distribution network. Heat exchangers are installed at the substation at a user building to transfer heat between the chilled water of KTDCS and the chilled water of the user building's air-conditioning installation; and (c) according to the design conditions of KTDCS, there are temperature parameters for chilled water supply and return temperatures at the primary and secondary sides of heat exchanger at the substation at a user building. In general, the primary side refers to KTDCS supply side and the secondary side refers to user building's air-conditioning installation (paras. 3.2 and 3.4).

9. ***Non-compliance with Key Performance Indicators (KPIs).*** According to Contract B and the operation plan of KTDCS (approved by EMSD), there are two KPIs (KPI 1 and KPI 2 relating to chilled water supply temperature at the primary and secondary sides respectively) for measuring the performance of Contractor B in operating KTDCS. The maximum count per substation for non-compliance (i.e. the allowed Counts of Non-compliance (CNCs) per substation) for each KPI in each month is 20. Audit noted that since commissioning of KTDCS in January 2013 and up to 31 March 2021, for 8 substations, there were a total of 12 cases (occurring between December 2014 and July 2019 with 11 cases relating to KPI 1 and 1 case relating to KPI 2) where a substation's measured CNCs for a KPI in a month exceeded 20, ranging from 21 to 65. According to EMSD: (a) it will conduct investigations of Contractor B's non-compliance with KPIs; and (b) of the 12 cases, the causes of 11 cases were uncontrollable by Contractor B and the cause of 1 case was related to the actual performance of Contractor B in operating KTDCS. In Audit's view, EMSD needs to make continued efforts to closely monitor the performance of Contractor B in operating KTDCS (paras. 3.5 to 3.9).

10. ***Performance monitoring mechanism.*** Audit noted the following issues:

(a) ***Scope for improvement in operation payment adjustment mechanism.*** The monthly operation payment to Contractor B is adjusted based on a formula (comparing the total measured CNCs for a KPI for all the substations in a

month against the total allowed CNCs for the KPI for all the substations for that month) to reflect the level of performance achieved. According to EMSD, after gaining the experience from implementing the DBO contract for KTDCS, it was considering enhancing the KPI requirements in future contracts for operating KTDCS (including revising the formula for calculating operation payment adjustment to suit the actual operation as needed) (paras. 3.6 and 3.10); and

(b) ***Need to consider incorporating new KPIs.*** Apart from KPIs on chilled water supply temperatures (which were included in Contract B), an additional KPI on system coefficient of performance was included in a DBO contract (for the provision of an additional DCS at KTD — see para. 16(b)) awarded in November 2020 for better monitoring of energy efficiency. In addition, apart from operating the DCS plants, Contractor B also performed other administration and reporting duties. However, there were no KPIs under Contract B related to such duties (para. 3.10).

11. ***Performance audit of KTDCS facilities.*** According to Contract B, Contractor B is required to appoint an independent professional engineer to carry out a performance audit of KTDCS facilities annually. As of October 2021, 8 performance audits (each covering a 12-month period from May of a year to April of the following year) had been completed. Audit noted the following issues:

(a) ***Chilled water return temperature lower than design temperature.*** All the 8 performance audits identified that the primary side chilled water return temperatures were lower than the design temperature. According to EMSD: (i) the primary side chilled water return temperatures depended on the secondary side chilled water return temperatures at user buildings' substations. The control mechanism to adjust the secondary side chilled water return temperature was under the responsibility of user buildings' air-conditioning systems. A DCS consumer should maintain the chilled water return temperature on consumer side at the design temperature; (ii) the chilled water return temperature on consumer side not being maintained at the required value would affect the operation or reliability of the district cooling services when the cooling demand was close to full-load capacity of the DCS plants; and (iii) extensive temperature resets were implemented in September 2021 to maintain the secondary side chilled water return temperatures within the specified range. As EMSD expects that the DCS plants will reach full-load capacity in 2025, in Audit's view,

EMSD needs to keep under review the impact of low chilled water return temperatures on the operation and reliability of KTDCS, and the effectiveness of the measures taken to address the issue (paras. 3.17 to 3.19); and

(b) ***Automatic operating mode of district cooling instrumentation, control and communication system (DCICCS) not fully in use.*** DCICCS is provided for controlling and monitoring of the whole KTDCS. All the 8 performance audits identified that automatic operating mode of DCICCS was not fully in use. According to the performance audit report for the period from May 2019 to April 2020, accelerating the implementation of fully automatic operating mode could improve the overall system efficiency and performance. According to EMSD, in view of the dramatic change in the cooling demand profile and the new electrical and mechanical equipment with different characteristics in operation in the next few years, it was planned to implement the fully automatic operating mode upon reaching full-load capacity tentatively in 2025. In Audit's view, EMSD needs to keep under review the operation of KTDCS and implement the fully automatic operating mode as and when appropriate (paras. 3.20, 3.22 and 3.23).

12. ***Scope for improvement in incident reporting.*** According to Contractor B's incident reporting procedures, incidents are classified into four levels (from Levels 1 to 4 (being the most serious)) with different reporting requirements. For Levels 3 and 4 incidents, Contractor B needs to inform EMSD (by telephone or in person) within 15 minutes. For Levels 2 to 4 incidents, Contractor B needs to submit separate incident reports to EMSD. According to EMSD, since commissioning of KTDCS in January 2013 and up to 30 June 2021, 25 incident reports were submitted by Contractor B to it. Audit noted that all the reports had not reported the level of the incidents and some of them had not set out the time of reporting to Contractor B's management and EMSD. In addition, EMSD had not maintained records showing when Contractor B notified it of the incidents and its follow-up actions taken (paras. 3.24 and 3.25).

Provision of district cooling services and other related issues

13. ***Information for following up developments for provision of district cooling services not included in the list of development sites for connection to KTDCS.*** All public and private non-domestic developments at KTD are required to connect to KTDCS (see para. 4). According to EMSD: (a) it keeps track of the developments at KTD via the Outline Development Plan for KTD and assesses the technical feasibility of DCS connection to development sites included in the Outline Development Plan to identify development sites that are required to connect to KTDCS; and (b) it prepares a list of development sites for connection to KTDCS (connection list) and updates the connection list from time to time based on the latest Outline Development Plan. Audit noted that the connection list did not include information for following up developments at the sites for provision of district cooling services (e.g. responsible government bureau/department (B/D) or party, site development status and the progress of connection to KTDCS) (paras. 4.2, 4.3 and 4.6).

14. ***Need to keep up efforts in liaising and exploring feasibility with B/Ds and parties concerned for provision of district cooling services.*** According to EMSD, as of August 2021: (a) 5 public developments and 3 private non-domestic developments at KTD were under coordination for provision of district cooling services (expected to commence between the first quarter of 2022 and the second quarter of 2026); and (b) 6 existing public developments and 3 existing private non-domestic developments at KTD were not yet connected to KTDCS as they had been constructed before district cooling services were available to them. In Audit's view, EMSD needs to closely liaise and explore with the relevant B/Ds and the responsible parties of these developments for provision of district cooling services and the feasibility of connecting their developments to KTDCS when opportunities arise (paras. 4.6 and 4.7).

15. ***Need to keep under review the cooling demand of developments at KTD.*** Audit noted that: (a) there was an increase in development intensity of KTD as announced in the 2017 Policy Address; (b) in his 2021-22 Budget Speech, the Financial Secretary announced that the Government was examining the feasibility of rezoning five commercial sites in Kowloon East for residential use. According to ENB, there would be an impact on the finance and operation of KTDCS as the five commercial sites were potential consumers of KTDCS; and (c) new DCS consumers were expected in the next few years (see para. 14(a)). In view of the changing

developments at KTD, Audit considers that EMSD needs to keep under review the cooling demand of developments at KTD with a view to matching the demand by KTDCS (paras. 4.8 and 4.9).

16. ***Need to complete interim tariff review as scheduled and conduct regular tariff reviews.*** The District Cooling Services Ordinance sets out the tariff level (comprising two major components, namely capacity charge and consumption charge) for the district cooling services of KTDCS and the adjustment mechanism. According to ENB and EMSD, both the capital and operating costs of KTDCS would be recovered from DCS consumers over the 30-year service life. According to ENB, apart from the annual tariff adjustments, a regular DCS tariff review will be conducted at least once every 5 years. Audit noted that: (a) a DCS tariff review concerning the existing DCS at KTD (implemented under KTDCS project) was completed in June 2020. Based on the review findings, the existing cost recovery rate was close to full-cost recovery level. As such, EMSD proposed in July 2020 and ENB endorsed in October 2020 to maintain the prevailing tariff level; and (b) in June 2020, FC approved a funding of $4,269.3 million for the provision of an additional DCS at KTD as EMSD anticipated in 2017 that the existing DCS at KTD would not be able to meet the growth in projected cooling demand of user buildings. The project for the additional DCS at KTD commenced in December 2020 and the provision of district cooling services is planned to commence in phases starting from 2022-23. According to EMSD, an interim tariff review would be conducted to ascertain whether the 30-year full cost recovery principle could be met concerning the existing DCS and the additional DCS at KTD. It expected that the review report would be available by the end of 2021. In Audit's view, EMSD needs to complete the interim tariff review for KTDCS as scheduled and conduct regular tariff reviews, taking into account all relevant data and latest developments relating to KTDCS (paras. 1.18 and 4.10 to 4.15).

17. ***Scope for improving project cost estimation.*** The estimated overall project cost for KTDCS project was $1,671 million in May 2009. In January 2011 and May 2013, in the submissions to the Public Works Subcommittee of FC of LegCo, ENB said that: (a) it forecasted that the estimated overall project cost had increased (to $3,646.3 million as at January 2011 and $4,945.5 million as at May 2013) due to various reasons (e.g. cost of additional works made necessary by project design development and changes in construction requirements due to unexpected site constraints); and (b) it would seek approvals from the Public Works Subcommittee and FC for further increasing the approved project estimate (APE) for KTDCS project subject to the progress and development programme of KTD. In the event, funding

approvals were sought between February 2011 and January 2019 for increasing APE for KTDCS project from $1,671 million to $4,945.5 million. Audit noted that there was a significant increase in the estimated overall project cost for KTDCS project by $3,274.5 million (or 196%) from $1,671 million in 2009 to $4,945.5 million in 2013. In Audit's view, in implementing DCS projects in future, EMSD needs to take measures to ensure that the project costs are estimated as accurately as possible (paras. 4.24 to 4.26).

Audit recommendations

18. **Audit recommendations are made in the respective sections of this Audit Report. Only the key ones are highlighted in this Executive Summary. Audit has *recommended* that the Director of Electrical and Mechanical Services should:**

Administration of KTDCS project

(a) **in implementing DCS projects in future, continue to improve the pre-tender site investigations on underground utilities and enhance the phasing arrangement of construction works before inviting tenders (paras. 2.14(a) and 2.21);**

(b) **complete the defects rectification works of installing the noise logger system on schedule and keep under review its performance (para. 2.31(a));**

Monitoring of operation of KTDCS

(c) **make continued efforts to closely monitor the performance of Contractor B in operating KTDCS (para. 3.12(a));**

(d) **enhance the operation payment adjustment mechanism in future contracts for operating KTDCS and consider incorporating new KPIs into such contracts (para. 3.12(b) and (c));**

(e) **keep under review the impact of low chilled water return temperatures on the operation and reliability of KTDCS, and the effectiveness of the measures taken to address the issue (para. 3.28(a));**

(f) **keep under review the operation of KTDCS and implement the fully automatic operating mode as and when appropriate (para. 3.28(c));**

(g) **enhance the monitoring of Contractor B's compliance with the incident reporting requirements (para. 3.28(d));**

Provision of district cooling services and other related issues

(h) **include in the list of development sites for connection to KTDCS information for following up developments at the sites for provision of district cooling services (para. 4.16(a));**

(i) **closely liaise and explore with the relevant B/Ds and the responsible parties of the relevant developments for provision of district cooling services and the feasibility of connecting their developments to KTDCS when opportunities arise (para. 4.16(c) and (d));**

(j) **keep under review the cooling demand of developments at KTD with a view to matching the demand by KTDCS (para. 4.16(e));**

(k) **complete the interim tariff review for KTDCS as scheduled and conduct regular tariff reviews, taking into account all relevant data and latest developments relating to KTDCS (para. 4.16(f)); and**

(l) **in implementing DCS projects in future, take measures to ensure that the project costs are estimated as accurately as possible (para. 4.30(a)).**

Response from the Government

19. The Director of Electrical and Mechanical Services agrees with the audit recommendations.

PART 1: INTRODUCTION

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

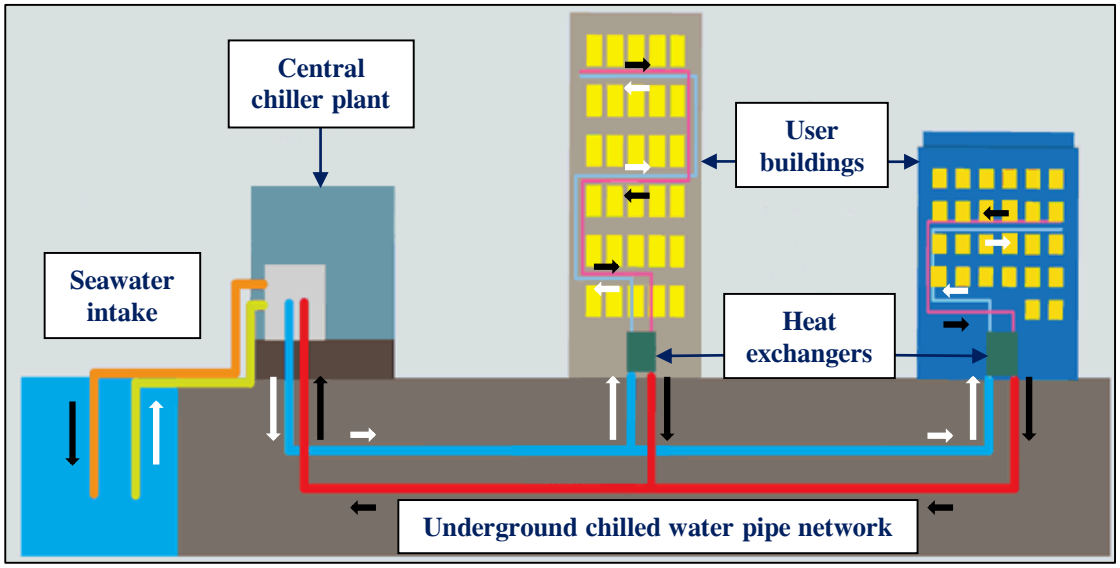
Background

1.2 ***District cooling system.*** According to the Electrical and Mechanical Services Department (EMSD), a district cooling system (DCS) is a centralised air-conditioning system of a very large scale. It consists of one or more chiller plants to produce chilled water and a closed-loop network of underground pipes for chilled water distribution. Chilled water is pumped to user buildings for use in their air-conditioning systems (via heat exchangers — Note 1) and is then returned to the central chiller plant for re-chilling. Heat rejected from the chilled water network is carried away either by seawater 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 using seawater for heat rejection.

Note 1: *Heat exchangers are installed at the substations at user buildings. Cooling energy required by each user building will be transferred via heat exchangers connected to the distribution network of DCS.*

Figure 1

Schematic diagram of a DCS using seawater for heat rejection



Source: *EMSD records*

1.3 ***Benefits of DCS.*** According to the Government, DCSs are a very energy-efficient cooling solution as they take full advantage of economy of scale, diversity in cooling demand of different buildings, and high standard of plant operation and maintenance. Although actual energy savings arising from DCSs vary according to their configurations, a typical saving of around 35% and 20% can be achieved when compared with traditional air-cooled air-conditioning system and individual water-cooled air-conditioning system using cooling towers respectively. The technology has been widely adopted overseas (Note 2). Apart from energy saving, a DCS will bring about other benefits, including:

(a) reduction in upfront capital cost for installing chiller plants (about 5% to 10% of the total building cost) and more flexible building designs for user buildings (as they do not need to install chillers and associated electrical and mechanical (E&M) equipment);

Note 2: *According to the Environment Bureau, examples of overseas DCSs are at Chicago Downtown in the United States of America, City Centre of Paris in France, City of Toronto Downtown in Canada and Yokohama Minato Mirai 21 in Japan.*

(b) no noise and vibration arising from the operation of heat rejection equipment and chillers of air-conditioning plants at user buildings;

(c) mitigation of heat island effects (Note 3) in the areas serviced and contributing to air quality improvement and the vision of achieving low-carbon economy; and

(d) a more adaptable air-conditioning system to meet the varying air-conditioning demand as compared to individual air-conditioning system.

