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EXECUTIVE COMMITTEE OF
THE MULTILATERAL FUND FOR THE
IMPLEMENTATION OF THE MONTREAL PROTOCOL
Eighty-second Meeting
Montreal, 3-7 December 2018

REPORTS ON PROJECTS WITH SPECIFIC REPORTING REQUIREMENTS

1. This document serves as a follow-up to the issues raised in the last annual progress and financial reports submitted to the 79th meeting,[1] and in relation to projects and activities for which specific reports were requested in previous meetings.

2. The document is divided into the following parts:

Part I: Financial audit reports for the CFC production, halon, polyurethane (PU) foam, process agent II, refrigeration servicing and solvent sectors in China

Part II: Methyl bromide (MB) phase-out projects

Part III: Phase-out in consumption and production of CTC in India (decision 81/23)

Part IV: ODS waste disposal projects

Part V: Chiller projects

Part VI: Demonstration projects for low-global-warming potential (GWP) alternatives to HCFCs and feasibility studies for district cooling (decision 72/40)

Part VII: Temporary use of a high-GWP technology in approved projects

Part VIII: Reports related to HCFC phase-out management plans (HPMPs)

3. Each part contains a brief description of progress, and the Secretariat's comments and recommendations.

*Re-issued for technical reasons on 20 November 2018

[1] UNEP/OzL.Pro/ExCom/79/8-13.

PART I: FINANCIAL AUDIT REPORTS FOR THE CFC PRODUCTION, HALON, PU FOAM, PROCESS AGENT II, REFRIGERATION SERVICING AND SOLVENT SECTORS IN CHINA

Background

4. In line with decisions 71/12(b)(ii) and (iii)[2], 72/13[3], 73/20(b)[4], 75/18[5], 77/26(b)[6], and 80/27[7], the Government of China has submitted to the 82nd meeting, through the relevant bilateral and implementing agencies, final progress reports, relevant research, technical assistance reports, and audit reports including the interest accrued during the implementation of the CFC production, halon, PU foam, process agent II, refrigeration servicing and solvent sector plans.

Planned budgets and progress reports

5. As of 31 August 2018, remaining balances amounted to US $22,236,071. Table 1 presents an overview of fund disbursements between 1 July 2017 and 31 August 2018, fund balances, and the planned completion dates for each of the sector plans.

Table 1. Planned budgets for the use of remaining funds (US $)

Activity	Balance as at 30 June 2017	New disbursement	Balance as at 31 August 2018	Completion date
CFC production: Total approved US $150,000,000 (World Bank)				
Recruitment for technical support, and organization of technology workshop on alternatives	0	0	0	2014
ODS import and export management MIS	0	0	0	2015
Research and development on ODS alternatives	788,857	368,768	420,089	2018
Supervision and management-	233,411	33,646	199,765	2018
Total	1,022,267	402,414	619,853	

[2] The Committee invited the Government, through the relevant implementing agency, in future financial audit reports, to provide data on all funds that were being held by the Government for disbursement to beneficiaries, and the interest accrued from those balances, on the process agent II, solvent and the refrigeration servicing sector plans; and information on progress related to the work plans for the sector plans and its proposal on how to use potential balances.

[3] The Committee invited the Government, through the relevant implementing agency, to submit to the 73rd meeting the financial audit reports for the process agent II, solvent and CFC refrigeration servicing sectors, together with the plans for the remaining funds for the halon, CFC production, foam, process agent II, solvent, and CFC refrigeration servicing sectors, describing how they would be used for activities related to ODS phase-out and allow for the completion of those sector plans by the end of 2018.

[4] The Government and the relevant bilateral and implementing agencies were requested to submit annual progress reports, audit reports, and interest accrued during the implementation of the CFC production, halon, PU foam, process agent II, refrigeration servicing and solvent sector plans, until the completion of all activities no later than 31 December 2018, and to submit project completion reports for the sector plans no later than the first meeting in 2019.

[5] The Government was invited to include the results of the activities on the screening and evaluation of CFC-free substitutes and the development of new substitutes in a report to be submitted when those activities had been completed; to collect information where available on halon recovery as part of its collection of information on CFC recovery during visits to ship dismantling centres; and to undertake a study on its country's production of CTC and its use for feedstock applications and to make the results of the study available to the Committee by the end of 2018.

[6] The Government was requested to provide to the 79th meeting final study reports on all research and development projects undertaken with funds from the Multilateral Fund under the CFC production sector.

[7] The Committee noted with appreciation that the Government has confirmed that the funding balances associated with each of the sector plans will be fully disbursed by the end of 2018; that relevant research and technical assistance reports will be submitted to the last meeting of 2018, and that the project completion reports will be submitted to the first meeting in 2019.

Activity	Balance as at 30 June 2017	New disbursement	Balance as at 31 August 2018	Completion date
Halon sector: Total approved US $62,000,000 (World Bank)				
Establishment of a national halon recycling management center, including capacity building, detecting equipment and information system	2,800,000	824,917	1,975,083	2022
Establishment of a halon-1211 recycling center, including collection, transportation, recycling and reclamation	2,550,000	(467,686)	3,017,686	2022
Establishment of a halon-1301 recycling center, including collection, transportation, recycling and reclamation	1,750,000	710,470	1,039,530	2022
Technical assistance: investigation of halon quantities for the civil aviation industry and for the ship recycling industry; and policy and regulations for halon recycling	3,087,250	169,314	2,917,936	2022
Disposal of unusable halon and residues	1,504,105	0	1,504,105	2022
Total	11,691,355	1,237,015	10,454,340	
Process agent II: Total approved US $46,500,000 (World Bank)				
Capacity building for local EPBs	288,357	0	288,357	2018
Research on ODS substitution and development of trends of alternative technologies	33,200	33,138	62	2018
CTC residue disposal	5,445,970	0	5,445,970	2018
Study on production of CTC and its use for feedstock applications	100,000	10,853	89,417	2018
Monitoring, management and post evaluation	1,605,050	146,329	1,458,721	2020
Total	7,472,577	190,050	7,282,527	
PU foam: Total approved US $53,846,000 (World Bank)				
Screening and evaluation of CFC-free substitutes and development of new substitutes	270,935	0	270,935	2018
Additional provincial foam activities (capacity building for 11 provinces)	760,532	269,720	490,812	2018
Technical service for the foam enterprise for better application of new alternatives	375,377	0	375,377	2018
Continue monitoring of CFC phase-out in the foam sector	580,824	210,451	370,373	2018
Project monitoring and management	174,278	26,377	147,901	2018
Total	2,161,946	506,548	1,655,398	
Refrigeration servicing: Total approved US $7,884,853 (Japan, UNEP, UNIDO)				
Ongoing activities (e.g., eight training centres, training on disposal ships sector, Shenzhen demonstration project)	138,648	129,524	9,124	2018
Training programmes for ICR/RAC sub-sectors	737,168	215,185	521,983	2018
Research on leakage of refrigeration during R-290 RAC servicing and operation	432,788	120,882	311,906	2018
Data survey	165,434	84,882	80,552	2018
Monitoring and management	95,846	0	95,846	2018
Total	1,569,884	550,473	1,019,411	
Solvent sector: Total approved US $52,000,000 (UNDP)				
Combating ODS illegal activities: capacity building for 10 local customs offices	413,305	(109,460)	522,765	2017
Capacity building for ODS-related personnel in 14 provinces	642,500	302,500	340,000	2018
Public awareness and publicity activities	139,744	139,744	0	2018
Alternative technology assessment and research	207,083	207,083	0	2017
Electronic file management system	53,663	(38,644)	92,307	2018
Activity management and monitoring	522,003	272,533	249,470	2018
Total	1,978,298	773,756	1,204,542	

6. The progress reports included disbursement as of 31 August 2018. Financial audits of the disbursements as of 30 June 2018 were conducted by Daxin Certified Public Accounts LLP according to national standards. The audit opinion was that the grant and expenditure statements for the CFC production, halon, CTC process agent, polyurethane foam, solvent and refrigeration servicing sectors were in compliance with the rules of the Montreal Protocol and the accounting standards of China and had been fairly and justly presented by the Foreign Economic Cooperation Office/Ministry of Ecology and Environment (FECO/MEE) of China.

7. The activities implemented in each sector plan since 1 July 2017 are summarized below.

CFC production sector

8. Since 2015, the only remaining activities in the CFC production sector plan are in research and development (R&D) of ODS alternatives, and supervision and management. A total of US $402,414 has been disbursed since the 80th meeting, and the remaining funding of US $619,853 is expected to be disbursed by the end of the year.

9. Regarding R&D of ODS alternatives, thirteen proposals have been selected, of which nine have been completed. Of the remaining four projects, three have completed all activities but not all the funding has been disbursed, while the last project (at Beijing University of Chemical Technology on a new production process of HFO-1234yf and HFO-1234ze in laboratory) is still ongoing and is expected to be completed by December 2018.

10. A total of US $233,411 had been allocated to supervision and management. FECO has disbursed US $33,646 to produce video training materials for ODS import and export management. The balance will be used by FECO to purchase instruments for ODS monitoring for local environmental protection bureaus (EPBs) to build their capacity and achieve sustainable CFC phase-out compliance.

Halon sector

11. A total of US $1,237,015 was disbursed between the last progress report and 31 August 2018. In 2014, FECO prepared a plan to develop the national halon recycling and management system (NHRMC), and the remaining funding of the halon sector was entirely designated to support this program. Between 2015 and 2016, FECO established the NHRMC in cooperation with the certification center for fire products within the Ministry of Public Security. In 2017, the NHRMC publicized halon recycling in Shanghai, and worked with the government and the private sector to encourage halon recycling. Based on the experience gained in the last three years and feedback received, in 2018, NHRMC and FECO redesigned the work plan, started a project to develop an information management system and recycled 1.5 tonnes of halon-1301 from Tianjin and Jiangsu. Part of the remaining funding will be used for the purchase of equipment for stations, centers and local fire-fighting bureaus to analyze halon product components and identify their purity during recycling.

12. FECO is currently selecting qualified enterprises to undertake the establishment of a halon-1211 recycling center. The project is estimated to start in 2019 and be completed in 2020. In the meantime, FECO will provide assistance to the enterprise Zhejiang Dongyang chemical Co., Ltd to ensure the safe storage of 2,261.4 tons of halon-1211. FECO and NHRMC plan to organize the policy and regulation research for halon recycling in 2019.

13. NHRMC and FECO are committed to exploring the feasibility of international cooperation on halon recycling and disposal, to assist other Article 5 countries in achieving the compliance target. In the next few decades, HFC fire-fighting products have the potential to become the main substitute for halon products. Considering that the Kigali Amendment will gradually reduce the production and consumption of HFC,

relevant experience learned from the establishment of NHRMC could be adapted to HFC recycling, reclaiming, recovering and disposal.

Process agent II

14. A total of US $190,050 was disbursed between the last progress report and 31 August 2018. Six EPBs working with producers of CTC and other ODS received assistance to set up ODS management offices, establish specialized channels for enterprises to report ODS data, and undertake on-site inspections of enterprises. The project has been completed and the last payment will be disbursed by the end of 2018.

15. A CTC residue disposal project is being implemented to support CTC by-producers in the disposal of their distillation residues from CTC refining and conversion facilities. Contracts for US $4.6 million in total were signed with nine enterprises for the construction of incinerators (3), the upgrading of existing incinerators (2), the construction of residue reduction devices (2), and for operation costs subsidies (2).

16. As per the requirements of decision 75/18 of the Executive Committee, a study on China's production of CTC and its use for feedstock applications was launched in March 2018. Questionnaires for methane chloride production enterprises (CTC by-producers) and CTC feedstock use enterprises have been designed and were distributed in July. On-site investigations at the enterprises are being carried out, and a report assessing current emissions from CTC production and the feedstock usage is under preparation. The results of this project are expected to be delivered by the end of November 2018.

17. The Government of China proposed to allocate US $1,200,000 for long-term monitoring and management, including purchase of ODS detectors for local EPBs, regular investigation of CTC producers and feedstock users, encouraging enterprises to develop and produce reagents to replace CTC, and training and capacity-building for local customs and EPBs.

18. Decision XXIII/6 specifies that after 31 December 2014, the use of CTC for the testing of oil in water would only be allowed under an essential use exemption. In 2017, China announced its commitment to phase out the use of CTC for laboratory testing of oil in water by 2019. In January 2018, FECO signed a contract with Tianjin Eco-Environmental Monitoring Center to develop alternative testing standards. Technical ways of replacing CTC with n-hexane have now been determined, and three national standards have been developed and were expected to be released in September 2018.

19. In addition, two projects have been launched to strengthen capacity building for sustainable compliance with the Montreal Protocol. One project is the design and construction of an ODS online data reporting information system (stage II). The online system will incorporate data on all ODS varieties and will join the online filing and approval function. The other project is capacity building for customs in the area of supervision and management of ODS. ODS detectors will be procured as part of the project to prevent potential illegal ODS import and export.

PU foam

20. A total of US $506,548 was disbursed between the last progress report and 31 August 2018. Ten research activities implemented in the PU foam sector were completed during the first half of 2018. These proposals had been selected to support the development of formulations with zero-ODP and low-GWP blowing agents at low prices that could be used by small and medium-sized enterprises (SMEs), and formulations of pre-blended polyol systems to optimize the stability, performance and insulation properties of foam products.

21. In June 2018, a spray field test was completed at a construction site in Hebei province with HFO as the blowing agent. The field test sprayed over 2,350 m^2 for domestic buildings. Dimensional stability,

insulation performance, and other relevant foam properties will be assessed in the winter under low ambient temperature.

22. In December 2014, FECO signed contracts with four systems houses that established production capacity for water-blown based pre-blend polyols by installing production facilities and laboratory equipment, and through trials and testing of the new formulations. Currently, the systems houses are providing technical services to downstream foam enterprises and have sold over 2,000 mt of alternative pre-blended polyols to downstream users including SMEs. The four projects were completed in June 2018.

23. FECO also signed contracts with EPBs in 11 provinces/cities aimed at enhancing public awareness of ozone layer protection, strengthening sustainable compliance capability, and ensuring that no CFCs or other controlled ODS would resurge post 2010. Up to the reporting date, the 11 local EPBs had fulfilled the goals and conditions as per required in the contract. The projects have strengthened the knowledge, management and enforcement capacity of these 11 regions, and promoted awareness of the national ODS management regulations. The 11 EPBs expect to complete the projects in December 2018.

24. The Government has issued the Regulations on ODS Management and the Circular on the Management of Construction of Facilities Producing or Using ODS, and has taken other policy actions to prohibit the re-use of phased out CFCs and enforce the controls on HCFCs. However, the foam sector contains a large number of enterprises with various applications. Therefore, FECO has continued monitoring activities through contracts with five provinces (i.e., Hebei, Henan, Shandong, Si Chuan and Tianjin), where the majority of systems houses and foam enterprises are located, to visit chemical dealers, systems houses, and foam enterprises to collect samples of blowing agents, pre-blended polyol systems, and final foam products. Over 420 foam enterprises and systems houses have been visited, and over 780 foam and raw material samples have been collected. According to the preliminary test of the samples, there is a small percentage of those samples suspected of probably containing phased out CFC/HCFC. The project implementers are sending suspicious samples to certified labs for further analysis and are screening the results. Once the suspicious samples are confirmed, the violators will be punished according to relevant rules and regulations.

25. The Government considers that the monitoring activities have effectively enforced the established policy system. However, the efficiency of inspection and monitoring of the foam sector can be hindered by the number of subsectors and system houses, inadequate knowledge on the part of inspectors regarding foam production, and an insufficient number of blowing-agent detectors (not all cities and counties have them). In addition, the regulations on ODS management are concise and do not provide detailed instructions on dealing with each specific situation that may arise, leaving things up to provincial policy and EPB interpretation. Moreover, the alternative technologies have not penetrated the sector and higher costs undermine the willingness of SMEs to convert to zero-ODP, low-GWP alternatives. These challenges are well noted by FECO and MEE, which will continue providing technical support to local EPBs and environmental monitoring branches via different channels.

<u>CFC refrigeration servicing sector</u>

26. A total of US $550,473 was disbursed between the last progress report and 31 August 2018. All of the 13 training centers established by FECO in 13 cities to implement vocational training courses for servicing technicians have completed their projects. As of August 2018, more than 4,100 technicians, trainers and students had been trained (three of the centres have completed the training programme). In 2017-2018, FECO conducted site visits and issued final reports for all 13 training projects.

27. By the end of 2018, an additional 500 technicians will have been trained in the two additional training centres contracted in 2017. In 2018, FECO signed contracts with three additional training centers for training in good refrigeration practices, undertook research on refrigerant leakage control during the operation and

servicing of R-290-based air-conditioning systems; and continued the two surveys on the disposal-ships sector and on the cold chain in supermarkets, which will be finished by the end of 2018.

28. Monitoring and management activities (including consultancy, training, evaluation and verifications) will be conducted by FECO to achieve sustainable compliance with CFC phase-out.

Solvent sector

29. A total of US $773,756 was disbursed between the last progress report and 31 August 2018. As of August 31, 2018, 3,800 officers from ten customs offices had received training on ODS-related issues and each customs office that had made ODS checking part of its regular work received testing equipment. As of 30 June 2018, more than 5,000 local EPB officers had received training on ODS-related policies, and over 18,000 people had participated in public awareness activities. Local EPBs organized more than 30 on-site inspections of ODS enterprises. EPBs are finishing completion reports and will receive the final payment by the end of 2018.

30. FECO, with the support of Peking University, finished the report "Analysis on the impacts of ratification by China of the Kigali Amendment on HFC management." Research on alternative technologies and on silicone oil optimization at five institutions[8] was completed. Management and monitoring activities, including on-site verifications, monitoring audits and project evaluations, continued to be implemented.

Interest accrued

31. Table 2 presents the amount of interest collected.

Table 2. Interest reported from the sector plans in China (US $)

Sector	1 July 2017 - 30 June 2018	1 January 2010 - 30 June 2018
CFC production, halon, process agent II, and PU foam	2,837	21,109
Refrigeration servicing	5,574	93,565
Solvent	11,364	325,636
Total	**19,775**	**440,310**

32. As in past reports, the interest accrued for the solvent sector is significantly higher than that accrued for other sectors, as interest from RMB accounts is higher than interest from US dollar accounts.

Secretariat's comments

Overall progress

33. At the 80th meeting, the implementing agencies provided reassurance that the funding balances associated with each of the sector plans would be fully disbursed by the end of 2018 and that the project completion reports would be submitted to the first meeting of the Executive Committee in 2019. Subsequently, the Executive Committee noted with appreciation *inter-alia* that the Government of China had confirmed that all activities associated with each of the sector plans would be completed by the end of 2018, that relevant research and technical assistance reports would be submitted to the last meeting of 2018, and that the project completion reports would be submitted to the first meeting of the Executive Committee in 2019 (decision 80/27(c)).

[8] Beijing Yuji, Dongyang Weihua, Shanghai Xilikang, Quzhou Sancheng and Huaxia Shenzhou.

34. Furthermore, during the 80th meeting, the Committee held informal discussions on the issue of the return of balances, and in reporting the outcome of those discussions, one member, supported by another member, said that, while the request for the return of the outstanding balances to the Fund had been withdrawn, in his view and in the view of others, outstanding balances should in principle be returned to the Fund or offset against future approvals, and the issue of the return of balances should be revisited at a future meeting of the Committee (UNEP/OzL.Pro/ExCom/80/59).

35. The progress reports submitted to the 82nd meeting indicate that the commitment to complete all activities by the end of 2018 has not been fulfilled in several of the sector plans, and some sector plans are proposed for extension to 2020 (process agent II) and to 2022 (halon). It is also noted that all other sector plans with the planned completion date of December 2018 (CFC production, PU foam, servicing, solvent) have balances, which are planned for disbursement in 2019. Out of the balance of US $25.89 million, as of 30 June 2017, only US $4.13 million (16 per cent) had been disbursed. The current balance of US $22.24 is still only 43 per cent of the total balance of US $52 million available in 31 December 2009.

36. The Government of China noted the points raised above, and emphasized that there was no specific decision or requirement to return funds, further stating that the remaining funds are necessary to achieve the overall goal of permanent and sustainable phase-out and have been programmed accordingly. In addition, the Government of China indicated that:

(a) All substantive activities in the CFC production, PU foam, refrigeration servicing and solvent sectors will be completed as scheduled by December 2018 and final disbursements will be made in 2019 after satisfactory completion of the activities by December 2018;

(b) The major reason for non-completion of the halon sector activities is that from 2014 to 2018, FECO focused on building the foundation and gradually developing the national halon recycling and management system. FECO summarized the lessons learned from the demonstration project of the halon bank (2008-2013) and set up a strategic plan that established the halon recycling system in 2014. After four years of efforts, the national halon recycling and management system is established and in operation;

(c) There were three main reasons for the non-completion of the process agent II sector plan. First, as CTC residue disposal is also controlled by the hazardous waste management system in China, FECO first completed the feasibility analysis before the project was launched, including site visits with experts to the CTC by-producers and hazardous waste disposal centers, and several rounds of discussion with the key provincial EPBs. Second, building the capacity of local EPBs is a long-term project under which the local EPBs were required to carry out numerous activities and to meet the relevant milestones. Finally, CTC, as a by-product of chloromethane (CM) plants, will continue to be generated, and it is expected that its use as a feedstock will continue in the future. Hence, continued long-term monitoring of the production and use of CTC is always required. And it is necessary for MEE to improve and refine the regulations.

Monitoring sustainability of the phase-out

37. Each sector plan allocated funds for activities the Secretariat considers would contribute to the sustainable, long-term monitoring of the phase-out, including supervision and management, activities related to information management, capacity building for EPBs, and other activities. At the Secretariat's request, the Government of China provided additional information on how the activities undertaken would contribute to the sustainable, long-term monitoring of the phase-out. The input provided by the Government of China and the Secretariat's comments are below.

CTC production sector and the process agent sector

38. The Government indicated that CTC continues to be co-produced at chloromethane (CM) plants (together with methyl chloride, methylene chloride and chloroform) where the ratio of CTC produced is reduced as much as possible. CTC is still used for feedstock by a number of chemical producers, for process agent (PA) applications where CTC emission control is applied, and for laboratory uses as allowed by the Parties to Montreal Protocol, governed by China's registration and quota system. In order to ensure that CTC production and consumption is limited within the amount allowed by China, CTC consumption quotas for laboratory uses and PA applications are issued by the MEE/FECO to relevant enterprises. Each CTC feedstock user is required to be registered in MEE/FECO. Qualified CTC producers are allowed to sell CTC to the CTC users with consumption quota or registration. Any excess CTC produced by qualified producers has to be converted to methylene chloride/perchloroethylene (MCl/PCE) or incinerated. Hence, continued monitoring of the production and use of CTC, and reporting of CTC production /consumption data to MEE/FECO, and regular inspection by local EPBs is required.

39. In order to strengthen the daily monitoring of CTC producers by both MEE and local EPBs, the CTC online monitoring system is planned to be restarted and upgraded. An online monitoring platform is to be set up, through which MEE and local EPBs would get real-time data from the CTC producers.

40. As identified during implementation of the CTC production phase-out plan, residues containing CTC are generated with CTC production. If not incinerated, or entrusted for incineration, there is a risk that CTC could be recovered and sold for illegal uses. In order to reduce the risk, incineration facilities at nine CM plants have been funded by FECO and the local EPBs will have to monitor disposal of CTC residues.

41. In 2017, China announced its commitment to phase out the use of CTC for laboratory testing of oil in water by the year of 2019. In order to replace CTC with a non-ODS extracting agent in oil in water tests, research, tests and analysis have been completed by MEE, through which ways for replacing CTC have been determined and the relevant national standards are expected to be released in the near future. Given that replacing CTC is not only a technical issue, MEE will continue to carry out relevant training and advocacy for alternative technologies and launch a project to encourage enterprises to improve the quality of the alternative reagent to replace CTC in laboratories.

42. The Government also indicated its understanding that the remaining funds could also be used for any new process agents the Parties might decide to add to the list of process agents controlled by the Montreal Protocol.

43. Understanding these challenges, China sees the need to extend the program beyond 2018 and continue to use the funds to ensure the sustainability of the phase-out of CTC for controlled uses.

44. The Secretariat noted with appreciation the proposal to allocate US $1,200,000 for long-term monitoring and management for the sector. While supporting the allocation of funding for this purpose, the Secretariat noted the substantial level of funding and sought to better understand how the activities that would be funded would relate to those already undertaken. The Secretariat also sought clarification on how CTC producers obtain their qualification; how users become registered, and whether such registration would be restricted to users with a demonstrated PA application, feedstock use, or laboratory use; whether and how FECO allocated a quota for CTC; additional information related to the online monitoring system, including when it is expected to be operational; and whether all chloromethane plants were required to have and operate an incinerator to dispose of CTC residues.

45. The Government of China informed that there are 15 chloromethanes (CMs) producers with co-production of CTC and other CMs. Only three out of the 15 CMs producers are allowed to sell CTC to registered users with an annual quota from FECO for feedstock, laboratory, and PA uses only. Only

CTC producers that have a production quota before 2007 are allowed to sell CTC. MEE/FECO reviews their status annually.

46. In total, there are eight enterprises for laboratory use and PA use that is required to apply for annual procurement quota to MEE. For 2017, MEE issued 395 mt quota to these eight enterprises. For feedstock users, MEE performs annual registration management. The CTC feedstock user applying for registration must submit the necessary approval documents, including an environmental impact assessment (EIA). FECO announces the registration results on its website after reviewing the submitted documents to confirm the feedstock use and the quantity of CTC, which cannot exceed the approved capacity of the feedstock facility in the EIA document. The registration specifies the type of product to be produced using CTC and quantity of CTC.

47. In China, the CTC residue disposal is required to comply with the hazardous waste management regulations, which is a different regime from ODS regulations. According to the current policy, CMs producers could choose to dispose the CTC residue at their own disposal facilities with EIA approved by local EPBs, or send the residue to a qualified hazardous waste disposal centre. The producers are required to report the amount of residue produced, disposed, and stored to local EPBs. In addition, in-house disposal facilities are monitored by local EPBs to ensure compliance with the national discharge standard and the requirements of the approved EIA.

48. The local EPBs inspect all CTC producers and registered users in areas under their jurisdiction. According to the current regulations, there is no mandatory requirement for inspection frequency, but in practice it is at least once a year. Local EPBs inspect distributors that store CTC onsite. Regular inspection of CTC producers and feedstock users will continue after the funding has been exhausted and the project completed.

49. The CTC on-line monitoring system was shut down in 2015 due to a technical issue. That system only covers CMs producers under the CTC sector plan but not the new CMs producers, and so MEE/FECO has been working to find ways to expand the CTC on-line monitoring system to all CMs producers.

50. US$ 1.2 million proposed for long-term monitoring and management will be implemented by FECO, and according to the preliminary plan, the activities will include investigations of CTC producers and feedstock users; purchase of CTC detectors for local EPBs to strengthen its verification capacity; encourage enterprises to develop and produce alternative reagents to replace CTC; regular training for CTC by-producers, dealers, users; and upgrade and operationalize the existing online CTC monitoring system.

51. The Executive Committee had invited the Government of China to undertake a study on its production of CTC and its use for feedstock applications and to make the results of the study available to the Executive Committee by the end of 2018 (decision 75/18(b)(iii)). At the time of finalization of the present document, the Secretariat had not yet received the study. The Secretariat will make that study available to the Executive Committee as soon as it is available.

CFC production phase-out

52. The Government indicated that, as found in recent atmospheric monitoring results, it appeared that there is some production and emission of CFCs, especially CFC-11. As all the known CFC production facilities were dismantled as part of the CFC Phase-out Sector Plan and FECO had visited all the previous producers of CFCs and found that none of them had restarted CFC production, any CFC production would come from illegal production facilities set up without permits. The Secretariat notes that the verifications

submitted in line with the CFC production phase-out sector plan included photographic and video evidence demonstrating that key equipment had been destroyed or rendered unusable.

53. In order to identify any illegal CFC production, the monitoring of CTC production will be strengthened as indicated under the PA project. In addition, FECO proposes to expand the provincial atmospheric monitoring program in some provinces where illegal production might take place.

54. Production of CFC requires CTC and anhydrous hydrogen fluoride. Noting that monitoring the use of anhydrous hydrogen fluoride would be difficult, the Secretariat considers that strengthened monitoring of CTC production will be a key step in preventing future illegal CFC production. Similarly, the Secretariat considers that the proposal to expand the provincial atmospheric monitoring program would be invaluable in detecting and deterring future illegal CFC production. The Secretariat enquired whether the current provincial atmospheric monitoring program already included instruments to observe CFCs and CTC, and how it would be expanded.

55. The Government informed that the provincial atmospheric monitoring program, dedicated to monitor CFC and CTC, was implemented at a pilot scale in five cities under a contract with Peking University. Samples were taken on a weekly basis, but it was not possible to develop meaningful analytical results due to limited implementation scope. To ensure sustainability of ODS monitoring, MEE is considering to include CFC, CTC, and other greenhouse gases in the list of air pollutants requiring regular monitoring by China's air quality monitoring network. It is not yet known when China’s air quality monitoring network will be able to do so.

PU foam sector

56. The Government indicated that while it assumed that CFC-11 had been phased out, it is now known that some CFCs might be illegally produced and used as blowing agents in the PU foam sector. In order to monitor what kind of blowing agents are used and to identify potential illegal use of CFC-11 in the PU foam sector, the inspection capacity of local EPBs has been strengthened. However, increased monitoring of PU foam manufacturers and foam systems houses is still needed. Hence, the Government considers that the continuation of the monitoring program beyond 2018 is needed until China’s funding is fully exhausted.

57. In addition, although there is extensive, ongoing monitoring of foam enterprises that converted from CFC-11, including sampling of foam for analysis of the foam blowing agent content, the Government recognizes that there could be a gap in CFC-11 monitoring if all applications are not addressed beyond foam. Accordingly, China and the implementing agencies plan to coordinate monitoring between sectors.

58. The Secretariat emphasized the need to ensure the sustained phase-out of CFC-11 even after the funding under the PU foam sector plan was exhausted, and noted that 420 foam enterprises and systems houses have been visited in five provinces, and over 780 samples of raw material have been collected for analysis. With regard to the small percentage of samples suspected to contain CFC-HCFC, the Secretariat asked if the analysis by the certified labs confirmed use of CFC and, if so, in what proportion and what relevant rules and regulations would apply to enterprises using it.

59. The Government informed that the enterprises that have samples containing CFC-HCFCs are under investigation and hence under the joint mandate of the local EPB and Public Security (local police). The results were expected to be released to the public by the end of October. The Secretariat followed up on the results but no information has been made available yet.

60. On the relevant rules and regulations that would apply to enterprises using banned ODS, the Government indicated that so far, three enterprises had been detected illegally using CFC-11, and had been subject to the punishment set out in accordance with ODS management regulation.

61. The Secretariat notes that the use of HCFC-141b by an enterprise that committed to phase out may be subject to an enforcement action according to local regulations. However, in the case of CFC-11, it would have to be determined whether the origin is stockpile, recycled gas from previous uses (e.g., chillers) or production after the total phase-out deadline, which would potentially incur a penalty for non-compliance with the Agreement for CFC production and perhaps the Agreement for CFC consumption. This would require further analysis.

Solvent sector

62. For the solvent sector plan, the Government indicated that to further strengthen sustainable, long-term monitoring of the phase-out in the solvent sector, FECO supported local EPBs to monitor ODS activities and control illegal ODS production and use in their province. In addition, some local EPBs had established long-term mechanisms by issuing ODS management policies and effectiveness assessment requirements for ODS management officers. Also, by supporting the development of implementation techniques for the solvent sector, several experts had been trained to provide long-term and effective support for the sustainable, long term monitoring of the phase-out. The Secretariat noted that those activities were helpful but that it was still unclear how these actions, in particular the latter, would help ensure the sustainable, long-term monitoring of the sector.

Servicing sector

63. The Government indicated that the technical assistance projects on research into servicing leakage and the data survey are closely connected to HPMP implementation. The research on leakage of refrigerant during R-290 RAC servicing and operation is part of research into alternatives. The data survey in the supermarket sub-sector is connected with promoting good servicing practices in that sub-sector. The Secretariat noted that those activities were helpful but not related to ensuring the sustainable, long-term monitoring of the sector.

Halon sector

64. The situation for the halon sector is somewhat different from other sectors as there is a continued demand for halon-1211 and halon-1301 for uses where alternatives are not available. Those applications are supposed to be met by recovered and recycled halons until alternatives are available. The halon recycling program was an essential element in the halon sector plan. The China halon sector plan also includes halon banking as a key component. The implementation of the halon banking component has been delayed as reported.

65. The Government considers that the risk of illegal production of halon-1211 is very low given the large stock of halon-1211 produced before the total phase-out and the minimal annual demand of 20 to 30 mt/year. The remaining stock of halon-1211 is at one former halon-1211 producer. The Government of China proposes to either move all or part of it so it can be stored under safe and controlled conditions, or to destroy/convert some of it. China believes that this is important to avoid the emission of over 2,200 mt of halon-1211.

66. In contrast, halon-1301 is still produced solely for feedstock use; such newly produced halon-1301 is not added to stocks but is instead used exclusively as a feedstock. The Government assumes that the demand for controlled uses of halon-1301 is covered by existing stocks, and that halon-1301 is recovered from dismantled fire-protection installations and reclaimed for applications where no alternatives exist yet. There is a continued demand for halon-1301 for existing fire extinguishing systems where no other alternatives can be used due to safety issues, and for civil aviation, where there are still no alternatives available for certain

aircraft fire suppression systems. Civil aviation is expanding globally, especially in China, with an expected annual growth of over 10 per cent over the next 5 to 10 years.

67. There are two issues related to halon-1301. First, halon-1301 is still being produced[9] for feedstock use by one producer and sold to eight producers of fipronil (a pesticide). Hence, it is essential to ensure that all newly produced halon is sold to those eight enterprises and that they are using it as feedstock for fipronil and not selling it for other uses. The second challenge is to ensure sufficient supply of halon-1301 to the remaining users with no approved alternatives, especially civil aviation. The Government considers that in order to avoid the need for production for essential use, it is clear that as of today, the demand can only be met by halon-1301 recovered from the market. Hence, continuation of the halon-1301 recycling programme is essential to ensure supply of halon 1013 and avoid the risk of illegal production.

68. The Secretariat agrees that the halon recycling programme is a valuable element in ensuring continued supply of halon-1301. However, the Secretariat was not clear how the Government of China intended to ensure the long-term, sustainable monitoring of the halon phase-out after completion of the project.

Financial issues in specific subsectors

69. With regard to the CFC production sector plan, the Secretariat noted that a contract for US $112,153 was signed for the production of a video on ODS basic knowledge, progress in the implementation of the Montreal Protocol and necessary implementation skills for enforcement officers and ODS dealers. In explaining how this activity is related to the CFC production sector and how it will enhance the sustainable monitoring of the phase-out, the Government explained that the series of video textbooks will be used by the customs department during the management of ODS import and export training aimed at improving the supervision ability of customs staff, and improving the performance knowledge of on-campus customs officers. It will also train enterprises engaged in ODS import and export to comply with the requirements of ODS management, in order to enhance the training sector's ODS compliance awareness, management skills and management level.

