

KAI TAK DISTRICT COOLING SYSTEM

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.

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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.

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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).

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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

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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,

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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

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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

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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));**

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- (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.