1.4 In October 2008, the Chief Executive of the Hong Kong Special Administrative Region announced in his 2008-09 Policy Address that, to further promote energy efficiency and conservation, and to reduce carbon dioxide emissions substantially, the Government would implement a DCS at the Kai Tak Development (KTD — Note 4) to supply chilled water to buildings in the new development area for centralised air-conditioning.

Note 3: *A heat island is a metropolitan area that is relatively hotter than the surrounding rural area. The difference in temperature is due to heat generated by human activities such as manufacturing, transportation and cooling/heating, and perpetuated by dense infrastructure and reduced vegetation in urban areas.*

Note 4: *KTD is a huge and highly complex development spanning a total planning area of over 320 hectares covering the 280-hectare ex-Kai Tak Airport site together with the adjoining hinterland districts of Kowloon City, Wong Tai Sin and Kwun Tong. According to the Environment Bureau, the public and private non-domestic development projects at KTD will generate substantial new demand for air-conditioning and associated electricity consumption growth.*

1.5 DCS at KTD (hereinafter referred to as the Kai Tak District Cooling System — KTDCS) is the first of its kind in Hong Kong. EMSD (through its Energy Efficiency Office (EEO — see Appendix A for an extract of EEO's organisation chart as at 31 August 2021)) is responsible for the planning, design, construction, operation and maintenance of KTDCS (Note 5). The Environment Bureau (ENB) is responsible for policy matters on energy efficiency and conservation, and for overseeing the operation of EMSD on the implementation of KTDCS. According to ENB, the development of KTDCS was implemented by phases and funding approvals were sought from the Finance Committee (FC) of the Legislative Council (LegCo) by phases for taking forward the works, having regard to the progress of KTD.

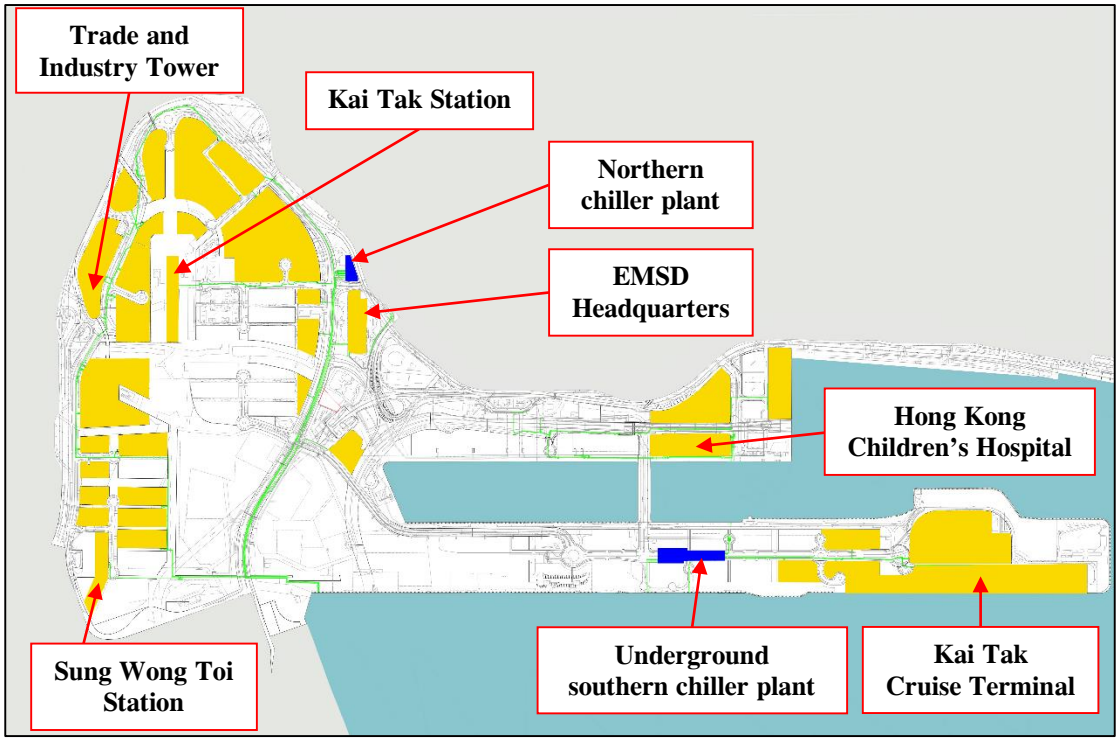
KTDCS project

1.6 To match the schedules of development projects at KTD, KTDCS project (see Figure 2 for the layout plan) was implemented in three phases (Phases I, II and III — see Table 1 for the major works components) with works commencing between February 2011 and July 2013. Upon completion of the whole project, the system will provide cooling capacity of about 284 megawatts for serving an estimated total public and private non-domestic air-conditioned floor area of about 1.73 million square metres (m^2).

Note 5: *According to EMSD: (a) as of August 2021, 28 staff in the Energy Efficiency Division C (led by a Chief Engineer) of EEO were involved in the implementation of KTDCS as well as DCSs in other new development areas (e.g. Tung Chung New Town Extension (East) and Kwu Tung North New Development Area); and (b) the related staff expenditure for 2020-21 was about $27.9 million.*

Figure 2

Layout plan for KTDCS project
(August 2021)



Legend:
- Service area of the northern and southern chiller plants
- Chiller plant
- Underground chilled water pipe network

Source: *EMSD records*

Remarks: *Of the 11 DCS consumers under KTDCS as of August 2021 (see Note 13 to para. 1.15), this Figure shows some of the major consumers (EMSD Headquarters, Hong Kong Children's Hospital, Kai Tak Cruise Terminal, Kai Tak Station, Sung Wong Toi Station, and Trade and Industry Tower).*

Table 1

Major works components under KTDCS project
(February 2011 to December 2025)

Phase	Major works component	Works commencement date	Works completion date	Project commissioning date
I	• Pipe laying works	February 2011	January 2013	January 2013 (see para. 1.12)
II	• Design for the whole DCS • Construction of a northern chiller plant and an underground southern chiller plant cum seawater pump house • Pipe laying works • Supply and installation of E&M equipment (e.g. chillers and pumps) • Provision of connection facilities (e.g. heat exchangers) at user buildings	March 2011	September 2014	
III (Note)	• Pipe laying works • Supply and installation of additional E&M equipment • Provision of connection facilities at user buildings	July 2013 (Note)	3 of 4 works packages completed by April 2020 and the remaining one scheduled for completion by December 2025 (Note)	

Source: *EMSD records*

Note: *The works under Phase III were divided into four packages (Packages A, B and C, and Remaining Works) to match the schedules of development projects at KTD. The works under Packages A, B and C commenced in July 2013, September 2015 and March 2017 respectively, and were completed in September 2017, February 2020 and April 2020 respectively. The works under Phase III (Remaining Works) commenced in January 2019 for completion by December 2025.*

1.7 A total funding of $4,945.5 million sought by ENB was approved by FC for KTDCS project between June 2009 and January 2019 (see Table 2). The works under Phases I and II were completed in January 2013 and September 2014 respectively. For Phase III, three of the four works packages were completed in phases between September 2017 and April 2020, and the remaining one is scheduled for completion by December 2025. The operation of KTDCS commenced in January 2013. According to ENB, upon full operation, the maximum annual saving in electricity consumption will be up to 85 million kilowatt-hours (kWh), corresponding to an annual reduction of about 59,500 tonnes of carbon dioxide emission (Note 6).

Table 2

Funding approvals for KTDCS project
(June 2009 to January 2019)

Date	Particulars	Approved amount ($ million)
June 2009	Provision of KTDCS	1,671.0
Increase in approved project estimate (APE) for taking forward the works under different project phases (Note)		
February 2011	Phases I and II	190.8
June 2013	Phase III (Package A)	1,284.1
July 2015	Phase III (Package B)	606.1
April 2016	Phase III (Package C)	153.7
January 2019	Phase III (Remaining Works)	1,039.8
	Total	4,945.5

Source: *EMSD records*

Note: *According to EMSD: (a) funding approvals for increasing APE were sought by phases between February 2011 and January 2019 for taking forward the works under different project phases, having regard to the progress of KTD as well as accommodating unexpected site constraints and project design changes (see para. 4.24); and (b) ENB forecasted the estimated overall project cost of $4,945.5 million for all phases of KTDCS project in the May 2013 funding application and there has been no change nor exceedance in the estimated overall project cost since then.*

Note 6: *According to EMSD, an annual reduction of about 59,500 tonnes of carbon dioxide emission is approximately equal to planting 2.3 million trees in an area of the size of 120 Hong Kong Victoria Park for carbon dioxide reduction.*

Implementation of KTDCS project

1.8 Between February 2008 and January 2014, EMSD awarded four consultancies for KTDCS project (see Table 3), as follows:

(a) one consultancy for the initial engineering design and investigation for KTDCS project; and

(b) three consultancies for the design and construction supervision work of KTDCS project which involved 11 works contracts (Contracts A to K — see para. 1.9).

Table 3

Consultancies for KTDCS project
(August 2021)

Consultancy	Consultant	Design and construction supervision work required	Consultancy fee ($ million)
Initial engineering design and investigation (Awarded in February 2008)	X (Note 1)	N/A	3.5
X (Awarded in April 2011)	X (Note 1)	Phase I: Contract A Phase II: Contract B (Note 2)	6.9
Y (Awarded in July 2012)	Y	Phase III (Packages A and C, and Remaining Works): Contracts C, D and I	8.9
Z (Awarded in January 2014)	X (Note 1)	Phase III (Package B and Remaining Works): Contracts E to H, J and K	8.8
		Total	28.1 (Note 3)

Source: EMSD records

Table 3 (Cont'd)

Note 1: *The consultancy for the initial engineering design and investigation and Consultancies X and Z were awarded to the same consultant (i.e. Consultant X).*

Note 2: *Contract B was a design-build-operate contract (see Note 9 to para. 1.11). Under Consultancy X, Consultant X was required to supervise the design and construction of the works under Phase II and the first 18-month operation of KTDCS.*

Note 3: *Of the $28.1 million, $19.1 million was funded under KTDCS project and $9 million for pre-construction consultancy work ($3.5 million for the consultancy for the initial engineering design and investigation, $2.9 million for Consultancy Y and $2.6 million for Consultancy Z) was funded under EMSD departmental vote.*

1.9 Between February 2011 and August 2020, EMSD awarded 11 works contracts (Contracts A to K) to 9 contractors (Note 7) for the implementation of KTDCS project (see Table 4), as follows:

(a) 1 contract under Phase I (Contract A);

(b) 1 contract under Phase II (Contract B); and

(c) 9 contracts under Phase III (Contracts C to K).

Except for 4 contracts (Contracts H to K under Phase III (Remaining Works)) which were still in progress as of August 2021, the other 7 contracts (Contracts A to G) were completed between January 2013 and February 2020, which were 1 to 16.4 months later than their original contract completion dates (see Table 4). Contract expenditures as of August 2021 are shown at Appendix B.

Note 7: *Contracts A and D were awarded to the same contractor. Another contractor was awarded Contracts C and F.*

Table 4

Contracts A to K for KTDCS project
(August 2021)

Phase	Contract	Commencement date	Original contract completion date	Actual completion date	No. of months later than original contract completion date
I	A	28.2.2011	29.6.2012	25.1.2013	6.9
II	B	7.3.2011	6.3.2014 (Note 1)	23.9.2014 (Note 1)	6.6
III (Package A) (Note 2)	C	26.7.2013	18.5.2016	29.9.2017	16.4
	D	26.7.2013	24.1.2016	29.10.2016	9.2
III (Package B) (Note 2)	E	1.9.2015	30.8.2017	23.1.2018	4.8
	F	1.9.2015	30.6.2019	29.7.2019	1.0
	G	18.9.2018	11.12.2019	18.2.2020	2.3
III (Package C) (Note 2)		7.3.2017	29.7.2019	13.4.2020	8.5
III (Remaining Works) (Note 2)	H	31.1.2019	29.6.2021	In progress (Note 3)	
	I	22.2.2019	17.2.2022		
	J	26.2.2019	29.8.2021		
	K	12.8.2020	27.9.2021		

Source: *EMSD records*

Note 1: *Contract B was a design-build-operate contract. The original contract completion date and actual completion date referred to the design and construction portions.*

Note 2: *The major works under Phase III (Packages A and B, and Remaining Works) were pipe laying works and E&M installation works. According to EMSD, to achieve better coordination and interface, some of the pipe laying works under Phase III (Packages A and B, and Remaining Works) were entrusted to the Civil Engineering and Development Department for implementation together with the infrastructure works of KTD. Regarding Phase III (Package C), as all works were pipe laying works, they were all entrusted to the Civil Engineering and Development Department for implementation and the dates shown in this Table referred to those related to the section for such entrustment works under the Department's relevant works contract.*

Note 3: *According to EMSD: (a) as of August 2021, Contracts H to K were expected to be completed between September 2021 and December 2022 (see Table 6 in para. 2.28); (b) as Contracts H to K only cover part of the works under Phase III (Remaining Works), EMSD will monitor the development of KTD and award other works contracts for the remaining works; and (c) the anticipated final completion date for the whole Phase III (Remaining Works) is December 2025.*

Costs of KTDCS project

1.10 As of August 2021, $4,120.1 million (83%) of APE totalling $4,945.5 million (see para. 1.7) for KTDCS project had been incurred. Of the $4,120.1 million, $3,880.6 million (94%) was related to expenditures on construction works for KTDCS project (Note 8). The remaining $239.5 million (6%) was resident site staff costs of $214.4 million, consultancy fees of $19.1 million (see Note 3 to Table 3 in para. 1.8) and other costs of $6 million.

Operation of KTDCS

1.11 EMSD adopted a design-build-operate (DBO — Note 9) contract arrangement for implementing KTDCS. In February 2011, EMSD awarded Contract B (see para. 1.9(b)) to Contractor B for the design (Note 10), construction, operation and maintenance of KTDCS at a contract sum of $1,941.1 million ($1,640.8 million for the design and construction portions and $300.3 million for the operation stage). The design and construction portions were completed in September 2014.

Note 8: *Expenditures on construction works comprised contract expenditures under Contracts A to K amounting to $3,470.5 million (see Note 6 to Appendix B) and entrustment works to the Civil Engineering and Development Department for Phase III amounting to $410.1 million.*

Note 9: *DBO is a form of contract procurement whereby the contractor is required to design and construct a proposed facility in accordance with all requirements set forth in the contract by the Government. Upon completion, the contractor will be required under the contract to operate and maintain the completed facility for a specified period of time. The ownership of the facility will remain with the Government throughout the contract duration. Upon expiry of the operation phase specified in the contract, the facility will be handed back to the Government free of any charges in a specified condition.*

Note 10: *Contract B covered the overall engineering design of DCS for the whole KTD and detailed design for Phase II works of KTDCS project. For Phases I and III works of KTDCS project, the detailed design was covered under Consultancies X to Z (see Table 3 in para. 1.8).*

1.12 The operation of KTDCS commenced on 29 January 2013 and the provision of district cooling services to user buildings within KTDCS's service area had commenced progressively since February 2013. Under Contract B, the operation period was 6.5 years (i.e. expiry in July 2019) and EMSD had an option to extend the operation period for a further 8 years. In July 2018, after obtaining the Financial Services and the Treasury Bureau's approval, EMSD extended the operation period for 8 years from July 2019 to July 2027. For the first 18-month operation of KTDCS, Consultant X was the Supervising Officer for Contract B and responsible for supervising Contractor B's operation and reporting Contractor B's performance to EMSD. After the first 18-month operation (i.e. since 29 July 2014), EMSD has fully taken up the work for monitoring (including supervising) Contractor B's operation.

1.13 Under Contract B, there is a set of Key Performance Indicators (KPIs) for measuring the performance of Contractor B. The monthly operation payment to Contractor B is adjusted to reflect the level of performance achieved, which is assessed based on monitoring results on KPIs in the same month. In 2020-21, the total cooling energy consumption of all user buildings was about 126 million kWh and the operation payment to Contractor B amounted to $58.7 million. The total operation payment to Contractor B since commissioning of KTDCS (i.e. 29 January 2013) and up to 31 March 2021 was about $374 million.