70. In relation to PA II, in August 2018 contracts for US $4.6 million were signed with nine enterprises for the construction of three incinerators, the upgrading of two existing incinerators, the construction of two residue reduction devices, and for operation cost subsidies in two cases. Given that the enterprises will receive the first installment of 80 per cent of the contract value by the end of 2018, the Secretariat requested clarification regarding the milestone that the enterprises need to achieve to receive the funding and asked whether this was a retroactive project. The Government explained that these are investment projects to be completed by 2019 (not retroactive) and that the milestone for the first payment is completion of the upgrade or establishment of the disposal facilities. The enterprises involved must bear most of the cost of establishing or upgrading the facilities, with FECO only providing a small portion of the funds to encourage the internal disposal of the CTC residues. This project is aimed at encouraging CTC producers to dispose of their CTC residue internally instead of sending it to other disposal centers or even selling it to be re-used. The Secretariat notes that such sale would be considered consumption.

Research and technical assistance reports

71. On the expected impact of the technical assistance provided with these balances on the implementation of the HPMP sector plans, the HPPMP, and the phase out of HCFCs, the Government affirmed that technical assistance is necessary in the CFC PU foam and CFC production sectors to ensure that manufacturers using alternatives and producers of alternatives to CFC continue to have the best technical options available to them as the market evolves. In particular, the goal is to prevent those enterprises that have

[9] As noted in UNEP/OzL.Pro/ExCom/82/SGP/03, HFC-23 is used as a feedstock during the production of halon-1301.

chosen ODS alternatives from defaulting to HCFCs if they have experienced challenges with other alternatives.

72. In the past four years, the solvent sector plan supported research and several studies, including research and development for alternatives with zero-ODP and low GWP. Two new alternatives (HC solvent, solvent-free silicon oil) had been chosen by solvent enterprises to replace HCFC-141b during phase-out implementation, and the other three alternatives are at the stage of preparing related qualified certification for more applications. The goal of this research and these studies is to provide sustainable technical solutions to industry, and to try to prevent them from using HCFCs when they encounter any technical challenges.

73. The progress report of the PU foam sector included interesting abstracts of the studies completed, mostly on the performance of alternatives. Taking into consideration that the studies have taken place with Multilateral Fund assistance, the Secretariat requested the complete reports of the research activities in all sectors in order to consider how they could be disseminated. FECO noted the Secretariat's request for submission of the relevant reports, and indicated that it would communicate with the institutions to confirm whether there is confidential information that cannot be disclosed.

Secretariat's recommendation

74. The Executive Committee may wish:

(a) To note:

(i) The financial audit reports for the CFC production, halon, polyurethane (PU) foam, process agent II, solvent and servicing sectors in China, contained in document UNEP/OzL.Pro/ExCom/82/20;

(ii) That the funding balances associated with each of the sector plans had not been fully disbursed by the end of 2018;

(iii) That research and technical assistance reports **of the relevant sector plans** had not been submitted to the last meeting of 2018, as per decision 80/27(c);

(iv) That the Government of China has confirmed that the PU foam, CFC production, solvent and servicing sector plans will be completed in 2018, the balances will be **disbursed** between 2018 and 2019, and the project completion reports will be submitted to the first meeting in 2020;

(v) **The extension of the date of the completion of the process agent II sector plan to 31 December 2020, and the halon plan to 31 December 2022;**

(b) To request the Government of China, through the relevant implementing agency:

(i) **To use the remaining balances still available for each one of the sector plans to strengthen local institutions to undertake permanent monitoring of the sustained phase-out of the controlled substances addressed in each sector plan once they are financially completed**;

(ii) To submit to the 83rd meeting, a proposal for the establishment of a monitoring system that would ensure the long term sustainability of the phase-out of controlled uses of CFCs, CTC, methyl bromide, and halons in the consumption and production sectors, **after the sector plans are financially completed** in light of any guidance provided by the Executive Committee at the 82nd meeting;

(iii) To report to the 83rd meeting, on the results of the analysis of samples of foam and raw material collected from foam enterprises and systems houses on whether controlled substances already phased out are being used, including the legal measures applied to the enterprises **that were found to be** in non-compliance; and

(iv) To submit the completed research and technical assistance reports undertaken in all **sector plans, for** dissemination to other Article 5 countries.

PART II: METHYL BROMIDE (MB) PHASE-OUT PROJECTS

75. Part II contains a report on the critical use exemptions of MB for Argentina; phase II of the national plan for the phase-out of MB in China; and the sector phase-out plan of MB production in China.

MB phase-out plan in Argentina (UNIDO)

Background

76. At the 30th meeting, the Executive Committee approved the project for the phase-out of MB in strawberry, protected vegetables and cut flower production in Argentina, and at the 36th meeting, the Executive Committee approved the project for the phase-out of MB for soil fumigation in tobacco and non-protected vegetable seed-beds. The Agreement between the Government of Argentina and the Executive Committee was subsequently modified at the 45th meeting of the Executive Committee. While the Agreement explicitly excluded quarantine and pre-shipment (QPS) applications from the targets for national MB consumption, the Agreement did not include an exclusion for critical-use exemptions (CUEs) the Parties to the Montreal Protocol may authorize and instead specified zero national consumption of MB by 2015. The Parties authorized CUEs for Argentina at the 26th, 27th, 28th and 29th Meetings of the Parties for use in 2015, 2016, 2017 and 2018, respectively.

77. Argentina reported MB consumption of 57.00 ODP tonnes in 2017 which was below the authorized CUEs of 61.76 ODP tonnes for that year. Accordingly, the Secretariat considers that the level of consumption of MB for Argentina in 2017 was zero, as the maximum level specified in the Agreement, except for any CUEs approved by the Parties.

Secretariat’s recommendation

78. The Executive Committee may wish to note that the level of consumption of methyl bromide for Argentina in 2017 was zero, as the maximum level specified in the Agreement between the Government and the Executive Committee, except for any critical-use exemptions approved by the Parties to the Montreal Protocol.

Phase II of the national plan for the phase-out of MB in China

Progress report

79. On behalf of the Government of China, UNIDO submitted the 2017 – 2018 progress report for the methyl bromide (MB) phase-out plan, which included the following components: management of MB for critical uses exemptions (CUEs); optimization of soil disinfestation systems; and establishment of a sustainable performance management system.

80. The Parties authorized CUEs for MB for China for 2017 (92.977 metric tonnes (mt), 65.08 ODP tonnes)[10] and 2018 (87.24 mt, 61.08 ODP tonnes).[11] China reported MB consumption in 2017 under Article 7 of the Montreal Protocol below the amount authorized for the CUEs (54 ODP tonnes).

81. For 2017 and 2018, the Rural Environment and Energy Conservation Station of Shandong Province was commissioned to develop a tracking system to ensure that MB consumption would not exceed the CUEs for those years; an annual monitoring report on the usage of MB would be prepared to confirm that the CUE allocations for open field and protected cultivation ginger are tracked and used only in areas with high rates of soil-borne disease.

82. The Institute of Plant Protection of the Chinese Academy of Agricultural Sciences (IPP-CAAS), completed the soil disinfection technology evaluation for ginger. The report on the technologies for integrated soil-borne disease prevention and control, and the evaluation of technologies for strawberry and tomato will be completed in December 2018.

83. Alternative technologies such as chloropicrin, dazomet, metham-sodium and dimethyl disulfide, were adopted for ginseng and yam crops. Training on these technologies was provided, field visits were conducted for agricultural departments, technicians and growers. Reports and a documentary film on soil disinfection were published and broadcasted, and a project brochure will be completed in 2018.

84. Capacity building included the recruitment of four new officers responsible for project management of the MB sector plan, supervision of project sub-contractors, review of reports, and preparation of progress reports. In addition, 120 participants from local agricultural departments were trained in soil disease occurrence for ginseng, current situation of soil disinfection technology and its applications, and shared experiences gained from field visits.

Financial report

85. Of the total amount of US $926,958 approved for the last tranche, US $807,058 had been disbursed; the balance of US $119,900 will be disbursed by December 2018.

Implementation plan for 2018 – 2019

86. The project is expected to be completed by the end of 2018. UNIDO has submitted the workplan and budget for October – December 2018, as shown in Table 3.

Table 3. 2018 budget (US $)

Activities	Budget (US $)
Management of CUEs of MB	14,355
Optimization of soil disinfection technical system	7,177
Sustainable performance capacity building	60,062
Project management	38,306
Total	**119,900**

[10] Decision XXVIII/7
[11] Decision XXIX/6

Comments

87. The Secretariat noted that the Government of China continues to control the use of MB within the country, and that the consumption of MB has been within the amounts approved for CUEs.

88. In discussing the work plan for the MB consumption sector plan, the Secretariat reiterated decision 77/8(c)(ii)[12] and reminded UNIDO that the project cannot be extended beyond December 2018. UNIDO confirmed that the work plan provided would be implemented by this time, except for a final payment to be made in February 2019 to the institute contracted to monitor the CUE uses in China. This payment will be made only after confirmation of total MB consumption at the end of the year, and after submission of a final report by the end of December 2018. After discussion with UNIDO, there was an understanding that the MB consumption sector plan will be fully completed by the end of 2018.

Recommendation

89. The Executive Committee may wish:

(a) To note the progress report on the implementation of **phase II of the national plan for the phase-out of** the methyl bromide (MB) in China submitted by UNIDO, contained in document UNEP/OzL.Pro/ExCom/82/20;

(b) To note that the maximum level of consumption of MB for China in 2017 was zero, as in the Agreement between the Government and the Executive Committee, except for any critical-use exemptions approved by the Parties to the Montreal Protocol; and

(c) To request the Government of China and UNIDO to submit to the 83rd meeting the final report **of phase II of the national plan for the phase-out of MB** in China, to return any balances to the Multilateral Fund, and to submit the project completion report, no later than the 84th meeting.

Sector phase-out plan of MB production for China (UNIDO)

90. UNIDO, on behalf of the Government of China, had submitted to the 82nd meeting, a report on the status of implementation of the sector plan for the phase-out of MB production, and the 2017 production and controlled use verification report, in line with decision 73/56(b).

Background

91. The Executive Committee approved the fourth (and final) tranche of the sector plan of the phase-out of MB production at the 73rd meeting, on the understanding that the Government would continue to use existing balances to undertake activities for the phase-out of MB production, and that all project activities would be completed no later than 31 December 2018, and requested the Government and UNIDO to submit the project completion report no later than the first meeting in 2019 (decision 73/56).

92. The Agreement with the Executive Committee specified a maximum annual allowable production of MB for controlled uses for 2015 and beyond of zero save for QPS, feedstock and critical uses to be approved by the Parties. The Parties authorized 92.977 metric tonnes (mt) and 87.24 mt for CUEs for China for 2017 and 2018, respectively. The Government of China did not submit a critical-use nomination for production for

[12] The Executive Committee decided to extend the approved completion date of the methyl bromide national phase-out plan in China (CPR/FUM/72/INV/542) to December 2018 (or as soon as possible), with any remaining balances returned.

2019. The 2017 verification report confirmed that China's production was consistent with the Agreement. The Government reported under Article 7 of the Montreal Protocol MB production that is consistent with the verification report; Article 7 data for 2018 is not yet available.

Table 4. 2017 Article 7, verified MB production, and authorized CUEs for China (mt)

MB production	**2017**
Article 7 production for controlled uses	92.92
Verified production for controlled uses	92.916
CUEs authorized by the Parties	92.977

Progress report from 2017

93. Of the US $9.79 million approved, a total of US $7,716,101 has been disbursed, including compensation provided to the three MB producers, as shown in Table 5. Payments for technical assistance cooperation projects with AQSIQ (Table 20 of UNEP/OzL.Pro/ExCom/80/12), AQSIQ training, public awareness and management and information system (MIS), for research and development (R&D) and MB alternatives registration, and for monitoring and supervision were expected to be disbursed by 30 June 2019, based on activities that will be completed by 31 December 2018 or shortly thereafter.

Table 5. MB production allocation and disbursement

Activity	**Allocation (US $)**	**Contract amount (US $)**	**Disbursed 30 Sep. 2018 (US $)**	**Expected Disbursement 31 Dec. 2018 (US $)**	**Expected Disbursement 30 June 2019 (US $)**	**Balance (US $)**	**Status**
Compensation to MB producers (2005-2015)	3,818,253	3,818,253	3,818,253	0	0	0	Completed
Additional one-off compensation to MB producers (2016-2018)	1,806,279	1,806,279	1,806,279	0	0	0	Completed
Disposal of MB stock	156,438	156,438	156,438	0	0	0	Completed
MB Feedstock uses survey (2010-2012)	54,000	54,000	54,000	0	0	0	Completed
International consultants (UNIDO)	200,000	200,000	200,000	0	0	0	Completed
Monitoring and supervision (2007-2014)	84,787	84,787	84,787	0	0	0	Completed
Monitoring and supervision (2015-2018)	220,000	191,297	181,297	5,000	5,000	28,703	Ongoing
Technical assistance for AQSIQ[a]	1,510,220	1,510,220	696,327	597,000	216,893	0	Ongoing
AQSIQ training, public awareness and MIS[b]	489,780	200,000	116,320	58,000	25,680	289,780	Ongoing
R&D and registration of MB alternatives	1,000,000	1,000,000	407,655	342,345	250,000	0	Ongoing
Project completion report	190,000	128,400	24,745	72,155	31,500	61,600	Ongoing

Activity	Allocation (US $)	Contract amount (US $)	Disbursed 30 Sep. 2018 (US $)	Expected Disbursement 31 Dec. 2018 (US $)	Expected Disbursement 30 June 2019 (US $)	Balance (US $)	Status
International consultants (UNIDO)	90,000	90,000	90,000	0	0	0	Completed
Independent Audit (UNIDO)	80,000	80,000	80,000	0	0	0	Completed
Total (US $)	**9,699,757**	**9,319,674**	**7,716,101**	**1,074,500**	**529,073**	**380,083**	

[a] Table 20 of document 80/12
[b] The MIS system programme is part of the contract signed with AQSIQ. As AQSIQ has been incorporated into the Custom Authority, the MIS component will be reviewed accordingly to the new structure. FECO and the Custom Authority are negotiating a way to incorporate the MIS component into the monitoring and supervision programme that will be implemented by the Custom Authority.

94. A total of US $5,624,532 was disbursed to the three MB producers, including the additional one-time compensation of US $1,806,279. Of the US $304,787 allocated to FECO for monitoring and supervision (for 2007-2018), US $266,084 have been disbursed, a further US $10,000 are expected to be disbursed by 30 June 2019, leaving a balance of US $28,703.

95. Of the US $2,000,000 allocated for the coordination mechanism with AQSIQ to reinforce the Government's management and supervision on MB consumption for QPS use, contracts for a total value of US $1,710,220 have been signed, leaving a balance of US $289,780. Additional disbursements of US $655,000 are expected by 31 December 2018, with final disbursements of US $242,573 expected by 30 June 2019.

96. Of the US $1,000,000 allocated for R&D and registration of MB alternatives, contracts for the same value were signed, and a total of US $407,655 have been disbursed. Additional disbursements of approximately US $342,345 are expected by 31 December 2018, with the final disbursement of US $250,000 by 30 June 2019.

97. A total of US $128,400 was allocated to activities related to the project completion report, of which US $24,745 had been disbursed. An additional US $103,655 are expected to be disbursed by 30 June 2019, leaving a balance of US $61,600.

Verification reports

98. The verification for controlled uses of MB to audit production and sales in the three MB production enterprises was carried out from 16 to 28 April 2018. The verification team concluded that none of the three enterprises has produced controlled uses of MB exceeding the quotas and production is within the limit of industry plans.

Secretariat's comments

99. While the project budget is in US dollars, FECO issued contracts in renminbi (RMB) at different times over the last 10 years. Given changes in the value of the RMB relative to the US dollar, and that disbursements executed at a particular time were based on the currency exchange rate at that time, the value of those contracts has changed, resulting in a difference of US $90,243 between the funds approved by the Executive Committee (US $9.79 million) and the value of the contracts signed by FECO (US $9,699,757). Moreover, the value of previously reported disbursements appears to have changed given changes in the exchange rate between RMB and the US dollar. Notwithstanding the information provided by UNIDO and the Government of China, at the time of finalization of the present document the Secretariat was unable to reconcile the changes in disbursement reported to the 80th meeting.

100. The Secretariat recalled that the final (2018) payment to the three MB producers was expected to be made after the verification of 2018 production, i.e., in 2019. UNIDO clarified that the payment had already been made, and that FECO would conduct the 2018 production verification in 2019 and, in the event any non-compliance was found, FECO would recall the related payment according to the terms of the contract. The Secretariat notes, however, that paragraph 3(e) of the Agreement between the Government of China and the Executive Committee specified a penalty of US $5,000 per mt of reductions not achieved.

101. Regarding the funding of US $190,000 associated with the project completion report (PCR), the Secretariat noted that the PCR was UNIDO's responsibility and, therefore, covered by UNIDO's support costs. UNIDO clarified that this activity was mislabelled and that the funding was for data collection and assessment, noting that the MB production phase-out project started in 2006 and involved a large number of counterparts and activities. The data that will be gathered will be used by UNIDO in submitting the PCR, and will assist FECO in designing the long-term, sustainable monitoring and supervision of the phase-out. The data collected from MB producers; feedstock users; QPS users, including fumigation companies; custom authorities; and other relevant authorities. Assessment will include a cross-reference between production and consumption data and compliance with national regulation and commitments for production and computation of MB for controlled, feedstock and exempted uses.

102. Given that approximately US $1,603,573 are expected to be disbursed by 30 June 2019, and at least US $470,326 would remain available after the payments for all outstanding activities had been made, the Secretariat suggested that it would be meaningful to extend the project so that those balances could be used for activities that would further ensure the long-term, sustainable monitoring of the phase-out.

103. Accordingly, the Government of China proposed to allocate US $470,000 for five activities:

(a) Verification of MB producers in 2019, 2020, and 2021 (US $40,000);

(b) Verification of MB feedstock uses in 2019, 2020, and 2021 (US $120,000);

(c) Data collection and assessment in 2019, 2020, and 2021 (US $20,000);

(d) A monitoring and supervision programme with the Customs Authority (2019-2021) (US $275,000); and

(e) Wrap-up meeting in 2022 (US $15,000).

104. The proposed activities will ensure the continued monitoring of the MB production and sales records, including periodically cross-checking and verification of the MB producer records, the continued verification of application documents from MB feedstock users, and the continued monitoring of sales contracts through 2021.

105. The Secretariat considers the proposed activities useful and appropriate, but sought additional clarification of how long-term, sustainable monitoring would be ensured after the funding from the project was fully utilized and the project was completed:

(a) While verifications of production and feedstock uses through 2021 will be useful, such verifications will be one-off activities rather than contributing to a long-term, sustainable monitoring programme;

(b) Similarly, it was not clear how US $15,000 for a wrap-up meeting in 2022 would effectively ensure the long-term, sustainable monitoring of the phase-out.

106. Accordingly, the Secretariat suggested that the Government of China consider to undertake a single verification for the period 2019-2021 and to allocate US $53,333 for that purpose, and to allocate the remaining US $106,667, plus the US $15,000 for the wrap-up meeting, to the monitoring and supervision programme with the Customs Authority so that sufficient capacity would be built within the relevant institutions to ensure continued monitoring after the completion of the project. The Secretariat also sought additional clarification on the data collection and assessment activity, how it related to the monitoring and supervision activity, and the need for the specified funding level, which appeared high. At the time of finalization of the present document, discussions on these matters continued with UNIDO. The Secretariat will provide an update on those discussions to the 82nd meeting.

Conclusion

107. The verified MB production and that reported under Article 7 of the Montreal Protocol are consistent with that allowed under the Agreement. A total of US $7,716,101 had been disbursed, with a further US $1,603,573 expected to be disbursed by 30 June 2019. Notwithstanding the significant progress in implementing activities according to the agreed work plan, not all activities will be completed by 31 December 2018. Moreover, given changes in the exchange rate between RMB and the US dollar, there would be remaining balances after all disbursements associated with existing contracts have been made. The Secretariat considers a meaningful use for those balances would be for activities that would further ensure the long-term, sustainable monitoring of the phase-out after the project has been completed. Establishing a sustainable system for such sustainable monitoring is particularly important for a phase-out project where the production capacity is not permanently dismantled, as in the case of production of MB where QPS and feedstock uses are expected to continue. The Secretariat considers that the activities planned through 2021 will build capacity within FECO and the Customs Authority so that continued monitoring of the phase-out of MB production will persist after the completion of the project in 2021.

Secretariat's recommendation

108. The Executive Committee may wish:

(a) To note the report on the status of implementation of the sector plan for the phase-out of methyl bromide (MB) production in China, submitted by UNIDO;

(b) To request the Government of China, through UNIDO, to provide a progress report to the 84th meeting on the contract for the development of the management information system and its incorporation in the monitoring and supervision programme that will be implemented by the Custom Authority;

(c) To note the proposed 2019-2021 work plan to ensure the long-term, sustained monitoring of MB production in China, and to request the Government of China, through UNIDO, to provide to the 84th meeting an update to the work plan to ensure the long-term, sustained monitoring of MB after the **sector phase-out plan of MB production has been financially completed**;

(d) To note that the 2019 progress report will include the verification of the 2018 **MB** production;

(e) To request the Government of China, **through UNIDO**, to include in all subsequent progress reports the disbursement in US dollars at the time of the submission of the progress report and the value of contracts signed in the currency in which they were signed; and

(f) To request the Government of China and UNIDO to submit annual reports on the status of implementation of the sector plan for the phase-out of MB production, and the project completion report, to the Executive Committee no later than the last meeting in 2022.

PART III: PHASE-OUT IN CONSUMPTION AND PRODUCTION OF CTC IN INDIA (DECISION 81/23)

Background

109. At the 81st meeting, the Executive Committee considered a status report on the implementation of the project.[13] The Secretariat received the study on the country's use of CTC for feedstock applications, submitted by UNDP on behalf of the Government of India, immediately before the 81st meeting; accordingly, the Committee requested:

(a) The Secretariat to submit to the 82nd meeting a document on the use by India of CTC for feedstock applications, based on the submitted report; and

(b) The World Bank, together with the Governments of France, Germany and Japan, and UNDP and UNIDO as cooperating implementing agencies, to submit to the 82nd meeting the project completion report on the phase-out of CTC consumption and production (decision 81/23).

This document is prepared in response to decision 81/23.

Summary of the report on the use of CTC for feedstock applications in India

110. The main objective of the study was to assess the use of CTC for feedstock applications, including the co-production of CTC during the production of chloromethane and documenting the use of CTC in various feedstock applications. The quantity of CTC produced and its use for feedstock is shown in Table 6. The collected data was compared with the data reported under Article 7 of the Montreal Protocol.

Table 6. CTC production data in India for 2013-2016*

Production	Total (metric tonnes)
2013	
CTC production	17,663.754
CTC production for feedstock	17,663.754
2014	
CTC production	19,621.277
CTC production for feedstock	19,621.277
2015	
CTC production	19,324.792
CTC production for feedstock	19,324.792
2016	
CTC production	18,003.149
CTC production for feedstock	18,003.149

* CTC producers

[13] Paragraphs 135 to 138 of document UNEP/OzL.Pro/ExCom/81/10.

111. Key findings of the report are summarized below:

(a) CTC is used exclusively as a feedstock in the production of DV acid chloride[14] by eight enterprises and vinyl chloride monomer (VCM) by one enterprise. Production of DV acid chloride accounts for 97 per cent of the feedstock use of CTC, with VCM production accounting for the remainder;

(b) There are currently five CTC producers in India, one of which started producing CTC in 2016. All five produce CTC exclusively for feedstock use. All production of CTC in India is during the production of chloromethane, where CTC is co-produced;

(c) The details of CTC production and consumption from 2013 – 2016 as reported under Article 7 are shown below in mt:

Year	Production	Import	Export	Feedstock
2013	17,663.754	-	-	17,663.754
2014	19,621.277	944.000	-	20,565.277
2015	19,324.792	-	0.180	19,324.612
2016	18,003.149	1,037.000	0.312	19,039.837

(d) There is no foreseen cessation of CTC production for feedstock applications;

(e) Under the ODS (Regulation and Control) Rules, 2000 and its amendments, there is an annual statutory reporting requirement for monitoring CTC production and feedstock use that is applicable to all enterprises, and use of CTC is prohibited for non-feedstock applications; and

(f) The monitoring system, which is one of the outputs of technical assistance activities of the National CTC phase-out plan project, requires all enterprises manufacturing CTC for feedstock use to annually report to the Ozone Cell their CTC production, opening and closing stocks. CTC feedstock users are also subjected to statutory reporting requirements on an annual basis. This system allows the Ozone Cell to monitor CTC production and use.

Comments

112. Of the five CTC producers, three received funding under the CTC production phase-out plan (i.e., Gujarat Alkalies and Chemicals Limited, Chemplast Limited, and SRF Limited) and two new enterprises started production after the initiation of the CTC production phase-out plan (i.e., Gujarat Fluorochemicals Ltd. and Sree Rayalaseema Alkalies and Allied Chemicals Ltd.). The requirement to annually report to the Ozone Cell production, opening and closing stocks applies to all CTC producers, irrespective of whether they received funding under the CTC production phase-out plan; the requirement would also apply to any new CTC producers. However, CTC producers are not required to report technical material use ratios, which a comprehensive monitoring system would also include. Such reporting could be monitored through appropriate mechanisms at national level; such mechanisms would need to ensure confidentiality of reported data.

113. UNDP clarified that the import of CTC for feedstock is under a license issued by the Directorate General of Foreign Trade, Ministry of Commerce and Industry, based on the recommendations of the Ozone Cell. The application for import details the nature of use and the process to be followed, which is certified by

[14] DV acid chloride is mainly used for the manufacture of cypermethrin, an insecticide; it can also be used for the manufacture of permethrin, beta cypermethrin.

a national/accredited laboratory for conformity with the approved feedstock processes (i.e., DV acid chloride and VCM). Prior to making a recommendation for a license for import, the Ozone Cell does the required due diligence in terms of actual need as well as the nature of use, including by assessing any shortfall between domestic production and demand.

114. Production of chloromethane can result in not only the co-production of CTC, but also of chloroform and methylene chloride. Indeed, it is common to have some contaminated chloromethanes containing a combination of methylene chloride, chloroform, and CTC in a production plant due to the technical configuration of the plant. Any such contaminated cholorومethanes are destroyed.

115. Regarding fugitive emissions, UNDP clarified that under the ODS (Regulation and Control) Rules, 2000 and its amendments, the registration by an enterprise for a feedstock use of CTC is independently certified for negligible emissions. Therefore, fugitive emissions of CTC during the production of DV acid chloride and VCM are negligible.

Project completion report

116. With regard to decision 81/23(b), the Secretariat notes that at the time of finalization of the present document, the World Bank, together with the Governments of France, Germany and Japan, and UNDP and UNIDO as cooperating implementing agencies, has not submitted the project completion report on the phase-out of CTC consumption and production to the present meeting as had been requested.

Conclusion

117. Feedstock uses of CTC in India are expected to continue for the foreseeable future; likewise, production for feedstock uses are expected to continue, though some demand may be met through imports. The Secretariat considers that the Government of India has a robust system in place to monitor the production and use of CTC to ensure continued compliance with the phase-out of consumption of CTC and production of CTC for controlled uses. The comprehensive monitoring system currently in place could be further strengthened by including appropriate reporting of technical material use ratios.

Recommendation

118. The Executive Committee may wish:

(a) **To note the document on the use of CTC for feedstock applications in India submitted by UNDP;**

(b) To note the Government of India would continue monitoring the production and use of CTC to ensure continued compliance with the phase-out of consumption of CTC and production of CTC for controlled uses; and

(a) To urge the World Bank, together with the Governments of France, Germany and Japan, and UNDP and UNIDO as **cooperating agencies**, to submit no later than 31 December 2018, the project completion report on the phase-out of CTC consumption and production.

PART IV: ODS WASTE DISPOSAL PROJECTS

Background

119. At the 79th meeting, the Executive Committee requested, *inter alia,* bilateral and implementing agencies to submit final reports on outstanding ODS disposal pilot projects[15] other than those for Brazil and Colombia, and to return to the 82nd meeting the remaining balances for projects for which reports had not been submitted to the 80th or 81st meetings (decision 79/18(d)).

120. With regard to the projects for Brazil and Colombia, the Executive Committee requested UNDP:

(a) To complete the project in Brazil by December 2022; to submit the final report of the project to the first meeting of 2023 and a project completion report no later than July 2023, and to return fund balances no later than December 2023, on the understanding that no further extensions of the completion date of the project would be considered by the Executive Committee;

(b) To complete the project in Colombia in June 2019, to submit the final report of the project to the last meeting of 2019 and a project completion report no later than June 2020, and to return fund balances no later than December 2020, on the understanding that no further extensions of the completion date of the project would be considered by the Executive Committee; and

(c) To submit annual progress reports for the two projects in sub-paragraphs (a) and (b) above as "projects with specific reporting requirements" until the projects had been completed (decision 79/18(c)).

121. At the 81st meeting, relevant bilateral and implementing agencies submitted, on behalf of the Governments of China, Colombia, Nigeria and Turkey, final reports on the implementation of ODS waste disposal projects.[16] Subsequently, the Executive Committee *inter alia* noted, with appreciation, the final reports on the pilot ODS waste management and disposal projects for China, Colombia, Nigeria and Turkey; further noted that a synthesis report on the pilot ODS disposal projects, would be submitted to the 82nd meeting; and that balances of all ODS waste disposal projects would be returned to the 82nd meeting (decision 81/24).

122. The synthesis report on the pilot ODS disposal projects has been submitted to the 82nd meeting.[17]

Brazil: Progress report on the pilot demonstration project on ODS waste management and disposal (UNDP)

Background

123. UNDP, as designated implementing agency, submitted the progress report on the implementation of the pilot demonstration project on ODS waste management and disposal in Brazil, in line with decision 79/18(c)(iii).[18]

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[15] Final reports of the pilot projects for Georgia, Ghana and Nepal were submitted to the 79th meeting and for Mexico and the Europe and Central Asia (ECA) region were submitted to the 80th meeting.
[16] Paragraphs 140 to 162 of document UNEP/OzL.Pro/ExCom/81/10.
[17] UNEP/OzL.Pro/ExCom/82/21.
[18] To request UNDP to submit annual progress reports for the pilot ODS disposal projects in Brazil and Colombia as "projects with specific reporting requirements" until the projects had been completed.

Progress report

124. Implementation of the project included building capacity of the reclaim centres by providing isotanks to increase storage capacity for collected gases, and laboratory equipment for testing (gas chromatograph) and other materials. Equipment installation will be completed by December 2018, and testing and training will follow. The contract with the incineration facility (Essencis) was signed during the first quarter of 2018, and the plan of action and protocols for the environmental requirements for the test burns have been completed. The facility will only be able to make the required installations once CETESB[19] issues the license for both equipment and installation; it is expected to be issued by the end of November 2018. Burn test is scheduled to be carried out in February 2019.

Comments

125. The Secretariat noted that the pilot demonstration project is progressing well. Upon a request for clarification on any challenges that may cause further delays in project implementation, UNDP clarified that the project is being coordinated with CETESB; after test burns are completed, by the beginning of 2020, the incineration facility would have initiated the destruction of the ODS wastes, and the business model for efficient ODS waste management would be established.

Recommendation

126. The Executive Committee may wish to note the progress report on the pilot demonstration project on ODS waste management and disposal in Brazil, submitted by UNDP.

PART V: CHILLER PROJECTS

Background

127. At the 79th meeting, the Executive Committee requested bilateral and implementing agencies to submit project completion reports (PCRs) no later than June 2018 and to return fund balances no later than December 2018, for all chiller projects except the global chiller project implemented by the World Bank, for which the PCR should be submitted no later than December 2018 and fund balances returned no later than June 2019 (decision 79/19(b)(ii)). At the 80th meeting, the Executive Committee extended the demonstration project for accelerated conversion of CFC chillers in five African countries on an exceptional basis, for completion by April 2018 and submission of the final report to the 82nd meeting (decision 80/29(b)).

128. The report on the implementation of the projects, excluding the Argentina component of the global chiller project,[20] is given below.

Brazil: Demonstration project for integrated management of the centrifugal chiller sub-sector, focusing on application of energy-efficient CFC-free technologies for replacement of CFC-based chillers (UNDP)

129. The project was approved at the 47th meeting at a total funding of US $1,000,000 and was completed in June 2017; the PCR was submitted in July 2018. The main activities accomplished are given below:

[19] Companhia Ambiental do Estado de São Paulo, an environmental institution that monitors and grants licenses to projects in the state, considered potentially polluting activities; this is the NOU of Brazil.
[20] Transferred from the World Bank to UNIDO at the amount of US $808,438, plus agency support costs of US $60,633 (decision 80/31(b)(ii)).

(a) National inventory of chillers was undertaken, indicating a limited number of chillers operating with CFC, and approximately 3.2 million tonnes of refrigeration (TRs) in 130,000 chillers in operation using HCFC-22 (ranging from 1 to 700 TRs);

(b) Conversion of two chillers to HFC-134a-based technology, resulting in energy efficiency gains of 11.3 per cent. Four studies for retro-commissioning of HCFC-22-based chillers used in buildings were carried out. The chiller in one building is being converted to HFC-134a; public resources are sought for renovating chillers in two public buildings; and in another building, the project was not implemented due to change in building ownership;

(c) Three seminars on ozone layer protection and technical issues relating to new emerging alternatives and retro-commissioning, and two courses covering the theory and practical aspects relating to installation, maintenance and operations of chilled water systems and chillers were conducted; and

(d) Technical literature on chillers, case study on retro-commissioning, and awareness material on the outcome of the demonstration project were developed and disseminated; Brazil's retro-commissioning process is now adopted in other countries for improving energy efficiency in chillers.

130. The Government of Brazil and UNDP complemented the project with funds from the Global Environment Facility (GEF) on "Market Transformation for Energy Efficiency in Buildings" in the amount of US $13.5 million. Though specific details are not available, UNDP informed that this project facilitated the replacement of a large number of chillers.

African region: Strategic demonstration project for accelerated conversion of CFC chillers in five African Countries (Cameroon, Egypt, Namibia, Nigeria and Sudan) (UNIDO and the Governments of France, Germany and Japan)

131. The project was approved at the 48th meeting at a total funding level of US $1,945,881 (UNIDO: US $693,381; France: US $360,000; Germany: US $192,500; and Japan: US $700,000). The project was implemented in Cameroon, Egypt, Namibia, Nigeria, Senegal[21] and the Sudan. Details of the activities implemented are given below:

Chillers replaced

132. Table 7 presents information on the number of chillers replaced against the planned levels in all countries. The replacement was mostly to HFC-134a, as the buyers considered these chillers as energy efficient and cost-effective compared to CFC-based chillers; the availability of low-GWP-refrigerant-based chillers (e.g., CO_2, low-GWP blends) was limited in the past.