Provision of district cooling services

1.14 According to EMSD, KTDCS aims to provide services to the following developments at KTD:

(a) as a demonstration of the Government's determination to reduce energy consumption, all public developments (Note 11) at KTD are mandated to connect and subscribe to the district cooling services provided that their implementation programme can match the development schedule of KTDCS; and

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Note 11: *Public developments refer to all government premises and facilities of public bodies which are not for domestic use.*

(b) all private non-domestic developments at KTD are required to connect to KTDCS (Note 12) with a view to maximising the environmental benefits of KTDCS.

1.15 As of August 2021, there were 11 DCS consumers (Note 13) under KTDCS and all were public developments. According to EMSD:

(a) it is expected that 2 DCS consumers of private developments will be connected to KTDCS in the first quarter of 2022 and the second quarter of 2023 respectively; and

(b) upon the connection of all DCS consumers to KTDCS, 45% of them will be public developments and 55% will be private developments. For the overall cooling capacity of KTDCS, 50% will be for public developments and 50% will be for private developments.

1.16 The provision of district cooling services of KTDCS is governed by the District Cooling Services Ordinance (Cap. 624 — DCSO), which was enacted on 27 March 2015. DCSO provides for, among other things, the application to become an approved consumer of district cooling services and the imposition of charges for

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Note 12: *The connection requirement is implemented by prescribing the appropriate provisions in the conditions of land sale or the conditions of land grant, whichever are appropriate, to require the purchaser or the grantee (collectively referred to as the lot owner) to construct and maintain DCS substations with such associated necessary wirings and facilities for connection to DCS in accordance with the guidelines issued by EMSD. As a general practice for new developments on sale sites or applicable privately owned sites, the Lands Department will check compliance with the positive obligations in the conditions of land sale or land documents concerned on completion of the new development before the issue of a Certificate of Compliance (which would only be issued to the lot owner of the site by the Lands Department upon satisfactory compliance with the positive obligations). Insofar as the requirement to connect to DCS is concerned, the Lands Department will consult EMSD to ensure that the requirement in relation to DCS has been complied with to the satisfaction of EMSD.*

Note 13: *The 11 DCS consumers were the Kai Tak Cruise Terminal, the Trade and Industry Tower, two primary schools, a secondary school, the EMSD Headquarters, a shopping centre in public housing estate, the Hong Kong Children's Hospital, a Regional Headquarters and Operational Base-cum-Divisional Police Station and two Mass Transit Railway stations (i.e. Kai Tak Station and Sung Wong Toi Station).*

the district cooling services provided by the Government. Under DCSO, any eligible person (e.g. owner or management company of a building) who wishes to subscribe to the district cooling services shall submit an application (with information on the estimated maximum cooling capacity of the building and the intended services starting date) to EMSD. EMSD will approve the applicant as an approved consumer of district cooling services if all relevant requirements and conditions are met.

1.17 DCSO also sets out the tariff level and the adjustment mechanism. The major tariff components are capacity charge (for covering the capital cost and the operation and maintenance costs of DCS) and consumption charge (for covering the costs (e.g. electricity cost) that will vary with the actual consumption of district cooling services by DCS consumers). The charging arrangements apply to non-government buildings using DCS specified in Schedule 1 to DCSO (as of August 2021, KTDCS was the only DCS specified in this schedule). Government buildings using district cooling services are not subject to the charging regime provided in DCSO. The consumption charges arising from the provision of district cooling services to user bureaux/departments are recovered by way of allocation warrants (Note 14).

Provision of an additional DCS at KTD

1.18 The cooling capacity of the existing DCS (implemented under KTDCS project) was designed during the initial development of KTD in 2008. According to EMSD, it had been monitoring closely new developments since then, and anticipated in 2017 that the existing DCS would not be able to meet the growth in projected cooling demand of user buildings (Note 15). In June 2020, FC approved a funding

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Note 14: *According to EMSD: (a) under an administrative arrangement, government user bureaux/departments issue allocation warrants to EMSD to share the electricity cost arising directly from the operation of KTDCS (i.e. consumption charges); and (b) the capacity charges have also been taken into account for the purpose of evaluating the overall financial performance of DCS. EMSD will incorporate both the consumption charges paid through allocation warrants by government user bureaux/departments and the notional capacity charges in evaluating KTDCS's payback (see para. 4.10(b)).*

Note 15: *These user buildings include the New Acute Hospital, the Kai Tak Sports Park, and the addition of commercial floor area of about 400,000 m^2 arising from the increase in development intensity of KTD as announced in the 2017 Policy Address.*

of $4,269.3 million for the provision of an additional DCS at KTD (Note 16). The project commenced in December 2020 for completion by December 2028, providing cooling capacity of about 178 megawatts for serving an estimated total additional public and private non-domestic air-conditioned floor area of about 811,000 m^2. The provision of district cooling services is planned to commence in phases starting from 2022-23 to tie in with the commissioning of the related developments. According to ENB, upon full operation, the maximum annual saving in electricity consumption will be up to 53 million kWh, corresponding to an annual reduction of about 37,000 tonnes of carbon dioxide emission (Note 17).

Audit review

1.19 In April 2021, the Audit Commission (Audit) commenced a review to examine EMSD's work in managing the implementation and operation of KTDCS. The audit review has focused on the following areas:

(a) administration of KTDCS project (PART 2);

(b) monitoring of operation of KTDCS (PART 3); and

(c) provision of district cooling services and other related issues (PART 4).

Audit has found room for improvement in the above areas and has made a number of recommendations to address the issues.

Acknowledgement

1.20 Audit would like to acknowledge with gratitude the full cooperation of the staff of ENB and EMSD during the course of the audit review.

Note 16: *The major works components included construction of a chiller plant cum seawater pump house, pipe laying works, supply and installation of E&M equipment, and provision of connection facilities at user buildings.*

Note 17: *According to EMSD, an annual reduction of about 37,000 tonnes of carbon dioxide emission is approximately equal to planting 1.4 million trees in an area of the size of 75 Hong Kong Victoria Park for carbon dioxide reduction.*

PART 2: ADMINISTRATION OF KAI TAK DISTRICT COOLING SYSTEM PROJECT

2.1 This PART examines the administration of KTDCS project by EMSD, focusing on administration of Contract A (paras. 2.3 to 2.15), Contract B (paras. 2.16 to 2.22) and Phase III works (paras. 2.23 to 2.32).

Background

2.2 KTDCS project was implemented in three phases (Phases I, II and III). Between February 2011 and August 2020, EMSD awarded 11 works contracts (Contracts A to K — see Table 4 in para. 1.9) for the implementation of KTDCS project, as follows:

(a) Contract A under Phase I;

(b) Contract B under Phase II; and

(c) Contracts C to K under Phase III.

Administration of Contract A

2.3 In February 2011, EMSD awarded Contract A (a remeasurement contract — Note 18) to Contractor A at a contract sum of $129.7 million for implementing

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Note 18: *Under a remeasurement contract, the costs of works are based on the actual quantities of works done to be remeasured and the prices of different works items as priced by the contractor in the Bills of Quantities according to the contract. According to the Project Administration Handbook for Civil Engineering Works issued by the Civil Engineering and Development Department, Bills of Quantities is a list of items giving brief identifying descriptions and estimated quantities of the works to be performed. Bills of Quantities forms a part of the contract documents, and is the basis of payment to the contractor. The main functions of Bills of Quantities are to allow a comparison of tender prices and provide a means of valuing the works.*

Phase I works which mainly involved pipe laying. The contract works mainly included the construction of:

(a) about 800 metres chilled water pipes; and

(b) valve chambers, access manhole, thrust blocks, insulation provision for chilled water pipes.

2.4 The works under Contract A commenced in February 2011 and were completed in January 2013, about 6.9 months (210 days) later than the original contract completion date of June 2012. Of the 210 days, extensions of time (EOTs — Note 19) of 177.5 days were granted to Contractor A (Note 20) and the remaining 32.5 days were delays subject to liquidated damages (Note 21). Consultant X was the Engineer responsible for supervising the contract works. The account of Contract A

Note 19: *According to the General Conditions of Contract for Civil Engineering Works, regarding contract works commencement, completion and delays: (a) the works and any section thereof shall be completed within the time or times stated in the contract calculated from and including the date for commencement notified by the Engineer or such extended time as may be determined; (b) if the contractor fails to complete the works or any section of works within the time for completion or such extended time as may be granted, then the Employer shall be entitled to recover from the contractor liquidated damages for delay; and (c) if in the opinion of the Engineer, the cause of any delay to the progress of the works or any section of works is any of those stipulated in the General Conditions of Contract (e.g. inclement weather, a variation order issued by the Engineer, the contractor not being given possession of site, etc.), then the Engineer shall within a reasonable time consider whether the contractor is entitled to an EOT for completion of the works or any section thereof. According to the Project Administration Handbook for Civil Engineering Works issued by the Civil Engineering and Development Department, an EOT for completion in effect deprives the Government of the right to liquidated damages for delay in completion of the works for the period of the extension and therefore has a financial implication.*

Note 20: *EOTs granted to Contractor A were mainly due to variations of works (140 days) to cater for the existing site constraints (e.g. limited working space due to congested underground utilities and the need to maintain the necessary traffic on site under temporary traffic arrangement) and inclement weather (37.5 days).*

Note 21: *Liquidated damages of $1.5 million in total relating to five sections of works (including $0.3 million relating to the section of works with delay of 32.5 days) of Contract A were imposed on Contractor A.*

was finalised in February 2014 and the final contract sum was $138.1 million (an increase of $8.4 million (6.5%) over the original contract sum of $129.7 million).

Scope for conducting more thorough pre-tender site investigations on underground utilities

2.5 Under Contract A, Contractor A was required to construct chilled water pipes at four locations (Locations A to D) by open-cut method (Note 22). During the pipe laying works, congested underground utilities (e.g. electricity cables, telecom cables, sewage pipes and fresh water mains) were found at Locations A to D. In the event, Consultant X issued four variation orders (VOs — Note 23) (VOs A to D — later valued at a total cost of $6.4 million) to instruct Contractor A to change the pipe laying method from open-cut method to trenchless method (Note 24) to cater for the existing site constraints at Locations A to D (Note 25).

Note 22: *Open-cut method is a conventional method for laying of pipes which involves digging a trench along the length of the proposed pipeline route, placing the pipe in the trench on suitable bedding materials, and then backfilling. This method may involve opening of road along the proposed pipeline route. This will generally be acceptable when the traffic and environmental impacts arising from the open-cut method are not serious, and when the underground utilities present are not congested.*

Note 23: *According to the General Conditions of Contract for Civil Engineering Works, the Engineer shall: (a) order any variation to any part of the works that is necessary for the completion of the works; (b) have the power to order any variation that for any other reason shall in his opinion be desirable for or to achieve the satisfactory completion and functioning of the works; and (c) determine the sum which in his opinion shall be added to or deducted from the contract sum as a result of issuing a VO.*

Note 24: *Trenchless method involves the pre-drilling of a hole of suitable diameter and subsequently the insertion of a new pipe along the hole formed. Common trenchless techniques include pipe jacking, horizontal directional drilling and micro-tunnelling.*

Note 25: *According to EMSD, the change of pipe laying method under VOs A to D involved a total of 60-metre length of chilled water pipes (i.e. about 8% of the total 800-metre length of pipework under Contract A (see para. 2.3(a)).*

2.6 According to Environment, Transport and Works Bureau Technical Circular (Works) No. 17/2004 on "Impossibility/Unforeseen Ground Conditions/Utility Interference":

(a) project officers should arrange to carry out all necessary site investigations and satisfy themselves that sufficient ground information has been made available prior to commencement and during the detailed design; and

(b) before the completion of the detailed design, project officers should satisfy themselves that the utility records obtained from utility undertakings or other sources are reasonably accurate. Depending on the scale and nature of the contract, project officers should conduct desk search and, if necessary, site inspection for the purpose of verifying the utility records.

2.7 In October 2021, EMSD informed Audit that:

(a) before the tender exercise of Contract A, it had coordinated with the relevant interfacing parties and utility undertakings to obtain the latest information on site conditions including records of site investigations conducted by others on nearby underground utilities; and

(b) there was a practical limit on the extent of site investigations that could be done at the design stage, particularly when the site areas concerned had not been possessed at that stage.

2.8 In Audit's view, in implementing DCS projects in future, EMSD and its consultants need to continue to improve the pre-tender site investigations on underground utilities with a view to providing better information on site conditions for design and tender purposes.

Need to make continued efforts to coordinate with all related parties on interfacing works

2.9 The pipe laying works executed under Contract A fell within the works sites of a works contract implemented by the Civil Engineering and Development Department (CEDD) (hereinafter referred to as the CEDD works contract).

According to Contract A, Contractor A should carry out the contractual works in accordance with the agreed programme with the contractor of the CEDD works contract.

2.10 During the construction stage of Contract A, there were interfacing problems with the CEDD works contract relating to the pipe laying works at three locations (Locations E to G), as follows:

(a) ***Locations E and F.*** When Contractor A programmed to commence the pipe laying works at Locations E and F, the related roads with the proposed pipe laying works underneath had already been paved under the CEDD works contract and temporary traffic arrangements (TTAs) were already in place at Locations E and F. Consultant X considered that:

(i) it was practically impossible for Contractor A to implement separate TTAs for laying the DCS pipes at Locations E and F. The pipe laying works under Contract A needed to match with the road works under the CEDD works contract by making use of the TTAs already implemented at Locations E and F; and

(ii) trenchless method instead of open-cut method of construction for pipe laying at Locations E and F should be adopted in order to avoid delay to both Contract A and the CEDD works contract.

In the event, Consultant X issued two VOs (VOs E and F — later valued at a total cost of $6.2 million) to instruct Contractor A to change the pipe laying method from open-cut method to trenchless method at Locations E and F. VO F resulted in EOTs of 208.5 and 261.5 days for completing two sections of works of Contract A (Note 26); and

(b) ***Location G.*** When Contractor A took possession of the site at Location G, the related road with the proposed pipe laying works underneath had already been paved under the CEDD works contract and construction vehicles had been using the road for transport. In order to avoid the need for traffic diversion at Location G during peak hours, Consultant X

Note 26: *EOTs due to VO F were assessed together with another two VOs under Contract A.*

considered that trenchless method instead of open-cut method of construction for pipe laying at Location G should be adopted. In the event, Consultant X issued a VO (VO G — later valued at a cost of $3.2 million) to instruct Contractor A to change the pipe laying method from open-cut method to trenchless method at Location G, resulting in EOT of 96 days for completing a section of works of Contract A.

2.11 Audit noted that:

(a) the proposed pipe laying works at Locations E to G under Contract A adopted open-cut method originally; and

(b) the roads with the proposed pipe laying works underneath at Locations E to G had been paved under the CEDD works contract before the commencement of the proposed pipe laying works under Contract A, leading to the change of pipe laying method at Locations E to G.

2.12 In October and November 2021, EMSD informed Audit that:

(a) Contractor A was not able to carry out the contractual works in accordance with the agreed programme with the contractor of the CEDD works contract (see para. 2.9) as Phase I works of KTDCS project commenced later than the scheduled time; and

(b) from the experience gained in implementing Contract A, both EMSD and CEDD were aware of the fact that there could be areas for improvement in the interfacing works amongst different works contracts. As such, EMSD coordinated and agreed with CEDD in early 2012 that the feasibility of entrusting future DCS pipe laying works to relevant CEDD road works projects should be explored as appropriate in order to minimise interfacing problems between DCS works and other road works projects at KTD. With the entrustment arrangement, the coordination between works contracts under KTDCS project and other works contracts was enhanced. This could be proved by the smooth delivery of the entrusted DCS pipe laying works since the implementation of the entrustment arrangement in 2013. The entrustment arrangement was also extended to cover DCSs in other new development areas (see para. 4.20).

2.13 In Audit's view, in implementing DCS projects involving interfacing works in future, EMSD needs to make continued efforts to coordinate with all related parties with a view to facilitating the implementation of DCS works.

Audit recommendations

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

(a) **in implementing DCS projects in future, continue to improve the pre-tender site investigations on underground utilities with a view to providing better information on site conditions for design and tender purposes; and**

(b) **in implementing DCS projects involving interfacing works in future, make continued efforts to coordinate with all related parties with a view to facilitating the implementation of DCS works.**

Response from the Government

2.15 The Director of Electrical and Mechanical Services agrees with the audit recommendations. He has said that:

(a) EMSD will continue to improve the pre-tender site investigations on underground utilities with a view to providing better information on site conditions for design and tender purposes; and

(b) as the entrustment arrangement implemented since 2013 has been proven to be very effective in resolving interfacing problems between works contracts, EMSD will make continued efforts to continue this arrangement and coordinate with all related parties with a view to facilitating the implementation of DCS works.

Administration of Contract B

2.16 In February 2011, EMSD awarded Contract B (a DBO contract) to Contractor B at a contract sum of $1,941.1 million ($1,640.8 million for the design and construction portions and $300.3 million for the operation stage). The design and construction works included:

(a) overall engineering design of DCS for the whole KTD; and

(b) detailed design and construction of Phase II works, including:

(i) construction of a northern chiller plant (see Photograph 1);

(ii) construction of an underground southern chiller plant cum seawater pump house;

(iii) chilled water/seawater pipe laying works;

(iv) construction of a water leakage detection system for chilled water pipes (see Note 29 to para. 2.24) and district cooling instrumentation, control and communication system (DCICCS — see para. 3.20);

(v) supply and installation of E&M equipment (e.g. chillers (see Photograph 2) and pumps (see Photograph 3)); and

(vi) provision of connection facilities at substations at user buildings.

Photograph 1

Northern chiller plant
(December 2013)

Source: *EMSD records*

Photograph 2

Chillers at southern chiller plant

Source: *EMSD records*

Photograph 3

Pumps at southern chiller plant

Source: EMSD records

2.17 The design and construction works under Contract B commenced in March 2011 and were completed in September 2014, about 6.6 months (201 days) later than the original contract completion date of March 2014 with EOTs for the whole period granted to Contractor B (mainly due to inclement weather — Note 27). Consultant X was the Supervising Officer responsible for supervising the contract works. The account of Contract B (design and construction portions) was finalised in December 2015 and the final contract sum was $1,732.5 million (an increase of $91.7 million (5.6%) over the original contract sum of $1,640.8 million).

Scope for improvement in phasing arrangement of construction works

2.18 Of the three phases (Phases I, II and III) of works under KTDCS project (see para. 1.6), Contract B was for implementing Phase II works. Audit noted that, during the construction stage, Consultant X instructed Contractor B to carry out some builder's works (e.g. concrete plinths for E&M equipment, and partition walls with

Note 27: *Of the 201 days of EOTs granted, 183 days were due to inclement weather.*

associated finishes, doors and windows) originally scheduled under Phase III, leading to claims from Contractor B. The salient points are as follows:

(a) ***Additional builder's works under Contract B.*** Consultant X considered that some builder's works at the northern and southern chiller plants originally scheduled under Phase III were more appropriate to be carried out by Contractor B at an early stage (i.e. under Phase II) before the operation of DCS plants (Note 28). As a result, in May 2012, Consultant X instructed Contractor B to carry out the additional builder's works. According to EMSD, such builder's works were part of the works under the whole KTDCS project and had been advanced from Phase III to Phase II to suit the project development and minimise disturbance to the operation of DCS plants during the implementation of Phase III works;

(b) ***Delay mitigation measures.*** Due to carrying out the additional builder's works under Contract B (see (a) above), Consultant X considered that the progress of Phase II works would be affected and substantial delay to the completion of a section of works of Contract B would be resulted if no mitigation measures were implemented. As a result, in July 2012, Consultant X instructed Contractor B to carry out mitigation measures (i.e. adoption of alternative construction method of using concrete filling instead of general backfilling and carrying out additional overtime works) to catch up with the works programme and minimise further delay of Contract B; and

(c) ***Contractor B's claims.*** Contractor B submitted claims for additional costs for carrying out the additional builder's works (see (a) above) and implementing the delay mitigation measures (see (b) above). In the event, $47.2 million was paid to Contractor B to settle the claims ($16.5 million for additional builder's works and $30.7 million for delay mitigation measures).

Note 28: *Consultant X considered that if the builder's works were carried out at a later stage (i.e. under Phase III), DCS plants in the northern and southern chiller plants would be in operation by that time. It would have adverse impact on the progress of Phase III works and would create unnecessary disturbance to the operation of the DCS plants.*

2.19 In October 2021, EMSD informed Audit that:

(a) since the development of KTD would span about 15 years, KTDCS project was implemented in different phases to better tie in with the latest development of KTD; and

(b) for Contract B (i.e. Phase II), the tender invitation was issued in August 2010 and the builder's works mentioned in paragraph 2.18(a) were originally scheduled under Phase III based on the then available information. Along with the continuous development of KTD, more detailed and accurate information on the scope of Phase III was subsequently obtained. It was considered more appropriate to carry out the abovementioned builder's works under Phase II in order to minimise disturbance to the operation of DCS plants (e.g. avoiding interfacing issues between the DCS operator and the building works contractor, exposing the operating E&M equipment to dusty environment during the construction of builder's works and associated safety implication, and the impact on the progress of Phase III works).

2.20 In Audit's view, there is scope for improvement in phasing arrangement of construction works for DCS projects in future.

Audit recommendation

2.21 **Audit has *recommended* that, in implementing DCS projects in future, the Director of Electrical and Mechanical Services should enhance the phasing arrangement of construction works (e.g. builder's works) before inviting tenders.**

Response from the Government

2.22 The Director of Electrical and Mechanical Services agrees with the audit recommendation. He has said that:

(a) for projects with a long time span like KTDCS, sometimes changes between phases of works to suit the latest situation and development are beneficial to the construction and operation of the project; and

(b) EMSD will continue to enhance the phasing arrangement of construction works before inviting tenders.

Administration of Phase III works

2.23 Phase III works were divided into four packages (Packages A, B and C, and Remaining Works) to tie in with the latest development of KTD. EMSD awarded 9 works contracts (Contracts C to K) for the implementation of Phase III works (see Table 5). Except for Contracts H to K which were still in progress as of August 2021, the other 5 works contracts (Contracts C to G) were completed between October 2016 and February 2020 (see Table 4 in para. 1.9). Consultant Y was the Engineer responsible for supervising the works under Contracts C, D and I. Consultant X was the Engineer responsible for supervising the works under Contracts E to H, J and K.

Table 5

Contracts C to K for Phase III works
(August 2021)

Package	Contract	Contract type (Note 1)	Works (Note 2)	Final contract sum/ up-to-date contract expenditure (Note 3) ($ million)
A	C	Lump sum contract	E&M installation works	248.3
	D	Remeasurement contract	Pipe laying works	582.0
B	E		Pipe laying works	144.0
	F	Lump sum contract	E&M installation works	105.5
	G	Remeasurement contract	Pipe laying works	7.0
C	Pipe laying works (Note 2)			
Remaining Works	H	Lump sum contract	E&M installation works	375.8
	I	Remeasurement contract	Pipe laying works	84.6
	J		Pipe laying works	52.9
	K	Lump sum contract	E&M installation works	9.4
			Total	1,609.5

Source: EMSD records

Table 5 (Cont'd)

Note 1: *Under a lump sum contract, the quantities of various works items are substantially measured firm and the final price to be paid is ascertained by adding to/deducting from the contractor's accepted tender price the value of variations and other specified items (e.g. provisional quantities and contingency items). The nature of a remeasurement contract is set out in Note 18 to paragraph 2.3.*

Note 2: *According to EMSD, to achieve better coordination and interface, some of the pipe laying works under the four works packages of Phase III were entrusted to CEDD for implementation together with the infrastructure works of KTD. As all works under Phase III (Package C) were pipe laying works, they were all entrusted to CEDD for implementation.*

Note 3: *The accounts of Contracts C, E, F and G were finalised in October 2020, January 2019, August 2020 and March 2021 respectively. As of August 2021, the account of Contract D had not been finalised and Contracts H to K were still in progress.*

Malfunction of some water leakage detection cables

2.24 Contract D mainly involved chilled water pipe laying works. Such works included the construction of a water leakage detection system for chilled water pipes (Note 29). According to Contract D:

(a) water leakage detection cables should be installed between the pipe jacket and the outer surface of the chilled water pipes; and

(b) Contractor D should:

(i) carry out the resistance test to ensure that the sensing cables embedded in the pre-insulated pipe for water leakage detection

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Note 29: *Water leakage detection system involves the installation of water leakage detection cables in the chilled water distribution network. The system can help give early warnings when there is a gradual and slow leakage in the pipework so as to facilitate timely repair works. The location of leakage can also be identified quickly for isolating the pipes concerned by stop valves to contain the impact on the operation of DCS as far as practicable. According to EMSD, the cost of water leakage detection system for chilled water pipes under Contract D was $6.9 million (i.e. less than 2% of Contract D's original contract sum of $520 million).*

purpose have been installed to the required standards and in accordance with manufacturers' requirement;

(ii) be responsible for testing and commissioning to demonstrate that the sensing cables possess suitable physical and electrical characteristics after completion of installation; and

(iii) carry out maintenance works including any works of repair or rectification, or make good any defect, imperfection, shrinkage, settlement or other fault at its own cost during the 12-month maintenance period.

2.25 Contract D was substantially completed in October 2016 and the maintenance period expired in October 2017. Audit noted that:

(a) there was malfunction of water leakage detection cables for all three sections of pipeline under Contract D; and

(b) as of September 2021 (i.e. about 4 years after the expiry of the maintenance period in October 2017), the related defects rectification works had not been completed and the account of Contract D had not been finalised.

2.26 According to EMSD:

(a) in September 2016 (i.e. before the completion of Contract D), the test results of water leakage detection cables indicated that the insulation resistance and circuit continuity were different from the recommended values, which implied that the overall healthiness and functionality of the system became inconclusive. EMSD requested Consultant Y and Contractor D to investigate and provide professional advice for the case;

(b) Consultant Y worked with Contractor D to carry out further tests on the water leakage detection cables to verify their performance, and conducted a comprehensive review covering the insulation resistance and circuit continuity of the cables in 2017. After a series of deliberations, Consultant Y concluded in mid-2018 that the water leakage detection cables were defective as the level of insulation resistance and circuit continuity of

the water leakage detection cables for the three sections of pipeline were found lower than the manufacturer's requirement due to poor workmanship. Consultant Y's conclusion was agreed by Contractor D and EMSD;

(c) as the roads with the three sections of pipeline underneath had already been paved for opening to traffic, it was impracticable for Contractor D to reopen the road for replacing the water leakage detection cables with defects. Therefore, EMSD, Consultant Y and Contractor D had jointly studied various technical solutions to rectify the defects in the water leakage detection system since November 2018;

(d) in May 2019, Contractor D worked out a remedial proposal by using noise logger system with leak noise correlation technique to rectify the defects in the water leakage detection system (Note 30). In May 2020, site trials were conducted by Contractor D to verify the effectiveness of the remedial proposal;

(e) in August 2020, Contractor D submitted the site trial results which demonstrated that the remedial proposal was practical and performed effectively on site. In November 2020, based on the recommendations of Consultant Y, EMSD agreed the remedial proposal. The cost of remedial proposal was borne by Contractor D;

(f) as of September 2021, installation works of the remedial proposal were almost completed by Contractor D and EMSD would continue to monitor the works progress for completion by December 2021. After that, the account of Contract D would be finalised in the first half of 2022;

(g) the defects in the water leakage detection system were minor in nature and such system was designed as only an auxiliary feature in detecting water leakage. The defects rectification works were very common in construction contract administration attributing to a small portion of the contract scope.

Note 30: *Any fluid leakage will cause a level of noise that will transfer along the pipe. Comparing with water leakage detection cables, noise loggers can provide similar functions of leak monitoring, leak alarming and leak locating. The noise logger system with leak noise correlation technique would replace the defective water leakage detection cables for the three sections of pipeline.*

The current ongoing rectification works had no adverse impact on the overall operation of DCS;

(h) the poor workmanship had been reflected as a poor rating under a sub-item "Achievement in period" in Contractor D's performance report for the period from 1 December 2018 to 28 February 2019; and

(i) to identify areas for improvement and prevent occurrence of similar defects in future, EMSD had reviewed and updated in 2019 the relevant technical specifications of water leakage detection cables based on the experience from past site works. The updated technical specifications had been implemented since 2019 with a view to strengthening site supervision and training to workers.

2.27 In Audit's view, EMSD needs to:

(a) complete the defects rectification works of installing the noise logger system on schedule and keep under review its performance; and

(b) finalise the account of Contract D as soon as possible.

Need to closely monitor works progress of Phase III works

2.28 Contracts H to K under Phase III (Remaining Works) were still in progress as of August 2021. According to EMSD, as of August 2021, Contracts I and K were expected to be completed on schedule while Contracts H and J were expected to be completed later than their original contract completion dates by 18.1 and 2.9 months respectively (see Table 6). In addition, according to EMSD, as Contracts H to K only cover part of the works under Phase III (Remaining Works), it will monitor the development of KTD and award other works contracts for the remaining works. The anticipated final completion date for the whole Phase III (Remaining Works) is December 2025.

Table 6

Expected completion dates for Contracts H to K
(August 2021)

Contract	Commencement date	Original contract completion date	Expected completion date	No. of months later than original contract completion date (Note 1)
H	31.1.2019	29.6.2021	31.12.2022	18.1
I	22.2.2019	17.2.2022	17.2.2022	—
J	26.2.2019	29.8.2021	25.11.2021	2.9
K	12.8.2020	27.9.2021	27.9.2021 (Note 2)	—

Source: *EMSD records*

Note 1: *For Contract H, EOTs were being assessed by Consultant X. For Contract J, EOTs for the whole period (88 days) were granted.*

Note 2: *EMSD informed Audit in October 2021 that Contract K was substantially completed on schedule (i.e. 27 September 2021).*

2.29 In October 2021, EMSD informed Audit that:

(a) while the completion dates of Contracts H and J were extended (to December 2022 and November 2021 respectively) due to the delay in completion of testing and commissioning works and inclement weather respectively, such extensions would not affect the anticipated final completion date of December 2025 for the whole Phase III (Remaining Works); and

(b) the overall progress of KTDCS project could tie in with the latest development of KTD. District cooling services had so far been timely provided to all the 11 existing DCS consumers (see Note 13 to para. 1.15).

2.30 According to ENB, KTDCS is a major infrastructure in support of the sustainable and environmentally-friendly development at KTD. In Audit's view, EMSD needs to closely monitor works progress of Phase III (Remaining Works) of

KTDCS project (including Contracts H to K) with a view to ensuring the timely completion of such works and providing district cooling services to match the schedules of development projects at KTD.

Audit recommendations

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

(a) **complete the defects rectification works of installing the noise logger system on schedule and keep under review its performance;**

(b) **finalise the account of Contract D as soon as possible; and**

(c) **closely monitor works progress of Phase III (Remaining Works) of KTDCS project (including Contracts H to K) with a view to ensuring the timely completion of such works and providing district cooling services to match the schedules of development projects at KTD.**

Response from the Government

2.32 The Director of Electrical and Mechanical Services agrees with the audit recommendations. He has said that:

(a) the defects rectification works of installing the noise logger system will be completed in December 2021 and its performance will be kept under review;

(b) the account of Contract D will be finalised in the first half of 2022; and

(c) EMSD will continue to closely monitor works progress of Phase III (Remaining Works) of KTDCS project (including Contracts H to K) with a view to ensuring the timely completion of such works and providing district cooling services to match the schedules of development projects at KTD.

PART 3: MONITORING OF OPERATION OF KAI TAK DISTRICT COOLING SYSTEM

3.1 This PART examines EMSD's work in monitoring the operation of KTDCS, focusing on:

(a) monitoring of contractor performance (paras. 3.4 to 3.13); and

(b) other operational issues (paras. 3.14 to 3.29).