Table 7. Number of chillers replaced

Country	Chillers replaced		Refrigerant used after replacement
	Target	Actual	
Cameroon	4	8	HFC-143a; R-410A; HCFC-22; HFC-134a
Egypt	7	15	HFC-134a
Namibia	1	2	Not available
Nigeria	5	1	HFC-134a

[21] Senegal was added to the original list of countries in 2007.

Country	Chillers replaced		Refrigerant used after replacement
	Target	Actual	
Senegal	-	3	HFC-134a
Sudan	2	5	HFC-134a
Total	**19**	**34**	

Mobilising additional resources

133. For most countries covered under this project, direct partial reimbursement to industries for chiller conversion costs was provided; this option was chosen as it was easy to manage, acceptable to the recipients, and did not involve multiple agencies or complicated financial and operational management processes. In the case of Cameroon, the Government also set up a revolving fund which was identified as the best option, keeping in view economic aspects associated with the replacement of chillers. The fund was set up with three companies and was to be held with either a commercial bank or the central bank; a Board was established for managing the fund. Limited details are available on the impact of these projects.

134. Additional funds amounting to 750,000 Euros were obtained from *Fonds français pour l'environnement mondial* (FFEM) for complementing Multilateral Fund's resources, and were used for chiller replacement and setting up a financial mechanism in Cameroon and Egypt.

135. The average annual coefficient of performance increased from 3-3.5 to 5.5-5.8 at full-load operations through the replacement project;

136. Against the total funds amounting to US $1,945,881 approved for the project, US $1,915,579 was disbursed, as given in Table 8.

Table 8: Financial report of the project (US $)

Agency	Approved (US $)	Disbursed (US $)	Disbursement rate (%)
UNIDO	693,381	693,381	100
France	360,000	329,802	92
Germany	192,500	192,500	100
Japan	700,000	699,896	100
Total	**1,945,881**	**1,915,579**	98

137. The Government of France submitted its PCR in November 2018; the project will be financially closed and remaining balances will be returned by December 2018. The Government of Japan has not submitted the PCR as of date of issue of the document.

Global: Global chiller replacement project (China, India, Indonesia, Jordan, Malaysia, Philippines and Tunisia) (World Bank)

138. The project was approved[22] at the 47th meeting at a funding of US $6,884,612. At the 80th meeting, the Argentina component of the project, amounting to US $808,438 was transferred to UNIDO.

139. Activities were not undertaken in China, Malaysia and Tunisia as requirements under decision 47/26 on leveraging additional funding and the number of chillers to be replaced could not be fulfilled. In the case

[22] Approval includes the following conditions: (a) Disbursement of the amounts approved was dependent upon the availability of external resources to be confirmed by the Secretariat based on the advice from the agency that external funding had been secured. (b) The ratio between the maximum amount of Fund resources that could be disbursed and the external resources confirmed by the Secretariat should be equal to the ratio between the amount approved and the

of Indonesia, the project was cancelled as it failed to obtain endorsement from the GEF due to use of HFC-based refrigerants in the replacement chillers. The funding relating to these projects was returned by the 80th meeting.

140. The status of implementation of the India, Jordan and the Philippines components is given below:

(a) In India, Jordan and the Philippines, the number of CFC-based chillers replaced amounts to 34, 20 and 72, respectively, against the target of 370, 20 and 53, respectively. The total amount of CFCs recovered and stored in India, Jordan and the Philippines amount to 7 mt, 4 mt and 6.9 mt,[23] respectively, and

(b) Energy efficiency gains were reported in different ways. In India, 0.63 KW/TR was achieved against 1 KW/TR; in Jordan, based on measurements made at five sites, energy savings were in the range of 17.0 to 24.4 per cent; and in the Philippines, 151.4 Gigawatt hours (GWh) of energy savings were achieved.

141. The status of funds approved and balances is given in Table 9.

Table 9: Financial report of the global chiller project

Particulars	Amount (US $)
Total funds approved at the 47th meeting	6,884,612
Return to the 71st meeting	(3,149,056)
Return to the 76th meeting	(481,628)
Return to the 80th meeting	(1,031,031)
Funds disbursed	**2,222,897**

142. The PCR would be submitted before the 82nd meeting. As of the date of issue of this document, the PCR was not received.

Secretariat comments

<u>Inventory of CFC-based chillers and replacement technology</u>

143. UNIDO identified delays in the establishment of the chiller inventory by about seven years (i.e., from the date of approval to the date of validation) as a barrier for all projects, resulting in difficulties in assessing chiller replacement progress and project impact. Moreover, the absence of legislation to monitor the change in number and type of chillers that are removed from service makes quantification of replacement impact difficult.

144. The Secretariat also noted that low-GWP technologies were in limited use and often not attractive commercially when the chiller project was approved. Therefore, most of the replacement technologies used HFC-based refrigerants.

corresponding amount of associated external resources. (c) The bilateral and implementing agencies are requested to inform the Secretariat on an annual basis, in time for the last meeting of the Executive Committee in every year of project implementation, as well as in the year of completion, on progress in terms of implementation, main experiences and additional external resources acquired for the chiller phase-out and major market transformations observed.

[23] This includes CFCs and HCFCs.

Financing replacement of chillers

145. The project in Brazil included additional funds secured from GEF; one of the outcomes of the GEF project addressed replacement of CFC-based chillers with energy-efficient chillers. The Indonesia component of the global chiller project could not be implemented as GEF funding was not available due to the possibility of use of HFC-based refrigerants in the replacement chillers. The Secretariat notes that there would be challenges relating to project implementation if alternate sources of funding were to be secured to complement individual project activities, potentially resulting in project implementation delays.

146. UNIDO also mentioned that financial barriers for the implementation of the project were primarily due to the small size of the project for conversion and to the below-average credit-worthiness of potential borrowers. An environment fund dedicated to providing support in replacing chillers and covering certain transaction costs could help in making these projects sustainable and more attractive. The importance of support from the Government and the active, ongoing involvement of the NOU was also highlighted in the report.

Energy efficiency gain in chiller replacement

147. UNIDO informed that baseline energy consumption data was not available during the survey. As a result, energy efficiency gains from the project were difficult to measure and were thus provided at an estimated overall level. In the case of the global chiller replacement projects, energy efficiency gains data were provided in different ways. The Secretariat noted that the chiller project resulted in a greater awareness among end-users on the energy-efficiency impact of the replacement of CFC-based chillers.

148. UNIDO requested the extension to December 2020 of the Argentina component of the global chiller project that was transferred at the 80th meeting. UNIDO informed that after the project was transferred, about 73 chillers operating with CFCs have been identified and a call for chiller replacement was issued with a deadline of 20 November 2018. After identifying potential participants, the project would take about 24 months to complete. UNIDO also agreed to provide energy efficiency data for the converted chillers for a period of six months after the conversion.

Recommendation

149. The Executive Committee may wish:

(a) To note the information on chiller projects submitted by the Governments of France and Japan, UNDP, UNIDO and the World Bank;

(b) To request the Government of Japan to submit the project completion report (PCR) and to return the balances for the strategic demonstration project for accelerated conversion of CFC chillers in five African Countries (Cameroon, Egypt, Namibia, Nigeria and Sudan), no later than the 83rd meeting;

(c) To request the Government of France to return the balances **remaining from for the Strategic demonstration project for accelerated conversion of CFC chillers in five African countries (Cameroon, Egypt, Namibia, Nigeria and Sudan);**

(d) To urge the World Bank to submit the PCR for the global chiller **replacement** project to the 82nd meeting; and

(e) To extend **the completion date of** the Argentina component of the global chiller replacement project (GLO/REF/80/DEM/344) **to end of** December 2020, and **to** request UNIDO to submit a final report on implementation and **the** PCR no later than the first meeting of 2021.

PART VI: DEMONSTRATION PROJECTS FOR LOW-GWP ALTERNATIVES TO HCFCs AND FEASIBILITY STUDIES FOR DISTRICT COOLING (DECISION 72/40)

Background

150. At the 74th, 75th and 76th meetings, the Executive Committee approved three feasibility studies for district cooling (Dominican Republic (the), Egypt, and Kuwait) and 17 projects to demonstrate low-GWP technologies pursuant to decision XXV/5 and decision 72/40 including: seven projects in the refrigeration and air-conditioning and assembly sub-sector (China, Colombia, Costa Rica, Kuwait, Saudi Arabia (two), a global (Argentina and Tunisia) and a regional (West Asia[24]) project; five in the foam sector (Colombia, Egypt, Morocco, Saudi Arabia, South Africa, Thailand); and three in the refrigeration servicing sector (Maldives, Europe and Central Asia region, and a global project (Eastern Africa and Caribbean regions)). The status of those 20 projects is summarized in Table 10.

Table 10. Status of 17 projects to demonstrate low-GWP technologies and three feasibility studies for district cooling

Country	Project title (code)	Agency	Amount approved (US $)[a]	Expected completion date	Final report
China	Demonstration project for ammonia semi-hermetic frequency convertible screw refrigeration compression unit in the industrial and commercial refrigeration industry at Fujian Snowman Co. Ltd. (CPR/REF/76/DEM/573)	UNDP	1,026,815	30 June 2018	82nd meeting
Colombia	Demonstration of HC-290 (propane) as an alternative refrigerant in commercial air-conditioning manufacturing at Industrias Thermotar ltd (COL/REF/75/DEM/97)	UNDP	500,000	completed	Submitted to the 81st meeting
Colombia	Demonstration project to validate the use of hydrofluoro-olefins for discontinuous panels in Article 5 parties through the development of cost-effective formulations (COL/FOA/76/DEM/100)	UNDP	248,380	completed	Submitted to the 81st meeting
Costa Rica	Demonstration of the application of an ammonia/carbon dioxide refrigeration system in replacement of HCFC-22 for the medium-sized producer and retail store of Premezclas Industriales S.A. (COS/REF/76/DEM/55)	UNDP	524,000	completed	Submitted to the 81st meeting
Egypt	Demonstration of low-cost options for the conversion to non-ODS technologies in polyurethane foams at very small users (EGY/FOA/76/DEM/129)	UNDP	295,000	31 Dec. 2018	83rd meeting

[24] The demonstration project in West Asia on promoting refrigerant alternatives for high ambient temperature countries referred to as PRAHA-II.

Country	Project title (code)	Agency	Amount approved (US $)[a]	Expected completion date	Final report
Kuwait	Demonstration project for HCFC-free, low-GWP technology performance in air-conditioning applications (KUW/REF/76/DEM/32)	UNDP	293,000	13 May 2019	84th meeting
Maldives	Demonstration project for HCFC-free low-GWP alternatives in refrigeration in the fisheries sector (MDV/REF/76/DEM/30)	UNDP	141,000	completed	Submitted to the 81st meeting
Morocco	Demonstration of the use of low-cost pentane foaming technology for the conversion to non-ODS technologies in polyurethane foams at small and medium-sized enterprises (MOR/FOA/75/DEM/74)	UNDP	280,500	31 Dec. 2018	83rd meeting
Saudi Arabia	Demonstration project at air-conditioning manufacturers to develop window and packaged air-conditioners using low-global warming potential refrigerants (SAU/REF/76/DEM/29)	World Bank	1,300,000	30 Sep. 2018[b]	82nd meeting[b]
Saudi Arabia	Demonstration project on promoting HFO-based low-global warming potential refrigerants for air-conditioning sector in high ambient temperatures (SAU/REF/76/DEM/28)	UNIDO	796,400	31 Dec. 2018	83rd meeting
Saudi Arabia	Demonstration project for the phase-out of HCFCs by using HFO as foam blowing agent in the spray foam applications in high ambient temperatures (SAU/FOA/76/DEM/27)	UNIDO	96,250	31 Dec. 2018	83rd meeting
South Africa	Demonstration project on the technical and economic advantages of the vacuum assisted injection in discontinuous panels plant retrofitted from HCFC-141b to pentane (SOA/FOA/76/DEM/09)	UNIDO	222,200	completed	Submitted to the 81st meeting
Thailand	Demonstration project at foam system houses to formulate pre-blended polyol for spray polyurethane foam applications using low-global warming potential blowing agent (THA/FOA/76/DEM/168)	World Bank	352,550	30 Sep. 2018[c]	83rd meeting
Regional (West Asia), PRAHA-II	Promoting alternative refrigerants in air-conditioning for high ambient countries in West Asia (PRAHA-II) (ASP/REF/76/DEM/59 and 60)	UNEP and UNIDO	700,000	31 Dec. 2018	83rd meeting
Regional: Europe and Central Asia	Development of a regional centre of excellence for training and certification and demonstration of low-GWP alternative refrigerants (EUR/REF/76/DEM/16)	Russian Federation (the)	591,600	13 May 2019	84th meeting
Global (Argentina and Tunisia)	Demonstration project for the introduction of trans-critical CO_2 refrigeration technology for	UNIDO	846,300	13 Nov. 2018[d]	83rd meeting

Country	Project title (code)	Agency	Amount approved (US $)[a]	Expected completion date	Final report
	supermarkets (GLO/REF/76/DEM/335)				
Global (Eastern Africa and Caribbean regions)	Demonstration projects on refrigerant quality, containment and introduction of low-GWP refrigerants (GLO/REF/76/DEM/333 and 334)	UNEP and UNIDO	395,000	13 May 2018[e]	82nd meeting[e]
Dominican Republic (the)	Feasibility study for district cooling in Punta Cana (DOM/REF/74/TAS/57)	UNDP	91,743	31 Dec. 2017	82nd meeting
Egypt	Feasibility study for district cooling in New Cairo (EGY/REF/75/TAS/127 and 128)	UNEP	27,223	30 June 2018	82nd meeting

[a] This value does not include project preparation fund and agency support costs.
[b] One enterprise has dropped out of the project and the associated funds of US $220,000 plus agency support costs of US $15,400 will be returned to the 82nd meeting. It is expected that project activities at the second enterprise will be completed in November 2018. The final report will be submitted to the 83rd meeting.
[c] The expected date of completion was December 2018. The final report will be submitted to the 83rd meeting.
[d] The project in Argentina was expected to be completed by November 2018 but an extension to 31 March 2019 is recommended; implementation of the project in Tunisia has not yet started and is therefore recommended for cancellation. Funds of approximately US $300,000 plus agency support costs associated with the project in Tunisia, plus any remaining balances associated with the project in Argentina, will be returned by 31 March 2020.
[e] UNIDO component has progressed but was not completed in May 2018. It is recommended for extension with the final report to be submitted by the 84th meeting. UNEP was not yet able to initiate activities and therefore that component is recommended for cancellation. Funds of US $50,000 plus agency support costs of US $6,500 will be returned to the 82nd meeting.

151. Final reports for the projects in China, and the three feasibility studies for district cooling have been submitted to the 82nd meeting in line with decision 80/26. In addition, progress updates for the demonstration projects in Egypt, Morocco, Saudi Arabia (both UNIDO projects), Thailand, and PRAHA-II have been submitted to the 82nd meeting (with the final reports due at the 83rd meeting), as shown in Table 11.

Table 11. Progress updates on low-GWP demonstration projects submitted to the 82nd meeting

Country (Agency)	Project title	Completion date	Progress reported to the 82nd meeting
Egypt (UNDP)	Demonstration of low-cost options for the conversion to non-ODS technologies in polyurethane foams at very small users	Dec. 2018	Budgets have been allocated with specific procurement plans moving forward to optimize equipment models. In line with decision 80/26(e), a final report will be submitted no later than the 83rd meeting.
Morocco	Demonstration of the use of low-cost pentane foaming technology for the conversion to non-ODS technologies in polyurethane foams at small- and medium-sized enterprises)	Dec. 2018	Terms of reference were prepared for the supply of a foaming line; safety system; technical assistance; training of technicians, operators and maintenance personnel. The equipment is expected to be installed in the third quarter of 2018; a workshop will be organized in the fourth quarter; and a detailed project report will be submitted by early 2019.
Saudi Arabia (UNIDO)	Demonstration project on promoting HFO-based low-global-warming-potential (GWP) refrigerants for the air-conditioning sector in high ambient temperatures	Dec. 2018	The contract with the supplier has been signed. The development of prototypes is ongoing. Components (e.g., compressors) have been delivered for testing. Visit of engineers from the equipment supplier, the delivery of production equipment and production of first R-290 units are still pending. In line with decision 80/26(g), the final report will be submitted no later than the 83rd meeting.
Saudi Arabia (UNIDO)	Demonstration project for the phase-out of HCFCs by using HFO as a foam blowing agent in the spray foam applications in high ambient temperatures	Dec. 2018	On-site mission was organized in February 2018. Testing of the new HFO-1233zd foam system has been conducted, demonstrating the cost-effectiveness and similar physical properties of the new system as compared to HCFC-141b-based systems. In line with decision 80/26(i), the final report will be submitted no later than the 83rd meeting.

Country (Agency)	Project title	Completion date	Progress reported to the 82nd meeting
Thailand (World Bank)	Demonstration project at foam system houses to formulate pre-blended polyol for spray polyurethane foam applications using low-global warming potential blowing agent	Sep. 2018	Both system houses have installed equipment and have secured an initial supply of HFO-123zd and HFO-1336mzz(Z). Formulation work has begun and one of the two system houses has completed reformulation of one of its polyol systems with satisfactory test results. More formulations are under development. Final test results of the first formulation for the second system house are not yet available. Three additional months are needed to complete reformulation of the full range of polyol systems, therefore the project will be completed by the end of 2018.
Regional (West Asia), PRAHA-II	Promoting alternative refrigerants in air-conditioning for high ambient countries in West Asia (PRAHA-II) (ASP/REF/76/DEM/59 and 60)	Dec. 2018	Several activities have been implemented including capacity building of the local research and development facilities in high-ambient temperature countries; for the HFC-32 technology, activities were conducted in cooperation with the Japan Refrigeration and Air Conditioning Industry Association (JRAIA) and Japanese industry; for the R-290 technology, activities were conducted in cooperation with the China Household Electrical Appliances Association (CHEAA) and the Chinese industry; and for the HFO technology, activities were conducted with the Air Conditioning, Heating, and Refrigeration Institute (AHRI) and the technology providers of refrigerant and compressor manufacturers. Risk assessment activities were conducted for designing, developing and examining a risk assessment model suitable for use pattern and operating conditions for high ambient conditions to be completed by October 2018. Activities related to testing and optimization using prototypes that were previously developed under the project PRAHA-I, will be completed by November 2018.

152. Final reports for Saudi Arabia (World Bank) and the global project in the servicing sector (Eastern Africa and Caribbean regions) that were expected at the 82nd meeting were not submitted as the projects could not be completed as planned. The reported progress was:

(a) Saudi Arabia (World Bank): Prototypes are under development by Petra Engineering Industries (KSA) Co. Ltd., one of the two air-conditioning manufacturers participating in the project. Prototypes are expected to be completed by mid-October and testing of the prototypes is expected to be completed in November 2018. The second air-conditioning manufacturer, Saudi Factory for Electrical Appliances Ltd., decided not to participate in the project, resulting in the return of US $220,000, plus US $15,400 in agency support costs for the World Bank, to the 82nd meeting;

(b) Global (Eastern Africa, UNEP and UNIDO): Local experts were contracted to undertake surveys on refrigerant quality, and two workshops were undertaken: to train trainers where three new HCFC-based air-conditioners were evaluated, two of which were charged with locally purchased "HCFC-22," which was fake refrigerant that included a mixture of HCFC-22, HFC-134a, hydrocarbons and other refrigerants, and with refrigerant-quality R-290; and to raise awareness of refrigerants currently on the market, fake refrigerants and their effects, as well as the use of equipment to identify refrigerants and their quality. UNIDO's disbursement was 54 per cent and UNEP's was zero; and

(c) Global (Caribbean, UNIDO): a regional workshop on curriculum development, technician training, and certification schemes was held in May 2017; tools and equipment suitable for low-GWP flammable refrigerants were provided to the regional training centre in Grenada; a regional train-the-trainers workshop was held in August 2017, including on the safe handling of refrigerants and alternatives, good servicing practices, the differences between retrofit and drop-in and the consequences; and a regional training and certification curriculum was designed to ensure that only qualified technicians are handling and servicing equipment and flammable refrigerants. The curriculum will be adapted by each country in the region for their respective certification schemes. A market assessment is ongoing to estimate the market for low-GWP-based equipment in the region, and procurement of two R-290 AC units per country is ongoing to enable the remaining four countries to continue in-country training sessions, with delivery expected by the end of 2018. UNIDO's disbursement was 66 per cent and UNEP's was zero.

Secretariat's comments

153. The Secretariat noted that a number of projects were extended by the agency implementing the project beyond the date of completion specified in a decision of the Executive Committee, notwithstanding decision 77/8(l). This issue is further discussed in the consolidated progress report (UNEP/OzL.Pro/ExCom/82/14) and the document on overview of issues identified during project review (UNEP/OzL.Pro/ExCom/82/31).

154. Regarding the requested extensions for the demonstration project at air-conditioning manufacturers (SAU/REF/76/DEM/29), the Secretariat noted that the World Bank did not comply with decision 80/26(h), including, *inter-alia*, that the project should be completed by 30 September 2018, that no further extension of the project implementation would be requested, and that the final report would be submitted no later than the 82nd meeting. The Secretariat did not consider it meaningful to extend the date of completion of the project as the requested extension was before the 82nd meeting. The final report will be submitted to the 83rd meeting.

155. Regarding the demonstration project at foam system houses in Thailand (THA/FOA/76/DEM/168), the Secretariat recalled decision 80/26(k), which specified that the project should be completed by 30 September 2018 and that no further extension of the project implementation would be requested, and noted that the results of the demonstration project are directly relevant to stage II of the HPMP for Thailand submitted to the 82nd meeting. As no detailed results from this project are available, the Secretariat would base its review of the spray foam component of the stage II submission on results available from other projects and other sources of information. The World Bank clarified that the demonstration project could not be completed by the planned date because, while the two system houses had installed all the necessary equipment in early 2018, they were only able to obtain a supply of HFO-1233zd and HFO-1336mzz(Z) for testing in July 2018. Since then, both enterprises have been working on the formulations. One systems house has completed the formulation with reduced HFO-1336mzz(Z), with stability tests still pending. In light of this progress, the Secretariat recommends extending the project, notwithstanding that the Executive Committee had decided that no further extensions of project implementation would be requested.

156. Regarding the global servicing projects in Eastern Africa and the Caribbean (GLO/REF/76/DEM/333 and 334), UNIDO has made considerable progress, though an extension to June 2019 was requested to complete the outstanding activities. In light of the progress and the limited remaining activities, the Secretariat recommends that the project be extended to 30 June 2019 and that final report be submitted to the 84th meeting. Notwithstanding best efforts by UNEP, there were unavoidable delays and UNEP's activities could not be implemented as planned. Given the advanced stage of implementation of the activities by UNIDO in Eastern Africa, and that the project was designed to be jointly implemented through complementary activities by UNIDO and UNEP, it was agreed to cancel UNEP's component of the project. In order to ensure that countries in the region would benefit from the project, UNEP CAP will include a focus on the results of the demonstration project in regional network meetings and in other assistance it provides to countries in the regions. Funds of US $50,000 plus agency support costs of US $6,500 will be returned to the 82nd meeting.

157. The Secretariat asked for an update on the global (Argentina and Tunisia) demonstration project for the introduction of trans-critical CO_2 refrigeration technology for supermarkets (GLO/REF/76/DEM/335) that was to be completed in November 2018. The sub-project in Argentina has seen substantial progress: the equipment was successfully installed, with initial measurements indicating reductions of up to 25 per cent of energy consumption. Additional time is required to complete the data gathering and for a workshop to present the results, expected to be held in March 2019. Accordingly, the Secretariat recommends extending the project to 31 March 2019, on the understanding that the final report will be submitted by 30 June 2019. In contrast, the sub-project in Tunisia has not yet started as, despite best efforts by the NOU and UNIDO, the identified beneficiary did not decide to proceed with the project due to the required cost-share. Given the completion date specified by the Executive Committee, it was agreed to cancel the sub-project in Tunisia. The disbursement for the project is 59 per cent. The remaining funding of approximately US $300,000, plus any remaining balances associated with the Argentina project, will be returned to the Multilateral Fund by 31 March 2020. The final report will be submitted by June 2019.

158. The project on demonstration of low-cost options for the conversion to non-ODS technologies in PU foam at very small users in Egypt (EGY/FOA/76/DEM/129) was experiencing delays with equipment purchase being in process; however, UNDP confirmed that no extension would be requested, that the final report will be submitted to the 83rd meeting as per decision 80/26(e), and any remaining balances would be returned no later than to the 84th meeting.

Secretariat's recommendation

159. The Executive Committee may wish:

(a) To note the reports on the progress of implementation of the demonstration projects submitted by the implementing agencies contained in document UNEP/OzL.Pro/ExCom/82/20;

(b) Regarding the demonstration project at air-conditioning manufacturers to develop window and packaged air-conditioners using low-global warming potential (GWP) refrigerants (SAU/REF/76/DEM/29):

(i) To note the return to the 82nd meeting of US $220,000, plus agency support costs of US $15,400 for the World Bank, associated with the enterprise Saudi Factory for Electrical Appliances Ltd. that had decided to exit the project; and

(ii) To urge the World Bank to submit the final report as soon as possible so that it can be presented to the 83rd meeting;

(c) **Regarding the component of global demonstration project on refrigerant quality, containment and introduction of low-GWP refrigerants in Eastern Africa and the Caribbean implemented by UNEP and UNIDO:**

(i) **To cancel the component implemented by UNEP (GLO/REF/76/DEM/334), and to note the return to the 82nd meeting of US $50,000 plus agency support costs of US $6,500 for UNEP;**

(ii) **To extend the project completion date to 30 June 2019, of the component implemented by UNIDO (GLO/REF/76/DEM/333) on the understanding that no further extension of project implementation would be requested, and to request UNIDO to submit the final report no later than the 84th meeting;**

(d) Regarding the global demonstration project for the introduction of trans-critical CO_2 refrigeration technology for supermarkets (Argentina, Tunisia) project (GLO/REF/76/DEM/335):

(i) **To extend** the project completion date to 31 March 2019 **for the project component for** Argentina, on the understanding that no further extension of project implementation would be requested;

(ii) To cancel the project **component for** Tunisia **and to request UNIDO to return the balances;**

(iii) To request UNIDO to submit the **project completion report to the 83rd meeting** and to return all remaining balances **no later than** 31 March 2020;

(e) To request UNDP to provide an update on the progress in implementing the demonstration project for HCFC-free, low-GWP technology performance in air-conditioning applications (KUW/REF/76/DEM/32) to the 83rd meeting;

(f) To request the Russian Federation to provide an update on the progress in development of a regional centre of excellence for training and certification and demonstration of low-GWP alternative refrigerants (EUR/REF/76/DEM/16) to the 83rd meeting; and

(g) **To reiterate the dates of completion and meetings to which final reports on completed projects will be submitted as specified in Table 10 of document UNEP/OzL.Pro/ExCom/82/20 and as amended by the present decision, and that all remaining balances on completed projects shall be returned within 12 months of the date of completion of the project unless otherwise specified by the Executive Committee.**

Demonstration project for ammonia semi-hermetic frequency convertible screw refrigeration compression units in the industrial and commercial refrigeration industry at Fujian Snowman Co. Ltd., in China (UNDP)

Background

160. At the 76th meeting, the Executive Committee approved the demonstration project for ammonia semi-hermetic frequency convertible screw refrigeration compression units in the industrial and commercial refrigeration (ICR) industry at Fujian Snowman Co. Ltd., in China,[25] in the amount of US $1,026,815, plus agency support costs of US $71,877 for UNDP (decision 76/22).

161. The project proposed to establish the suitability of NH_3 semi-hermetic frequency convertible screw refrigeration compression units with carbon dioxide (CO_2) as the secondary heat transfer fluid used in small- and medium-sized ICR systems. The use of screw compressors for NH_3/CO_2 refrigeration systems had not been tested in China. The participating enterprise, Fujian Snowman Co., Ltd., manufactures compressors, ice-making equipment, water-cooling equipment, ice storage, and cooling systems, and has research and development capacity. The production line for ice makers and ice storage was modified to implement the project. The demonstration covered product and process design, development of the prototype of the NH_3-based compression unit, construction of the testing device for performance evaluation, and training. Documentation of the results and dissemination of technology was also carried out.

[25] UNEP/OzL.Pro/ExCom/76/25.

162. On behalf of the Government of China, UNDP has submitted the final report of the demonstration project (the final report is attached to the present document). The following activities were conducted during the demonstration:

(a) Completed the design of three NH_3 semi-hermetic compressor prototypes and three sets of NH_3 refrigeration systems with CO_2 as secondary refrigerant;

(b) Manufactured nine prototype compressors and three sets of auxiliary equipment (e.g., including compressor housing, rotor, bearing, sealing gasket, shaft seal);

(c) Tested the three NH_3 compressors and the three sets of NH_3 refrigeration systems, analyzed the experimental data, and optimized the design parameters of different-sized units to maximize efficiency and performance of the units;

(d) Converted one HCFC-22 compressor line to an NH_3 compressor manufacturing line with a capacity of 3,000 units per year; and

(e) Carried out promotional activities for the applications of NH_3 compressors in supermarkets and food processing industries in China.

163. The demonstration concluded the following:

(a) The first model (SSSCA50) NH_3 compressor has been validated for cold food storage applications with a capacity of 216.3 kW and cooling temperature of zero degrees. The co-efficient of performance (COP) of the refrigeration system has been tested at 2.94;

(b) The second model (SSSCA60) NH_3 compressor has been validated for cold food storage applications with a capacity of 56.7 kW and cooling temperature of -25^{o}C. The COP of the refrigeration system has been tested at 1.57; and

(c) The third model (SSSCA210) NH_3 compressor has been validated for cold food storage applications with a capacity of 167.1 kW and cooling temperature of -25^{o}C. The COP of the refrigeration system has been tested at 1.63.

164. The demonstration concluded that the NH_3 refrigerant has lower operating pressure than HCFC-22, the NH_3 refrigeration system requires less refrigerant charge. The NH_3 compressor is suitable for replacing the HCFC-22 compressor in refrigeration systems and the technology has been validated.

Secretariat's comments

165. The Secretariat noted that the demonstration has validated the use of semi-hermetic NH_3 compressors in cold storage applications. As compared to the open type NH_3 compressor, the demonstrated semi-hermetic NH_3 compressor and refrigeration system reduced the leakage of NH_3 refrigerant, which is toxic and minor flammable, therefore improved the safety of the refrigeration system. UNDP further reported that the NH_3/CO_2 system has an improved COP as it has improved the design and incorporated energy-saving features.

166. The Secretariat further inquired about the dissemination and replicability of the demonstrated technology and how compressor manufacturers in China and other countries can benefit from the demonstration project. UNDP reported that the Fujian Snowman Co. Ltd. is willing to share the technical data and information used in the design and operation of the compressor and cooperate with other companies to further develop and improve the NH_3 semi-hermetic compressor. The test data has been presented in the final

report. Training was conducted for designers, production engineers and equipment managers. The trained personnel can provide training for other enterprises.

167. The Secretariat further noted that one manufacturing line has been converted to produce NH_3 compressors with co-funding from the enterprise. So far 230 units of NH_3 compressors have been sold.

Secretariat's recommendation

168. The Executive Committee may wish:

(a) To note, with appreciation, the final report, submitted by UNDP, of the demonstration project for ammonia semi-hermetic frequency convertible screw refrigeration compression units in the industrial and commercial refrigeration industry at Fujian Snowman Co. Ltd. in China **contained in document UNEP/OzL.Pro/ExCom/82/20**; and

(a) To invite bilateral and implementing agencies to take into account the report referred to in sub-paragraph (a) above when assisting Article 5 countries in preparing projects for manufacturing ammonia semi-hermetic frequency convertible screw refrigeration compressors.

Feasibility study for district cooling

Background

169. At the 72nd meeting, the Executive Committee *inter alia* invited bilateral and implementing agencies to submit proposals for feasibility studies, including business cases for district cooling, to assess possible projects, their climate impact, economic feasibility and options for financing such undertakings (decision 72/40(c)).[26] In line with decision 72/40, at the 74th and 75th meetings, the Executive Committee approved three feasibility studies for district cooling in the Dominican Republic, Egypt, and Kuwait.

170. Relevant implementing agencies submitted, on behalf of the Governments of the Dominican Republic and Egypt, the final reports on the feasibility studies on district cooling; and a draft report for the study in Kuwait. These reports are summarized below. Full reports are attached to the present document.

<u>Dominican Republic (the): Feasibility study for district cooling in Punta Cana</u> (UNDP)

171. At the 74th meeting, the Executive Committee approved the request for funding the feasibility study to develop a business model for district cooling in Punta Cana, the Dominican Republic,[27] in the amount of US $91,743, plus agency support costs of US $8,257 for UNDP.

172. The feasibility study would assess the use of alternative sources of energy generation, such as the use of waste heat from existing waste incineration facility owned by Grupo Puntacana, as well as deep seawater from Punta Cana Bay. The district cooling system could potentially reduce by 80 per cent the energy demand (depending on the energy source selected) and achieve large reductions in greenhouse gas (GHG) emissions.

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[26] Bilateral and implementing agencies were invited to provide proposals for feasibility studies, including business cases for district cooling, no later than the 75th meeting. The resulting studies should assess possible projects, their climate impact, economic feasibility and options for financing such undertakings. The studies should enable stakeholders to understand the advantages and challenges as compared to business as usual. The funding for each study would be limited to a maximum of US $100,000, with a maximum of four studies to be funded. The Executive Committee is not agreeing with this approval to consider further funding beyond the feasibility studies.

[27] UNEP/OzL.Pro/ExCom/74/15

The expected output of the feasibility study included the identification of different technical and financial options that could be applied to make viable the implementation of a district cooling system in Punta Cana.

173. On behalf of the Government of the Dominican Republic, UNDP submitted the final report on the feasibility study, in line with decision 80/26(m). The report indicates that there are opportunities to develop and implement a district cooling system based on several waste heat sources. A summary of the study results implemented by DEVCCO[28] on behalf of the Government of the Dominican Republic is presented below:

(a) The district cooling facility is expected to have a cooling capacity of approximately 7 megawatt (MW), which could respond to the total peak cooling demand of 10 MW in 2016-2024. The plant intends to serve as a base load facility with the annual capacity of 45 gigawatt hours (GWh) cooling energy, while the existing on-site chiller will serve as peak production in the integrated system when needed, to produce a total of 14 GWh cooling energy per year;

(b) The facility will use the absorption chiller technology, which would use waste heat from existing sources that can be converted into cooling energy with only a small supply of electricity;

(c) The facility will have four main sub-systems: sources of waste heat, absorption chillers for cooling, a distribution network, and energy transfer stations;

(d) The facility is expected to cost US $8.9 million; the results from the business model study were summarized and financial projections show an internal rate of return of 16 per cent; and

(e) The challenges that need to be investigated prior to construction of the project include: optimization of the use of two existing Wartsila 32 engines built primarily for electricity production, vis-à-vis the introduction of the district cooling system; optimization of a robust technical system in combination with various scenario analyses of fuel and refrigerant price projections; further analysis of the distribution design temperatures and the possibilities to increase actual operational differential temperatures; assessment of water quality and ground water extraction; and exploring synergies between the distribution pipe system and other installations and utilities, such as water distribution systems and electrical cables in the area.