Operation of KTDCS

3.2 The operation of KTDCS is as follows:

(a) chilled water is produced at the two chiller plants (the northern chiller plant and the southern chiller plant cum seawater pump house). The chilled water is distributed by variable speed pumps (Note 31) through the distribution network to substations at user buildings where cooling energy is transferred for user buildings' use, and is then returned to the chiller plants for re-chilling (see Figure 1 in para. 1.2);

(b) each user building has its own chilled water distribution network, which is separated from the KTDCS distribution network. Heat exchangers are installed at the substation at a user building to transfer heat between the chilled water of KTDCS and the chilled water of the user building's air-conditioning installation; and

(c) the chilled water of the user building is then distributed via pipework in the user building to the cooling coils of air handling units at individual spaces in which air is driven by fan to blow across the cooling coil and then the cooled air is delivered into the space to achieve the overall air-conditioning

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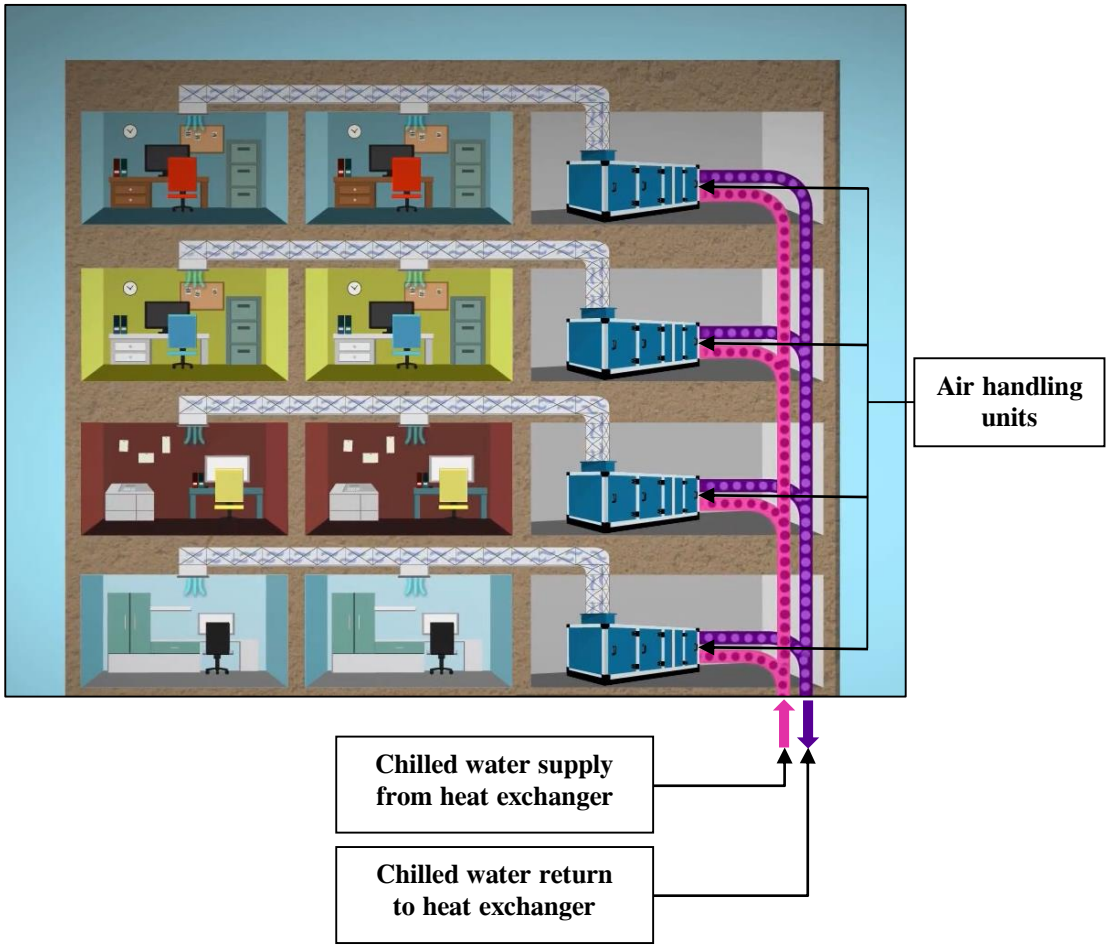
Note 31: *According to EMSD, variable speed pumping system is adopted with a view to optimising the energy consumption. The DCS chilled water supply flow rate to each substation will be adjusted according to the cooling demand of the user building.*

for the user building. Figure 3 shows a schematic diagram of air-conditioning installation of a user building.

Figure 3

Schematic diagram of air-conditioning installation of a user building



Source: *EMSD records*

3.3 EMSD adopted a DBO contract arrangement for implementing KTDCS. The operation of KTDCS commenced on 29 January 2013. Under Contract B (i.e. the DBO contract), Contractor B (i.e. the operator) would operate KTDCS for 14.5 years from January 2013 to July 2027 (Note 32). For the first 18-month operation of KTDCS, Consultant X was the Supervising Officer for Contract B and responsible for supervising Contractor B's operation and reporting Contractor B's performance to EMSD. After the first 18-month operation (i.e. since 29 July 2014), EMSD has fully taken up the work for monitoring (including supervising) Contractor B's operation (see paras. 1.11 and 1.12).

Monitoring of contractor performance

3.4 According to the design conditions of KTDCS, there are temperature parameters for chilled water supply and return temperatures at the primary and secondary sides of heat exchanger at the substation at a user building (see Table 7). In general, the primary side refers to KTDCS supply side and the secondary side refers to user building's air-conditioning installation (see Figure 4).

Table 7

Design conditions of KTDCS

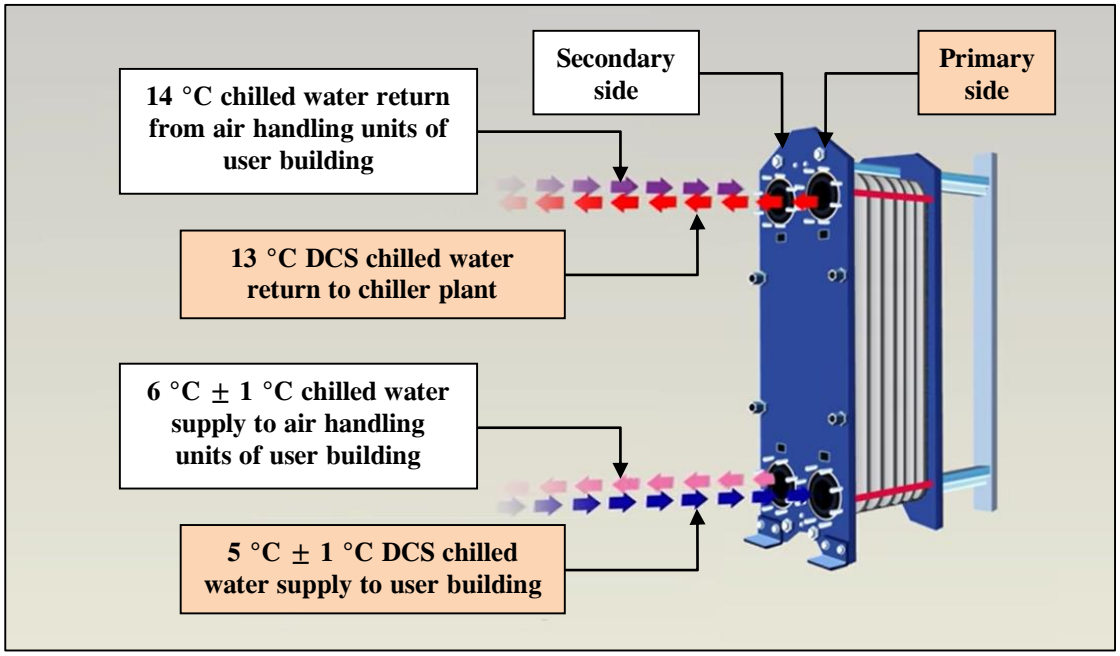
Parameter	Primary side of heat exchanger	Secondary side of heat exchanger
Chilled water supply temperature	5 degree Celsius (°C) ± 1 °C	6 °C ± 1 °C
Chilled water return temperature	13 °C	14 °C

Source: EMSD records

Note 32: *The operation period originally expired in July 2019 after 6.5 years of operation and was later extended for 8 years to July 2027.*

Figure 4

Schematic diagram for chilled water temperature parameters at heat exchanger



Source: *EMSD records*

3.5 According to Contract B and the operation plan (Note 33) of KTDCS, there are two KPIs (hereinafter referred to as KPI 1 and KPI 2) for measuring the performance of Contractor B in operating KTDCS, as follows:

(a) ***KPI 1.*** This KPI is primary side chilled water supply temperature at 5 °C ± 0.5 °C. According to EMSD, this KPI is for measuring the system performance by KTDCS; and

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Note 33: *According to Contract B: (a) Contractor B shall submit an operation plan to the Supervising Officer for approval; and (b) the operation plan shall set out the policies and procedures for the systematic management approach to occupational health, safety and rehabilitation, environmental considerations, operations and maintenance activities associated with the operation of the DCS plant. The latest version of operation plan was Revision 15 of March 2021.*

(b) ***KPI 2.*** This KPI is secondary side chilled water supply temperature at 6 °C ± 0.5 °C (Note 34). According to EMSD, this KPI is for measuring the conditions of heat exchangers.

3.6 The monthly payment to Contractor B for operation of KTDCS (covering four elements, namely air-conditioning plant, structure, pipework and customer services) is subject to the rates as set out in Contract B and remeasurement on actual quantities (Note 35). According to Contract B and the operation plan of KTDCS:

(a) for assessment of KPI compliance, chilled water temperature is measured every 3 minutes for each substation through DCICCS (see para. 3.20). If continuous 11 measurements are out of the acceptable temperature range (i.e. continuous 30 minutes of non-compliance), one Count of Non-compliance (CNC) is recorded;

(b) the maximum count per substation for non-compliance (i.e. the allowed CNCs per substation) for each KPI in each month is 20;

(c) the monthly operation payment to Contractor B is adjusted to reflect the level of performance achieved, which is assessed based on monitoring results on KPIs in the same month. The maximum payment adjustment is a deduction of 20% of the monthly operation payment; and

(d) the monthly operation payment adjustment is based on a formula comparing the total measured CNCs for a KPI for all the substations in a month against the total allowed CNCs for the KPI for all the substations for that month.

Note 34: *KPI 2 was originally specified as primary side chilled water supply pressure in Contract B. In August 2014, in view of the fact that KTDCS was a primary variable flow system of which the chilled water supply pressure would be variable according to the cooling demand of consumer and different between each substation, Contractor B submitted a KPI improvement proposal to revise KPI 2 as secondary side chilled water supply temperature. In October 2014, Contractor B's proposal was approved.*

Note 35: *The actual quantities subject to remeasurement are: (a) average cooling demand for air-conditioning plant element; (b) construction floor area of structure (e.g. chiller plants and seawater pump house) for structure element; (c) pipe size and pipe length for pipework element; and (d) number of substations at user buildings for customer services element.*

If the total measured CNCs do not exceed the total allowed CNCs, no deduction will be made.

According to EMSD, since commissioning of KTDCS in January 2013 and up to 31 March 2021, no operation payment adjustment had been made.

3.7 According to EMSD, it will conduct investigations of Contractor B's non-compliance with KPIs, as follows:

(a) when a substation's measured CNCs for a KPI in a month exceeded 20 (i.e. a substation's allowed CNCs for a KPI in a month — see para. 3.6(b)), it will carry out investigations to ascertain the causes of non-compliance for the substation concerned;

(b) if the causes of non-compliance are uncontrollable by the contractor, it will formulate mitigation measures to avoid recurrence of non-compliance for the substation concerned in future; and

(c) if there are repeated cases of non-compliance due to the contractor's operation performance, it will issue an advisory letter or a warning letter to the contractor as necessary and reflect the contractor's operation performance in the performance report for the period concerned.

Non-compliance with KPIs

3.8 Audit noted that since commissioning of KTDCS in January 2013 and up to 31 March 2021, for 8 substations, there were a total of 12 cases (occurring between December 2014 and July 2019 with 11 cases relating to KPI 1 and 1 case relating to KPI 2) where a substation's measured CNCs for a KPI in a month exceeded 20, ranging from 21 to 65. In October 2021, EMSD informed Audit that, of the 12 cases:

(a) the causes of 11 cases were uncontrollable by Contractor B and were not due to the actual performance of Contractor B in operating KTDCS. The causes included testing and commissioning of air-conditioning installation of user building during its initial operating stage, incident of pipe damage caused by other works contractors and low cooling demand of user building; and

(b) the cause of 1 case was due to unavailable data resulting from repair works of sensors, which was related to the actual performance of Contractor B in operating KTDCS (Note 36). Notwithstanding this, the defective sensors were replaced quickly within a reasonable time.

3.9 In Audit's view, EMSD needs to make continued efforts to closely monitor the performance of Contractor B in operating KTDCS (including compliance with KPIs) and take follow-up actions as needed.

Scope for improvement in performance monitoring mechanism

3.10 Audit noted that there was scope for improvement in performance monitoring mechanism, as follows:

(a) ***Scope for improvement in operation payment adjustment mechanism.*** In response to Audit's enquiries about the operation payment adjustment mechanism under Contract B as mentioned in paragraph 3.6, EMSD informed Audit in September and October 2021 that:

(i) the formula for calculating operation payment adjustment under Contract B (see para. 3.6(d)) was derived to provide a fair and reasonable assessment of the overall performance of Contractor B in case of unforeseen operating conditions not under the control of Contractor B;

(ii) the allowed CNCs for a KPI for a substation in a month of 20 was intended for a certain buffer on the fluctuation of chilled water supply temperature to cater for some common circumstances that were uncontrollable by Contractor B. All cases exceeding 20 CNCs for a KPI for a substation in a month would be investigated by EMSD to ascertain the root cause of the cases (see para. 3.7); and

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Note 36: *According to Contract B, non-availability of any required sample or any sampling result for the purposes of assessing the relevant KPI is deemed to be a non-compliant sample.*

(iii) after gaining the experience from implementing the DBO contract for KTDCS, which was the first of its kind in Hong Kong, EMSD was considering enhancing the KPI requirements in future contracts for operating KTDCS (including revising the formula for calculating operation payment adjustment to suit the actual operation as needed);

(b) ***Need to consider incorporating new KPIs.*** According to EMSD, KPIs should be continuously and objectively measurable, and KPIs relating to performance of the DCS plant are adopted in a DBO contract for DCS. Audit noted that:

(i) a DBO contract for the provision of an additional DCS at KTD (see para. 1.18) was awarded in November 2020. Apart from KPIs on chilled water supply temperatures, an additional KPI on system coefficient of performance (Note 37) was included in the DBO contract. According to EMSD, the inclusion of this new KPI was for better monitoring of the energy efficiency of the additional DCS plant; and

(ii) apart from operating the DCS plants, Contractor B also performed other administration and reporting duties (e.g. customer services, incident handling and reporting, and report submission). There were no KPIs under Contract B related to such duties; and

(c) ***Scope for improving site inspection mechanism.*** According to EMSD, its staff conduct site inspections for monitoring the performance of Contractor B in operating KTDCS, including monthly surprise inspections on records of KPIs, cooling demand and maintenance works, weekly DCS network patrols, and monthly inspections of substation energy meters. Audit noted that:

(i) while there was an established practice for conducting site inspections for monitoring the performance of Contractor B in operating KTDCS, EMSD had not promulgated guidelines in this

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Note 37: *System coefficient of performance refers to the ratio of the cooling output to the power input, in consistent units, for the chiller plant system including chillers, chilled water pumps and seawater pumps.*

regard. In addition, EMSD only commenced the recording of site inspections since November 2020 and the inspection reports did not include information on site inspection results and follow-up actions taken. In response to Audit's findings, EMSD informed Audit in October 2021 that, since October 2021, it had formalised the existing practice and promulgated guidelines on conducting site inspections for monitoring the contractor performance in operating KTDCS. It had also included the discussion of site inspection results with Contractor B in the regular monthly progress meetings; and

(ii) EMSD had not regularly compiled management information (e.g. highlights or summaries) on site inspection results for KTDCS for monitoring purpose.

3.11 In Audit's view, EMSD needs to:

(a) enhance the operation payment adjustment mechanism in future contracts for operating KTDCS with a view to better reflecting the level of performance achieved by the contractors;

(b) consider incorporating new KPIs (e.g. system coefficient of performance and KPIs relating to the contractor's administration and reporting duties (e.g. customer services, and incident handling and reporting)) into future contracts for operating KTDCS;

(c) remind its staff to follow the guidelines on conducting site inspections for monitoring the contractor performance in operating KTDCS and include in the inspection reports information on site inspection results and follow-up actions taken; and

(d) regularly compile management information (e.g. highlights or summaries) on site inspection results for KTDCS for monitoring purpose.

Audit recommendations

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

(a) **make continued efforts to closely monitor the performance of Contractor B in operating KTDCS (including compliance with KPIs) and take follow-up actions as needed;**

(b) **enhance the operation payment adjustment mechanism in future contracts for operating KTDCS with a view to better reflecting the level of performance achieved by the contractors;**

(c) **consider incorporating new KPIs (e.g. system coefficient of performance and KPIs relating to the contractor's administration and reporting duties (e.g. customer services, and incident handling and reporting)) into future contracts for operating KTDCS;**

(d) **remind EMSD staff to follow the guidelines on conducting site inspections for monitoring the contractor performance in operating KTDCS and include in the inspection reports information on site inspection results and follow-up actions taken; and**

(e) **regularly compile management information (e.g. highlights or summaries) on site inspection results for KTDCS for monitoring purpose.**

Response from the Government

3.13 The Director of Electrical and Mechanical Services agrees with the audit recommendations. He has said that:

(a) EMSD will continue to:

(i) make efforts to closely monitor the performance of Contractor B in operating KTDCS (including compliance with KPIs) and take follow-up actions as necessary; and

(ii) enhance the operation payment adjustment mechanism in future contracts for operating KTDCS and is exploring new payment adjustment mechanisms for DCS projects at new development areas;

(b) EMSD has already incorporated the KPI on system coefficient of performance in the DBO contract for the provision of an additional DCS at KTD. EMSD will continue to consider incorporating new KPIs into contracts for operating KTDCS and is exploring new KPIs for DCS projects at new development areas;

(c) EMSD has reminded its staff to follow the guidelines on conducting site inspections which have been implemented smoothly, and it will continue to include in the inspection reports information on site inspection results and follow-up actions taken; and

(d) commencing from December 2021, EMSD will regularly compile management information on site inspection results for KTDCS for monitoring purpose.

Other operational issues

Performance audit of KTDCS facilities

3.14 According to Contract B, Contractor B is required to appoint an independent professional engineer (i.e. the auditor) to carry out a performance audit of KTDCS facilities annually. The scope of performance audit includes inspection and auditing of the maintenance manual, schedules and reports for compliance, visual inspection of all plant and equipment for state of maintenance and repairs, inspection of performance records and performance evaluation of plant and equipment in operating condition, and making recommendations on enhancement of the operation and maintenance of KTDCS facilities where applicable. Each performance audit covers a 12-month period from May of a year to April of the following year. As of October 2021, 8 performance audits had been completed.

3.15 Audit noted that two issues identified in the first performance audit (for the period from May 2013 to April 2014) were repeatedly highlighted by the auditor in the subsequent 7 performance audits, as follows:

(a) chilled water return temperature lower than design temperature (see paras. 3.16 to 3.19); and

(b) automatic operating mode of DCICCS not fully in use (see paras. 3.20 to 3.23).

Chilled water return temperature lower than design temperature

3.16 According to EMSD:

(a) the right amount of cooling energy to each user building is delivered by means of the control of chilled water flow and the chilled water temperature difference (i.e. the difference between chilled water supply and return temperatures);

(b) the DCS operator can control the chilled water flow and the chilled water supply temperature but not the chilled water return temperature; and

(c) the chilled water return temperature at the DCS plants depends on the operating conditions of air-conditioning installations of user buildings (i.e. consumer side).

3.17 Audit noted that:

(a) the design chilled water return temperature at the primary side of heat exchanger was 13 °C and that at the secondary side of heat exchanger was 14 °C (see Table 7 in para. 3.4). All the 8 performance audits identified that the primary side chilled water return temperatures were lower than the design temperature of 13 °C. According to the latest performance audit report for the period from May 2020 to April 2021, the yearly average primary side chilled water return temperatures at the northern and southern chiller plants were about 10.89 °C and 10.4 °C respectively (i.e. 2.11 °C and 2.6 °C below the design chilled water return temperature of 13 °C at the primary side respectively). According to EMSD:

(i) these primary side chilled water return temperatures corresponded to the yearly average secondary side chilled water return

temperatures (of user buildings' substations serving by the northern and southern chiller plants respectively) of 11.89 °C and 11.4 °C (i.e. 2.11 °C and 2.6 °C below the design chilled water return temperature of 14 °C at the secondary side respectively); and

(ii) the primary side chilled water return temperatures at the two DCS plants depended on the secondary side chilled water return temperatures at user buildings' substations. The control mechanism to adjust the secondary side chilled water return temperature was under the responsibility of user buildings' air-conditioning systems (Note 38);

(b) according to the two latest performance audit reports (covering the period from May 2019 to April 2021):

(i) a low chilled water return temperature would affect the efficiency and performance of KTDCS plants (see also para. 3.18(a)); and

(ii) the low secondary side chilled water return temperatures at user buildings' substations would seem to persist if there was no cost on consumer side and no control of their secondary side chilled water return temperatures;

(c) according to the District Cooling Services Supply Conditions (Note 39) issued by EMSD:

Note 38: *According to EMSD: (a) the air-conditioning control system should adjust the chilled water flow rate and be capable of coping with different cooling loads, such that the chilled water return temperature will be regulated to meet the requirement; and (b) if the requirement cannot be met, the air-conditioning control system should be fine-tuned by various means (e.g. system balancing and further testing and commissioning of the air-conditioning system).*

Note 39: *The District Cooling Services Supply Conditions set out the general and technical terms and conditions upon which EMSD will supply district cooling services, as well as conditions relating to the use of the district cooling services. The Supply Conditions apply to both EMSD and DCS consumers. Under DCSO, a DCS consumer is required to give undertaking to comply with conditions imposed by EMSD relating to the provision or use of district cooling services (e.g. the Supply Conditions). The requirement regarding the issue of Improvement Notice (see para. 3.17(c)(ii)) is also set out in DCSO.*

(i) a DCS consumer shall be responsible for proper maintenance of the consumer installation to perform and maintain the chilled water return temperature on consumer side at 14 °C; and

(ii) EMSD may issue an Improvement Notice to a DCS consumer if it is in the opinion that the behaviour of, or an installation of the building by, the DCS consumer is jeopardising or will jeopardise the operation or reliability of the district cooling services, for example, the chilled water return temperature on consumer side is not maintained at 14 °C as required. According to EMSD, since commissioning of KTDCS in January 2013 and up to 30 June 2021, it had not issued any Improvement Notice to DCS consumers in this regard (Note 40);

(d) according to Contractor B, although DCS consumers had not jeopardised the operation or reliability of the district cooling services, it had discussed with EMSD about the possibility of imposing a penalty on DCS consumers if they could not maintain the secondary side chilled water return temperature within the specified range; and

(e) while Contractor B maintained records of chilled water return temperature for each substation at user buildings through DCICCS, as of August 2021, there was no readily available information on DCS consumers' compliance with the chilled water return temperature requirement (see (c)(i) above).

3.18 Between September and November 2021, EMSD informed Audit that:

(a) it found that although some DCS consumers could not regularly maintain the chilled water return temperature at 14 °C, it had not affected the operation or reliability of KTDCS as the DCS plants were not at their design

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Note 40: *According to EMSD, the chilled water return temperature on consumer side not being maintained at the required value alone is not enough to conclude that a DCS consumer is jeopardising or will jeopardise the operation or reliability of the district cooling services, as it is only one of the factors that may affect the operation or reliability of the district cooling services. Other important factors (e.g. the total cooling demand against the installed cooling capacity of the plant) should also be considered.*

full capacities (Note 41). The chilled water return temperature on consumer side not being maintained at the required value would affect the operation or reliability of the district cooling services when the cooling demand was close to full-load capacity of the DCS plants;

(b) it had adopted a collaborative approach by communicating with the consumers for improving the situation instead of issuing Improvement Notices. The condition for issuing Improvement Notice had not been met given that, at the moment, the DCS consumers had not yet jeopardised the operation or reliability of the district cooling services. This was because the chilled water return temperature on consumer side was not crucial to the operation or reliability of the district cooling services at the moment given that the current cooling demand was not close to the design full capacities of the plants. EMSD had been continuously liaising with the consumers to assist them to achieve the chilled water return temperature requirement by any feasible means;

(c) Contractor B focused more on the resultant chilled water return temperatures at the northern and southern chiller plants (i.e. the overall chilled water return temperatures at the two DCS plants) rather than the chilled water return temperatures at individual substations at user buildings as the former was one of the key parameters for the operation of DCS plants. The information on resultant chilled water return temperatures at the two DCS plants was included in each monthly operation report prepared by Contractor B. Information on DCS consumers' compliance with the chilled water return temperature requirement could easily be compiled as and when required;

Note 41: *According to EMSD: (a) as of October 2021, the total cooling capacity required by all existing user buildings and the plant production capacity by duty chillers of KTDCS were only 20% and 23% of the full-load capacity respectively; (b) under the current part-load operating condition, the chilled water return temperature on consumer side not being maintained at the required value is neither jeopardising the operation nor reliability of the district cooling services; and (c) the lower the chilled water return temperature on consumer side, the higher the chilled water flow to user buildings' substations is required in order to transport the same amount of cooling energy to the user buildings. Under the current part-load operating condition, the higher chilled water flow has no impact on the operation of KTDCS and the district cooling services to existing user buildings. Regarding energy consumption, the effect of higher chilled water flow may be offset by the higher efficiency of chiller at part-load operation. There is no noticeable impact on the overall energy consumption of KTDCS at the moment.*

(d) while temperature resets (Note 42) had been implemented for some user buildings' substations in different periods in the past, extensive temperature resets for different user buildings' substations were implemented in September 2021 to maintain the secondary side chilled water return temperatures within the specified range. It was found that the average secondary side chilled water return temperature had increased and the overall situation had improved (Note 43); and

(e) the latest version of Technical Guidelines for Connection to District Cooling System (updated and issued by EMSD in May 2020) was enhanced by adding the requirements for DCS consumers to install a by-pass pipe in their chilled water systems on consumer side (Note 44) to facilitate better control of the chilled water return temperatures. This was another means that could be adopted to handle the issue of low chilled water return temperature.

3.19 According to EMSD, the chilled water return temperature on consumer side not being maintained at the required value would affect the operation or reliability of the district cooling services when the cooling demand was close to full-load capacity of the DCS plants (see para. 3.18(a)). As EMSD expects that the DCS plants will reach full-load capacity in 2025 (see para. 3.22(b)), in Audit's view, EMSD needs to:

Note 42: *According to EMSD: (a) temperature reset is the process of raising the secondary side chilled water supply temperature (relating to KPI 2) by decreasing the chilled water flow rate on the primary side but keeping the primary side chilled water supply temperature (relating to KPI 1) unchanged; (b) the effect is to raise the secondary side chilled water return temperature so as to reduce the gap between the actual and the required chilled water return temperature; and (c) since temperature reset will inevitably affect the secondary side chilled water supply temperature, the KPI 2 requirement will not be applicable for the period when temperature reset is implemented.*

Note 43: *According to EMSD, in September 2021, the average secondary side chilled water return temperatures of user buildings' substations serving by the northern and southern chiller plants were 12.25 °C and 11.33 °C respectively, which were higher than the respective temperatures of 11.66 °C and 10.6 °C in August 2021 (i.e. before implementing extensive temperature resets).*

Note 44: *According to EMSD, one of the common feasible means to control the chilled water return temperature is to install a by-pass pipe and associated control valve connecting the secondary chilled water supply and secondary chilled water return on consumer side.*

(a) keep under review the impact of low chilled water return temperatures on the operation and reliability of KTDCS, and the effectiveness of the measures (e.g. temperature resets) taken to address the issue; and

(b) consider requiring Contractor B to compile and report regularly to EMSD information on DCS consumers' compliance with the chilled water return temperature requirement.

Automatic operating mode of DCICCS not fully in use

3.20 DCICCS is provided for controlling and monitoring of the whole KTDCS. It comprises computers and network links to manage the operation of field devices and network controllers. All the 8 performance audits identified that automatic operating mode of DCICCS was not fully in use. According to the performance audit report for the period from May 2019 to April 2020, accelerating the implementation of fully automatic operating mode could improve the overall system efficiency and performance.

3.21 According to Contractor B, in response to the findings of the performance audit report for the period from May 2019 to April 2020:

(a) the cooling demand profile of KTDCS would be under dramatic change in the next few years due to increasing DCS consumers and occupancy rate of user buildings;

(b) new E&M equipment would be installed and the operation characteristics of the new equipment were not yet known;

(c) an optimisation programme (which would suggest the optimum operating configuration for a particular loading demand and ambient condition) in the northern chiller plant was in progress. It was not a good timing to incorporate a fully automatic operating programme; and

(d) it was considered that operating the system in manual operating mode had not compromised the effectiveness of accomplishing energy saving at the moment.

3.22 In October 2021, EMSD informed Audit that:

(a) as of October 2021, the total cooling capacity required by all existing user buildings and the plant production capacity by duty chillers of KTDCS were only 20% and 23% of the full-load capacity respectively; and

(b) in view of the dramatic change in the cooling demand profile and the new E&M equipment with different characteristics in operation in the next few years, it was planned to implement the fully automatic operating mode upon reaching full-load capacity tentatively in 2025.

3.23 In Audit's view, EMSD needs to keep under review the operation of KTDCS and implement the fully automatic operating mode as and when appropriate for improving the overall system efficiency and performance.

Scope for improvement in incident reporting

3.24 According to Contract B, Contractor B should as soon as possible but not exceeding 15 minutes of first becoming aware of any serious and emergency incident inform the Supervising Officer (i.e. EMSD) by telephone or in person, and offer assistance in handling the serious and emergency incident to facilitate management and control of such incident. According to Contractor B's incident reporting procedures as detailed in the operation plan of KTDCS (approved by EMSD), incidents are classified into four levels (from Levels 1 to 4 (being the most serious)) with different reporting requirements (see Table 8). For example, for Levels 3 and 4 incidents, Contractor B needs to inform EMSD (by telephone or in person) within 15 minutes. For Levels 2 to 4 incidents, Contractor B needs to submit separate incident reports to EMSD.

Table 8

Requirements on incident reporting

Level	Nature of incident	Reporting requirement	Submission of separate incident report to EMSD
1	Non-emergency incident	Inform the operation manager of Contractor B in a reasonable time	No (Note)
2	Urgent fault involving system or equipment failure, bearing safety implication, or seriously affecting the operation or chilled water supply	• Inform the project manager of Contractor B as soon as possible after becoming aware of the incident • Inform EMSD by telephone or in person when it is expected that the system or equipment concerned cannot resume operation within two hours	Yes
3	• Serious and emergency incident having impact on the public and requiring support from the management of Contractor B or EMSD • Personal injury case without fatal	After becoming aware of the incident: • inform the managing director of Contractor B as soon as possible; and • inform EMSD within 15 minutes by telephone or in person	Yes
4	Crisis situation requiring significant resources from parties outside Contractor B, having significant impact on the public and media interest, and having the potential to cause reputation damage		Yes

Source: *EMSD records*

Note: *Level 1 incidents are reported to EMSD on a regular basis (e.g. through monthly operation report of KTDCS).*

3.25 According to EMSD, since commissioning of KTDCS in January 2013 and up to 30 June 2021, 25 incident reports were submitted by Contractor B to it. Audit noted that all the reports had not reported the level of the incidents and some of them had not set out the time of reporting to Contractor B's management and EMSD. In addition, EMSD had not maintained records showing when Contractor B notified it of the incidents and its follow-up actions taken. In October 2021, EMSD informed Audit that:

(a) it maintained records through mobile applications that had records of Contractor B's notification time for each incident. Contractor B's prompt notifications were recorded for each incident by EMSD staff within a very short period of time;

(b) since the adoption of mobile applications in July 2018, the time of reporting incidents to Contractor B's management and EMSD had not been recorded in the incident reports; and

(c) it would enhance the record keeping by archiving all messages, keeping all in files and extracting the incident occurrence time and notification time for better record keeping and contractor performance monitoring.

3.26 In Audit's view, EMSD needs to enhance the monitoring of Contractor B's compliance with the incident reporting requirements, including:

(a) requiring the contractor to include information on the level of incident and the time of reporting the incident to its management and EMSD in the incident report; and

(b) enhancing the record keeping on incidents notified by Contractor B by telephone or in person and EMSD's follow-up actions.