Comments

174. The technical report indicates that there are opportunities to develop and implement a district cooling system based on several waste heat sources in the Dominican Republic. UNDP indicated that Grupo Puntacana, which is working closely with the Government in implementing the study, is exploring funding options and sources based on the business model to see how the project could be implemented for both new developments and existing buildings in the country.

175. The Secretariat noted that the description of the next steps in the development phase, with special focus on the implementation and build-up of the strategy for Punta Cana District Cooling, was not included in the report. UNDP indicated that this is still under consideration, and will be provided at a later stage.

[28] DEVCCO engages in project development including district energy projects in partnership with local utilities, property developers and other stakeholders. In 2015, UNDP, together with the Environmental Bureau of the Dominican Republic, assigned DEVCCO to perform services related to the development of a 20 MW district cooling system in Punta Cana.

Egypt: Feasibility study for district cooling in New Cairo (UNEP and UNIDO)

176. At the 75th meeting, the Executive Committee approved the request for funding the feasibility study for district cooling in New Cairo, Egypt, which would include a business model,[29] in the amount of US $27,223, plus agency support costs of US $3,539 for UNEP, and US $63,521, plus agency support costs of US $5,717 for UNIDO.

177. The feasibility study was envisaged to focus on one district of the new capital, would include residential and non-residential districts; and would simulate the dynamic cooling load profile through the chosen district. Design, simulation and optimization of multiple energy inputs powered by natural gas, a solar thermal energy source and a fresh water heat sink would be considered.

178. On behalf of the Government of Egypt, UNEP and UNIDO have submitted the final report of the feasibility study, in line with decision 80/26(n). The report described its implementation in three parts: a technical study, a financial study and an institutional regulatory framework study.

179. While the original project design was to focus on New Cairo City, during implementation, New Alamein City was also considered. Both locations are part of the country's development plan and are a priority in terms of new cities to be built. The study examined the possibility of using district cooling with not-in-kind (NIK) technologies (i.e., deep sea cooling system) as compared with conventional cooling for New Alamein City. Data from available development plans, architectural and building designs, estimated population, utilities required, and other relevant elements were used to complete the technical and financial feasibility for New Alamein City.

180. With regard to New Cairo City, phase I of the development is already completed and uses district cooling combined with a conventional refrigeration system based on HFC-134a. Therefore, the study focused on phase II, specifically on the future site of the Government centre, using similar data as those collected for New Alamein City. Both cities are expected to be fully constructed and populated by 2022.

181. The following are the main achievements resulting from feasibility study:

(a) The technical and financial study for New Alamein City has resulted in a business model that has demonstrated the potential for district cooling using NIK technologies;

(b) The economic model assumed that the owner, property developer, or a specialized company, would construct the district cooling system through a build, own and operate (BOO) scheme, and in return collect fees from the users;

(c) The technical and financial studies were based on an estimated load capacity of 10,863 tonnes of refrigeration (TR) for New Alamein City, and 60,000 TR stations for New Cairo City; both included a mixed use of absorption chillers and a large thermal storage unit for better efficiency;

(d) The total investment cost, including the construction of the civil and electromechanical works was estimated at US $53.3 million and US $230 million for New Alamein City and New Cairo City, respectively; with a favourable equity internal rate of return (IRR) of 29 per cent and project IRR of 36 per cent for New Alamein City, and an equity IRR of 42 per cent and

[29] UNEP/OzL.Pro/ExCom/75/30 and 75/31.

project IRR of 30 per cent for New Cairo City, both with payback periods of less than five years; and

(e) The results of the feasibility study have encouraged the development of national institutional and regulatory framework for district cooling; currently, district cooling codes and guidelines are being developed.

Comments

182. Upon request for clarification, UNIDO and UNEP indicated that the information and analyses presented in the study were based on field data and market quotation as well as Government tariff values and banking information. Given the interest shown by financial institutions to fund this approach (deep sea cooling technology), the business model for New Alamein City has generated subsequent funding from the Kigali Cooling Efficiency (KCEP) to advance this study through building the international bidding process. The Government of Egypt considers the project in New Alamein City as a model for future developments in the country, especially new cities and settlements at coastal proximity. The study for New Cairo City will also be used as another model for new cities and settlements that can use gas-fired absorption systems instead of vapour-compression applications.

183. High level meetings held with the ministries responsible for housing and city development are expected to lead to a national policy to reduce dependency on conventional cooling systems, and promote NIK technologies. In November 2018, the Ministry of Housing issued a Ministerial Decree enacting, for the first time, the National District Cooling Code.

184. UNIDO and UNEP also indicated that once the international bidding process and the final selection of the developer is completed, the Government of Egypt may be in a position to provide a further report of the process which would document the steps taken for the activities done after the feasibility study. This report could be useful for other countries that would like to undertake the same analysis in future.

<u>Kuwait: Feasibility study comparing three not-in-kind (NIK) technologies for use in central air-conditioning</u> (draft final report) (UNEP and UNIDO)

185. At the 75th meeting, the Executive Committee approved the request for funding the feasibility study comparing three NIK technologies for use in central air-conditioning in Kuwait, which would include a business model,[30] in the amount of US $27,223, plus agency support costs of US $3,539 for UNEP and US $63,521, plus agency support costs of US $5,717 for UNIDO.

186. The original approach of the feasibility study was to present a full comparative analysis of three NIK technologies: deep seawater free cooling, waste heat absorption and solar assisted chilled water absorption systems, to determine the most cost-effective option for central cooling systems. It was expected to include an analysis of renewable energy sources, legal barriers, energy saving mechanisms and environmental benefits; and development of a financial scheme and co-financing mechanisms.

187. On behalf of the Government of Kuwait, UNEP and UNIDO have submitted a preliminary report on the feasibility study, in line with decision 80/26(o).

[30] UNEP/OzL.Pro/ExCom/75/30 and ExCom/75/31.

188. The preliminary report is summarized below:

(a) After consideration of the original NIK technologies, the study decided on using chilled water systems combined with evaporative cooling as the best technology for central air-conditioning systems suitable for Kuwait's climatic conditions;

(b) The study demonstrated the technical feasibility of this option for use in two locations, a school and a mosque, using two-stage[31] "direct/indirect" evaporative cooling (TSDI). The school air-conditioning was designed using a chilled water system connected by a chilled water pipeline network to air handling units and fan coil units system, incorporating a small number of split units and one large packaged unit with an estimated cooling load of approximately 1,000 tonnes of refrigeration (TR); the mosque was designed with a direct expansion air-conditioning system;

(c) Based on the designs, these systems are being installed with the assistance of technology providers in the form of free equipment and services, in two pilot locations. The project will demonstrate how these systems work for all climatic conditions in the country, and collect data on costs and energy savings; after the pilot phase, an independent evaluation will be done through the Kuwait Institute for Scientific Research (KISR) who will make recommendations to the Government on the feasibility of the approach; and

(d) The pilot implementation will be completed at the end of 2019.

Comments

189. The Secretariat sought clarification from UNIDO and UNEP on the reasons for not considering the technologies identified in the proposal. It was explained that there was an initial reluctance to consider district cooling (DC) as an option because most of the country's infrastructure was already developed, and there was concern that redesigning existing buildings/installations to allow for DC would be costly. Therefore, the feasibility study focused on exploring options for central air-conditioning for public facilities (e.g., schools, mosques, social clubs, and similar structures), offered by the Kuwait Public Authority for Housing Welfare (KPAHW). In addition, technical challenges posed by the original options included: deep sea cooling would be very expensive; no accessible deep seawater source; challenges with the temperature gradient; no available downstream natural gas supply nor waste heat sources close by for the absorption using natural gas.

190. In further explaining the pilot implementation phase, which is beyond the scope of the feasibility study, the agencies explained that this was necessary to facilitate the acceptance of the use of NIK technologies as compared with conventional cooling. It is expected that the independent evaluation of the pilot project would demonstrate the success of the evaporative cooling applications in the two pilot sites. Based on the outcomes of the evaluation, KPAHW is willing to consider adjusting its bidding process for future public buildings to move towards TSDI evaporative cooling systems. This would then support plans to implement this NIK technology in other selected sites in the city, to be implemented from 2020.

191. UNIDO and UNEP also clarified that the final report will be submitted to the 83rd meeting, while a later report on the approaches and steps taken for the pilot implementation of the NIK technology may be provided in future, no earlier than the first meeting in 2020.

[31] In the first stage, hot outside air passes inside a heat exchanger that is cooled by evaporation on the outside. During this initial cooling phase, the incoming air stream is cooled without raising its humidity. In the second stage, the same air stream passes through a water-soaked pad where the additional cooling takes place and the air picks up some additional humidity.

Recommendation

192. The Executive Committee may wish:

(a) To note, with appreciation, the final reports on the feasibility study for district cooling in the Dominican Republic, submitted by UNDP, and for Egypt submitted by UNIDO and UNEP **contained in document UNEP/OzL.Pro/ExCom/82/20**;

(b) To further note the preliminary report for the feasibility study comparing three not-in-kind technologies for use in central air-conditioning in Kuwait, **submitted by UNEP and UNIDO**, and to request **UNEP and UNIDO** to submit the final report to the 83rd meeting;

(c) To request:

(i) UNDP to submit the project completion report for the feasibility study for district cooling in the Dominican Republic to the 83rd meeting; and return any balances from the project no later than the 84th meeting;

(ii) UNEP and UNIDO to submit the project completion report for the feasibility study for district cooling in Egypt to the 83rd meeting, and the project completion report for the feasibility study comparing three not-in-kind technologies for use in central air-conditioning in Kuwait to the 84th meeting, and return any balances from these projects no later than the 84th meeting; and

(d) To encourage the Governments of Egypt and Kuwait through UNEP and UNIDO to provide updated information on the actions taken as a result of the feasibility studies to a future meeting of the Executive Committee.

PART VII: TEMPORARY USE OF A HIGH-GWP TECHNOLOGY IN APPROVED PROJECTS

193. Relevant bilateral and implementing agencies submitted, on behalf of the Governments of Lebanon and Mexico, reports on the implementation of projects under stage I or stage II of HPMPs with specific reporting requirements.

<u>Stage II of the HPMP for Lebanon (use of interim technology by Iceberg SARL, progress report)</u> (UNDP)

Background

194. On behalf of the Government of Lebanon, UNDP as designated implementing agency, has submitted the progress report on the implementation of the conversion at the enterprises in the refrigeration and air-conditioning manufacturing sector, in the context of stage II of the HPMP, in line with decisions 81/50(d)(ii)[32] and (iii).[33]

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[32] To report to the Executive Committee on the status of use of the interim technology selected by Iceberg SARL, at each meeting, until the alternative technology originally selected or another technology with a lower GWP had been fully introduced, also providing an update from the suppliers on the progress made towards ensuring that the selected technologies, including associated components, were available on a commercial basis in the country.

[33] To report to the 82nd meeting the status of implementation of the conversion at the remaining enterprises (Frigo Liban, UNIC, CGI Halawany and Industrial and Commercial Refrigerators) on the understanding that the funds remaining from the conversion of the enterprises would be returned to the Multilateral Fund after the total conversion of the sector had been fully addressed, and that all expenditures would be recorded.

<u>Progress report</u>

195. UNDP reported that the conversion of the enterprise Iceberg SARL has been completed and the enterprise has phased out 12.60 mt (0.69 ODP tonnes) of HCFC-22 and 14.00 mt (1.54 ODP tonnes) of HCFC-141b and converted to the alternatives of HFC-32 and HFC-365mfc, respectively, where HFC-365mfc is used as an interim substitute technology. Availability of HFO systems in the country remains a challenge. The Government through the NOU is working closely with technical consultants and suppliers of HFOs in order to have this technology available as soon as possible. However, UNDP cannot confirm a date for the commercial availability of the technology in the country.

196. With regard to the air-conditioning manufacturing sector, conversion of the enterprise Frigo Liban is progressing well, and will be completed at the end of 2018. The agreements with the other enterprises (CGI Halawany, Industrial and Commercial Refrigerators and UNIC) will be signed only in 2019. It is noted that the other small commercial air-conditioning enterprise (CGI Halawany) might also temporarily use HFC-365mfc as a blowing agent for the foam component owing to the lack of availability of HFOs at this time.

Comments

197. The Secretariat noted the efforts taken by UNDP to assist especially Iceberg SARL to facilitate the availability of HFO systems so that the enterprise can finally convert to this technology when available. It also noted the status of the conversion of the remaining air-conditioning enterprises in relation to the concerns expressed by the Secretariat at the 81st meeting on the funding allocations for these enterprises, and encouraged UNDP to ensure that when these are completed any balances would be returned in line with decision 81/50.

Recommendation

198. The Executive Committee may wish:

(a) To note with appreciation, the report provided by UNDP, and the efforts made to facilitate the supply of technology with low global-warming potential (GWP) to the enterprise Iceberg SARL in Lebanon; and

(b) To request UNDP:

(i) To continue assisting the Government of Lebanon in securing the supply of low-GWP alternative technology and to provide a report on the status of the conversion of Iceberg SARL and CGI Halawany, to each meeting, until the technology originally selected or another technology with a low-GWP has been fully introduced; and

(ii) To report to the 83rd meeting on the progress and status of implementation of the conversion at the remaining enterprises, including funding distribution – Frigo Liban, UNIC, CGI Halawany and Industrial and Commercial Refrigerators.

Stage II of the HPMP in Mexico (temporary use of a high-GWP technology by an aerosol enterprise that had been converted to a low-GWP technology) (UNIDO/UNEP/Germany/Italy/Spain)

Background

199. At the 81st meeting, the Government of Mexico submitted a request for approval of the third tranche of stage II of its HPMP,[34] indicating that in 2017, one enterprise in the aerosol sector, Tecnosol, consumed on an interim basis two metric tonnes (mt) (of its total consumption of 117.3 mt) of a blend of HFC-365mfc (93 per cent) and HFC-227ea (7 per cent) for very specific automotive applications where only non-flammable substances can be used, and where perchloroethylene cannot be used as it is corrosive. Tecnosol was also developing other alternatives for this application with the assistance of UNIDO.

200. Accordingly, in approving the third tranche, the Executive Committee requested UNIDO to report on the status of use by Tecnosol of the interim HFC-365mfc and HFC-227ea blend technology in the cleaning application at each meeting, until the technology originally selected or another low-GWP technology has been fully introduced (decision 81/34(a) on blanket approval of projects).

201. In line with decision 81/34(c), UNIDO has reported that the interim technology HFC-365mfc/HFC-227ea is no longer being used at Tecnosol. The enterprise has started to use the originally approved technology (perchloroetylene/HFC-134a) for all its clients, except for one where the issue of corrosiveness prevails. A low-GWP alternative technology considered was based on HFOs, but their cost is US $110/kg for HFO-1234yf used as propellant, and US $30/kg for HFO-1234ze used as solvent. In view of the lack of an affordable low-GWP alternative, the enterprise is no longer supplying that client. The project has been completed.

202. UNIDO informed that if the price of HFC-365mfc/HFC-227ea is reduced in the future while the price of HFOs remains high, other enterprises might request temporary use of the blend for specific uses.

Comments

203. The Secretariat noted with appreciation the efforts of the Government of Mexico and UNIDO to introduce the approved technology and to discontinue the temporary use of a high-GWP alternative in the beneficiary enterprise. On this basis, no further reporting on this matter is required.

204. The Secretariat also noted the information provided by UNIDO on the potential risk of other enterprises facing difficulties in introducing HFO-based technology, given current prices.

Recommendation

205. The Executive Committee may wish to note, with appreciation, the report provided by UNIDO and the efforts made by the Government of Mexico and UNIDO to discontinue the temporary use of a high-global warming potential (GWP) technology and to introduce the approved low-GWP technology in all the applications at the beneficiary enterprise.

Trinidad and Tobago: HCFC phase-out management plan (stage I – fourth tranche) (UNDP)

Background

206. At the 81st meeting, the Executive Committee considered the request for the fourth tranche of stage I of the HPMP for Trinidad and Tobago and noted that one of the enterprises in the foam sector was using a

[34] UNEP/OzL.Pro/ExCom/81/45

different alternative foam blowing agent from the one that had been approved by the Executive Committee. In light of this, the Executive Committee decided to request UNDP to provide, to the 82nd meeting, a status report on the use of methyl formate and the alternative blowing agent being used, under stage I of the HPMP, in the enterprise being assisted by the Multilateral Fund (decision 81/52(b)).

207. UNDP informed that due to inability in scheduling the expert mission, it was not possible to further analyze the situation in the enterprise; therefore, they are unable to provide the update on the status of use of the substance at the enterprise.

Comments

208. The Secretariat noted with concern that update on the use of methyl formate and the alternative blowing agent at the enterprise is not available as this information would be useful for the Executive Committee to be informed of the situation in Trinidad and Tobago in line with decision 74/20(a)(ii).

Recommendation

209. The Executive Committee may wish to reiterate decision 81/52(b), and to urge UNDP to provide, to the 83rd meeting, a status report on the use of methyl formate and the alternative blowing agent being used, under stage I of the HPMP for Trinidad and Tobago, in the enterprise being assisted by the Multilateral Fund.

PART VIII: REPORTS RELATED TO HCFC PHASE-OUT MANAGEMENT PLANS

210. This part consists of progress reports of stages I or II of HPMPs for Bangladesh, Honduras, Indonesia, Jordan, Malaysia, **Maldives,** Mexico, Qatar, Venezuela (Bolivarian Republic of) and Viet Nam.

Bahamas: HCFC phase-out management plan (stage I – third tranche) (UNEP)

Background

211. At the 80th meeting, the Executive Committee considered the request for the third tranche of stage I of the HPMP for Bahamas. It noted that the Secretariat had drawn attention to safety concerns associated with the use of R-22a for the retrofitting of appliances using HCFC-22, and that UNEP would conduct a study to explore the best available options. In light of this, the Executive Committee requested UNEP to provide an update at the 82nd meeting on the findings of the study to explore the best available options for the pilot project to assess, monitor, and retrofit two air-conditioning systems (decision 80/62(b)).

212. A report on the study was not provided by UNEP.

Comments

213. The Secretariat noted with concern that the findings of the study was not provided.

Recommendation

214. The Executive Committee may wish to urge UNEP to provide, to the 83rd meeting, an update on the findings of the study to explore the best available options for the pilot project to assess, monitor, and retrofit two air-conditioning systems in the Bahamas, in line with decision 80/62(b).

Stage I of the HPMP of Bangladesh (progress and verification reports) (UNDP and UNEP)

Background

215. On behalf of the Government of Bangladesh, UNDP, as lead implementing agency, has submitted the 2017 verification report and annual progress report on implementation of the work programme associated with the third and fourth tranches of stage I of the HPMP,[35] in line with decision 80/63(b). The annual progress report submitted by UNDP also included a request from the Government for an extension of the implementation period for stage I until March 2019 due to delays related to administrative procedures.

HCFC consumption

216. The verification report confirmed the consumption of 1,154.74 mt (63.33 ODP tonnes) of HCFCs in 2017, which was 12.8 per cent below the consumption baseline and 3 per cent below the allowable consumption (65.39 ODP tonnes) stipulated in the Agreement between the Government and the Executive Committee. The licensing and quota system for HCFC imports and exports continues to be enforced.

Progress report on the implementation of the third and fourth tranches of the HPMP

Activities in the manufacturing sector and other capacity building activities (UNDP)

217. The planned activities under stage I of the HPMP have been completed with a phase-out of 20.2 ODP tonnes of HCFC-141b used in foam production at Walton Hi-Tech Industries.

218. In addition, other non-investment activities (US $55,000) that were transferred from the completed national ODS phase-out plan to stage I of the HPMP, related to building capacity for regulatory actions, amendment of the ODS regulations (updated harmonized system codes for all ODS including HCFCs, requirement of permit for the sale of compressors for manufacturing equipment that use HCFC including record keeping and penalties for violations), are yet to be implemented. No disbursements from this reallocated funding has been made since the 65th meeting.

Activities in the refrigeration servicing sector (UNEP)

219. Activities implemented since the final tranche approved at the 80th meeting include:

(a) The funding agreement was signed between the Government of Bangladesh and UNEP in June 2018 and the first payment of US $17,000 was disbursed to the Government in July 2018. Technicians training on good servicing practices will start in March 2019;

(b) Discussions to revise national technical and vocational training system to include ODS issues and good servicing practices were carried out and these revisions will be completed by December 2018; the refrigeration and air-conditioning syllabus for a diploma degree in engineering was revised by the Technical Education Board of Bangladesh to include information related to alternative technologies and Montreal Protocol requirements concerning the servicing sector;

(c) A meeting with the Customs representatives, national ozone units, and border security personnel of neighbouring countries (Bhutan, China, India, Myanmar and Nepal) to strengthen cooperation between bordering countries on issues related to potential illegal trade

[35] The combined third and fourth (final) tranches of stage I of the HPMP was approved at the 80th meeting in the amount of US $35,000, plus agency support costs of US $4,550 for UNEP.

and enhance monitoring and control of ODS import and export, and accurate data reporting was held; and

(d) Distribution of information materials and publications on Montreal Protocol and HCFC phase-out continued.

Level of fund disbursement

220. As at August 2018, of the US $1,556,074 approved, US $1,479,033 had been disbursed, as shown in Table 12.

Table 12. Financial report of stage I of the HPMP for Bangladesh

Agency	Approved (US $)	Disbursed (US $)	Disbursement rate (%)
UNDP	1,201,074	1,146,074	95.4
UNEP	355,000	332,959	93.8
Total	**1,556,074**	**1,479,033**	**95.0**

Comments

221. In discussion with UNDP, the Secretariat sought clarification on the need to extend the project for additional three months until the end of March 2019, noting that no progress or disbursement had been made since the 65th meeting in the UNDP component of the non-investment project, and the postponement of training activities until the beginning of 2019. The Secretariat also asked UNDP to explain why funds should not be returned for those activities where no disbursements were made.

222. UNDP explained that the initial focus of the HPMP was to complete the foam investment component and enable the country's compliance with its targets; in addition, administrative issues related to fund transfers (i.e. difficulty in transferring funds from an earlier approved project) contributed to the delayed implementation of capacity building activities. With regard to UNEP's component, for training workshops, funds were transferred only in middle of 2018.

223. Further to discussions, UNDP submitted a work plan for the remaining activities with their corresponding budget until project completion and indicated the commitment of the Government to complete all activities, and return any balances remaining at the end of March 2019. The Secretariat notes that the request for a three-month extension of stage I of the HPMP is justified.

224. UNDP committed to submit the final progress report and project completion report submitted to the 83rd meeting.

Recommendation

225. The Executive Committee may wish:

(a) To note the 2017 verification and progress reports on the implementation of stage I of the HCFC phase-out management plan (HPMP) for Bangladesh, submitted by UNDP;

(b) To approve the request for the extension of stage I of the HPMP until 31 March 2019, on the understanding that no further extensions for stage I will be considered, that the final report for stage I of the HPMP and the project completion report will be submitted to the 83rd meeting; and that the balances from stage I of the HPMP will be returned no later than the 84th meeting.

<u>Progress report on stage I of the HPMP for Honduras</u> (UNEP)

226. At the 81st meeting, the Executive Committee approved (under the list of blanket approval projects) the fourth tranche of stage I of the HPMP for Honduras, and the corresponding 2018-2020 tranche implementation plan on the understanding:

(a) That UNEP and the Government of Honduras will intensify efforts to implement the training activities for refrigeration technicians associated with stage I of the HPMP;

(b) That UNEP would submit a progress report to each meeting on the implementation of activities under UNEP's components associated with stage I of the HPMP, including disbursements achieved, until the submission of the fifth and final tranche of stage I of the HPMP; and

(c) That the disbursement targets for the total amount of funds approved for the UNEP components of the first, second and third tranches of stage I of the HPMP for Honduras are 50 per cent by 30 September 2018, 80 per cent by 31 March 2019, and 100 per cent by December 2019, and for the UNEP component of the fourth tranche are 20 per cent disbursement by 31 March 2019 and 50 per cent disbursement by December 2019.

227. In line with the above request, UNEP has submitted to the 82nd meeting a progress and financial report on the implementation of the UNEP's activities under stage I of the HPMP for Honduras.

Progress report on the implementation of stage I of the HPMP

228. The following activities have been implemented since the 81st meeting:

(a) Six dissemination and awareness-raising sessions were carried out for a total of 478 refrigeration and air-conditioning (RAC) technicians and RAC students to promote the evaluation and certification of good refrigeration practices;

(b) A memorandum of understanding between UNEP, the national ozone unit (UTOH), the Environment Ministry (MI AMBIENTE), and the national training institute (INFOP) was drafted with the purpose of advancing the revision of the training and certification processes for good practices in the RAC servicing sector; and

(c) Eight seminars-workshops were carried out in different cities in which 536 technicians were trained on the theory and practice of safe-handling of flammable refrigerants.

Level of fund disbursement

229. As at 30 September 2018, of the total amount of US $175,000 of funds approved for the first, second and third tranches for UNEP, US $76,848 (44 per cent) had been disbursed as shown in Table 13. UNEP had advanced US $30,000 from the first tranche to the Government of Honduras on 23 August 2018, bringing the total amount of funds advanced for the first, second and third tranches to US $106,848 (61 per cent).

Table 13. Financial report of stage I of the HPMP for Honduras

Tranche	Approved (US $)	Expenditures recorded in UMOJA in 2018 (US $)			Actual disbursement rate (%)	Target disbursement rate (%)	Advances (US $)	Advances (%)
		As at 15/4/2018	From 15/4/2018 to 30/9/2018	Total				
First	75,000	7,047	30,000	37,047	49.4		30,000	89.4
Second	50,000	33,529	0	33,529	67.1			
Third	50,000	5,000	1,272	6,272	12.5			
Sub-total	**175,000**	**45,576**	**31,272**	**76,848**	**43.9**	**50**	**106,848**	**61.1**
Fourth	50,000	0	0	0	0	n.a.	0	0

Update on the implementation plan for stage I of the HPMP

230. The following activities are planned for the period October 2018 to March 2019:

(a) Training of 100 customs and enforcement officers on import controls for HCFCs and HCFC-based equipment;

(b) Design of the electronic register of HCFC importers, suppliers and end-users;

(c) Reformulation of the certification scheme for refrigeration technicians, including the certification of 10 certifiers from INFOP and the approval of criteria and methods for launching the certification scheme of technicians; and

(d) Training workshops for RAC technicians and students on good practices and safe-handling of ODS alternatives.

Secretariat's comments

231. The Secretariat noted that Honduras restarted training for the RAC servicing sector, and had taken steps to initiate the revision of the curricula and to reformulate the certification scheme for RAC technicians to integrate new technology and skills required by RAC technicians.

232. UNEP indicated that the new curriculum for INFOP courses should be finalized by December 2019, and that the workshops that had taken place had been based on the new trial curriculum. The revision of standards for flammable low-global-GWP refrigerants had been postponed pending discussions on international standards, awareness on safety standards had been included in workshop programmes.

Disbursement targets and schedule of advances

233. The Secretariat noted that the country achieved a disbursement rate of 44 per cent against the target of 50 per cent for the UNEP components of the first, second and third tranches by 30 September 2018. UNEP explained that US $30,000 of funds advanced to the country would also be recorded as disbursements by 1 December 2018 bringing the disbursement rate to 61 per cent. In addition, a cash advance of US $7,952 would be released by 15 December 2018. Furthermore, UNEP will directly hire three experts, using the budget of the first, second, and third tranches, to provide the NOU with technical support to implement the planned activities.

234. UNEP informed that following discussions with the Government of Honduras, the agreement for the fourth tranche would be signed and implementation initiated in January 2019. UNEP expects to achieve the 50 per cent disbursement of the fourth tranche by December 2019.

Secretariat's recommendation

235. The Executive Committee may wish:

(a) To note the progress report provided by UNEP on the implementation of activities under UNEP's components associated with stage I of the HCFC phase-out management plan (HPMP) for Honduras; and

(b) To request UNEP to continue submitting a progress report to each meeting on the implementation of activities under UNEP's components associated with stage I of the HPMP, including disbursements achieved, until the submission of the fifth and final tranche of stage I of the HPMP.

Indonesia: HCFC phase-out management plan – stage I: 2017-2018 progress report and update on enterprise conversion of technology (UNDP, UNIDO, World Bank, and the Government of Australia)

Background

236. On behalf of the Government of Indonesia, UNDP as the lead implementing agency, has submitted to the 82nd meeting the annual progress report on the implementation of the work programme associated with the third and final tranche of the HCFC phase-out management plan (HPMP),[36] in line with decision 76/47(d), and a report on the status of enterprises temporarily manufacturing high global-warming potential (GWP)-based refrigeration and air-conditioning (RAC) equipment at enterprises that received funding to convert to low-GWP alternatives in line with decisions 77/35 and 81/11(c).

HCFC consumption

237. The Government of Indonesia reported a consumption of 239.79 ODP tonnes of HCFC in 2017,[37] which is 34 per cent below the HPMP target of 363.51 ODP tonnes for 2017, and 41 per cent lower than the established baseline of 403.9 ODP tonnes. The Government submitted sector consumption data under the 2017 country programme implementation report consistent with the data reported under Article 7 of the Montreal Protocol.

Progress report on the implementation of the third and final tranche of the HPMP

Polyurethane (PU) foam sector

238. In the foam sector, one systems house (PT. Sutindo Chemical Indonesia) completed its conversion, while the other systems house (PT. TSG Chemical, with a funding allocation of US $301,539, plus agency support costs of US $22,615 for the World Bank), is still considering whether to withdraw from the project. In addition, the NOU has initiated discussions with relevant ministries and stakeholders to prepare the policy to ban the use and import of HCFC-141b in bulk and pre-blended form for all sectors. It is expected that the policy and regulation would be issued by 1 January 2021. UNIDO completed the umbrella project to phase

[36] The third and final of stage I of the HPMP was approved at the 76th meeting at a total cost of US $1,260,461, consisting of US $901,102, plus agency support costs of US $67,583 for UNDP, and US $271,420, plus agency support costs of US $20,356 for the World Bank.
[37] On 11 June 2018, UNDP submitted, on behalf of the Government of Indonesia, the 2016-2017 verification report; funding for the second tranche of stage II of the HPMP was released from the Treasurer to UNDP and the World Bank following the Secretariat's review, in line with decision 81/49(b).

out HCFC-141b used at Isotech Jaya Makmur, Airtekindo, Sinar Lentera Kencana and Mayer Jaya in January 2017 (IDS/PHA/64/INV/194).

RAC manufacturing sector

239. Stage I of the HPMP included conversion of 48 enterprises in the RAC manufacturing sector to low-GWP technologies. However, during implementation, 28 enterprises (16 in the air-conditioning sector and 12 in the commercial refrigeration sector) decided to convert to high-GWP technology with their own resources and returned US $3,134,216, plus agency support costs, to the Multilateral Fund.

240. Of the remaining 20 enterprises, only one (Panasonic) is currently manufacturing air-conditioners based on HFC-32 technology. Eight large- and medium-sized enterprises have manufactured HFC-32-based prototype equipment, while eight small-sized enterprises are assemblers that work based on custom-made orders; to date, no orders for HFC-32-based equipment have been received. Three additional enterprises were still waiting for the market for HFC-32-based equipment to improve before undertaking their conversion. Currently, all these enterprises are manufacturing equipment based on high-GWP (principally R-410A, R-404A, and HFC-134a) refrigerants.

241. The reasons for the delay in the conversion and manufacturing of RAC equipment with the agreed technology by 19 enterprises are: limited commercial availability of HFC-32-based compressors and components at affordable prices; lack of demand in the local market for HFC-32-based equipment; and higher cost of HFC-32-based equipment compared to other equipment available in the country (e.g. based on the R-410A refrigerant).

242. To enable these manufacturing enterprises to start manufacturing using the technology for which the funding had been approved, the national ozone unit (NOU) together with UNDP conducted awareness activities and a study tour to China in October 2017. From the study tour, enterprises learnt that compressor manufacturers in China were waiting for the approval of safety standards to initiate mass production of HFC-32-based commercial compressors. Those standards were approved in July 2018; given their recent approval, national demand in China has not yet materialized. UNDP informed the Secretariat that under these market conditions, the Chinese compressor manufacturers are still not able to provide the HFC-32 compressors to Indonesia, and therefore the Indonesian RAC enterprises cannot complete their projects at this time.

243. UNDP also consulted a compressor manufacturer in Thailand, as suggested by the Secretariat at the 81st meeting. The enterprise manufactures smaller HFC-32-based compressors, which are mostly used in room air-conditioners. The compressors required by the Indonesian RAC manufacturers (of more than eight horsepower) are still under development, with first testing units expected to be available by February 2019. Given the need for those units to be tested by prospective clients in order to verify acceptance and performance, February 2019 cannot be considered the target date for commercial-scale supply.

244. UNDP informed that the RAC manufacturers depend on the commercial-scale supply from the compressor manufacturers. The current supply-chain scenario for HFC-32 compressors of the required size is still unclear, and therefore the enterprises cannot yet commit to the completion of the project. Accordingly, UNDP proposed to extend the completion of the RAC manufacturing sector plan to December 2020 (i.e., in two years) to allow manufacturers to test the recently developed HFC-32 compressor, to initiate commercial manufacturing of the HFC-32 equipment, and to allow the payment of incremental operating costs (IOCs) to the manufacturers.

Servicing sector

245. Activities in the refrigeration servicing sector were initiated and will continue through stage II of the HPMP. Finalization of the implementation modalities of the product stewardship programme, upgrade of the training curriculum and awareness activities are ongoing. A study tour to Australia was conducted in August 2018 to assess the technicians' licensing system and to collect lessons that could help Indonesia replicate such a scheme. The Government is reviewing the qualifications and skills system for licensing or certifying technicians. The Indonesia National Standard agency adopted as a national standard ISO 817/2014 for designating refrigerants, including a safety classification to refrigerants based on toxicity and flammability, and a means of determining the refrigerant concentration limit. The Government of Australia will complete the technical assistance for refrigerant management project (IDS/PHA/64/TAS/196) by 31 December 2018.

Project management unit (PMU)

246. The PMU organized the study tour to Australia, assisted in the follow-up to the RAC investment activities required in decision 81/11(c), and supported the NOU in liaising with training centres to facilitate the implementation of the servicing activities.

Level of fund disbursement

247. As of September 2018, of the US $12,692,684 approved, US $11,038,267 (87 per cent) had been disbursed (US $7,981,905 for UNDP, US $777,285 for UNIDO, US $2,088,042 for the World Bank, and US $191,035 for the Government of Australia) as shown in Table 14.

Table 14. Financial report of stage I of the HPMP for Indonesia (US $)

Agency	Approved (US $)	Disbursed (US $)	Disbursement rate (%)
UNDP	8,901,102*	7,981,905*	90
UNIDO	777,395	777,285	100
World Bank	2,714,187**	2,088,042**	77
Government of Australia	300,000	191,035	64
Total	**12,692,684**	**11,038,267**	**87**

* Including US $3,134,216 returned at the 76th meeting.
** Including US $35,000 returned at the 81st meeting.

Secretariat's comments

248. The Government of Indonesia is requesting an additional extension for the completion of stage I of the HPMP from 31 December 2018 to 31 December 2020, to allow the payment of the IOCs associated with the conversion of the RAC manufacturing sector to HFC-32 technology, and the completion of the conversion of the foam enterprises and the systems houses. Issues discussed between the Secretariat and the implementing agencies on the request for the extension of the completion date are presented below.

<u>Extension of the RAC manufacturing sector</u>

249. In decision 64/42(a), the Executive Committee acknowledged with appreciation the commendable efforts made by Indonesia towards establishing forward-looking regulatory and policy action to sustain the HCFC phase-out. The Secretariat also noted with appreciation the efforts made by the Government, with the support of UNDP, industry and other stakeholders, to ensure the conversion to the agreed technology of the RAC manufacturing enterprises in stage I of the HPMP. Notwithstanding those efforts, the Government requested to extend the completion of the RAC manufacturing sector plan from December 2018 (with the

project completion report to be submitted to the first meeting of 2019 in line with decision 76/47(d)) to December 2020, given the challenges in introducing the HFC-32 technology (as previously explained).

250. Noting the challenges in introducing the HFC-32 technology and the activities being undertaken by the Government on this matter, the Secretariat suggested additional measures that could be considered, namely introducing financial incentives for HFC-32-based RAC equipment (i.e., a subsidy) and/or disincentives on high-GWP-based RAC equipment (i.e., a tax); and/or bulk procurement that could reduce the cost of the equipment (due to economies of scale) and build consumer confidence in the new technology. However, UNDP indicated that the Government was currently unable to put in place such measures; in addition, it would depend on a complex coordination process amongst stakeholders with varied interests. Recalling that funding was approved at the 81st meeting for enabling activities,[38] the Secretariat invited the Government and UNDP to continue exploring mechanisms and implementing actions favouring the introduction of low-GWP alternatives in the RAC manufacturing sector.

251. In approving the stage I of the HPMP, the Executive Committee acknowledged with appreciation the commendable efforts made by Indonesia towards establishing forward-looking regulatory and policy action to sustain the HCFC phase-out (decision 64/42(a)). The Government of Indonesia, with the support of UNDP, industry and other stakeholders, is making its best efforts to ensure the conversion to the agreed technology. Accordingly, the Secretariat recommends an extension of the RAC manufacturing sector.

252. Given the current constraints in introducing the HFC-32 technology in the local market, regardless of the efforts undertaken by the Government and the stakeholders, the Secretariat proposed that if by 1 January 2020 the enterprises were not manufacturing equipment with the agreed (i.e., HFC-32) technology, to deduct the quantity of R-410A charged in equipment manufactured by the converted enterprises after 1 January 2020 from the country's starting point for aggregate reduction on HFC consumption, after taking into account the quantity of HFC-32 that would have been phased in and would be included in the starting point, until the enterprises were manufacturing equipment based on the agreed alternative technology. In presenting this proposal, the Secretariat noted that, in line with paragraph 18(b) of decision XXVIII/2,[39] the RAC enterprises that were manufacturing with HFC-32 would be eligible for funding under the HFC phase-down, while any consumption of R-410A by those enterprises would not be eligible for funding. The Secretariat considers that the proposed path forward is consistent with those principles.

253. On behalf of the Government, UNDP expressed the following concerns about this proposal: it was unclear how the starting point would be established; even if enterprises were to start manufacturing HFC-32-based equipment in time, the starting point would need to cope with the tail for servicing of the R-410A-based equipment already deployed in the market; and that there was currently no decision that would fully take into account the special case of Indonesia. The proposal could be seen as penalizing the enterprises and the country for factors that are external to the HPMP implementation, and could discourage ongoing efforts in the country to ratify the Kigali Amendment. Subsequent to a discussion, it was agreed to extend the date of completion of stage I of the HPMP to 31 December 2019, on the understanding that the Government of Indonesia could submit a further request to extend stage I of the HPMP to the last meeting of 2019 and, in

[38] The enabling activities would *inter alia* include a review of existing legislation on ozone and climate protection; exploring synergy and increasing coordination among government departments involved in ozone protection/climate including capacity-building; reviewing the 2014 HFC survey and update the analyses to forecast the HFC baseline level and develop a list of alternative technologies based on the projected HFC baseline; developing a draft strategy based on different phase-down scenarios to proceed with the ratification and be compliant with its commitments.

[39] Enterprises that have already converted to hydrofluorocarbons in phasing out CFCs and/or HCFCs will be eligible to receive funding from the Multilateral Fund to meet agreed incremental costs in the same manner as enterprises eligible for first conversion (decision XXVIII/2, paragraph 18(b)).

such case, the Executive Committee could consider a possible deduction from the starting point for sustained aggregate reductions for HFC consumption at that time.

254. In addition, and noting the challenges in ensuring the uptake of the agreed technology in the market, it was agreed to allow, on an exceptional basis, the reallocation of the savings associated with the conversion at Panasonic, in the amount of US $23,000, to technical support activities to facilitate the manufacturing of HFC-32-based equipment at the enterprises assisted under stage I.

Extension of the PU foam sector

255. At the 76th meeting, the Executive Committee revised the Agreement for stage I of the HPMP to combine the third (2015) and fourth (2018) tranches to *inter alia* allow the assistance to the two systems houses to be provided as early as possible, facilitating the introduction of low-GWP alternatives in the foam sector and to minimize the overlap between stage I and stage II of the HPMP. However, additional time is required to complete the phase-out. The lack of steady supply and the high cost of blowing agents in the country are preventing one systems house from finalizing special formulations for small clients in the integral skin sector. Concurrently, discussions with the second systems house will continue with the objective that it will be converted rather than withdraw from the project and return the associated funding (US $301,538, plus agency support costs of US $22,615) to the Multilateral Fund.

256. The total funding remaining from PU foam sector amounts to US $492,104 as shown in Table 15. Savings associated with the three rigid foam enterprises that converted to hydrocarbons in 2014 and 2015 in the amount of US $134,041, plus agency support costs of US $10,053 for the World Bank, will be returned to the 82nd meeting. Furthermore, any additional balances from the PU foam sector would be returned to the Multilateral Fund upon financial completion of the project.

Table 15. Remaining funding in the foam sector

Activity	Budget (US $)
Integral skin sector	130,565
Systems house (TSG)	301,539
TA	30,000
PMU	30,000
Total	**492,104**

Actions required for extending the completion date of stage I of the HPMP

257. The Government of Indonesia, UNDP, and the World Bank would continue to submit progress reports on a yearly basis on the implementation of stage I of the HPMP through the completion of the project, progress reports would continue to be provided to the Executive Committee through the completion of stage I, and the project completion report by 30 June 2020, unless a further extension of the stage I of the HPMP were requested at the last meeting of 2019.

Recommendation

258. The Executive Committee may wish:

(a) To note:

(i) The update on enterprise conversion of technology and the progress report on the implementation of stage I of the HCFC phase-out management plan (HPMP) for Indonesia, submitted by UNDP;

(ii) With appreciation the efforts by the Government of Indonesia and UNDP to facilitate the introduction of the low-global warming potential (GWP) technology selected by the refrigeration and air-conditioning (RAC) manufacturing enterprises funded under stage I of the HPMP;

(b) To request the Government of Indonesia and UNDP to continue exploring mechanisms and implementing actions favouring the introduction of low-GWP alternatives in the RAC manufacturing sector, noting that funding was approved at the 81st meeting for enabling activities;

(c) To approve, on an exceptional basis, the reallocation of US $23,000, representing the savings from the conversion at Panasonic, to technical assistance to facilitate the manufacturing of HFC-32-based equipment at the enterprises assisted under stage I;

(d) To note the return, to the 82nd meeting, of:

(i) US $134,041, plus agency support costs of US $10,053 for the World Bank, associated with savings at the three rigid foam enterprises that converted to hydrocarbons; and

(ii) [US $301,538, plus agency support costs of US $22,615 for the World Bank, associated with the withdrawal of the PT. TSG Chemical from stage I of the HPMP;] or [to allow PT. TSG Chemical until the 83rd meeting to decide whether it wishes to participate in stage I of the HPMP];

(e) To note that the servicing sector plan would be completed by 31 December 2018, and that all remaining balances from the sector would be returned no later than 31 December 2019; and

(f) To agree to extend the completion date of stage I of the HPMP for Indonesia until 31 December 2019, on the understanding that:

(i) The Government of Indonesia could submit a further request to extend stage I of the HPMP to the last meeting of 2019;

(ii) That, if the Government of Indonesia were to submit the request in sub-paragraph (f)(i) above, the Executive Committee could consider at the last meeting of 2019 the further extension and its potential impact to the starting point for sustained aggregate reductions for HFC consumption for the country;

(iii) That, absent the submission of the request in sub-paragraph (f)(i) above:

a. All remaining balances from the **polyurethane** foam and the RAC manufacturing sectors would be returned to the Multilateral Fund by the last meeting of 2020; and

b. The Government of Indonesia, UNDP, and the World Bank would continue to submit progress reports on a yearly basis on the implementation of stage I of the HPMP through the completion of the project, and the project completion report by 30 June 2020

Stage I of the HPMP for Jordan (annual progress report) (UNIDO)

Background

259. On behalf of the Government of Jordan, UNIDO as the lead implementing agency, has submitted the annual progress report on the implementation of the work programme of stage I of the HPMP, in line with decision 75/60(c). This project should have been completed by December 2017 and the project completion report should have been submitted to the 81st meeting; however, the project was not completed as the bidding for equipment and tools could not be completed by 2017 due to lack of response.

HCFC consumption

260. The Government of Jordan reported HCFC consumption of 25.21 ODP tonnes in 2017, which is 62 per cent below the HPMP target of 66.4 ODP tonnes for 2017, and 70 per cent lower than the established baseline of 83.0 ODP tonnes. The Government also submitted sectoral consumption data for 2017 under the country programme (CP) implementation report (33.55 ODP tonnes), which is different from the data reported under Article 7. This issue is being addressed in the document on CP data and prospects for compliance.[40] The maximum quota for the year 2018 is 33 ODP tonnes of HCFC-22.

261. There was a significant decrease in HCFC consumption in Jordan during the period from 2015 to 2017 (73.99 ODP tonnes in 2015 and 25.21 ODP tonnes in 2017); this was mainly due to the reduction in manufacturing of HCFC-22-based air-conditioners; UNIDO informed that HCFC-22 consumption in the service sector may increase in the future due to the growing demand for servicing of the ageing population of existing equipment. They also clarified that the increase in consumption of HCFC-141b contained in imported pre-blended polyols (from 19.8 ODP tonnes in 2015 to 26.07 ODP tonnes in 2017) was due to the growing demand for building insulation caused by the inflow of refugees and was temporary. The situation has now stabilised and, as a result, the consumption is expected to decrease.

Progress report on the implementation of the second tranche of the HPMP

262. The Government continued to implement the licensing system and national regulations, particularly the prohibition of manufacturing and import of HCFC-22-based air-conditioning (AC) units and the mandatory minimum energy performance standard (MEPS) for AC equipment (as of December 2016), which prohibits marketing of equipment below the most energy-efficient category. As of September 2018, all enterprises covered under the AC sector plan completed conversions and phased out 162.36 mt (9.53 ODP tonnes) of HCFC-22 and HCFC-141b in manufacturing, and funds amounting to US $2,921,533 were disbursed. The timing of the AC sector conversion in stage I was complementary to the Government's policy on energy efficiency.

Technical assistance (TA) component

263. Two procurement activities for equipment and tools for the training center and for larger shops that service air-conditioners were undertaken in 2017 and early 2018. However, due to non-responsive bids and lack of offers, the procurement activities had to be redone; this is proposed to be completed by December 2018.

264. Under the TA component, outreach activities are planned for the fourth quarter of 2018 and in early 2019, including a final workshop to share experiences, outcomes of the conversion and new ODS regulations in October 2018; a final workshop for the Customs department and the Jordan Standards and Metrology Organisation (JSMO) in November 2018; and a workshop for the service sector in

[40] UNEP/OzL.Pro/ExCom/82/9.

December 2018. TA-related activities for servicing, Customs and enforcement training were completed before December 2017.

Project implementation and monitoring unit (PMU)

265. In 2018, activities for project monitoring and implementation included monitoring the completion of investment projects through site visits and consultations, and organization of workshops for technical outreach and support, including for the servicing sector. A project implementation manual that specifies the procedures, processes, procurement plans and terms of references for project activities was completed by the Ministry of Environment with the assistance from the World Bank, and serves as a guide for project management.

Level of fund disbursement

266. As of August 2018, of the US $3,366,017 approved, US $3,193,745 had been disbursed as shown in Table 16. The balance of US $172,272 is planned to be disbursed by March 2019, once the extension request is approved.

Table 16. Financial report of stage I of the HPMP for Jordan

Agency	Approved (US $)	Disbursed (US $)	Disbursement rate (%)
UNIDO	2,385,717	2,385,717	100.0
World Bank	980,300	808,028	82.4
Total	**3,366,017**	**3,193,745**	**94.9**

Comments

267. The Secretariat noted the submission of a comprehensive report on progress on the activities of stage I of the HPMP and reviewed the information submitted in light of decision 75/60(c), noting that the project should have been completed by December 2017, and that no extension request was submitted to the 80th or the 81st meeting. The lead implementing agency should request an extension of the date of completion of a project prior to that date. This issue will be considered in the Overview of issues identified during project review document.[41]

268. Regarding the difference between HCFC-22 consumption reported for 2017 under Article 7 and the CP data (25.21 and 33.55 ODP tonnes, respectively), the World Bank indicated that data reported under the CP is the best estimate, but that the Government would revise the CP data at the time of the World Bank's mission to the country in early 2019, at which time the CP data for the years 2013, 2014 and 2015 would also be revised. The Secretariat noted that, while sectoral consumption is indeed based on best estimates, that accurate reporting of data under both Article 7 and CP is critical, and that the imports reported under Article 7 and CP data should be the same. Accordingly, the Secretariat urged the Government to ensure that the CP data was complete, that the imports reported under Article 7 and the CP were consistent, and that the sectoral consumption reflected the HCFCs consumed by each sector in the country in the respective year.

269. The Secretariat requested clarifications on why some TA activities and the procurement of equipment were expected to continue in 2018. The World Bank informed that the bidding for equipment and tools could not be completed by 2017 due to lack of response from potential equipment suppliers, and that staffing changes in the national ozone unit (NOU) contributed to the delays. However, these issues have been addressed, the NOU is fully operational, and the remaining activities could be completed by the end of June

[41] UNEP/OzL.Pro/ExCom/82/31.

2019, according to the plan summarized in Table 17. The World Bank proposed that the remaining balance of US $172,272 be allocated as shown in Table 17 below.

Table 17. Plan for the utilisation of remaining funds

Project activities	Impact	Budget (US $)	Expected completion date (month/year)
Procurement of equipment			
Procurement and distribution of equipment and tools to training centers and servicing shops	AC servicing sector is capable of handling multiple refrigerants	89,000	January 2019
Training of service technicians		20,044	February 2019
Awareness, information outreach and project management			
Workshop on lessons learned (good practices, management of the trade of refrigerant gases, legislation and regulations)	Sustainable conversion of AC manufacturers and ensuring that the ban in HCFC-22-based AC imports and manufacturing is upheld	21,000	October 2018
Workshop for Customs and JSMO on enforcement of the HCFC-22 ban in the AC sector		15,000	November 2018
Project management unit	Stage I is effectively implemented and managed until completion.	27,228	June 2019
Total		**172,272**	

270. The Secretariat noted that the awareness information outreach and project management activities could be undertaken under stage II of the HPMP, which would result in the return of US $63,228. The World Bank informed that these activities were planned for implementation under stage I and had been committed. Implementation of PMU activities under stage II was limited as the Government was in the process of recruiting PMU staff.

271. The Secretariat noted the process and organisational level difficulties that resulted in the delays as highlighted above and considers that the project could be extended to ensure completion of activities by no later than June 2019.

Recommendation

272. The Executive Committee may wish:

(a) To take note of the 2018 progress report on the implementation of stage I of the HCFC phase-out management plan (HPMP) **for** Jordan, submitted by UNIDO;

(b) To consider the request for extension of the duration of stage I of the HPMP of Jordan up to 30 June 2019, on the understanding that no further extension of project implementation **of stage I** would be requested, that the project completion report would be submitted by the 84th meeting, and that the remaining balances **would be returned to the 84th meeting;** and

(c) To urge the World Bank to work with the Government of Jordan on revising the country programme data for the years 2013, 2014, 2015 and 2017 in order to ensure that they are consistent with the data reported under Article 7 of the Montreal Protocol**, and to submit revised country programme data reports to the Secretariat as soon as possible.**

Stage I of the HPMP for Malaysia (2017-2018 progress report and 2017 verification report) (UNDP)

Background

273. On behalf of the Government of Malaysia, UNDP as the designated implementing agency, has submitted to the 82nd meeting the annual progress report on the implementation of the work programme associated with the fourth and final tranche of the HPMP[42], in line with decision 77/36.

HCFC consumption

274. The Government of Malaysia reported HCFC consumption of 235.78 ODP tonnes in 2017, which is 46 per cent below the HPMP target of 438.40 ODP tonnes for 2017, and 54 per cent lower than the established baseline of 515.8 ODP tonnes. The Government submitted sector consumption data under the 2017 country programme implementation report consistent with the data reported under Article 7 of the Montreal Protocol.

Progress report on the implementation of the fourth and final tranche of the HPMP

275. The following activities were undertaken:

(a) A four-day study tour in China for foam enterprises and a systems house, and development of a guidance document on technical and economic aspects of alternative blowing agents to assist in the selection of blowing agents based on specific applications;

(b) Six technical assistance workshops for 2,000 technicians and continued information dissemination and seminars on flammable refrigerants; refresher courses for 150 technicians and 113 trainers on good refrigeration servicing practices; 23 sets of recovery and recycling machines distributed to training centers; continued online certification of technicians, with 2,268 technicians certified through June 2018; a hands-on training for 20 trainers on HFC-32, distribution of 168 HFC-32 air-conditioners and training display racks to 44 training centres, and training on installation and servicing of HFC-32-based equipment at seven training centres; and training of 48 customs officers; and

(c) Project coordination and monitoring.

Level of fund disbursement

276. As of September 2018, of the US $9,587,470 approved, US $9,370,016 (98 per cent) had been disbursed.

Comments

277. The Executive Committee decided to approve the extension of the duration of stage I of the HPMP to 1 June 2018, on the understanding that no further extension of project implementation would be requested and that the project completion report would be submitted to the second meeting in 2018 (decision 80/22(b)). In line with that decision, all project activities have been completed and the project completion report was submitted.

[42] The fourth and final of stage I of the HPMP was approved at the 77th meeting at the amount of US $141,295, plus agency support costs of US $10,597 for UNDP.

278. With regard to the remaining balance of US $217,454, UNDP indicated that it had been committed and was expected to be disbursed soon, as shown in Table 18.

Table 18. Budget, disbursement and commitment by component as of October 2018

	Budget (US $)	Disbursement (US $)	Commitment (US $)	Description
Foam sector	35,000	35,000	0	Not applicable
Servicing sector	651,276	455,794	195,482	Payment to vendors for equipment and tools, printing of manuals, payment for workshops
PMU	210,149	188,177	21,972	Payment to consultant and for missions already undertaken and other meeting and office expenses
Total	**896,425**	**678,971**	**217,454**	

279. Regarding the difficulty in distinguishing between the activities in the servicing sector supported by stage I with those supported under stage II, UNDP provided Table 19 summarizing the different activities supported under each stage.

Table 19. Activities in the servicing sector in stage I and in stage II

	Activities under stage I	Activities under stage II
Training	Authorised Training Centres (ATC) capacities were strengthened: -Good practices training delivered -51 ATCs received training tools and materials -All ATCs required to use training module for management purpose.	-Two centres of excellence strengthened with a focus on flammable refrigerants -Hands-on training and capacity building for technicians and master trainers, focusing on flammable refrigerants handling
Certification	On-line system Electronic Certification for Servicing Technicians Programme (eCSTP) developed	Upgrading the eCSTP programme
Private-public sector cooperation	Hands-on training for master trainers with technical assistance from Daikin Japan	Technical assistance from technology providers involved in stage I and other technology providers
Regulatory and legal framework and standardization	-Hands-on training conducted by ATCs were supervised and certified by Department of Environment -Syllabus and training manual revised in 2017 to include flammable refrigerants such as HFC-32 and hydrocarbons	Regulatory requirement will be followed

280. Regarding the support provided to the PMU under stage I versus that under stage II, UNDP clarified that the national implementation modality used by UNDP to implement the projects in Malaysia entails that funds are kept within UNDP accounts and the expenses are incurred as ordered by the national ozone unit. Those funds are controlled under different project numbers, which budgets are kept completely separated and cannot be crossed. In addition, two verifications are conducted, by the Government and by UNDP, to ensure that payments are not charged against the wrong projects and budget lines.

Recommendation

281. The Executive Committee may wish:

(a) To note the 2017-2018 progress report on the implementation of stage I of the HCFC phase-out management plan (HPMP) for Malaysia, submitted by UNDP;

(b) To note that US $217,454 had been committed but not yet disbursed, and to request UNDP to return any remaining balances to the 83rd meeting; and

(c) To note that the Government of Malaysia had completed the implementation of stage I of the HPMP by 1 June 2018, and had submitted the project completion report to the 82nd meeting, in line with decision 80/22(b).

Stage I of the HPMP for Maldives (transition from use of interim technology to low-GWP refrigerants and 2018 progress report) (UNEP and UNDP)

Background

282. On behalf of the Government of Maldives, UNEP, as lead implementing agency, has submitted the 2018 annual progress report on implementation of the work programme associated with the fourth (final) tranche of stage I of the HPMP,[43] for the country, in line with decision 80/70(b).

Progress report on the implementation of the fourth tranche of the HPMP

Legal framework

283. The quota and licensing system for HCFC imports continues to operate; the Government of Maldives has issued HCFC import quotas for 2018 at 22 mt (1.2 ODP tonnes), which is the same as the maximum allowable consumption under its Agreement with the Executive Committee. The Government also introduced tax incentives for imports of HCFC alternatives and disincentives for HCFC-containing equipment through its Import and Export Act (i.e., import tax was reduced from 10 per cent to five per cent for ammonia to provide incentive for adoption of low-GWP alternatives; and import tax was increased from 10 per cent to 100 per cent for HCFC and HCFC blends). Three training workshops on ODS identification and ODS trade control were conducted for 76 Customs officers; three Customs officers participated in an international workshop on risk profiling and prevention of illegal ODS trade.

Activities in the refrigeration

284. Five RAC technicians were trained on the use of flammable refrigerants (i.e. HC-based refrigerants) for room air-conditioning systems; 30 participants attended consultation workshops on RAC technician certification, where good servicing practices training programme will be integrated into the national vocational and technical training and education curriculum; training was conducted for technicians engaged in daily maintenance of refrigeration and air-conditioning units in the fisheries sector, and those service technicians participated in an inception workshop on the demonstration project for HCFC-free low-GWP alternatives in the fisheries sector.

Technical assistance

285. The recovery, recycling and reclamation unit will be transferred by the Government of the Maldives to the Maldives Industrial Fisheries Co (MIFCO), a semi-government organization which had been selected to be the provider of these services. Under the pilot retrofit/replacement incentive scheme, the Government has signed an agreement with MIFCO in October 2017, making them responsible for the project on the replacement of HCFC-22-based equipment, including the recovery of HCFC-22 from the replaced equipment,

[43] The fourth tranche of stage I of the HPMP was approved at the 80th meeting in the amount of US $50,000, plus agency support costs of US $6,500 for UNEP.

and sending the refrigerant to the reclamation centre for re-use. For this project, 101 HFC-32-based air-conditioners with different cooling capacities will be purchased by MIFCO and distributed to beneficiaries.

Status of use of the interim technology, including the availability of low-GWP refrigerants in the fisheries sector

286. In line with decision 75/62(c),[44] UNEP reported that the interim technology, which is used in fisheries sector, is R-438A.[45] One of the options being explored is R-448A[46], which is not yet commercially available in the Asian market, making procurement challenging. Following discussions with beneficiaries, the fisheries sector is unwilling to adopt the use of flammable refrigerants (i.e., HC-based) in fishing vessels because of fire risk. The country is waiting for a new non-flammable alternative refrigerant to be available that could be used to retrofit equipment.

Level of fund disbursement

287. As at September 2018, of the US $1,100,000 approved, US $937,372 (85 per cent) had been disbursed, as shown in Table 20.

Table 20. Financial report of stage I of the HPMP for Maldives

Tranche		UNEP	UNDP	Total	Disbursement rate (%)
First tranche	Approved	355,940	400,000	755,940	88
	Disbursed	355,940	311,432	667,372	
Second tranche	Approved	173,400	20,000	193,400	92
	Disbursed	173,400	4,100	177,500	
Third tranche	Approved	100,660	0	100,660	67
	Disbursed	67,500	0	67,500	
Fourth tranche	Approved	50,000	0	50,000	50
	Disbursed	25,000	0	25,000	
Total	Approved	680,000	420,000	1,100,000	85
	Disbursed	621,840	315,532	937,372	

Implementation plan for third and fourth tranches

288. The following activities will be implemented between October 2018 and December 2019:

(a) Training of 30 enforcement officers on new regulations;

(b) Two train-the-trainers workshops for 30 participants and training of 60 RAC servicing technicians on new regulations;

(c) Training of 20 participants on refrigerant alternative refrigerant in the fisheries sector;

(d) Workshops on HCFC phase-out and servicing requirements beyond 2020; and

[44] To request UNDP to report at the first meeting in 2017 and every year thereafter until another technology with a low-GWP had been fully introduced, on the status of use of the interim technology selected by the Government, including the availability of low-GWP refrigerants in the market and the potential use of recycled HCFC-22 from the recovery and recycling component of the HPMP, with a review by the Secretariat of the selected approach in 2019.

[45] Mixture of HFC-32/HFC-125/HFC-134a/HC-600/HC-601a (8.5/45.0/44.2/1.7/0.6)

[46] Mixture of HCFC-22/HFC-125/HFO-1234yf/HFC-134a/HFO-1234ze (26.0/26.0/20.0/21.0/7.0)

(e) Awareness raising on the Montreal Protocol and HCFC phase-out activities.

Comments

289. The Secretariat sought clarifications on some activities that had been planned for this period but no progress was provided in this report, in particular, the in-house training on monitoring/servicing retrofitted equipment in fishing vessels, and on the use of recycled HCFC-22 from the recovery and recycling component of the HPMP. The Secretariat also requested UNEP as lead implementing agency to provide a workplan for 2019 to enable a better monitoring of the remaining activities and to ensure their completion.

290. UNEP clarified that the in-house trainings were delayed and awaiting for the finalization of the procurement and import of alternative refrigerants for the retrofit process in the fisheries sector. The plan is to conduct on-site trainings after November 2018, once the available technology (R-448A) will have been tested under the fisheries demonstration project. With regard to the use of recycled HCFCs, UNEP explained that while the reclamation centre was set up, it was not operational due to administrative reasons. As of now no recycled HCFC-22 has been used. The fisheries sector is the single largest consumer of HCFCs, and the plan for MIFCO to be responsible for the reclamation centre is expected to yield better results.

291. UNEP also submitted a detailed workplan for the remaining activities along with the budget for each, for 2019. Information on the the demonstration project on the fisheries sector will be reported separately to the 83rd meeting.

Recommendation

292. The Executive Committee may wish to note the 2018 annual progress report on the implementation of stage I of the HCFC phase-out management plan for Maldives, submitted by UNEP.

Stage I of the HPMP for Mexico (annual progress report) (UNIDO/UNDP)

293. On behalf of the Government of Mexico, UNIDO as the lead implementing agency has submitted the annual progress report on the implementation of the work programme associated with the fifth and final tranche of the HCFC phase-out management plan (HPMP)[47] in line with decision 75/29(a).[48]

HCFC consumption

294. The Government of Mexico reported HCFC consumption of 414.22 ODP tonnes in 2017, which is 60 per cent below the 1,033.9 ODP tonnes for the same year in its Agreement with the Executive Committee, and 64 per cent below the HCFC baseline of 1,148.8 ODP tonnes. The Government also reported HCFC sector consumption data under the 2017 country programme implementation report that is consistent with the data reported under Article 7 of the Protocol.

295. Phase-out activities in the aerosol and polyurethane (PU) foam sectors contributed to the sustained decrease in HCFC consumption. In 2017, the consumption of HCFC-141b was substantially reduced due in part to the cancellation of quotas for several enterprises using HCFC-141b for aerosols, foam applications and solvents.

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[47] The fifth and final tranche of stage I of the HPMP was approved at the 75th meeting at a total cost of US $1,449,982, consisting of US $226,317 plus agency support costs of US $16,974 for UNIDO, and US $1,122,503 plus agency support costs of US $84,188 for UNDP.

[48] Provision reflected in Annex XII of document UNEP/OzL.Pro/ExCom/75/85.

296. The consumption of HCFC-22 shows a slight growing trend in the servicing sector to cover the needs of the aging inventory of installed HCFC-based equipment. The market has slowly been shifting toward HCFC-free equipment since new standards were put in place. However, HCFC-22 consumption is expected to remain at similar levels for the next few years or longer if no action is taken to completely phase out HCFC in the servicing sector through stage III of the HPMP.

Progress report on the implementation of the fifth tranche of the HPMP

Activities in the aerosol manufacturing sector

297. Silimex (11.0 ODP tonnes of HCFC-141b): Project completed in December 2014.

Activities in the PU foam manufacturing sector

298. Domestic refrigeration (Mabe, 55.9 ODP tonnes of HCFCs): Conversion to HC completed.

299. Systems houses project: The technical conversion of all systems houses has been completed and their formulations for all foam applications have been developed and are commercially available. The downstream users included in stage I have also completed the conversions to low-GWP alternatives. A summary of progress achieved on the systems houses project is presented in Table 21.

Table 21. Status of systems houses project as of September 2018.

Systems house (SH)	Technologies developed	Status	Downstream foam users	
			Qty	Status
Acsa/Pumex	Pre-blended HC; methyl formate (MF); methylal, water, HFO	Conversion completed; formulations developed and commercially available	37	Project completed
Aepsa	MF		5	Project completed
Comsisa	MF		19	Project completed
Eiffel	MF; water; methylal; methylal/HFC; HFO (self-funded); cyclopentane (self-funded)		91	Project completed
Maxima	MF; water; HFC/HFO		54	Project completed
Polioles	MF; water; HFO (self-funded)		4	Project completed
Urethane	MF		34	Project completed
Valcom	MF; methylal with HFC (HFO future)		12	Project completed
Zadro	Methylal; water		14	Project completed
Bayer	HFC; HFO (future)	Systems houses non-eligible for funding	1	Project completed
Dow	HFC; water; HFO (future)		14	Project completed
Huntsman	Water		n.a.	Voluntary phase-out

300. Commercial refrigeration (Fersa, Frigopanel, Metalfrio): Fersa (7.3 ODP tonnes) completed its conversion in 2017, and has obtained the TUV certification.[49] Ojeda/Frigopanel (6.4 ODP tonnes of HCFC-141b) completed its conversion and obtained the TUV certificate; project completion is expected in the first quarter of 2019. Metalfrio (9.2 ODP tonnes of HCFC-141b) completed its conversion and the TUV certification process is advanced. The project is completed and the funds disbursed. The enterprise is already operating under the local safety regulations and is finalizing the last steps of the TUV certification process with its own resources.

Activities in the extruded polystyrene (XPS) foam sector

301. At the 79th meeting, the Executive Committee approved the reallocation of US $1,293,558 in savings from the implementation of the PU foam sector plan to convert two eligible enterprises in the XPS foam sector (Plasticos Espumados and Termofoam Valladolid), and to completely phase out the use of HCFC-142b

[49] TUV (Technischer Überwachungsverein) certification on the safety of products for humans and the environment.

in the country. Currently, Termofoam has started its conversion to HFO-1234ze, is procuring the equipment and will complete the project in July 2019 as originally proposed. Plasticos Espumados is considering either adopting the alternative proposed, or converting with its own funds to an HFC alternative and waiting for a further project under the implementation of the Kigali Amendment.

Activities in the refrigeration servicing sector

302. An overview of the progress in the implementation of activities in the refrigeration servicing sector is presented in Table 22.

Table 22. Overview of the progress in the refrigeration servicing sector

Activity	Proposed output	Achieved so far	Updated output	Status
Customs officer training	2	2	2	Completed, 82 officers trained, including some from other countries in the region
Distribution of refrigerant identifiers	20	12	12	Completed, 12 refrigerant identifiers purchased for the 12 customs points that have ODS import/export operations
Training manual	4,000	4,000	4,000	Completed, 4,000 manuals were printed and delivered to the 11 training centres
Train-the-trainer courses	3	2	2	Completed, 38 trainers from 11 training centres
Technician training	4,000	3,000	3,500	Final target adjusted to 3,500 technicians – the remaining 500 will be trained in 2019
Distribution of servicing kits	200	275	275	Completed
Distribution of flushing kits	33	79	79	Completed
ODP tonnes of HCFC phased out as cleaning agent	23	23	23	Servicing kits have been distributed to technicians and HCFC-141b phase-out can be recorded
New standards for AC equipment and policy	3	2	3	Ongoing, NOM-026-Energy Efficiency (EE) for inverter AC developed; NOM-021-ENER/SCFI EE for window AC updated and published; EE standards for AC equipment (023-ENER-2010) currently updated

Level of fund disbursement

303. As of September 2018, of the US $18,066,211 approved, US $16,513,657 (91 per cent) had been disbursed (US $12,297,324 for UNDP, and US $4,216,333 for UNIDO). A balance of US $1,094,398 will be disbursed prior to 2019 (Table 23).

Table 23. Financial report of stage I of the HPMP for Mexico as of September 2018 (US $)

Component	Agency	Funds approved (US $)	Funds disbursed (US $)	Funds disbursed (%)	Planned disbursement (Oct. 2018 - 2019) (US $)	Balance (US $)
PU foam (Mabe)	UNDP	2,428,987	2,423,483	99.8	0	5,504
PU foam (systems houses) *		9,931,471	9,328,841	93.9	150,000	452,630
XPS foam (two enterprises)		1,293,558	545,000	42.1	748,558	0 **

Component	Agency	Funds approved (US $)	Funds disbursed		Planned disbursement (Oct. 2018 - 2019) (US $)	Balance (US $)
			(US $)	(%)		
PU foam (Metalfrío, Fersa, Ojeda)	UNIDO	2,046,110	1,851,911	90.5	194,199	0
Aerosol (Silimex)		520,916	520,894	100.0	0	22
Refrigeration servicing sector		1,845,169	1,843,528	99.9	1,641	0
Total		**18,066,211**	**16,513,657**	**91.4**	**1,094,398**	**458,156**

* A total of US $11,225,029 had been approved for this activity. At the 79th meeting the Committee approved a reallocation of US $1,293,558 for a new activity in the XPS foam manufacturing sector.