Need to make continued efforts to enhance the operation and maintenance of KTDCS plants

3.27 Since commissioning of KTDCS in January 2013 and up to 30 June 2021, submissions of separate incident reports to EMSD were required for 25 incidents (see para. 3.25), of which 5 were related to water leakage or flooding at chiller plants (see Table 9). For example, the water leakage and flooding incident at the southern chiller plant on 11 July 2018 was due to unsatisfactory workmanship of maintenance works for a chiller and the late discovery of the incident by Contractor B. According to EMSD, after this water leakage and flooding incident, Contractor B had implemented various measures to prevent recurrence of water leakage or flooding incidents at the plants (Note 45). In Audit's view, EMSD needs to make continued efforts to enhance the operation and maintenance of KTDCS plants with a view to avoiding recurrence of water leakage or flooding incidents at the plants.

Note 45: *According to Contractor B, improvement measures had been taken to improve the situation, including providing separate display for alarms, enhancing the visibility of closed-circuit television display for higher risk areas of DCS plants, increasing frequency of site patrol from 1 to 4 times in the night shift, and adding "Internet of Things" water sensors which could send text messages to operation staff when water was detected.*

Table 9

Water leakage or flooding incidents at chiller plants
(May 2013 to November 2018)

Date	Particulars
22 May 2013	Flooding was found at two basement levels of the northern chiller plant due to rainwater entering into the plant room through some unsealed/sealant damaged cable sleeves
10 February 2015	Water leaked out from a gap at the deformed gasket of a chiller (at Basement 2 level of the southern chiller plant) during water refill, causing wetting of the chiller starter and control panels
11 July 2018	• Due to a displacement of gasket of a chiller, water leaked out from the chiller, causing flooding at Basement 2 level of the southern chiller plant. The displacement of gasket was due to unsatisfactory workmanship of maintenance works for the chiller • The flooding incident was also caused by the late discovery of abnormality as the water leakage inducing the flooding happened at midnight but Contractor B only discovered the incident in the morning. According to Contractor B, the late discovery of the flooding incident was due to inattention of control system alarm and closed-circuit television display, and low frequency of site patrol during the night shift
13 July 2018	Water leaked out from fibre polyvinyl chloride duct at Basement 2 level of the southern chiller plant due to loosening of water stopper and damaged polyvinyl chloride duct between the plant room and fibre pit at the ground floor
1 November 2018	Water leaked out from a fresh water makeup pipe nearby the water meter box for chilled water makeup function (at Basement 2 level of the southern chiller plant) due to a loose pipe coupling installed inside the water meter box metal enclosure

Source: EMSD records

Audit recommendations

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

(a) **keep under review the impact of low chilled water return temperatures on the operation and reliability of KTDCS, and the effectiveness of the measures (e.g. temperature resets) taken to address the issue;**

(b) **consider requiring Contractor B to compile and report regularly to EMSD information on DCS consumers' compliance with the chilled water return temperature requirement;**

(c) **keep under review the operation of KTDCS and implement the fully automatic operating mode as and when appropriate for improving the overall system efficiency and performance;**

(d) **enhance the monitoring of Contractor B's compliance with the incident reporting requirements, including:**

(i) **requiring the contractor to include information on the level of incident and the time of reporting the incident to its management and EMSD in the incident report; and**

(ii) **enhancing the record keeping on incidents notified by Contractor B by telephone or in person and EMSD's follow-up actions; and**

(e) **make continued efforts to enhance the operation and maintenance of KTDCS plants with a view to avoiding recurrence of water leakage or flooding incidents at the plants.**

Response from the Government

3.29 The Director of Electrical and Mechanical Services agrees with the audit recommendations. He has said that:

(a) with the implementation of temperature resets, the performance outcome is very effective as the chilled water return temperatures are maintained closer to the required level. EMSD will continue to keep under review the impact of low chilled water return temperatures on the operation and reliability of KTDCS, and the effectiveness of the measures (e.g. temperature resets) taken to address the issue;

(b) EMSD will consider requiring Contractor B to compile and report regularly to EMSD information on DCS consumers' compliance with the chilled water return temperature requirement;

(c) EMSD will continue to keep under review the operation of KTDCS and implement the fully automatic operating mode upon reaching full-load capacity tentatively in 2025;

(d) EMSD has already implemented the enhancement measures on incident reporting as recommended; and

(e) following the water leakage and flooding incident in July 2018, enhanced monitoring, operation and maintenance practices have been adopted and there has been no similar incident since then. EMSD will continue to make efforts to enhance the operation and maintenance of KTDCS plants with a view to avoiding recurrence of water leakage or flooding incidents at the plants.

PART 4: PROVISION OF DISTRICT COOLING SERVICES AND OTHER RELATED ISSUES

4.1 This PART examines EMSD's work in the provision of district cooling services (paras. 4.2 to 4.17) and drawing on experience gained (paras. 4.18 to 4.31).

Provision of district cooling services

4.2 According to EMSD, its work relating to the provision of district cooling services under KTDCS is as follows:

(a) it keeps track of the developments at KTD via the Outline Development Plan (ODP — Note 46) for KTD and assesses the technical feasibility of DCS connection to development sites included in ODP to identify development sites that are required to connect to KTDCS, considering the following factors:

(i) schedule of completion of the development;

(ii) compatibility with the development's air-conditioning system (e.g. whether the development would adopt centralised air-conditioning system, which is a prerequisite requirement for using DCS);

(iii) availability of cooling capacity of DCS;

(iv) technical feasibility of associated construction works; and

(v) financial viability for cost recovery;

Note 46: *ODPs are administrative plans prepared within the framework of the statutory plans (e.g. Outline Zoning Plan). With a much larger scale, these plans show more detailed level planning parameters (e.g. site boundaries, location of access points and footbridges, specific types of government or community uses) to facilitate the coordination of public works, land sales and land reservation for specific uses.*

(b) it prepares a list of development sites for connection to KTDCS (hereinafter referred to as connection list) and updates the connection list from time to time based on the latest ODP so as to ensure that all development sites that are required to connect to KTDCS are identified (Note 47). The cooling capacities required for the development sites to be connected to KTDCS are estimated based on various engineering parameters such as total development floor area, development usage, etc. For development sites that have been connected to KTDCS, EMSD marks the sites as "existing DCS consumer" on the connection list; and

(c) it liaises and coordinates with the relevant government bureaux/departments (B/Ds) of public developments and the responsible parties of private non-domestic developments on the matters of construction of the facilities within the developments suitable for the connection to KTDCS. Prior to the commencement of the chilled water supply, EMSD liaises and coordinates with the relevant B/Ds of public developments and the responsible parties of private non-domestic developments on the matters of application (see para. 1.16) for subscription to the district cooling services (Note 48).

Note 47: *For private non-domestic development sites, EMSD will advise the Lands Department to incorporate appropriate provisions in the conditions of land sale or the conditions of land grant, whichever are appropriate, to require the lot owner to construct and maintain DCS substations with such associated necessary wirings and facilities for connection to DCS where appropriate (see Note 12 to para. 1.14(b)).*

Note 48: *According to EMSD, for development sites (e.g. private domestic development sites) that are not required to connect to KTDCS, it will promote KTDCS to the responsible parties for better utilisation of KTDCS. It would be possible to provide district cooling services to these development sites if centralised air-conditioning systems are adopted. If there are such requests from the responsible parties of these development sites, subject to the technical feasibility of DCS connection (see para. 4.2(a)), EMSD will liaise and coordinate with the responsible parties of these sites on the matters of construction of the facilities within the developments suitable for connection to KTDCS, and application for subscription to the district cooling services.*

Information for following up developments for provision of district cooling services not included in the connection list

4.3 According to EMSD's connection list (see para. 4.2(b)) as of October 2021, there were 56 development sites (27 public development sites and 29 private non-domestic development sites) which were required to connect to KTDCS. Audit noted that the connection list did not include information for following up developments at the sites for provision of district cooling services (e.g. responsible B/D or party, site development status, and the progress of connection to KTDCS and processing applications for subscription to the district cooling services). In Audit's view, EMSD needs to include in the connection list such information with a view to facilitating its follow-up actions for provision of district cooling services.

Scope for improvement in assessment mechanism for DCS connection

4.4 According to EMSD, it would assess the technical feasibility of DCS connection to development sites taking into account various factors (see para. 4.2(a)). Audit noted that EMSD had not promulgated guidelines on the mechanism for assessing technical feasibility and had not documented such assessments. In response to Audit's findings, EMSD informed Audit in October 2021 that:

(a) it promulgated on 13 September 2021 a checklist to establish a formal workflow and mechanism to record the assessment on DCS connection and approval for connecting/not connecting to DCS (hereinafter referred to as the checklist for connection to DCS); and

(b) the checklist for connection to DCS would facilitate a comprehensive documentation on the assessments on DCS connection and the subsequent follow-up actions on connection matters of the developments at KTD. The relevant staff had been instructed to follow the workflow and mechanism in the checklist.

4.5 In Audit's view, EMSD needs to regularly remind its staff to follow the workflow and mechanism in the checklist for connection to DCS, and document the assessments.

Need to keep up efforts in liaising and exploring feasibility with B/Ds and parties concerned for provision of district cooling services

4.6 All public developments at KTD are mandated to connect and subscribe to the district cooling services provided that their implementation programme can match the development schedule of KTDCS (see para. 1.14(a)). All private non-domestic developments at KTD are required to connect to KTDCS (see Note 12 to para. 1.14(b)). According to EMSD, as of August 2021:

(a) 5 public developments and 3 private non-domestic developments at KTD were under coordination for provision of district cooling services (expected to commence between the first quarter of 2022 and the second quarter of 2026); and

(b) 6 existing public developments and 3 existing private non-domestic developments at KTD were not yet connected to KTDCS as they had been constructed before district cooling services were available to them. EMSD would explore with the relevant B/Ds and the responsible parties the feasibility of connecting their developments to KTDCS when opportunities arose (e.g. by the time when the existing centralised air-conditioning plant approaching the end of life cycle and due for replacement).

4.7 In Audit's view, EMSD needs to:

(a) closely liaise with the relevant B/Ds and the responsible parties of the public and private non-domestic developments at KTD mentioned in paragraph 4.6(a) for provision of district cooling services; and

(b) explore with the relevant B/Ds and the responsible parties of the existing public and private non-domestic developments at KTD mentioned in paragraph 4.6(b) the feasibility of connecting their developments to KTDCS when opportunities arise.

Need to keep under review the cooling demand of developments at KTD

4.8 According to EMSD, the plant production capacity of the chiller plants under KTDCS (Note 49) would be increased by phases to match the schedules of development projects at KTD. Audit noted that:

(a) the increase in development intensity of KTD as announced in the 2017 Policy Address had contributed to the growth in projected cooling demand of user buildings at KTD and the provision of an additional DCS at KTD (see para. 1.18);

(b) in his 2021-22 Budget Speech, the Financial Secretary announced that the Government was examining the feasibility of rezoning five commercial sites in Kowloon East for residential use taking into account the latest economic situation and market response. According to the Development Bureau, the five commercial sites were located in KTD, with a total area of about six hectares. According to ENB, there would be an impact on the finance and operation of KTDCS arising from rezoning of the five commercial sites for residential use as the five commercial sites were potential consumers of KTDCS; and

(c) new DCS consumers were expected in the next few years (see para. 4.6(a)).

4.9 In view of the changing developments at KTD, Audit considers that EMSD needs to keep under review the cooling demand of developments at KTD with a view to matching the demand by KTDCS.

Note 49: *According to EMSD, as of August 2021, the plant production capacity by duty chillers of the northern chiller plant and the southern chiller plant were 29,191 kilowatts and 34,994 kilowatts respectively.*

Need to complete interim tariff review as scheduled and conduct regular tariff reviews

4.10 ***Charging principles for district cooling services of KTDCS.*** According to ENB and EMSD, the charging principles for the district cooling services of KTDCS are as follows:

(a) the DCS tariff would be set at a competitive level comparable to the cost of individual water-cooled air-conditioning system using cooling towers;

(b) both the capital and operating costs of KTDCS would be recovered from DCS consumers over the 30-year service life; and

(c) the charging mechanism provides price stability and is simple with common charge rates for all buildings regardless of their load profiles.

4.11 ***Tariff level.*** The provision of district cooling services of KTDCS is governed by DCSO, which sets out the tariff level for the district cooling services of KTDCS and the adjustment mechanism (see para. 1.17). The tariff comprises the following two major components (Note 50):

(a) ***Capacity charge.*** Capacity charge is for covering the capital cost and the operation and maintenance costs of DCS. It is calculated based on the contract cooling capacity (i.e. an estimation of the maximum designed cooling capacity for a user building) and the capacity charge rate, which is adjusted annually based on the rate of change in the Composite Consumer Price Index; and

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Note 50: *Apart from the two major tariff components, the tariff also comprises: (a) capacity overrun charge, which will be levied if the highest actual cooling capacity demand exceeds the contract cooling capacity. DCS consumers will have to pay an extra 10% for the capacity charges for the overrun part; and (b) surcharges for unpaid charges. A surcharge equal to 5% of the unpaid amount will be charged after the payment due date. If the amount remains unpaid for six months after the payment due date, a further surcharge equal to 10% of the total unpaid amount will be imposed.*

(b) ***Consumption charge.*** Consumption charge is for covering the costs that will vary with the actual consumption of district cooling services by DCS consumers. The major part of the charge is the cost of electricity used to generate chilled water for delivery to user buildings. It is calculated based on the actual monthly cooling energy consumption of a user building and the consumption charge rate, which is adjusted annually based on the rate of change in electricity tariff.

For 2021-22, the capacity charge rate and the consumption charge rate for the district cooling services of KTDCS are $132.47 per kilowatt per month and $0.2068 per kWh respectively. The total revenue of KTDCS since commissioning of KTDCS in 2012-13 and up to 2020-21 was $266.7 million (Note 51).

4.12 ***Regular tariff review.*** Both the capital and operating costs of KTDCS would be recovered from DCS consumers over the 30-year service life (see para. 4.10(b)). The opening tariff for the district cooling services of KTDCS was set at a level with cash flows generated from the activities (i.e. total revenue) equal to the total cost (i.e. total capital and operating costs) of the project over the life of the assets, both presented in present value terms. According to ENB, as the actual cost (e.g. DCS capital outlay and operating costs) and revenue may deviate from the forecasts, apart from the annual tariff adjustments (see para. 4.11), a regular DCS tariff review will be conducted at least once every 5 years.

4.13 ***Tariff review for the existing DCS.*** Regarding the existing DCS at KTD (implemented under KTDCS project), EMSD commissioned a consultancy study in March 2019 to review the DCS tariff based on the relevant actual data and updated forecasts in order to ascertain whether the 30-year full cost recovery principle could be met. The DCS tariff review was completed in June 2020. According to EMSD, based on the review findings, if the prevailing tariff level was maintained, the cost recovery rate over the project life would be about 97% of the full-cost recovery level.

Note 51: *The total revenue of $266.7 million comprised capacity charges of $153.3 million, capacity overrun charges of $13.1 million and consumption charges of $100.3 million. The total recurrent cost of KTDCS since commissioning of KTDCS in 2012-13 and up to 2020-21 was $549.4 million. DCSO provides that charges and fees received for the provision of district cooling services are used to settle the operation and maintenance fees for a DCS operator as well as utility costs for operating the DCS plants. The net recurrent cost of $282.7 million ($549.4 million − $266.7 million) was funded under EMSD departmental vote.*

As the existing cost recovery rate was close to full-cost recovery level (Note 52), EMSD proposed to maintain the prevailing tariff level and sought ENB's policy support on the proposal in July 2020. In October 2020, ENB endorsed EMSD's proposal.

4.14 ***Interim tariff review covering the additional DCS.*** The construction of the additional DCS at KTD (see para. 1.18) commenced in December 2020 with district cooling services planned to commence in phases starting from 2022-23. According to EMSD, under the consultancy study commissioned in March 2019 (see para. 4.13), an interim tariff review would be conducted to ascertain whether the 30-year full cost recovery principle could be met concerning both the existing and additional DCSs at KTD. It expected that the review report would be available by the end of 2021.

4.15 Apart from the construction of the additional DCS at KTD, the changing developments at KTD (see para. 4.8) may also affect the finance of KTDCS. In Audit's view, EMSD needs to complete the interim tariff review for KTDCS as scheduled and conduct regular tariff reviews, taking into account all relevant data and latest developments relating to KTDCS.

Audit recommendations

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

(a) **include in the list of development sites for connection to KTDCS information for following up developments at the sites for provision of district cooling services (e.g. responsible B/D or party, site development status, and the progress of connection to KTDCS and processing applications for subscription to the district cooling services) with a view to facilitating EMSD's follow-up actions for provision of district cooling services;**

Note 52: *According to Financial Circular No. 6/2016 on "Fees and Charges", where the existing cost recovery rate is close to full-cost recovery level (say, plus or minus 5%), and the revenue involved is likely to be immaterial, the Financial Services and the Treasury Bureau (Treasury Branch) has no objection to maintaining the existing fee levels for the time being if Directors of Bureaux and Controlling Officers so propose.*

(b) **regularly remind EMSD staff to follow the workflow and mechanism in the checklist for connection to DCS, and document the assessments;**

(c) **closely liaise with the relevant B/Ds and the responsible parties of the public and private non-domestic developments at KTD mentioned in paragraph 4.6(a) for provision of district cooling services;**

(d) **explore with the relevant B/Ds and the responsible parties of the existing public and private non-domestic developments at KTD mentioned in paragraph 4.6(b) the feasibility of connecting their developments to KTDCS when opportunities arise;**

(e) **keep under review the cooling demand of developments at KTD with a view to matching the demand by KTDCS; and**

(f) **complete the interim tariff review for KTDCS as scheduled and conduct regular tariff reviews, taking into account all relevant data and latest developments relating to KTDCS.**

Response from the Government

4.17 The Director of Electrical and Mechanical Services agrees with the audit recommendations. He has said that:

(a) EMSD has since November 2021 included in the list of development sites for connection to KTDCS information for following up developments at the sites for provision of district cooling services with a view to facilitating its follow-up actions for provision of district cooling services;

(b) the checklist for connection to DCS has been promulgated and the operation has so far been smooth;

(c) EMSD will continue to:

(i) closely liaise with the relevant B/Ds and the responsible parties of the public and private non-domestic developments at KTD

mentioned in paragraph 4.6(a) for provision of district cooling services;

(ii) explore with the relevant B/Ds and the responsible parties of the existing public and private non-domestic developments at KTD mentioned in paragraph 4.6(b) the feasibility of connecting their developments to KTDCS when opportunities arise; and

(iii) keep under review the cooling demand of developments at KTD with a view to matching the demand by KTDCS; and

(d) EMSD will complete the interim tariff review for KTDCS as scheduled and will continue to conduct regular tariff reviews, taking into account all relevant data and latest developments relating to KTDCS.

Drawing on experience gained

4.18 In April 2009, ENB informed the Public Works Subcommittee of FC of LegCo that:

(a) the proposed DCS under KTDCS project was the first of its kind in Hong Kong and was essentially a pilot project; and

(b) experience gained would serve as a reference for possible development of DCSs in other districts.

4.19 In her 2018 Policy Address, the Chief Executive of the Hong Kong Special Administrative Region announced that, in line with the Government's commitment to low-carbon development, the Government would explore the feasibility of providing DCSs in new development areas.

4.20 Apart from KTDCS project, FC approved funding in February 2021 for two DCS projects, as follows:

(a) ***Implementation of a DCS at Tung Chung New Town Extension (East).*** The project with an APE of $3,918.2 million was implemented by phases and commenced in June 2021 for completion by June 2034. DCS under the project would provide cooling capacity of about 123 megawatts for serving an estimated total air-conditioned floor area of about 0.7 million m^2; and

(b) ***Implementation of a DCS at Kwu Tung North New Development Area.*** The project with an APE of $5,787.7 million was implemented by phases and commenced in March 2021 for completion by December 2040. DCS under the project would provide cooling capacity of about 190 megawatts for serving an estimated total air-conditioned floor area of about 1.1 million m^2.

4.21 Audit noted that, apart from the issues identified above, there were various issues related to the implementation of KTDCS project, which merit EMSD's attention and follow-up actions, and EMSD could draw on the experience gained in implementing future DCS projects (see paras. 4.22 to 4.30).

Scope for improving project cost estimation

4.22 According to the Project Administration Handbook for Civil Engineering Works (hereinafter referred to as the Project Administration Handbook) issued by CEDD, any estimate must be as accurate as possible as it affects the management of public funds and it has a direct effect on fund allocation.

4.23 Under the original procurement strategy, KTDCS project would be implemented under a single DBO contract spanning over 17 years. After obtaining funding approval of $1,671 million for KTDCS project in June 2009, EMSD invited tenders for KTDCS project in July 2009. The returned tender prices far exceeded APE of KTDCS project. In the event, the tender exercise was cancelled. In view of the outcome of the abovementioned tender exercise and having reviewed the latest development plan of KTD, EMSD refined the work requirements of KTDCS project to provide more detailed site information, and revised the procurement strategy by implementing KTDCS project and inviting tenders for the related works in phases.

Provision of district cooling services and other related issues

4.24 The estimated overall project cost for KTDCS project was $1,671 million in May 2009. In January 2011 and May 2013, in the submissions to the Public Works Subcommittee, ENB said that:

(a) it forecasted that the estimated overall project cost had increased (to $3,646.3 million as at January 2011 and $4,945.5 million as at May 2013) due to reasons including the following:

  (i) the latest market price trend for major materials, E&M equipment and construction works which were specifically and extensively adopted for DCS;

  (ii) cost of additional works made necessary by project design development and changes in construction requirements due to unexpected site constraints;

  (iii) additional consultancy fees and resident site staff costs due to additional site supervision required for more complicated site works; and

  (iv) higher provision for price fluctuation adjustment as a result of the increase in the overall project estimate and latest price adjustment factors; and

(b) it would seek approvals from the Public Works Subcommittee and FC for further increasing APE for KTDCS project subject to the progress and development programme of KTD.

In the event, funding approvals were sought between February 2011 and January 2019 for increasing APE for KTDCS project from $1,671 million to $4,945.5 million (see Table 2 in para. 1.7).

4.25 Audit noted that there was a significant increase in the estimated overall project cost for KTDCS project by $3,274.5 million (or 196%) from $1,671 million in 2009 to $4,945.5 million in 2013. In October and November 2021, ENB and EMSD informed Audit that:

(a) EMSD had reviewed and updated the estimated overall project cost for KTDCS project from time to time taking into account the latest development progress of KTD. The increase in APE between February 2011 and January 2019 was due to the by-phase approach in taking forward the works and seeking funding approvals from FC, having regard to the latest development progress of KTD. This approach had been reported to LegCo all along; and

(b) the estimated overall project cost of $4,945.5 million provided in the 2013 funding application had been maintained since then.

4.26 In Audit's view, in implementing DCS projects in future, EMSD needs to take measures to ensure that the project costs are estimated as accurately as possible.

Scope for conducting post-completion review

4.27 According to the Project Administration Handbook:

(a) a post-completion review is a useful project management tool and shall be conducted upon the substantial completion of a major consultancy agreement or a major works contract on projects under the Public Works Programme. The emphasis and objective of the review are to gain maximum benefit from the experience accrued, rather than to apportion blame;

(b) there is no rigid definition for major projects or the minimum number of reviews to be undertaken by departments. As a broad guideline, post-completion reviews are generally not warranted for consultancy agreements and works contracts of a project which has a total cost less than $500 million or of a project which does not involve complicated technical and management issues;

(c) indicators that a project involves complicated issues may include project involving a claim of a substantial sum, say over $1 million;

(d) a post-completion review should be carried out within a reasonable period, say six months, after the substantial completion of a consultancy agreement or a works contract. For a project that comprises a number of contracts/consultancy agreements, the project office may elect, in view of the benefit of an overall review, to conduct a single post-completion review upon the substantial completion of the last contract; and

(e) upon the completion of a post-completion review, the department shall prepare a report documenting all concerned issues, findings, conclusions and recommendations for future reference by the department.

4.28 Audit noted that KTDCS project involved a significant project expenditure of $4,120.1 million as of August 2021 (see para. 1.10). Some of the works contracts under the project involved substantial sums (e.g. a claim over $1 million — see para. 4.27(c)) of claims or VOs (see paras. 2.5, 2.10 and 2.18). As of September 2021, while all works contracts under Phases I and II of KTDCS project had been substantially completed with total contract expenditure ($1,870.6 million — Note 53) much higher than $500 million (see para. 4.27(b)), and KTDCS had commissioned for some 8.7 years, no post-completion review had been conducted. According to EMSD, it had not conducted a post-completion review for KTDCS project as Phase III works were still under construction stage (scheduled for completion by December 2025).

4.29 As a post-completion review is a useful project management tool and to facilitate drawing on the experience gained in future DCS projects, Audit considers that EMSD needs to conduct a post-completion review for Phases I and II works of KTDCS project with a view to identifying areas for early improvement and facilitating drawing on the experience gained in future DCS projects.

Note 53: *The total contract expenditure of $1,870.6 million was 5.7% higher than the original total contract sum of $1,770.5 million for all works under Phases I and II of KTDCS project. According to EMSD, such increase was within 10% of project contingency.*

Audit recommendations

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

(a) **in implementing DCS projects in future, take measures to ensure that the project costs are estimated as accurately as possible; and**

(b) **conduct a post-completion review for Phases I and II works of KTDCS project with a view to identifying areas for early improvement and facilitating drawing on the experience gained in future DCS projects.**

Response from the Government

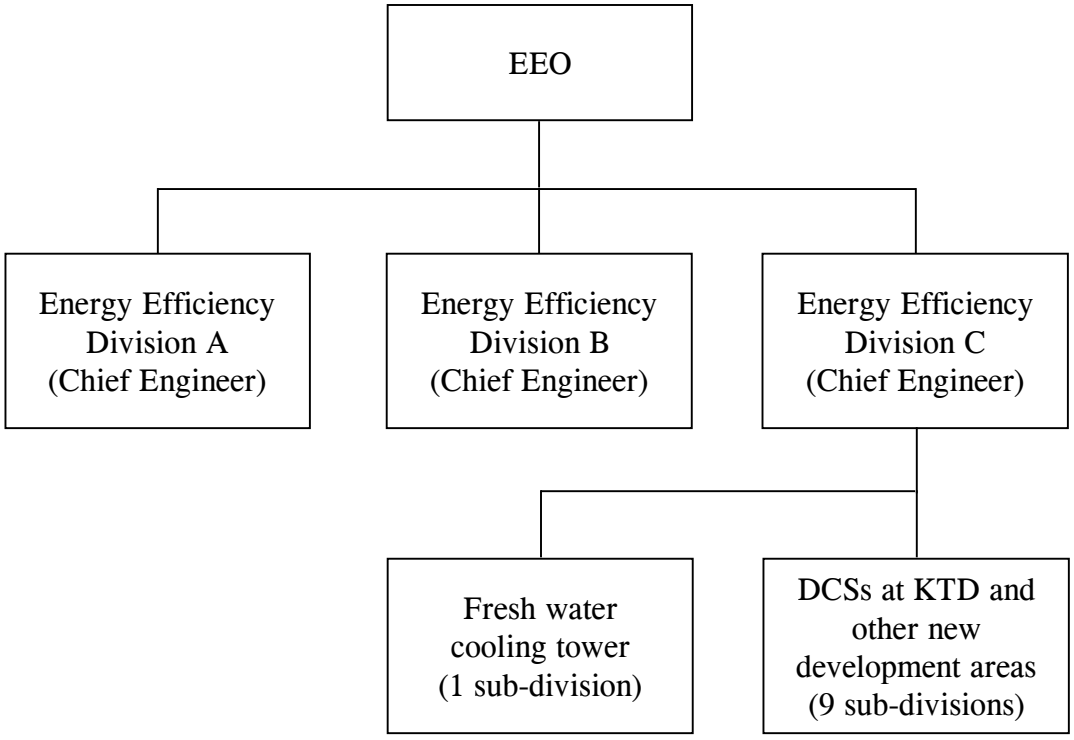
4.31 The Director of Electrical and Mechanical Services agrees with the audit recommendations. He has said that:

(a) the DBO contract for the provision of an additional DCS at KTD was awarded in November 2020 and the contract sum reflected that the project cost had been correctly estimated. Nevertheless, EMSD will continue to take measures to ensure that the project costs of DCS projects in future are estimated as accurately as possible; and

(b) EMSD will conduct a post-completion review for Phases I and II works of KTDCS project as recommended, with a view to identifying areas for early improvement and facilitating drawing on the experience gained in future DCS projects.

Appendix A
(para. 1.5 refers)

Energy Efficiency Office: Organisation chart (extract) (31 August 2021)



Source: EMSD records

Appendix B
(para. 1.9 and Note 8 to para. 1.10 refer)

Contract expenditures (August 2021)

Contract	Original contract sum (a)	Final contract sum/ up-to-date contract expenditure (Note 1) (b)	Increase/ (decrease) (c) = (b) − (a)		Increase/(decrease) in provision for price fluctuation adjustment (Note 2) (d)		Increase/(decrease) after price fluctuation adjustment (e) = (c) − (d)	
	($ million)	($ million)	($ million)	%	($ million)	%	($ million)	%
Phase I								
A	129.7	138.1	8.4	6.5%	9.8	7.6%	(1.4)	(1.1%)
Phase II								
B	1,640.8 (Note 3)	1,732.5 (Note 3)	91.7	5.6%	65.7	4.0%	26.0	1.6%
Phase III								
C	232.6	248.3	15.7	6.7%	—	—	15.7	6.7%
D	520.0	582.0	62.0	11.9%	(56.6)	(10.9%)	118.6	22.8%
E	201.0	144.0	(57.0)	(28.4%)	(43.0)	(21.4%)	(14.0)	(7.0%)
F	90.2	105.5	15.3	17.0%	—	—	15.3	17.0%
G	11.0	7.0	(4.0)	(36.4%)	(0.9)	(8.2%)	(3.1)	(28.2%)
H	521.6	375.8	(145.8)	(28.0%)	—	—	(145.8)	(28.0%)
I	82.6	84.6 (Note 4)	2.0	2.4%	(13.4)	(16.2%)	15.4	18.6%
J	138.9	52.9	(86.0)	(61.9%)	(28.6)	(20.6%)	(57.4)	(41.3%)
K	12.7	9.4	(3.3)	(26.0%)	—	—	(3.3)	(26.0%)
Total	1,810.6	1,609.5 (Note 5)	(201.1)	(11.1%)	(142.5)	(7.9%)	(58.6)	(3.2%)
Overall	3,581.1	3,480.1 (Note 6)	(101.0)	(2.8%)	(67.0)	(1.9%)	(34.0)	(0.9%)

Source: *EMSD records*

Note 1: *The accounts of 6 contracts (Contracts A to C and E to G) were finalised between February 2014 and March 2021. As of August 2021, the account of Contract D had not been finalised and 4 contracts (Contracts H to K) were still in progress. The respective amounts for these 5 contracts were the up-to-date contract expenditures as of August 2021.*

Note 2: *The original contract sums of Contracts A, B, D, E, G, I and J included provisions for price fluctuation adjustments. Contracts C, F, H and K did not include a provision for price fluctuation adjustments.*

Note 3: *Contract B was a design-build-operate contract. The amounts shown in this Table referred to the design and construction portions only. Of the final contract sum of $1,732.5 million, $1,728.6 million was related to KTDCS project and $3.9 million was related to works funded by a government department.*

Note 4: *For Contract I, of the up-to-date contract expenditure of $84.6 million, $78.9 million was related to KTDCS project and $5.7 million was related to works funded by a government department.*

Note 5: *Of the $1,609.5 million, $1,603.8 million was related to KTDCS project and $5.7 million (see Note 4) was related to works funded by a government department.*

Note 6: *Of the $3,480.1 million, $3,470.5 million was related to KTDCS project, and $9.6 million ($3.9 million (see Note 3) + $5.7 million (see Note 4)) was related to works funded by other government departments.*

Acronyms and abbreviations

APE	Approved project estimate
Audit	Audit Commission
B/Ds	Government bureaux/departments
CEDD	Civil Engineering and Development Department
CNC	Count of Non-compliance
°C	Degree Celsius
DBO	Design-build-operate
DCICCS	District cooling instrumentation, control and communication system
DCS	District cooling system
DCSO	District Cooling Services Ordinance
EEO	Energy Efficiency Office
EMSD	Electrical and Mechanical Services Department
ENB	Environment Bureau
EOTs	Extensions of time
E&M	Electrical and mechanical
FC	Finance Committee
KPIs	Key Performance Indicators
KTD	Kai Tak Development
KTDCS	Kai Tak District Cooling System
kWh	Kilowatt-hours
LegCo	Legislative Council
m^2	Square metres
ODP	Outline Development Plan
TTAs	Temporary traffic arrangements
VOs	Variation orders