** Additional estimated savings of US $683,300 would be returned to the Fund if the enterprise Plasticos Espumados does not participate in the HPMP.

Implementation plan for 2019

304. The following activities will be implemented during 2019: issuance of the TUV certificate and payment of incremental operational costs at Ojeda, last payments related to the PU foam downstream-user conversions; completion of conversion of one XPS foam enterprise to HFO-1234ze and reduction of the import quota for HCFC-142b to zero by 1 January 2020; training of additional 500 technicians in good servicing practices; continued quota issuance and monitoring; monitoring of the energy standard set in place for air conditioners, and monitoring of the imports, exports and production of HCFCs.

Comments

HCFC consumption

305. Upon request, UNIDO clarified that in 2018 HCFC-141b is still used by: one non-Article-5-owned domestic refrigeration enterprise that has converted its PU panel manufacturing during 2018, one medical laboratory for needle coating, and a few more non-Article-5-owned enterprises using it as a solvent, as other HFC or HFO alternatives are extremely expensive. The Government of Mexico plans to continue adjusting the HCFC-141b import quotas, taking into consideration the needs of the market and the goal of achieving a zero quota in 2022, or earlier if feasible.

PU foam and XPS foam

306. The Secretariat noted that the systems houses project was completed with potential savings. UNDP explained that there are still some limited expenditures expected in 2018 and 2019 related to clearing of all contracts, finalizing hand-over protocols, and other administrative and technical tasks (Table 3). UNDP will operationally close the project once the implementation has been entirely completed, and will then proceed with the financial completion in accordance with UNDP rules and regulations. Remaining balances have been preliminarily estimated at approximately US $450,000. Any remaining balances would be returned to the Fund in line with paragraph 7(e) of the Agreement.

307. UNDP explained that if the XPS foam enterprise Plasticos Espumados does not confirm its participation in stage I by 31 December 2018, the Government and UNDP will cancel the project, and the associated funding of US $683,300 will be returned to the Multilateral Fund along with the savings from the PU foam sector plan. UNDP confirmed that the commitment of the Government not to issue any import quota from 1 January 2020 for HCFC-142b (the only HCFC used in XPS foam in Mexico) is maintained.

308. In line with paragraph 7(c) of the Agreement and decision 80/23(b), UNDP submitted a comprehensive list with the names of 285 downstream foam users assisted under stage I, grouped by systems house, indicating the sub-sectors, technologies introduced and equipment provided (where applicable). While

this list can be considered final, UNDP will report if any additional downstream users are identified and added to an updated list, which would then be sent to the Secretariat.

309. UNDP confirmed that no high-GWP technologies were introduced in the PU foam sector through the project. Each of the systems house assisted signed an implementation contract to introduce only zero-ODP or low-GWP formulations. In a few applications, methyl formate and methylal formulations contained a limited amount of HFC-365 (no more than 20 per cent) to maintain the characteristics of the foam (e.g., stability, lower flammability), keeping the overall formulation with a low GWP. UNDP clarified that prior to the project some of the systems houses, especially non-Article-5-owned enterprises, were already using HFC-based formulations developed with their own funds.

310. For the PU foam enterprises that selected HFO-1233zd as alternative technology the price is between US $18/kg and US $20/kg.

311. The Secretariat notes that the Government of Mexico, with the assistance of UNIDO and UNDP, has continued to complete projects under stage I, meeting and exceeding HCFC consumption reduction targets, including the conversion of close to 300 manufacturing enterprises. Furthermore, one additional XPS foam enterprise is also on track to convert to a low-GWP alternative. The Government continues the implementation of the refrigeration servicing sector programme. All remaining activities under stage I will be completed before December 2019, the completion date established for stage I in the Agreement between the Government and the Executive Committee. UNDP would be able to include the level of savings from the foam sector plan in the annual report to be submitted to the second meeting in 2019, return balances by the time of completion of stage I in line with paragraph 7(e) of the Agreement for stage I of the HPMP, and submit the project completion report to the 85th meeting.

Recommendation

312. The Executive Committee may wish:

(a) To note the 2018 progress report on the implementation of stage I of the HCFC phase-out management plan (HPMP) for Mexico submitted by UNIDO;

(b) To request the Government of Mexico, UNIDO and UNDP to include in the next progress report of stage I of the HPMP to be submitted to the 84th meeting:

(i) Any update to the final list of downstream foam enterprises assisted by the Multilateral Fund under stage I, including their HCFC-141b consumption phased out, sub-sector, baseline equipment and technology adopted;

(ii) Confirmation on whether or not the enterprise Plasticos Espumados participated in stage I of the HPMP;

(iii) The **balances, including those from the foam sector** plan, to be returned to the Multilateral Fund **by the time of completion of stage I** in line with paragraph 7(e) of the Agreement for stage I of the HPMP; and

(c) To request UNDP and UNIDO to submit the project completion report no later than 30 June 2020.

Qatar: Extension of the HCFC phase-out management plan (stage I) (UNIDO and UNEP)

313. At its 81st meeting, the Executive Committee requested the Secretariat to send a letter to the Government of Qatar noting *inter alia* that the agreement or project document for stage I of the HCFC phase-out management plan (HPMP) had not been signed and urging the Government of Qatar to work with UNIDO and UNEP to address all the issues related to the signing of the agreement before the 82nd meeting so that a proposal for stage II of the HPMP could be submitted to the 83rd meeting, otherwise the project would be considered for possible cancellation at the 82nd meeting in the absence of any progress, and the outstanding balances returned to the Multilateral Fund (decision 81/27).

314. The agreement between the Government of Qatar and UNEP has been signed.

315. On behalf of the Government of Qatar, UNIDO as the lead implementing agency, has submitted a request for extending stage I of the HPMP.[50] The submission includes a tranche implementation plan for 2018-2019 and a revised updated draft Agreement.

Report on HCFC consumption

HCFC consumption

316. The Government of Qatar reported a consumption of 68.54 ODP tonnes of HCFC in 2017 which is 21.15 per cent below the HCFC baseline for compliance. The 2013-2017 HCFC consumption is shown in Table 24.

Table 24. HCFC consumption in Qatar (2013-2017 Article 7 data)

HCFC	2013	2014	2015	2016	2017	Baseline
Metric tonnes						
HCFC-22	1,368.48	1,495.35	1,096.01	1,066.10	1,084.66	1,335.50
HCFC-123	30.50	40.98	1.36	15.52	0	16.40
HCFC-141b	15.71	10.05	21.97	37.37	59.45	5.24
HCFC-142b	47.63	11.98	48.77	36.00	36.00	195.90
Total (mt)	1,462.32	1,558.36	1,168.11	1,154.99	1,180.11	1,553.04
ODP tonnes						
HCFC-22	75.27	82.24	60.28	58.64	59.66	73.45
HCFC-123	0.61	0.82	0.03	0.31	0.00	0.33
HCFC-141b	1.73	1.11	2.42	4.11	6.54	0.58
HCFC-142b	3.10	0.78	3.17	2.34	2.34	12.73
Total (ODP tonnes)	80.70	84.95	65.89	65.40	68.54	86.93

Country programme (CP) implementation report

317. The Government of Qatar reported HCFC sector consumption data under the 2017 CP implementation report which is consistent with the data reported under Article 7.

Verification report

318. As part of the request for the second tranche that was submitted to the 79th meeting but subsequently withdrawn, the Government of Qatar had submitted the 2013-2016 verification report that confirmed that the Government was implementing a licensing and quota system for HCFC imports and exports, that the total

[50] As per the letter of 31 October 2018 from the Ministry of Municipality and Environment (MME) of Qatar to the Secretariat.

consumption of HCFCs for 2013-2016 was as reported under Article 7, and that Qatar was in compliance with the Agreement with the Executive Committee.

Extruded polystyrene (XPS) foam manufacturing sector

319. Of three XPS foam manufacturing enterprises, one, Al Kawthar relocated to Oman; while the conversion at Qatar Insulation Factory (QIF) and at the Orient Insulation Factory (OIF) has been completed and phased out 19.45 ODP tonnes. Both converted to CO_2 system with dimethyl ether as organic solvent and HFC-152a. A savings of US $39,241, plus agency support costs of US $2,943 will be returned by UNIDO to the 82nd meeting.

Refrigeration servicing sector

320. As the agreement between UNEP and the Government of Qatar was only recently signed, the activities in the servicing sector have been limited but are now expected to accelerate. The following activities have been implemented to date: two workshops for local staff at the MME on ODS recording and training for customs inspectors on ODS import control were organized; an international institute was contracted and developed a certification programme for technicians and servicing workshops; technical documentation was drafted on national codes of good practice for different refrigeration and air-conditioning servicing professions for the country's approval; and a temporary committee was formed to review the draft certification documentation.

321. The following activities will be implemented by 1 July 2019, the completion of stage I:

(a) Continuation of the training programme for customs officers based on the updated regulations;

(b) Development and testing of a new e-licensing system based on the existing chemicals e-licensing system;

(c) Provision of training programme on good servicing practices by local training centres (Qatar University and the Canadian University in Doha);

(d) Training session for 12 master trainers (planned for the last week of November 2018 and a follow-up training in 2019); and

(e) Management and monitoring support activities.

Level of fund disbursement

322. As of October 2018 of the US $1,150,907 so far approved (US $1,045,907 for UNIDO and US $105,000 for UNEP), US $1,006,666 (96 per cent) had been disbursed by UNIDO and US $69,300 (66 per cent) by UNEP.

Secretariat's comments

323. Noting that the 2013-2016 verification report was part of the second tranche request submitted to the 79th meeting that was subsequently withdrawn, the Secretariat suggested that 2017 and 2018 verification be included with the proposal for stage II of the HPMP to be submitted to the 83rd meeting.

Revision to the HPMP Agreement

324. The following changes to the Agreement were agreed:

(a) At the 65th meeting, the Secretariat was requested, once the baseline data were known, to update Appendix 2-A to the Agreement to include the figures for maximum allowable consumption, and to notify the Executive Committee of the resulting change in the levels of maximum allowable consumption. Accordingly, the target specified in paragraph 1 and rows 1.1 and 1.2 of Appendix 2-A were updated based on the country's baseline of 86.9 ODP tonnes, as reported under Article 7 of the Montreal Protocol;

(b) Rows 2.1 to 3.3 of Appendix 2-A were updated to reflect that no further tranches would be submitted, and that the first and final tranche was the amount originally approved at the 65th meeting;

(c) Paragraph 14 was modified to specify the completion of stage I by 1 July 2019; and

(d) A new paragraph 16 was added to indicate that this Agreement replaces the one reached at the 65th meeting;

325. The relevant paragraphs and appendix of the updated Agreement between the Government of Qatar and the Executive Committee reached at the 65th meeting have been updated, as shown in Annex I to the present document. The full updated Agreement will be appended to the final report of the 82nd meeting.

326. The Secretariat noted the signature of the agreement between the Government of Qatar and UNEP that will allow the remaining activities in the servicing sector to be undertaken. Given the progress in the conversions in the XPS foam manufacturing sector, and that revising the Agreement between the Government and the Executive Committee would allow the submission of a comprehensive plan for stage II of the HPMP to the 83rd meeting that takes into account the developments in the country since the approval of the HPMP at the 65th meeting, the Secretariat supports the proposal to extend stage I of the HPMP and to amend the Agreement.

RECOMMENDATION

327. The Executive Committee may wish to consider:

(a) Noting:

(i) The request for extending stage I of the HCFC phase-out management plan (HPMP) for Qatar to 1 July 2019;

(ii) That the Fund Secretariat had updated paragraphs 1 and 14, **and** Appendix 2-A of the Agreement between the Government of Qatar and the Executive Committee, based on the country's baseline of 86.9 ODP tonnes as reported under Article 7 of the Montreal Protocol, the revised funding level to reflect that no further tranches would be requested following the first tranche of the HPMP approved at the 65th meeting, the revised completion date of 1 July 2019**;** and that a new paragraph 16 had been added to indicate that the updated Agreement superseded that reached at the 65th meeting, as contained in Annex I to the present document;

(iii) The return to the 82nd meeting of US $39,241, plus agency supports of US $2,943 for UNIDO, associated with the enterprise Al Kawthar that had **been** relocated to Oman;

(iv) That the Government of Qatar could submit the **project** proposal for stage II of the HPMP to the 83rd meeting, on the understanding that **it** would include the verification of Qatar's consumption for the years 2017 to 2018.

(b) Approving **the** 2018-2019 tranche implementation plan of stage I of the HPMP for Qatar; and

(c) Requesting the Government of Qatar, UNIDO and UNEP to submit, the final progress report to the 84th meeting, the financial completion and return the remaining balances by 31 December 2019, and the project completion report to the first meeting of the Executive Committee in 2020.

Stage I of the HPMP for Venezuela (Bolivarian Republic of): Final progress report (UNIDO)

328. On behalf of the Government of Venezuela (Bolivarian Republic of), UNIDO as the designated implementing agency has submitted the annual progress report on the implementation of the work programme associated with the fourth (final) tranche of stage I of the HCFC phase-out management plan (HPMP)[51] in line with decision 75/65(d).[52]

HCFC consumption

329. The overall HCFC consumption reported in 2017 is 17.10 ODP tonnes, which is 91 per cent below the 186.25 ODP tonnes allowable for that year in the Agreement between the Government and the Executive Committee, and 92 per cent below the established baseline of 206.94 ODP tonnes, as shown in Table 25.

Table 25. HCFC consumption in Venezuela (Bolivarian Republic of) (2013-2017 Article 7 data)

HCFC	2013	2014	2015	2016	2017	Baseline
Metric tonnes						
HCFC-22	2,264.21	1,685.36	831.24	259.86	273.22	2,938.7
HCFC-123	0.00	4.00	0.00	0.00	0.00	3.3
HCFC-124	0.00	9.60	0.00	0.00	0.00	0.0
HCFC-141b	93.06	94.00	0.00	100.00	18.80	359.6
HCFC-142b	0.00	20.00	0.00	20.00	0.00	87.4
Total (metric tonnes)	**2,357.27**	**1,812.96**	**831.24**	**379.86**	**292.02**	**3,389.0**
HCFC-141b in imported pre-blended polyols*	0.00	56.37	58.12	5.11	49.43	**17.4
ODP tonnes						
HCFC-22	124.53	92.69	45.72	14.29	15.03	161.36
HCFC-123	0.00	0.08	0.00	0.00	0.00	0.07
HCFC-124	0.00	0.21	0.00	0.00	0.00	0.00
HCFC-141b	10.24	10.34	0.00	11.00	2.07	39.56
HCFC-142b	0.00	1.30	0.00	1.30	0.00	5.68
Total (ODP tonnes)	**134.77**	**104.63**	**45.72**	**26.59**	**17.10**	**206.94**
HCFC-141b in imported pre-blended polyols*	0.00	6.20	6.40	0.56	5.44	**1.91

*CP implementation report data
**Average consumption between 2007 and 2009.

[51] The fourth (final) tranche of stage I of the HPMP was approved at the 75th meeting at a total cost of US $189,000 plus agency support costs of US $14,175 for UNIDO.
[52] Provision reflected in Annex XII of document UNEP/OzL.Pro/ExCom/75/85.

330. UNIDO and UNDP explained that the reduction in HCFC consumption was due to an abrupt decrease in HCFC production and imports caused by the Country's current economic slowdown and difficulties in importing materials. However, this severe scarcity of HCFCs does not reflect the real needs of the local economy, which is expected to eventually recover and return to higher consumption levels.

Progress report

331. The following activities were implemented under stage I:

(a) Drafting regulations concerning imports, exports, production and consumption of ozone depleting substances (ODS); improving the software developed to manage the ODS import and export licensing and quota system; training 120 customs officers as well as managers, trainers, and experts on HCFC import control and regulations; distributing 13 refrigerant identifiers to customs entry points;

(b) Establishing a refrigeration technicians training programme with the national training institute (INCES) and distributing didactic servicing tools for training including 16 refrigeration simulators to 36 of its centres;

(c) Training 80 trainers from INCES; training and certification of 819 technicians; updating the good refrigeration practices manual and producing a new manual for the use of hydrocarbon (HC) as an alternative technology to HCFCs;

(d) A study tour to Colombia, Mexico and Panama to visit recovery and reclaiming centres, technician training centres and refrigeration manufacturing plants using HCs, and establishing two reclaiming centres (equipment has not been commissioned yet); and

(e) Manufacturing an HC-based chiller as a pilot project and implementing a leak-reduction programme addressed to end users in commercial refrigeration transportation and launching a public awareness and information campaign.

332. Given the low availability of low-GWP alternatives, Venezuela (Bolivarian Republic of) is currently working on developing local production of R-290.

333. Project monitoring and implementation was undertaken by staff recruited by the project, working under the NOU, with the assistance of local experts when needed.

334. As of August 2018, of the US $1,883,822 approved for UNIDO, a total of US $1,878,794 (99.7 per cent) had been disbursed. The balance of US $5,028 will be returned to the Fund.

Comments

335. The Secretariat followed up on the submission of the project completion report (PCR), due at the 80th meeting (decision 75/65(d)(i)). Accordingly, UNIDO submitted the PCR on 8 November 2018, before the 82nd meeting. The balance of US $5,028 would be returned to the 83rd meeting, once the project is financially completed.

336. Upon request for clarification of the fact that the reclaiming units were not commissioned before stage I was completed, UNIDO confirmed that the commissioning and operation of the reclaiming units will continue as part of the ongoing stage II.

Recommendation

337. The Executive Committee may wish:

(a) To take note of the final progress report on the implementation of the HCFC phase-out management plan (stage I) for Venezuela (Bolivarian Republic of), submitted by UNIDO; and

(b) To note that UNIDO will return to the Multilateral Fund at the 83rd meeting a balance of US $5,028, plus agency support cost of US $377.

Stage II of the HPMP: Request for updating the Agreement of Venezuela (Bolivarian Republic of) (UNIDO/UNDP)

338. On behalf of the Government of Venezuela (Bolivarian Republic of), UNDP, as the implementing agency in charge of the polyurethane (PU) foam sector plan in stage II of the HPMP, has submitted a request to update the Agreement between the Government and the Executive Committee for the reduction in consumption of HCFCs, to reflect the removal of the PU foam component from stage II.

339. In its letter to UNDP, the Government of Venezuela (Bolivarian Republic of), reported that upon evaluation of the current situation in the PU foam sector, it has not found any significant consumption of HCFC-141b in PU foam enterprises that justifies their conversion, and has accordingly authorized UNDP to cancel the US $1,326,420 approved in principle for the implementation of this plan, and to return the US $76,420 already released to UNDP under the first tranche of the HPMP.

Comments

Removal of the PU foam sector plan from stage II

340. In reviewing this request, the Secretariat noted that the combined consumption of HCFC-141b pure and contained in imported pre-blended polyols over the last five years has been more than 50 per cent below the consumption of HCFC-141b pure during the baseline years (39.56 ODP tonnes), as shown in Table 25 Given the assessment made by the Government and the low level of consumption of HCFC-141b, the PU foam sector plan would not be needed at present. It was agreed that the removal of the PU foam sector plan from stage II of the HPMP would be on the understanding that if the economic situation changed and the relevant eligible enterprises included in the plan reinitiated consumption of HCFC-141b, the Government would be able to submit a revised proposal to address such consumption.

341. UNDP indicated that as no project document was signed with the Government, the unused balance from the first tranche of stage II (US $76,420, plus agency support cost of US $5,349) would be returned to the Fund at the 82nd meeting.

Revised plan of action for the refrigeration servicing sector and submission of the second tranche

342. Due to the current economic situation in the country and to changes within the NOU, UNIDO will submit the request for the second tranche of stage II at the 83rd meeting. UNIDO provided reassurance that activities in the refrigeration servicing sector can continue to be implemented. The NOU has not been transferred to any Ministry as originally planned, new staff has been hired to replace staff who have resigned, and they are receiving support from local experts working on the HPMP.

343. UNIDO provided a revised plan for the implementation of the remaining part of stage II of the HPMP, as follows:

(a) Continue the training plan for customs officers, border police, environmental inspectors, customs traders and other stakeholders, with the support of the Ministry of Environment;

(b) Continue the end-users programme on refrigerant leak reduction, which has shown positive results given the scarcity of virgin HCFC-22. This activity will include training for technicians and stakeholders in different cities and a plan for leak reduction and proper use of refrigerant;

(c) Continue the technician training activities being implemented with INCES, which is still in operation and has the capacity to organize training activities;

(d) Continue activities to disseminate good and safe servicing practices and skills in the use of alternative refrigerants. Given the difficulties faced in importing material in the manufacturing sector, there are ongoing initiatives outside of the HPMP to manufacture equipment with locally produced R-290. Activities in the servicing sector would help facilitate the safe introduction of this technology; and

(e) Continue the ongoing public-awareness-campaign programs addressing the need to ensure the containment of refrigerant and the potential for recycling. Once the reclaiming facilities are installed, the information will be delivered through different media.

344. UNIDO is proposing to revise the remaining funding available, as presented in Table 26.

Table 26. Revised tranches for stage II of the HPMP for Venezuela (Bolivarian Republic of)

ORIGINAL TRANCHE DISTRIBUTION APPROVED AT THE 76TH MEETING						
Particulars	**2016**	**2017**	**2018**	**2019**	**2020**	**Total**
Lead IA (UNIDO) agreed funding (US $)	600,000	575,000	596,000		196,144	1,967,144
Support costs for Lead IA (US $)	42,000	40,250	41,720		13,730	137,700
Cooperating IA (UNDP) agreed funding (US $)	76,420	200,000	200,000	800,000	50,000	1,326,564
Support costs for Cooperating IA (US $)	5,349	14,000	14,000	56,000	3,500	92,849
Total agreed funding (US $)	676,420	775,000	796,000	800,000	246,144	3,293,564
Total support costs (US $)	47,349	54,250	55,720	56,000	17,230	230,549
Total agreed costs (US $)	723,769	829,250	851,720	856,000	263,374	3,524,113
REVISED TRANCHE DISTRIBUTION						
Particulars	**2016**	**2017**	**2018**	**2019**	**2020**	**Total**
Lead IA (UNIDO) agreed funding (US $)	600,000	**0**	**0**	**575,000**	**792,144**	1,967,144
Support costs for Lead IA (US $)	42,000	**0**	**0**	**40,250**	**55,450**	137,700
Cooperating IA (UNDP) agreed funding (US $)	**0**	**0**	**0**	**0**	**0**	**0**
Support costs for Cooperating IA (US $)	**0**	**0**	**0**	**0**	**0**	**0**
Total agreed funding (US $)	**600,000**	**0**	**0**	**575,000**	**792,144**	**1,967,144**
Total support costs (US $)	**42,000**	**0**	**0**	**40,250**	**55,450**	**137,700**
Total agreed costs (US $)	**642,000**	**0**	**0**	**615,250**	**847,594**	**2,104,844**

345. The Secretariat considers that the action plan presented by UNIDO will help the country maintain the low level of HCFC consumption by reusing installed HCFC-22, applying good servicing practices, and strengthening the capacity to control HCFC imports and production in the event that the supply of refrigerants increases. At the 83rd meeting, when the request for the second tranche is submitted, the Secretariat will review progress achieved on the activities and evaluate the economic situation that would be present.

Revision to the HPMP Agreement

346. In view of the removal of the PU foam sector plan from stage II of the HPMP and the revised funding schedule, Appendix 2-A of the Agreement between the Government of Venezuela (Bolivarian Republic of) and the Executive Committee has been updated and a new paragraph 16 has been added to indicate that the updated Agreement supersedes that reached at the 76th meeting, as contained in Annex II to the present document. The full updated Agreement will be appended to the final report of the 82nd meeting.

Recommendation

347. The Executive Committee may wish:

(a) To note:

(i) The request from the Government of Venezuela (Bolivarian Republic of) to remove the polyurethane (PU) foam sector plan from stage II of the HCFC phase out management plan (HPMP) implemented by UNDP, on the understanding that if the eligible enterprises included in the project **reinitiated the use** of significant amounts of HCFC-141b **during the implementation of stage II of the HPMP**, UNDP could resubmit a proposal to address their conversion;

(ii) That US $1,326,564, plus agency support costs of US $92,849 approved in principle for UNDP for **the polyurethane foam sector plan of** stage II of the HPMP **would** be removed from the Agreement between the Government of Venezuela (Bolivarian Republic of) and the Executive Committee;

(iii) That UNDP is returning to the Multilateral Fund US $76,420, plus agency support costs of US $5,349, associated with **the polyurethane foam sector plan approved as part of the first tranche of** stage II of the HPMP, to the 82nd meeting;

(iv) The revised plan for stage II in the refrigeration servicing sector;

(v) That the Fund Secretariat has updated Appendix 2-A of the Agreement between the Government of Venezuela (Bolivarian Republic of) and the Executive Committee to reflect the removal of the PU foam sector plan implemented by UNDP and the revised funding schedule for the UNIDO component, and that a new paragraph 16 has been added to indicate that the updated Agreement supersedes that reached at the 76th meeting, as contained in Annex II to **document UNEP/OzL.Pro/ExCom/82/20.**

<u>Viet Nam: HCFC-phase out management plan (stage II) - Change in technology at Midea Consumer Electric (Viet Nam) Co. Ltd.)</u> (World Bank and the Government of Japan)

Background

348. At the 76th meeting, the Executive Committee approved in principle, stage II of the HCFC phase-out management plan (HPMP) for Viet Nam[53] for the period 2016 to 2022 to reduce HCFC consumption by 35 per cent of its baseline, in the amount of US $15,683,990 (US $14,411,204, plus agency support costs of US $1,008,784 for the World Bank, and US $233,630, plus agency support costs of US $30,372 for the Government of Japan).

[53] UNEP/OzL.Pro/ExCom/76/55.

349. Stage II of the HPMP includes the conversion of four air-conditioning (AC) manufacturing enterprises. Three of the enterprises (i.e., Hoa Phat, Nagakawa and REE) decided to convert to HFC-32, while the fourth, Midea Consumer Electric (Viet Nam) Co. Ltd. (Midea Viet Nam), decided to convert two manufacturing lines to R-290 based on the experience of the conversion of the Midea enterprise in China that received funding from the Multilateral Fund to convert to the same technology. Funding provided to Midea Viet Nam for conversion to R-290 technology amounted to US $837,017.

350. At the 81st meeting, the Executive Committee considered a request from the Government of Viet Nam to change the technology at Midea Viet Nam to HFC-32. Following a discussion in an informal group, the Executive Committee decided to defer consideration of the change of technology at Midea Viet Nam to the 82nd meeting to provide the enterprise with additional time to consider its technology selection on a best-effort basis, on the understanding that, if the enterprise were to decide to change to HFC-32, it could do so then but would subsequently not be eligible for further funding from the Multilateral Fund (decision 81/13).

351. In line with decision 81/13, and in accordance with paragraph 7(a)(v) of the Agreement between the Government of Viet Nam and the Executive Committee, the Government through the World Bank has re-submitted a request to change the technology for Midea Viet Nam from R-290 to HFC-32.

Request for change of technology

352. In explaining its decision to change technology, the enterprise indicated that according to its market survey for East Asia, there is no demand for R-290-based equipment; but rather for HFC-32-based equipment. Conversion to HFC-32 was in line with the requirements by the Viet Nam Department of Climate Change and the World Bank. The enterprise also affirmed its commitment that in the future, when the HFC-32 manufacturing line would need to be converted to R-290, the enterprise would carry out this conversion with its own funding and without support from the Multilateral Fund, and would strictly comply with all the requirements and conditions set out by the Multilateral Fund and Viet Nam Department of Climate Change. The enterprise noted that the decision to change technology to HFC-32 was representative only of Midea Viet Nam and did not relate to Midea China.

353. The World Bank emphasized that it had provided the enterprise with all its options for both alternatives (HFC-32 and R-290) and explained the potential consequence of each choice in terms of Executive Committee decision and Multilateral Fund financial support. The World Bank also noted the concerns previously expressed, regarding market acceptance of R-290-based room AC units; lack of a regulation or standard that would facilitate the sales of R-290-based equipment in the country; challenges to provide sufficient training to the servicing sector for safe handling of R-290 beyond the warranty period and under service contracts, as opposed to HFC-32 where several enterprises began training service workshops in safe handling of this refrigerant since 2014; and better parity with the other local AC manufacturers and importers in terms of the market and in addressing safety concerns and potential regulatory issues.

Incremental cost

354. Incremental capital and operating costs have been agreed as shown in Table 27. Costs items related to prototypes for testing and certification, official testing for rating and labelling, and technical assistance were not requested for the conversion to R-290 as Midea China had previously received funding from the Multilateral Fund for the conversion to that technology. Funding requested for the HFC-32 technology amounts to US $768,959, which is US $68,358 lower than for the R-290 technology, notwithstanding the increase in incremental capital costs. Avoided emissions to the atmosphere decreases by 40,801 mt CO_2-eq. due to the higher global warming potential value of HFC-32.

Table 27. Revised incremental cost of the conversion of Midea Viet Nam to HFC-32 technology (US $)

Cost components	R-290	HFC-32	Difference
Model redesign, research, development, in-house testing	50,000	66,000	16,000
Prototypes for testing and certification		10,800	10,800
Official testing for rating and labeling		5,000	5,000
Technical assistance		25,000	25,000
Training	5,000	4,000	1,000
Charging equipment	104,000	120,000	16,000
Vacuum pumps		33,600	33,600
Leak detectors	4,000	4,000	-
Safety measures, ventilation, electrical installations	70,000	50,000	(20,000)
Storage of refrigerant, transfer pump and piping	50,000	20,000	(30,000)
Contingency (10 per cent)	28,300	33,840	5,540
Installation and servicing	55,000	55,000	-
Total incremental capital costs (ICCs)	366,300	427,240	60,940
Total incremental operating costs (IOCs)	470,717	341,419	(129,298)
Total cost	837,017	768,659	(68,358)

Comments

355. The Secretariat noted that the recommended ICCs were consistent with the funding that was provided to the other three AC manufacturing enterprises that will convert to HFC-32, which was the most equitable approach to assessing the costs. In addition, the Secretariat noted that the overall cost of conversion was lower given the reduction in IOCs, which was due to the lower cost of HFC-32 compressors relative to R-290 compressors, which would result in the return of US $68,358, plus agency supports costs of US $4,785 for the World Bank, to the Multilateral Fund. The Agreement between the Government of Viet Nam and the Executive Committee would be amended to reflect this return when the second tranche of stage II of the HPMP would be submitted.

Recommendation

356. The Executive Committee may wish:

(a) To note the request submitted by the World Bank on behalf of the Government of Viet Nam for the change of technology in Midea Consumer Electric (Viet Nam) Co. Ltd., from R-290 to HFC-32 in the context of stage II of the HCFC phase-out management plan (HPMP);

(b) To approve the change of technology for Midea Consumer Electric (Viet Nam) Co. Ltd., from R-290 to HFC-32, in the amount of US $768,659, plus agency support costs of US $53,806 for the World Bank, resulting in the return to the 82nd meeting of US $68,358, plus agency supports costs of US $4,785 by the World Bank to the Multilateral Fund;

(c) To note that Midea Consumer Electric (Viet Nam) Co. Ltd. would not be eligible for further funding from the Multilateral Fund; and

(d) To note that the Agreement between the Government of Viet Nam and the Executive Committee for stage II of the HPMP would be amended to reflect the funding return indicated in sub-paragraph (b) when the second tranche of stage II of the HPMP was submitted.

Stage I of HPMPs for Brazil, China, India and Thailand (annual progress reports)

357. On behalf of the Governments of Brazil, China, India and Thailand, the relevant lead implementing agency, has submitted to the 82nd meeting the annual progress report on the implementation of the work programme of stage of I the HPMP. The relevant reports and the Secretariat's comments and recommendations can be found in the documents listed in Table 28.

Table 28: Annual progress reports and verification reports

Country	Project title	Agency	Decision	Document number	Recommendation
Brazil	HCFC phase-out management plan (stage I) (2017 progress report)	UNDP	75/53(b)	82/41	Paragraph 19
China	HCFC phase-out management plan (stage I) (2017 progress report) (extruded polystyrene foam sector plan)	UNIDO	75/54(b)	82/45	Paragraph 82
China	HCFC phase-out management plan (stage I) (2017 progress report) (polyurethane rigid foam sector plan)	IBRD	75/55(b)	82/45	Paragraph 101
China	HCFC phase-out management plan (stage I) (2017 progress report) (industrial and commercial refrigeration and air conditioning sector plan)	UNDP	75/56(b)	82/45	Paragraph 114
China	HCFC phase-out management plan (stage I) (2017 progress report) (room air-conditioner manufacturing sector plan)	UNIDO	75/57(b)	82/45	Paragraph 133
China	HCFC phase-out management plan (stage I) (2017 progress report) (refrigeration servicing sector including enabling programme)	UNEP/ Japan	75/29(a)	82/45	Paragraph 140
India	HCFC phase-out management plan (stage I, final progress report)	UNDP/UNEP/ Government of Germany	75/29(a)	82/52	Paragraph 11
Thailand	HCFC phase-out management plan (stage I, annual progress report)	World Bank	80/72(b)	82/59	Paragraph 23

358. The Executive Committee may wish to consider the recommendations of the Secretariat as set out in the relevant documents in Table 28.

Annex I

TEXT TO BE INCLUDED IN THE UPDATED AGREEMENT BETWEEN THE GOVERNMENT OF QATAR AND THE EXECUTIVE COMMITTEE OF THE MULTILATERAL FUND FOR THE REDUCTION IN CONSUMPTION OF HYDROCHLOROFLUOROCARBONS
(Relevant changes are in bold font for ease of reference)

1. This Agreement represents the understanding of the Government of Qatar (the "Country") and the Executive Committee with respect to the reduction of controlled use of the ozone-depleting substances (ODS) set out in Appendix 1-A ("The Substances") to a sustained level of **69.52 ODP tonnes by 1 January 2015 in compliance with Montreal Protocol schedules.**

14. The completion of stage I of the HPMP and the associated Agreement will take place **by 1 July 2019**. The reporting requirements as per sub-paragraphs 1(a), 1(b), 1(d), and 1(e) of Appendix 4-A will continue until the time of the completion unless otherwise specified by the Executive Committee.

16. **This updated Agreement supersedes the Agreement reached between the Government of the Qatar and the Executive Committee at the 65th meeting of the Executive Committee.**

APPENDIX 2-A: THE TARGETS, AND FUNDING

Row	Particulars	2011	2012	2013-2014	2015-2018	Total
1.1	Montreal Protocol reduction schedule of Annex C, Group I substances (ODP tonnes)	n/a	n/a	**86.9**	**78.21**	n/a
1.2	Maximum allowable total consumption of Annex C, Group I substances (ODP tonnes)	n/a	n/a	**86.9**	**69.52**	n/a
2.1	Lead IA UNIDO agreed funding (US $)	1,045,907	0	**0**	**0**	**1,045,907**
2.2	Support costs for Lead IA (US $)	78,443	0	**0**	**0**	**78,443**
2.3	Cooperating IA UNEP agreed funding (US $)	105,000	0	**0**	**0**	**105,000**
2.4	Support costs for Cooperating IA (US $)	13,650	0	**0**	**0**	**13,650**
3.1	Total agreed funding (US $)	1,150,907	0	**0**	**0**	**1,150,907**
3.2	Total support cost (US $)	92,093	0	**0**	**0**	**92,093**
3.3	Total agreed costs (US$)	1,243,000	0	**0**	**0**	**1,243,000**
4.1.1	Total phase-out of HCFC-22 agreed to be achieved under this Agreement (ODP tonnes)					45.81
4.1.2	Phase-out of HCFC-22 to be achieved in previously approved projects (ODP tonnes)					0
4.1.3	Remaining eligible consumption for HCFC-22 (ODP tonnes)					27.64
4.2.1	Total phase-out of HCFC-141b agreed to be achieved under this Agreement (ODP tonnes)					0
4.2.2	Phase-out of HCFC-141b to be achieved in previously approved projects (ODP tonnes)					0
4.2.3	Remaining eligible consumption for HCFC-141b (ODP tonnes)					0.58
4.3.1	Total phase-out of HCFC-142b agreed to be achieved under this Agreement (ODP tonnes)					12.05
4.3.2	Phase-out of HCFC-142b to be achieved in previously approved projects (ODP tonnes)					0
4.3.3	Remaining eligible consumption for HCFC-142b (ODP tonnes)					0

Annex II

TEXT TO BE INCLUDED IN THE UPDATED AGREEMENT BETWEEN THE GOVERNMENT OF THE BOLIVARIAN REPUBLIC OF VENEZUELA AND THE EXECUTIVE COMMITTEE OF THE MULTILATERAL FUND FOR THE REDUCTION IN CONSUMPTION OF HYDROCHLOROFLUOROCARBONS IN ACCORDANCE WITH STAGE II OF THE HCFC PHASE-OUT MANAGEMENT PLAN

16. **This updated Agreement supersedes the Agreement reached between the Government of the Bolivarian Republic of Venezuela and the Executive Committee at the 76th meeting of the Executive Committee.**

APPENDIX 2-A: THE TARGETS, AND FUNDING

Row	Particulars	2016	2017	2018	2019	2020	Total
1.1	Montreal Protocol reduction schedule of Annex C, Group I substances (ODP tonnes)	186.25	186.25	186.25	186.25	134.55	n/a
1.2	Maximum allowable total consumption of Annex C, Group I substances (ODP tonnes)	186.25	186.25	186.25	186.25	120.03	n/a
2.1	Lead IA (UNIDO) agreed funding (US $)	600,000	**0**	**0**	**575,000**	**792,144**	1,967,144
2.2	Support costs for Lead IA (US $)	42,000	**0**	**0**	**40,250**	**55,450**	137,700
2.3	Cooperating IA (UNDP) agreed funding (US $)	**0**	**0**	**0**	**0**	**0**	**0**
2.4	Support costs for Cooperating IA (US $)	**0**	**0**	**0**	**0**	**0**	**0**
3.1	Total agreed funding (US $)	**600,000**	**0**	**0**	**575,000**	**792,144**	**1,967,144**
3.2	Total support costs (US $)	**42,000**	**0**	**0**	**40,250**	**55,450**	**137,700**
3.3	Total agreed costs (US $)	**642,000**	**0**	**0**	**615,250**	**847,594**	**2,104,844**
4.1.1	Total phase-out of HCFC-22 agreed to be achieved under this Agreement (ODP tonnes)						22.94
4.1.2	Phase-out of HCFC-22 to be achieved in previously approved projects (ODP tonnes)						23.16
4.1.3	Remaining eligible consumption for HCFC-22 (ODP tonnes)						115.53
4.2.1	Total phase-out of HCFC-123 agreed to be achieved under this Agreement (ODP tonnes)						0.00
4.2.2	Phase-out of HCFC-123 to be achieved in previously approved projects (ODP tonnes)						0.00
4.2.3	Remaining eligible consumption for HCFC-123 (ODP tonnes)						0.07
4.3.1	Total phase-out of HCFC-124 agreed to be achieved under this Agreement (ODP tonnes)						0.00
4.3.2	Phase-out of HCFC-124 to be achieved in previously approved projects (ODP tonnes)						0.00
4.3.3	Remaining eligible consumption for HCFC-124 (ODP tonnes)						0.00
4.4.1	Total phase-out of HCFC-141b agreed to be achieved under this Agreement (ODP tonnes)						**0.00**
4.4.2	Phase-out of HCFC-141b to be achieved in previously approved projects (ODP tonnes)						0.00
4.4.3	Remaining eligible consumption for HCFC-141b (ODP tonnes)						**39.56**
4.5.1	Total phase-out of HCFC-142b agreed to be achieved under this Agreement (ODP tonnes)						0.00
4.5.2	Phase-out of HCFC-142b to be achieved in previously approved projects (ODP tonnes)						0.00
4.5.3	Remaining eligible consumption for HCFC-142b (ODP tonnes)						5.68
4.6.1	Total phase-out of HCFC-141b contained in imported pre-blended polyols agreed to be achieved under this Agreement (ODP tonnes)						**0.00**
4.6.2	Phase-out of HCFC-141b contained in imported pre-blended polyols to be achieved in previously approved projects (ODP tonnes)						0.00
4.6.3	Remaining eligible consumption for HCFC-141b contained in imported pre-blended polyols (ODP tonnes)						**1.91**

DEMONSTRATION PROJECT FOR AMMONIA SEMI-HERMETIC FREQUENCY CONVERTIBLE SCREW REFRIGERATION COMPRESSION UNIT IN THE INDUSTRIAL AND COMMERCIAL REFRIGERATION INDUSTRY AT FUJIAN SNOWMAN CO., LTD.

FINAL REPORT

24 SEPTEMBER 2018

Prepared and submitted by:

Foreign Economic Cooperation Office, Ministry of Ecology and Environment (FECO/MEE)

And

United Nations Development Programme (UNDP)

Executive Summary

Demonstration project for ammonia semi-hermetic frequency convertible screw refrigeration compression unit in the industrial and commercial refrigeration industry at Fujian Snowman Co., Ltd. was approved at 76th Executive Committee (ExCom) meeting at a funding level of US$1,917,296, of which US$ 1,026,815 was funded by the Multilateral Fund, US$ 890,454 was contributed by the company as counterpart funding.

This demonstration project was successful completed in March 2018, with two demonstration sub-projects that took place in two locations in China. The ammonia semi-hermetic frequency convertible screw refrigeration compression unit is to replace the HCFC-22 refrigeration unit.

The demonstration project covers product design, process redesign, construction of test devices for product performance, manufacturing of prototypes, personnel training and technology dissemination etc.

The successful completion of the demonstration project contributes to promotion of replacing HCFC-22 refrigeration systems in cold storage and freezing applications with the NH_3/CO_2 refrigeration system (NH_3 as the refrigerant, CO_2 as the secondary refrigerant).

1. Introduction

In 2007, the 19th Meeting of Parties (MOP) of the Montreal Protocol agreed to accelerate phase-out of HCFCs. To achieve the compliance targets, China is implementing HCFCs Phase-out Management Plan (HPMP) in the Industrial and Commercial Refrigeration and Air-conditioning (ICR) sector from 2010. In order to find solution for phasing out HCFCs in small- and medium sized cool storage system in the industrial and commercial refrigeration industry in the Stage II of HPMP, China proposed a demonstration project for ammonia semi-hermetic frequency-convertible screw refrigeration compression units, to be supported by the Multilateral Fund (MLF).

The Executive Committee approved the demonstration project at Fujian Snowman Co. Ltd. demonstration project at its 76th meeting in 2016 at a funding level of US $ 1,026,815. The project International Implementing Agency is the United Nations Development Programme (UNDP). The National Implementing Partner is the Foreign Economic Cooperation Office (FECO), Ministry of Ecology and Environment (MEE), China (formerly the Ministry of Environmental Protection, MEP).

The successful implementation of this demonstration project provides the demonstration of ammonia semi-hermetic frequency convertible screw refrigeration compression unit for enabling replication of this technology in similar applications in this sector in China and facilitate HCFC reductions for compliance with the HCFC control targets.

According to the system demonstrated, the manufacturing line of the R22 compressor was converted to that of NH_3 compressor. the production capacity of the converted manufacturing line of compressor is 3,000 units annually and thus resulted in reductions of 359 metric tons (MT) of HCFC-22 usage at

Fujian Snowman Co. Ltd., Furthermore, over a 15-year life-span of the refrigeration systems manufactured by the enterprise, the consumption of HCFCs for servicing of those systems is expected to be 226.16 MT in the life cycle. The total GHG emission reductions amount to about 1,041,602.60 CO2-eq tones, thus contributing to protection of both the ozone layer and the climate.

1.1 Background

The Industrial and Commercial Refrigeration and Air Conditioning (ICR) Sector in China has experienced remarkable growth in the past two decades, averaging at about 12% annually, due to the steep growth in the demand for consumer, commercial and industrial products, resulting from rapid overall economic development. This sector is categorized into several sub-sectors, namely: compressors, condensing units, small-sized air-source chillers/heat pumps, commercial and industrial chillers/heat pumps, heat pump water heaters, unitary commercial air conditioners, multi-connected commercial air conditioners, commercial and industrial refrigeration and freezing equipment, mobile refrigeration and air conditioning equipment and refrigeration and air conditioning components and parts. The 2014 estimated HCFC consumption in the sector based on ongoing surveys was about 40,805 metric tons, 98% of that HCFC is HCFC-22.

Refrigeration equipment is regarded as one important end-user product as stated in the Sector Plan for Phase-out of HCFCs in the Industrial and Commercial Refrigeration and Air-Conditioning Sector in China and it includes food display cases, transport refrigeration, icemakers, quick freezers, cold stores, refrigerated warehouses, beverage cooling equipment, etc. The main end-users are supermarkets, shops, air-conditioned refrigeration warehouses, restaurants, food distributors, kitchens of hotel, food process plants, etc. These systems are all medium and small industrial and commercial system which uses HCFC-22 as one important refrigerant. The amount of HCFC consumption is above 25% of ODS consumption in the industrial and commercial refrigeration sector. The refrigerant substitute is important for these field products. So, the new core technology developed for medium and small industrial and commercial refrigeration is significant for ODS substitute.

Fujian Snowman Co., Ltd. was established in March 2000, with a registered capital of RMB 600 million. The headquarter is located in MinJiang Industrial Zone, Fuzhou, Fujian Province, and the company covers an area of 300 acres in Binhai and Liren new industrial park of Changle City. The company has developed into the largest professional manufacturer of ice-making system, and it became a professional high-tech enterprise integrated with R&D, designing, manufacturing, sales and engineering unit installation of compressors, ice-making equipment, cooling water equipment, ice storage system and cooling system. The products are widely used in cold-chain logistics, food processing, ice storage cooling, mine cooling, nuclear power plant construction, water conservancy and hydropower and other fields.

Ice making machine： Fujian Snowman owns more than 100 exclusive patents with intellectual property rights. It has developed more than 40 types of products, especially its ice making machine sales ranking at the top in China.

Screw refrigeration compressor units: The Company has developed dozens of new types of high efficiency and energy saving screw refrigeration compressor, its technology has reached the international advanced level.

Compressor manufacture: Packaged systems with open (NH3), semi-hermetic (HCFC-22) and hermetic screw compressors (HCFC-22) and also reciprocating compressors (HCFC-22). The enterprise has two famous brands of compressors, which are SRM and RefComp.

Industrial refrigeration systems: Fujian Snowman Co., Ltd. is one of the largest manufacturers of integrated industrial refrigeration systems, such as large capacity brine chillers, ice makers, etc. based on screw compressors, with a 40-60% market share.

Fujian Snowman Co., Ltd. is committed to technology innovation, focusing on environment protection, energy efficiency and safety. Over 30-40% of its refrigeration products use natural substances.

In 2015 Fujian Snowman Co. Ltd. manufactured the following HCFC-22 integrated refrigeration systems:

No	Product Line	Evaporating temperature (°C)	Quantity (Nos.)	HCFC consumption (metric tons, MT)
1	Water Chillers	-5 to +3	50	N/A
2	Ice maker	-30 to -15	400	23
3	Brine Chillers	-40 to 3	11	N/A
4	Ice storage system	-18 to -5	20	1

1.2 Technical choice

Some of the zero-ODP alternatives to HCFC-22 currently available for this application are listed below:

Substance	GWP	Application	Remark
Ammonia	0	Industrial refrigeration and process chillers	Flammability and toxicity issues. Material compatibility issues. Regulatory issues.
CO_2	1	Refrigeration in a secondary loop and in stationary and mobile air conditioning systems	Major redesign of system components needed. Investment costs are prohibitive
R-404A	3,260	Low temperature applications	High GWP, less efficient at medium temperatures, synthetic lubricants needed

R-404A has high GWP and requires synthetic lubricants, although its thermodynamic properties are suitable for low-temperature applications. Its long-term sustainability from an environmental perspective is considered doubtful.

Ammonia is a traditional natural refrigerant with good environment properties as well as favorable thermodynamic properties. The operating pressures are low, it has low flow resistance and it has excellent heat transfer characteristics. Being a single substance, it is chemically stable. It has high refrigeration capacity. It is widely available at affordable prices. However, ammonia is quite reactive; it is toxic and moderately flammable. It is also not compatible with non-ferrous materials.

CO_2 was a commonly used refrigerant in the late 19th and early 20th centuries, however, its use gradually faded out. CO_2 has many favorable characteristics. It has Zero ODP and GWP of 1; it is inert, non-toxic and chemically stable, is compatible with almost all materials and available widely at affordable prices. For a given refrigeration capacity, the system components with CO_2 are much smaller compared to other refrigerants. However, the main disadvantage with CO_2 is its high operating pressures, which requires special designs for the system and components. Furthermore, CO_2 is also not very efficient at high ambient temperatures.

Fujian Snowman Co. Ltd. has selected ammonia semi-hermetic frequency convertible screw refrigeration compression unit with CO_2 in its design as the technological choice for its low-temperature coolant integrated refrigeration systems, considering the favorable environmental and thermodynamic properties of these two refrigerant alternatives.

2. Project Implementation

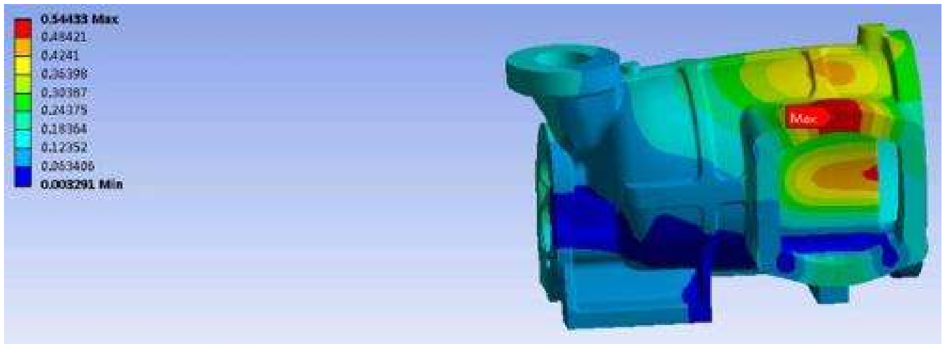
2.1 Product design

To meet the project goal, the following design had been carried out based on manufacturing process. The design elements comprised of the following

- **The design of ammonia semi-hermetic frequency convertible screw compressor**

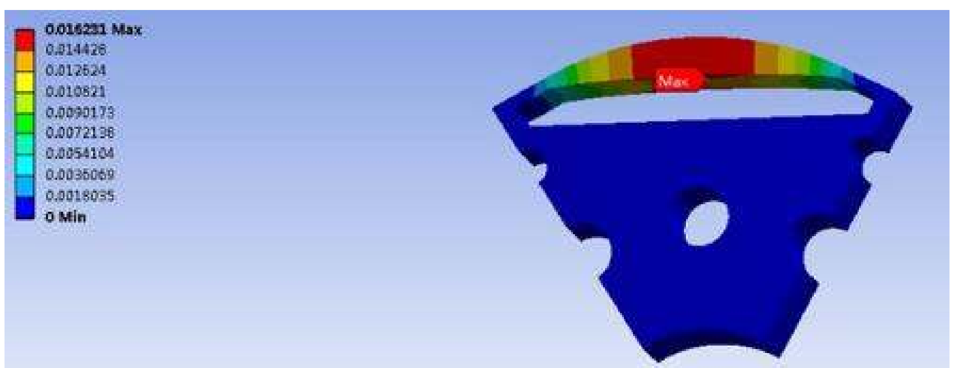
The project adopted the latest screw rotor "T" profile design for screw refrigeration compressor, making the screw compressor running smoothly and reducing noise greatly. It was completed at the end of March 2017, and the strength analysis of the compressor shell and silicon steel plate of compressor motor rotor is shown in Fig.1 below.

(a)

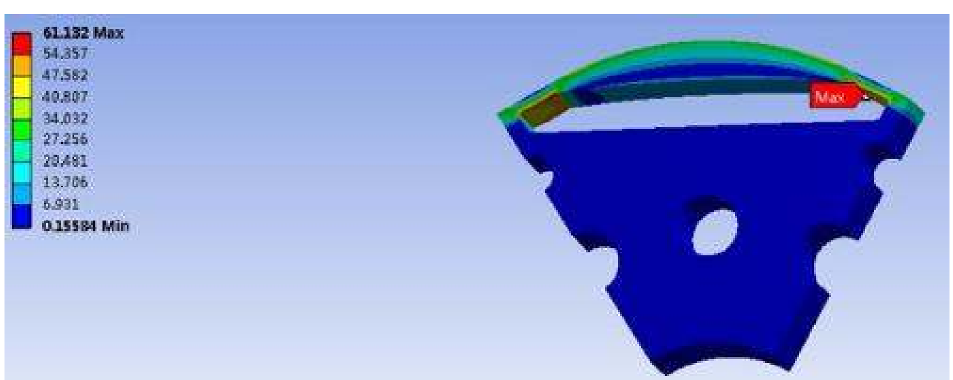


(b)

(c)



(d)



(e)

Fig.1 Screw design and strengthen design of the compressor parts

The system using the subcooling economizer can increase the COP and the cooling capacity, and the operation of the subcooling economizer is a key part for the SRS series semi-hermetic single machine double stage screw compressor. The subcooling economizer is shown in Fig.2.

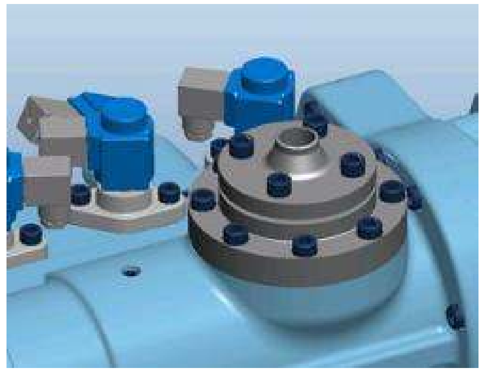


Fig.2 Subcooling economizer

- **The design of special motor for the ammonia semi-hermetic frequency convertible screw compressors;**

The Compressor Department completely designed and developed the semi closed motor for ammonia before March 2017 which is shown in Fig.3. Because of the strong corrosiveness of ammonia to the copper wire in the motor, the project focused on the corrosion resistance of the electromagnetic line and develop a long term electromagnetic line for ammonia refrigerant.

Fig.3 Type of motors

The cooling sleeve is made of aluminum alloy with good thermal conductivity, the motor is cooled fully, and the operation is stable. The cooling mode of the motor cooling adopts the dual cooling mode of oil cooling (or water cooling) and the refrigerant spray to ensure the motor running for a long time. The gas expansion and useless overheating caused by the suction cooling are avoided, and the efficiency of the compressor is significantly improved; at the same time, the motor overheating caused by inadequate motor cooling is avoided at the same time. The structure of the cooling sleeve is shown in Fig.4.

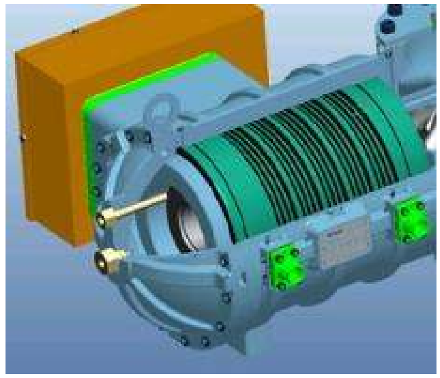


Fig.4 Structure of cooling sleeve

- **The design of NH_3 system of screw frequency convertible compressors unit**

The project completed the theoretical analysis of the system and the design of the whole machine at the end of March 2017. Fig.5 shows the variation of COP of NH_3 / CO_2 as the second refrigerant in refrigeration system with the isentropic efficiency of compressor. As the decrease of isentropic efficiency of compressor, the COP decrease linearly. When the evaporation temperature is -25 °C, the COP is 1.09 at the given isentropic efficiency of 0.4. And the COP is 2.18 at the given isentropic efficiency of 0.8, correspondingly.

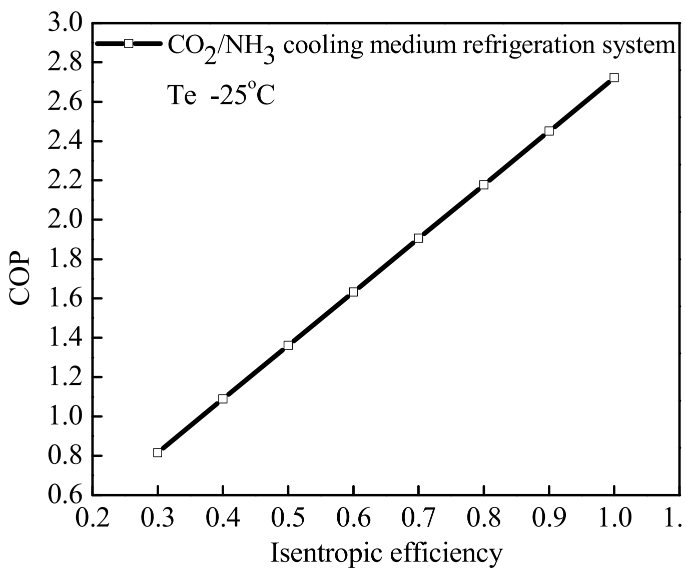


Fig.5 COP of NH_3/ CO_2 as second refrigerant refrigeration system varies with the isentropic efficiency of compressor

Table 1 The COP NH_3/CO_2 as second refrigerant refrigeration system varies with isentropic efficiency

NH_3 / CO_2 as second refrigerant refrigeration system								
Isentropic efficiency	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
COP	0.82	1.09	1.36	1.63	1.91	2.18	2.45	2.72

The design of the whole machine is shown in Fig.6.

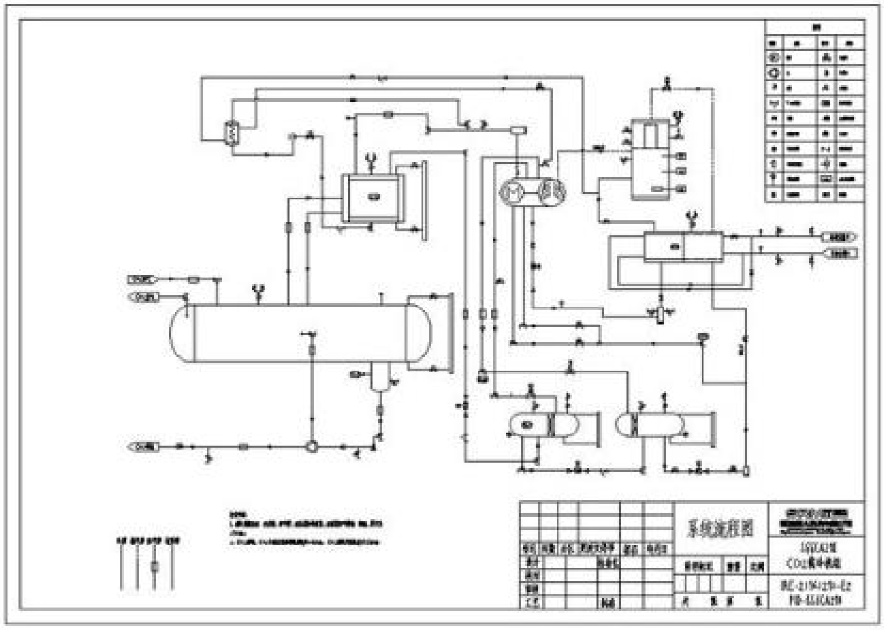
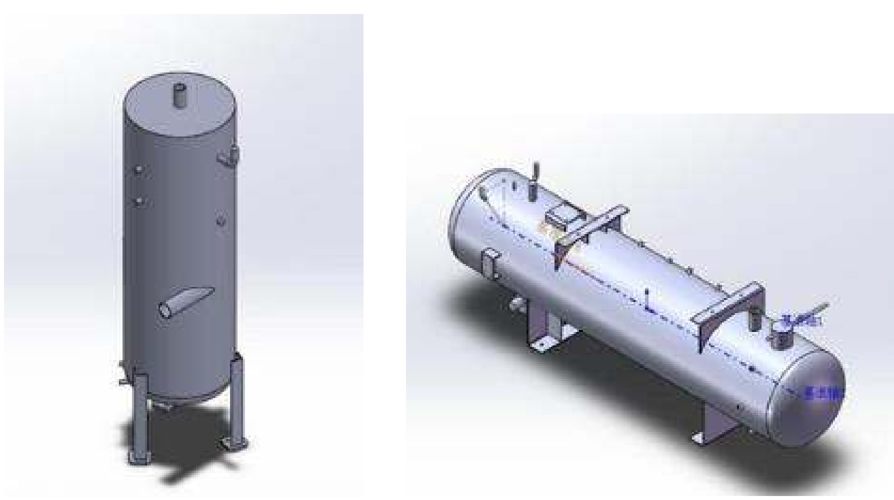


Fig. 6 System flow map of the NH_3/CO_2 compression unit

- **The design of NH_3 related pressure vessel screw frequency convertible compressors**

The pressure vessel design includes the design of high efficiency oil separator, CO_2 liquid storage device and economizer. The work of pressure vessel process analysis, processing control route, tooling design, pressure vessel forming, and welding process design are all completed by the Department of Pressure Vessel. The designed pressure vessel is shown in Fig.7.



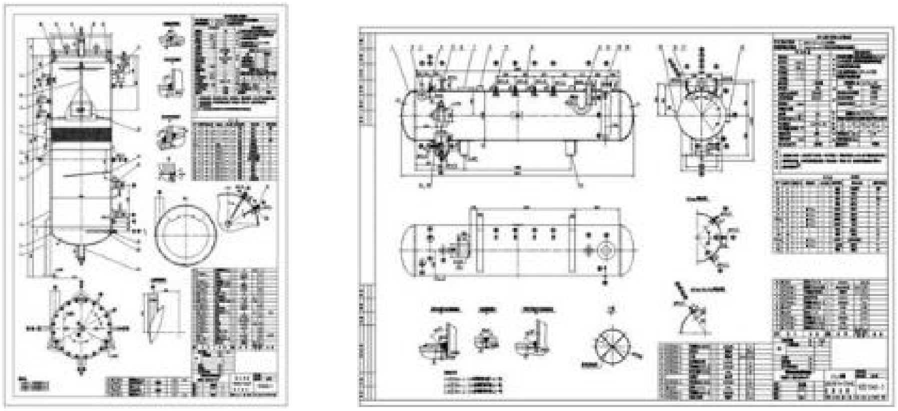
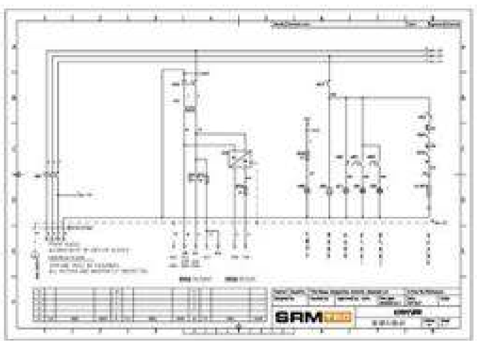


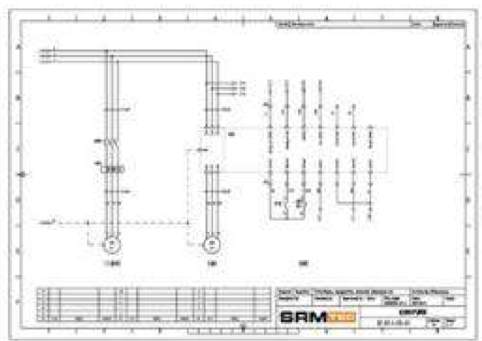
Fig.7 Pressure vessel design drawing

- **The electric control system design of compression unit;**

The electrical automation technology department has finished the design of the electric system of compression unit. The design work included the electrical drawing design of the unit, control cabinet and starting cabinet.



(a)



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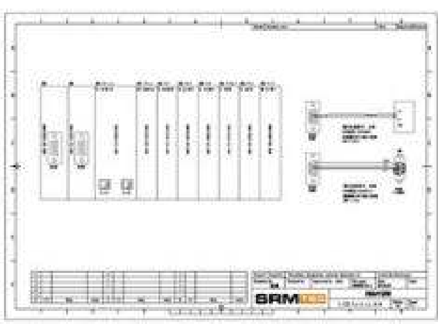

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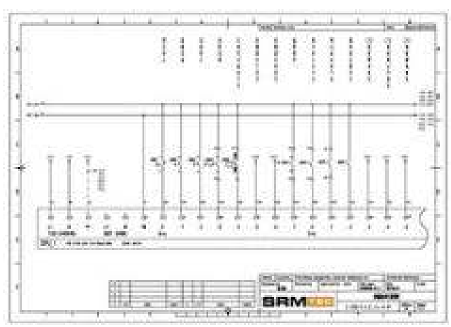


(d)

(e)

(f)

Fig.8 Drawing and picture of electric cabinet

- **The applied controlling software design.**

The system controlling concluded some hardware and software. The control system hardware is almost used foreign country brand which are shown in Table 2 and Fig.9. The software is shown in Fig.10.

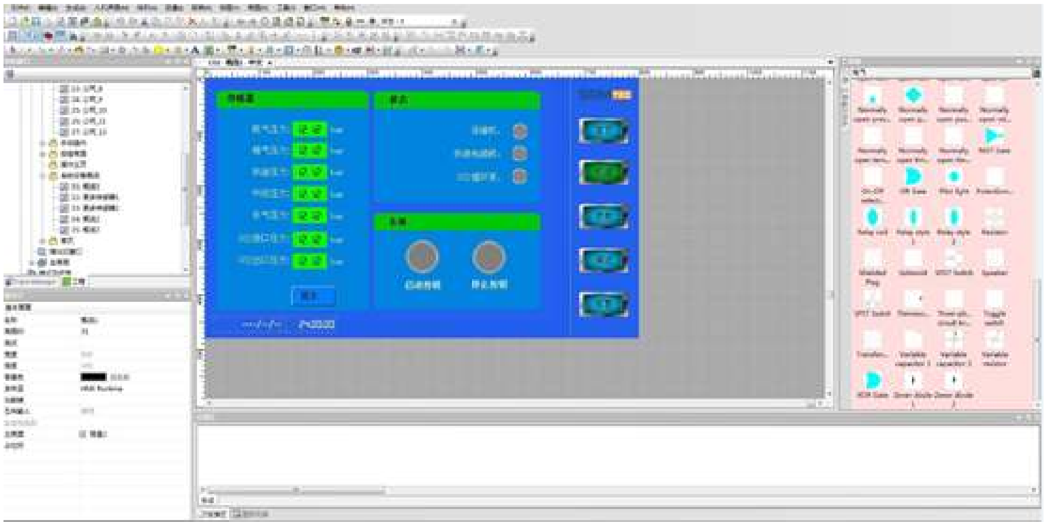
Table 2 The control system hardware

Name	Function	Brand
Electric expansion valve	Control of R717 refrigerant supplier	Parker
ICS Servo main valve+ CVP Guide valve	Control the internal pressure of the container	Danfoss
EVRA Solenoid valve	Control the flow of pipeline	Danfoss
Differential pressure switch	Detection of pressure difference between front and back of pump	Danfoss
Oil flow switch	Detection of lubricant oil flow	Hanike

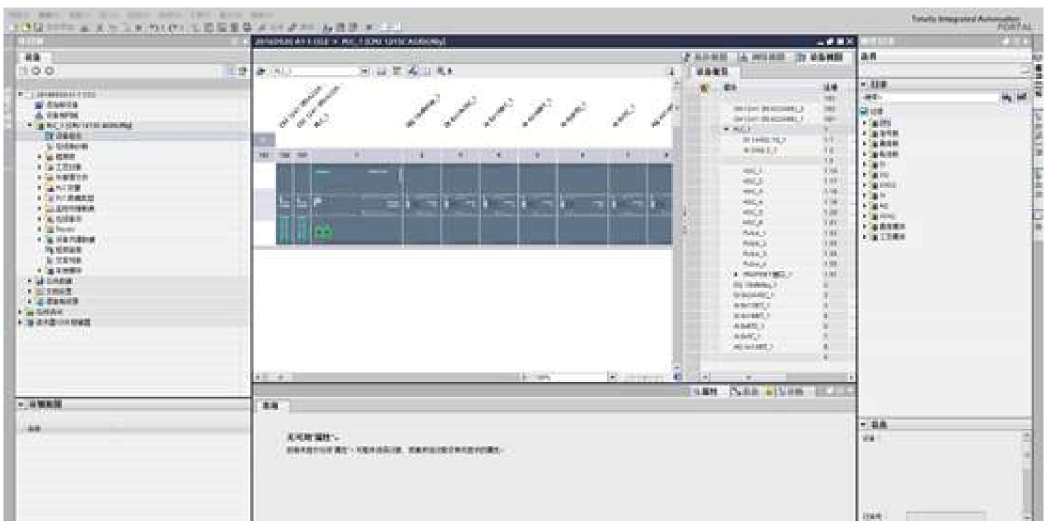
PLC

Touch screen

Fig.9 The PLC and Touch screen



Software 1



Software 2

Fig.10 The controlling software design

- **The design of three type of compression units**

The compression unit technology department completed the design of three types of compression units before June 2017, including system diagram, assembly drawing, structural drawing and production drawing. The 3D drawing of the system is shown in Fig.11.

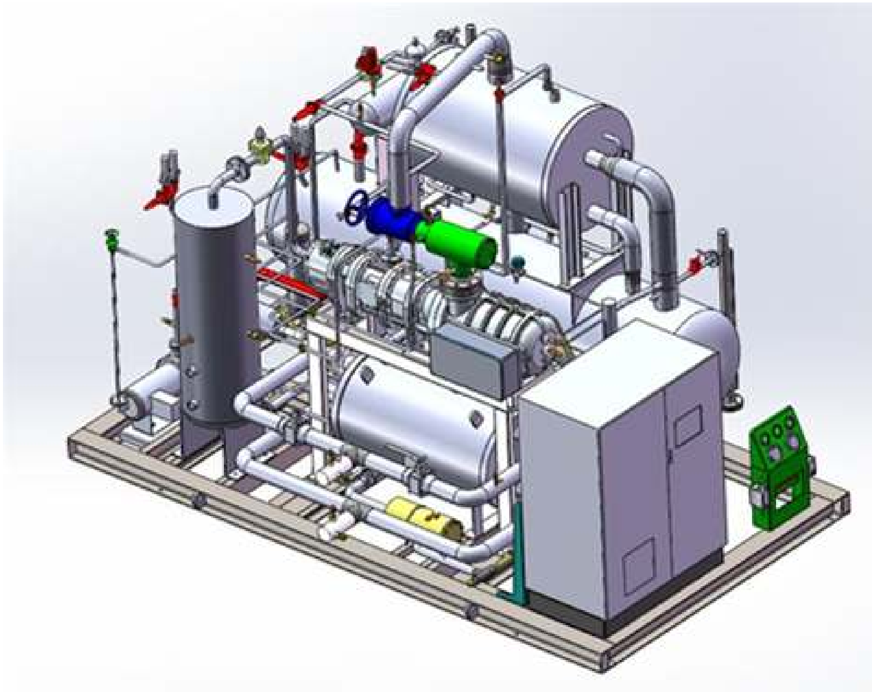
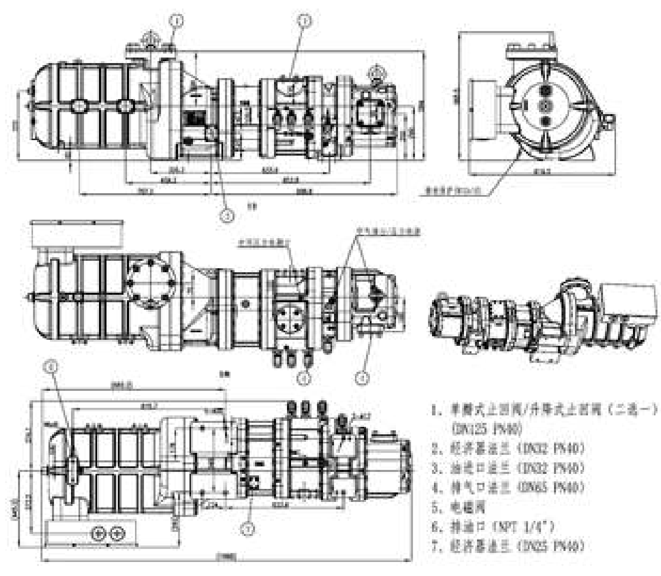
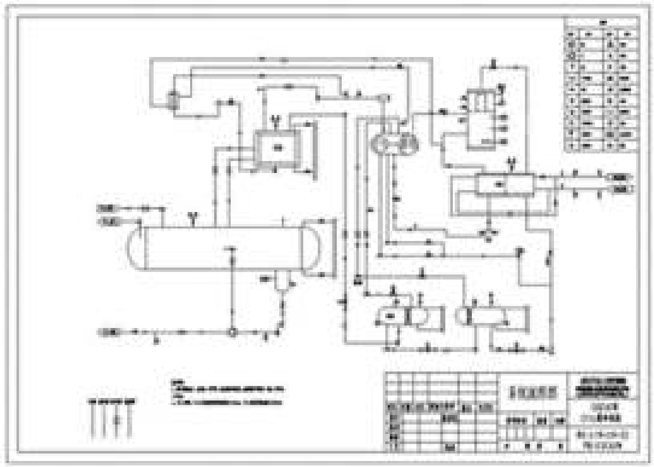


Fig.11 3D drawing of the compression unit

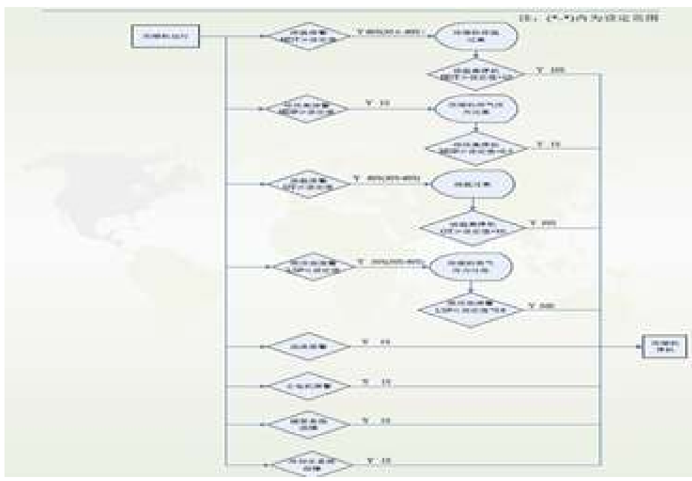
2.2 Process design

The process design is based on the compressor design and other parts design. Some process is changed because the special design of the system. The system flow chart and the control flow chart are all changed in this project, which are shown in Fig.12.





（system flow chart）



（Control flow chart）

Fig.12 Some flow charts of the project

2.3 Construction of test devices for product performance

As a new refrigeration system, the NH_3 system cannot be tested in the existing performance test laboratory mainly because of NH_3 corrosiveness and changes of system and pressure. The product test device of the medium and small NH_3 refrigeration system requires new facility construction. The test devices of NH_3 semi-hermetic compressor housing strength and air load are to be added. In addition, the following additions had to be done:

- **Pressure vessel strength testing device**

The pressure vessel technology department set up a pressure vessel test device and completed the related pressure vessel test which is shown in Fig.13.

Fig.13 Pressure vessel testing device

- **NH_3/CO_2 compression unit performance test equipment**

According to the design of the compressor and the unit performance testing device, the test center and the pressure vessel technology department set up and debug the performance test bed. The devices are shown in Fig.14.

(a)

(b)

(c)

Fig.14 Compressor and units testing device

2.4 Manufacturing of prototypes

According to the industrialization requirement of the NH_3 refrigeration system, three specifications of refrigeration systems had to be developed in October 2017. Before commercialization, the prototype of refrigeration system had to be manufactured and tested before mass production. As processing parts are numerous and processing precision is strict, the waste rate from casting to completion is very high.

Hence, three sets of rough parts had be produced for each compressor size. One set of rough parts had been manufactured for other auxiliary equipment.

- **Total nine sets of NH_3 semi-hermetic screw compressor prototypes manufactured**

The compressor production department and purchasing department completed the manufacture of three types of prototypes. Three sets for each SSSCA50, SSSCA210 and SSSCA60 prototypes were produced. Three types of compression units are shown in Fig.15.

（SSSCA60）

（SSSCA210）

（SSSCA50）

Fig.15 Picture of three types of compression units

- **The experimental test data of the prototypes and analysis**

This unit is CO_2 cooler unit, with SRS-12L compressor, it uses NH3 as its refrigerant, CO_2 as its secondary refrigerant. Design conditions are at evaporating temperature -8 ^oC and condensing temperature 35^oC.The system uses vertical oil separator, NH_3 water-cooled condenser (VAHTERUS), CO_2 condensing evaporator (VAHTERUS) and oil cooler (VAHTERUS), It is equipped with CO_2 reservoir and flash economizer, and it uses an electronically controlled valve (Parker) as its fluid regulator.

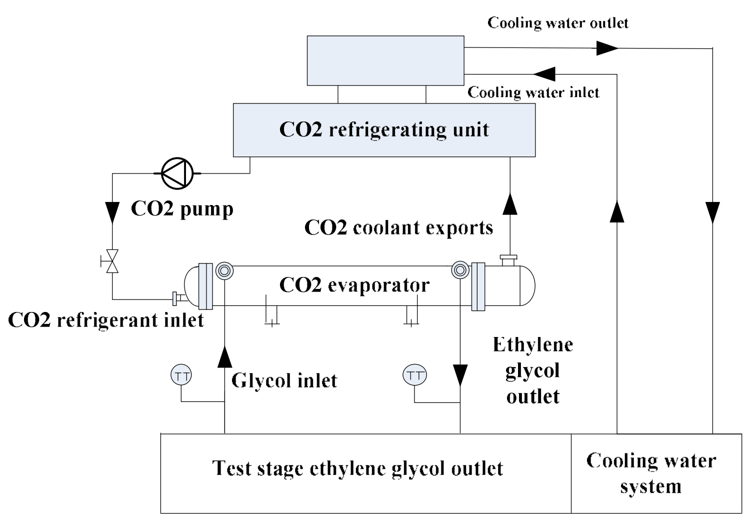


Fig.16 Test rig of the NH_3/CO_2 system

Table 3 Test result of SSSCA50

Test date	Jan. 25th 2018			Note
NH_3/CO_2 secondary refrigeration package SSSCA50	Suction pressure	bar	2.75	Saturation temperature: -11.4 ºC
	Discharge pressure	bar	13.43	Saturation temperature:34.8 ºC
	Middle offset pressure	bar	5.26	Saturation temperature:6.2 ºC
	Suction temperature	ºC	-11.1	
	Discharge temperature	ºC	72.3	
	Oil supply temperature	ºC	44.3	
	Compressor working power	kW	68.1	
	Rotation speed	RPM	3550	
Cooling water system	Water inlet temperature	ºC	26.85	
	Water outlet temperature	ºC	32.74	
	Water flow	m^3/h	42.95	
	Water pressure drop	kPa	50.12	
CO_2 system	Pressure before pump	bar	30.3	
	Pressure after pump	bar	34.59	
	CO_2 liquid supply temperature	ºC	-5.2	
	Pump power	kW	5.5	
Ethylene glycol system	Inlet temperature	ºC	3.08	
	Outlet temperature	ºC	-1.8	
	Water flow	m^3/h	41.7	
	Water pressure drop	kPa	12.85	
Unit refrigeration capacity		kW	216.3	
Compressor input power		kW	68.1	
Compressor COP		/	3.17	
Unit total power (compressor + CO_2 pump + inverter)		kW	73.6	
COP		/	2.94	
NH_3 charge amount		kg	16.8	Actual charge

Table 4 Test result of SSSCA60

Test date	Feb. 2nd 2018			Note
NH_3/CO_2 secondary refrigeration package SSSCA60	Suction pressure	bar	0.85	Saturation temperature: -36.8 ºC
	Discharge pressure	bar	13.62	Saturation temperature: 35.3 ºC
	Middle offset pressure	bar	3.14	Saturation temperature: -8.94℃
	Suction temperature	ºC	-36.2	
	Discharge temperature	ºC	72.8	
	Oil supply temperature	ºC	42.5	
	Compressor working power	kW	31.9	
	Rotation speed	RPM	3550	

Cooling water system	Water inlet temperature	ºC	26.56	
	Water outlet temperature	ºC	32.65	
	Water flow	m^3/h	13.68	
	Water pressure drop	kPa	57.70	
CO_2 system	Pressure before pump	bar	13.41	
	Pressure after pump	bar	17.55	
	CO_2 liquid supply temperature	ºC	-32.1	
	Pump power	kW	3.0	
Ethylene glycol system	Inlet temperature	ºC	-25.1	
	Outlet temperature	ºC	-28.2	
	Water flow	m^3/h	21.7	
	Water pressure drop	kPa	12.08	
Unit refrigeration capacity		kW	56.7	
Compressor input power		kW	31.9	
Compressor COP		/	1.77	
Unit total power (compressor + CO_2 pump + inverter)		kW	36.2	
COP		/	1.57	
NH_3 charge amount		kg	21.4	Actual charge

Table 5 Test result of SSSCA210

Test date	Feb. 6th 2018			Note
NH_3/CO_2 secondary refrigeration package SSSCA210	Suction pressure	bar	0.83	Saturation temperature: -37.2 ºC
	Discharge pressure	bar	13.62	Saturation temperature:35.3 ºC
	Middle offset pressure	bar	3.47	Saturation temperature: -6.29 ºC
	Suction temperature	ºC	-36.7	
	Discharge temperature	ºC	75.3	
	Oil supply temperature	ºC	46.8	
	Compressor working power	kW	96.3	
	Rotation speed	RPM	3550	
Cooling water system	Water inlet temperature	ºC	26.40	
	Water outlet temperature	ºC	32.27	
	Water flow	m^3/h	39.92	
	Water pressure drop	kPa	57.70	
CO_2 system	Pressure before pump	bar	13.39	
	Pressure after pump	bar	17.62	
	CO_2 liquid supply temperature	ºC	-32.1	
	Pump power	kW	5.5	
Ethylene glycol system	Inlet temperature	ºC	-24.8	
	Outlet temperature	ºC	-28.3	
	Water flow	m3/h	52.3	
	Water pressure drop	kPa	15.03	

Unit refrigeration capacity	kW	167.1	
Compressor input power	kW	96.3	
Compressor COP	/	1.73	
Unit total power (compressor + CO_2 pump + inverter)	kW	102.3	
COP	/	1.63	
NH_3 charge amount	kg	37.0	Actual charge

Table 6 the testing result of three type compression units

Model	Theoretical displacement (m^3/hr)	Theoretical NH_3 charge (kg)	Actual NH_3 charge (kg)
SSSCA50 (SRS-12L)	262	17	16.8
SSSCA210 (SRS-1612LM)	652	48	37.0
SSSCA60 (SRS-1008L)	221	22	21.4

2.5 Personnel Training

The company technical center conducted training for designers, technicians, production managers, manufacturing workers, installation personnel, product application engineers, equipment managers, and sales personnel designed for the project.

Fujian Snowman Co. Ltd. has organized 37 times of technical commission and personnel training under this project. Totally 679 class hours training were conducted, and 1,871 persons were trained. The training list is shown in table 7.

Table 7 the training list of this project

No.	Trainees	Training content	persons /Times	Class hour
1	Designers, technicians	Process design training for screw compressor, compressor rotor, compressor housing, mechanical assembly and so on.	471/9	17
2	Production management and manufacturing workers	Basic knowledge of welding, classification of welding methods and basic concepts, training of welder's work permit.	195/4	8
3	Installation and commissioning personnel	Machining exception handling process, nonconforming product handling procedure, cause analysis of machining collision tool, etc.	223/5	14
4	Salesman	Compressor features and application scope, compressor unit characteristics, unit electrical and control knowledge introduction, etc.	504/10	28
5	Product application engineer	The cooling principle, the electric control principle and the training of CO_2 as second refrigerant unit, etc.	478/9	16

Fig.17 Training workshop based on the project

2.6 Technology Dissemination

Small and medium cold storage includes refrigeration storage in large and small supermarkets, low-temperature cold storage, and food freezing storage. Ammonia or fluorine is often used as refrigerant in traditional small cold storages, which poses a potential safety hazard to the environment and the surrounding environment. The system demonstrated in this project is less charged with NH_3. It can be used in a small system with dense population.

NH_3 refrigeration system with ammonia semi-hermetic frequency convertible screw refrigeration compressor is new to domestic refrigeration industry. With the test of performance of prototype units at the end of 2017, the demonstration project has also been built and tested. The system unit also been shown in some exhibition such as the International Refrigeration Exhibition in China for the technical dissemination in 2018.

The following projects are used to disseminate the technology.

- Chengdu Taigu cold chain project uses NH_3/CO_2 as second refrigerant system.

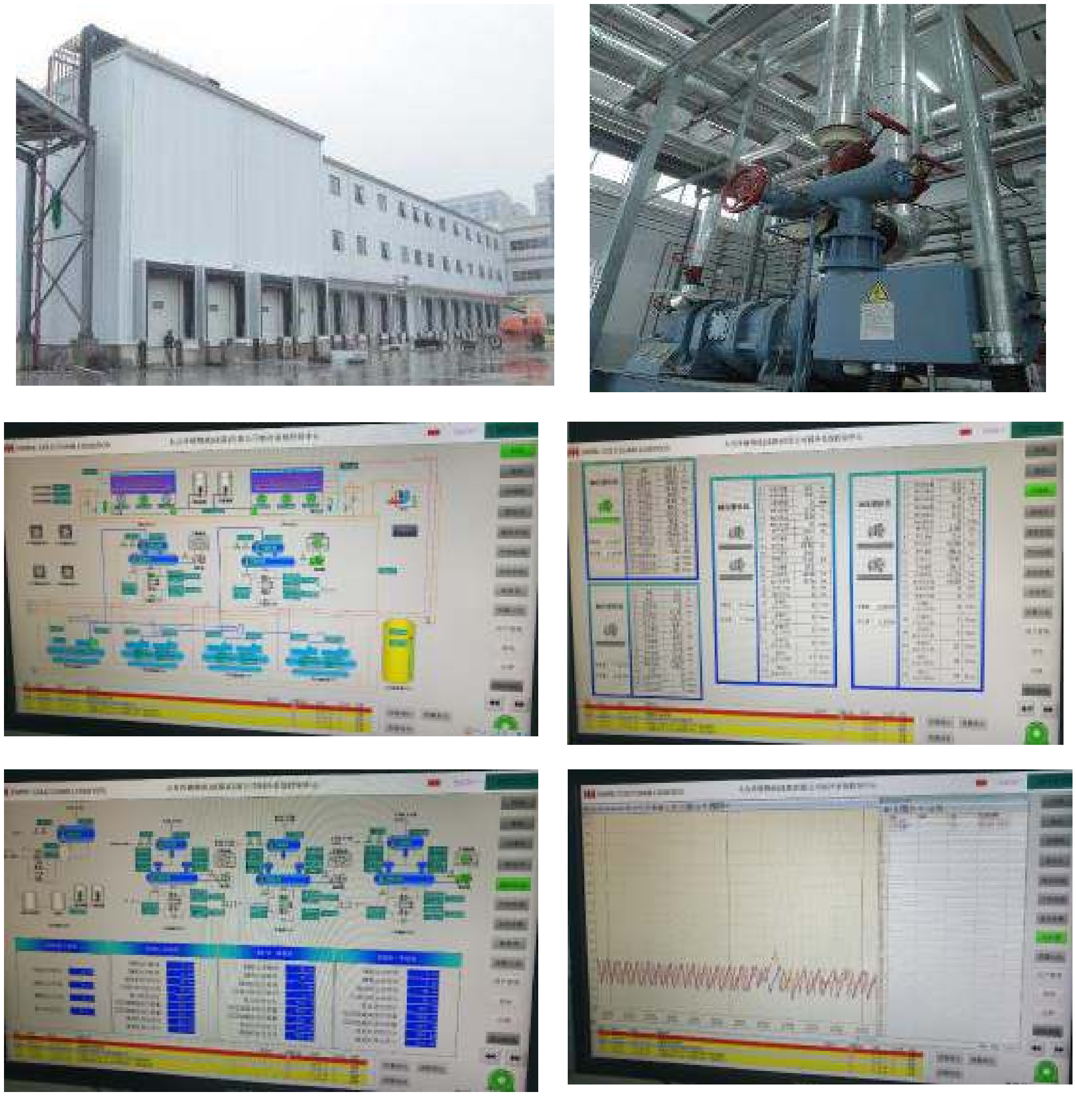


Fig.18 Application of the project system in Chengdu

- Participate in exhibitions, such as the International Refrigeration Exhibition in China, April 2018, Chinese Fisheries Exposition, and Chinese Food Processing Exposition; display the product and application technology.

Fig.19 The dissemination in International Refrigeration Exhibition in China April 2018

2.7 Management

The project is under the overall management and coordination of the Foreign Economic Cooperation Office, Ministry of Ecology and Environment of China. UNDP is the international implementing agency for the project, which provide international coordination and technical assistance as needed.

The project employs the Performance-based Payment (PBP) mechanism in its implementation. Under the PBP mechanism, the enterprise is tasked to carry out the conversion playing the role of a key executer, which is responsible for all the activities related to the conversion (with supervision of the technical expertise team hired by FECO and/or UNDP), including but not limited to: product redesign, procurement of raw material, components, equipment and consulting services as per the budget allocation table, construction product testing devices, etc., and project technical commissioning. The procurement is organized fully in line with the marketing principle, so that the goods and services procured are high quality, most reasonable price and suitable for product line conversion to make sure the new alternative technology applied feasibly and successfully. The detailed arrangement on procurement is defined in the contract between FECO/MEP and the Executor (enterprises).

Besides that, FECO and UNDP are monitoring the implementation of the project with aim to ensure the project activities are in compliance with the UNDP financial rules and procurement rules. UNDP and FECO are not involved in the procurement activities of the enterprise by any means other than make payment to the enterprise in tranches for the costs of procurement and conversion, at agreed payment dates given in the payment schedule, and when milestones prerequisite for the tranche have all been achieved on time.

3. Outcomes

After the demonstration project was approved at the 76th ExCom meeting, UNDP, FECO and the enterprise took prompt action, the implementation of the demonstration project was relatively smooth. By the end of October 2017, the work, including the testing equipment, was basically completed. Since then, a great deal of work has been done in training, technical advocacy, especially on the testing. By the end of 2017, all the required elements of the demonstration project were completed. However, in accordance with the relevant regulations of China, the process of national acceptance was initiated, and the entire process was completed in March 2018.

In addition to requirement of the project, great importance was attached to the practical application of the new system by the enterprise. In October 2017, Fujian Snowman discussed the plan with relevant supermarkets on setting up the refrigeration system based on the new technology. In the last quarter of 2017, after a preliminary test of the system, two systems began to be installed in the supermarkets and the installations of the new systems were completed in early 2018. The investments of the two demonstration systems in the supermarkets were financed by the relevant owners of the supermarkets. To-date, after operating for more than half a year, operation of the two new systems in the two supermarkets are stable. It is expected that after one year's operation of the supermarket systems, a comprehensive evaluation will be conducted to access the performance of the two systems.

In conclusion, the demonstration project has achieved the following good results:

1) The project focus on the corrosion resistance of the electromagnetic line and develop a long term electromagnetic line for ammonia medium.
2) The motor cooling adopts double cooling methods of oil cooling (or water cooling) and refrigerant spray, so as to ensure the motor works stably for a long time.
3) The system adopts single compressor with two-stage to improve system efficiency.
4) The project had finished the target and the system test result is shown in Table 4 above.

5) The system in the demonstration project has been built in two locations in China at the beginning of 2018. The systems are operating successfully at Xiamen Taigu cold storage and runs safely for half a year, and at the Chengdu Taigu cold storage which also began to run safely for half of year.

4. Assessment

4.1 Project process

The project was implemented smoothly according to the program schedule and was completed at the beginning of 2018. It successfully passed national acceptance in March 2018.

Each of milestones was achieved and verified, the main parts of project are as follows:

Milestones		Status
1st	Signing of the contact	FECO and the enterprise signed contract in November 2016.
2nd	Completion of system design and compressor design	Finished and verified in May 2017.
3rd	Prototypes manufactured, and performance tested	Finished and verified in January 2018.
4th	Demonstration project has been built and operation	Finished and verified in January 2018
5th	Technical commissioning completed successfully and relevant personnel trained	Finished and verified in March 2018
6th	Project national acceptance	Finished and verified in March 2018

The project detailed milestones from the date of receipt of funds is given in the table below.

MILESTONE/MONTHS	2016		2017												2018		
	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
Start-up of project activities																	
Project document signature	■																
Project organizer committee	■																
System design and compressor design																	
Motor design		■	■	■	■												
Compressor design		■	■	■	■												
Theoretical analysis and system design		■	■	■	■												
Pressure vessel design		■	■	■	■												
Electric system design				■	■	■	■										
Three type of compression units design					■	■	■										
Prototype manufacturing																	
Prototype manufacturing of compression units							■	■	■	■	■	■					
Testing device																	
Pressure vessel testing device							■	■	■								
Compressor/units performance testing device							■	■	■	■	■	■					
Performance test of prototype										■	■	■	■	■	■		
Training																	
Training				■			■			■	■		■				
Technology Dissemination																	
Technology Dissemination and verification														■			
Project acceptance																	
Project acceptance																	■

4.2 Technical performance

1. NH_3 is a traditional natural refrigerant with good environment properties.

2. NH_3 has good thermodynamic properties with GWP<1.

3. The NH_3 refrigeration unit operating pressures are lower than R22 refrigeration unit.

4. For the same cooling capacity, the charge quantity for NH_3 is about 25% of that of R22 depending on the application.

5. The COP of NH_3 refrigeration unit is the same as the R22 refrigeration unit at the same working condition.

4.3 Actual conversion cost

Total Final Actual Project Costs

The total final actual project costs amount to **US$ 2,011,945.01**, US$ **1,026,815** was funded by the Multilateral Fund, and US$ **985,130.01** was contributed by the company as counterpart funding.

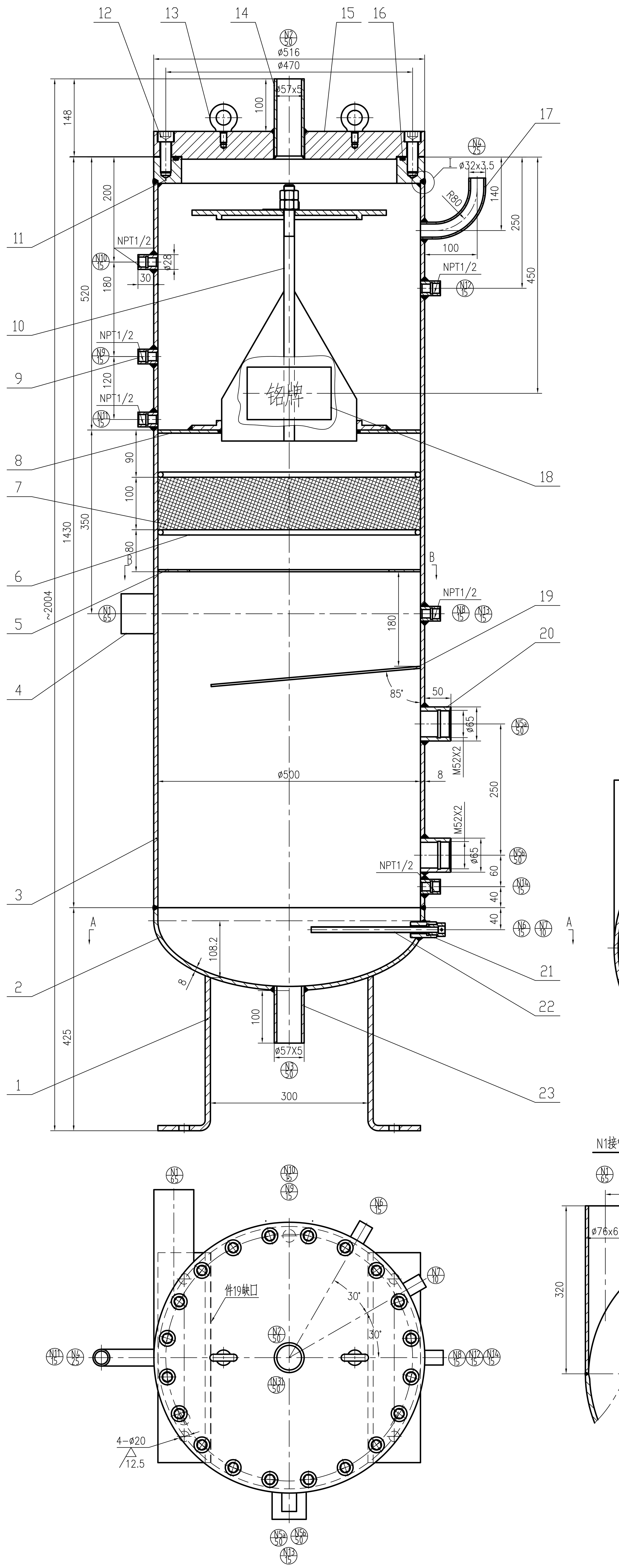
The detailed costs are indicated as follows：

No.	Content		Actual project cost(US$)		
			Actual cost (US$)	**MLF fund (US$)**	**Counterpart funding (US$)**
1	**Product and process design**	System design	118,393.63		118,393.63
		Process design	38,664.77		38,664.77
		Compressor design	163,325.45		163,325.45
		Heat exchange analysis software	83,787.10	83,787.10	0
2	**Compression unit performance test device construction**	Electric leakage detector	2,689.43		2,689.43
		Detector	4,628.24		4,628.24
		Helium detector	68,837.63		68,837.63
		Compression unit performance test equipment	458,965.66	458,965.66	0
		Pressure vessel strength test device	128,337.70		128,337.70
3	**Material for the prototype production**	NH_3 compressor	303,715.03	295,775.00	7,940.03
		NH_3 oil separator	30,869.21	30,869.21	0
		CO_2 liquid-storage tank	58,320.46	58,320.46	0
		Heat exchanger	78,696.08		78,696.08
		Starting cabinet（inverter）	62,519.06		62,519.06
		Electric control cabinet	8,387.40		8,387.40
		Valve parts, pipe, flanges	37,464.01		37,464.01
		Metal hose（testing）	9,799.88		9,799.88
		CO_2 Pump	30,157.53	30,157.53	0
		CO_2 (0.9999)	56,368.51		56,368.51
		NH_3	7,705.67		7,705.67
		Frozen Oil	2,054.85		2,054.85
		Helium	4,079.47		4,079.47
		Nitrogen	483.49		483.49
4	**Training**	Training on process and product design	134,474.84	68,940.04	65,534.80
		Welder training	9,419.43		9,419.43
		Material fee	8,705.07		8,705.07
5	**Market Promotion**	Market Promotion	101,095.41		101,095.41
Total			**2,011,945.01**	**1,026,815.00**	**985,130.01**

4.4 Impact

Following the system demonstration, the product line of the R22 compressor is successfully considered to be converted to NH_3, which results in production of new refrigeration system at production capacity of 3,000 units annually and thus achieved reduction of 359 metric tons of HCFC-22 usage at Fujian Snowman Co. Ltd. Furthermore, over a 15-year life-span of the refrigeration systems manufactured by the enterprise, the consumption of HCFCs for servicing those systems is expected to be 226.16 metric tons in the life cycle. The total GHG emission reductions amount to about 1,041,602.60 CO_2-eq tones, thus contributing to the protection of both the ozone layer and the climate.

The successful completion of the demonstration project contributes towards promotion of this technology for replacing HCFC-22 based refrigeration systems in cold storage and freezing applications and enable cost-effective conversions at other similar manufacturers in this sub-sector.



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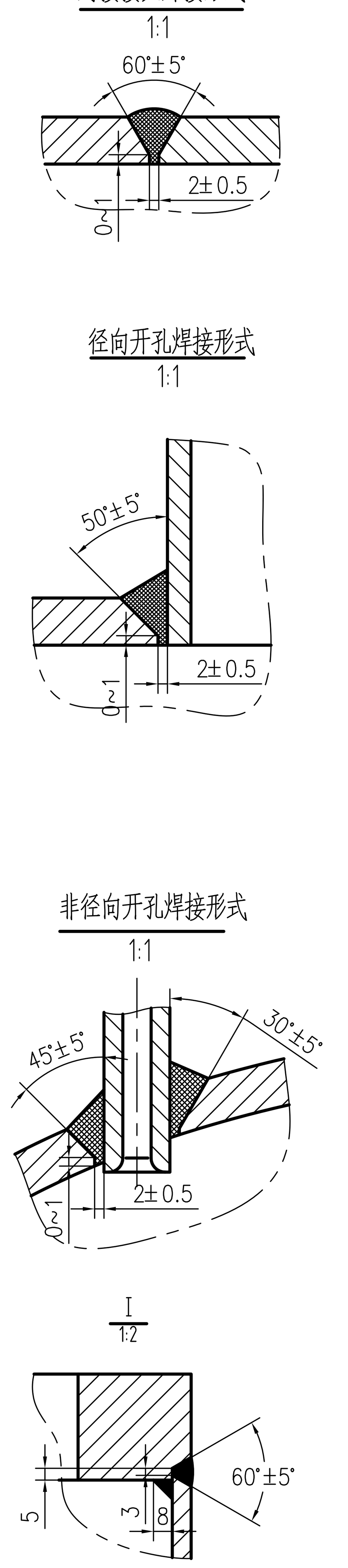

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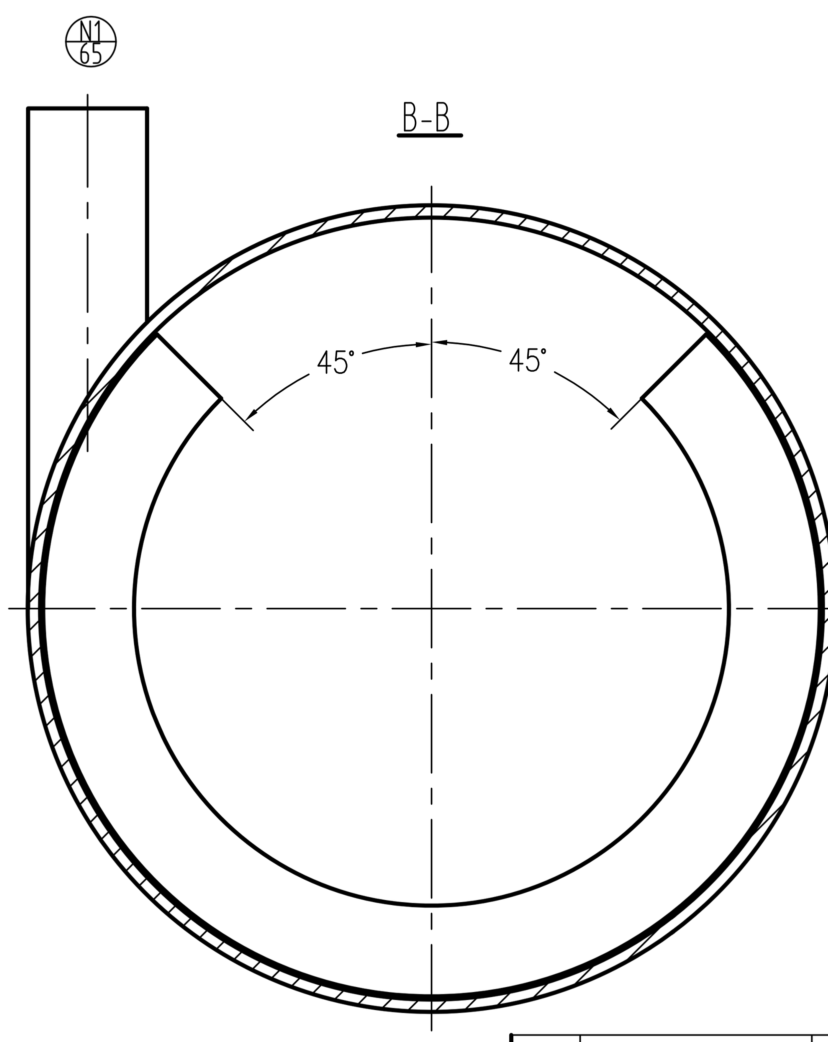
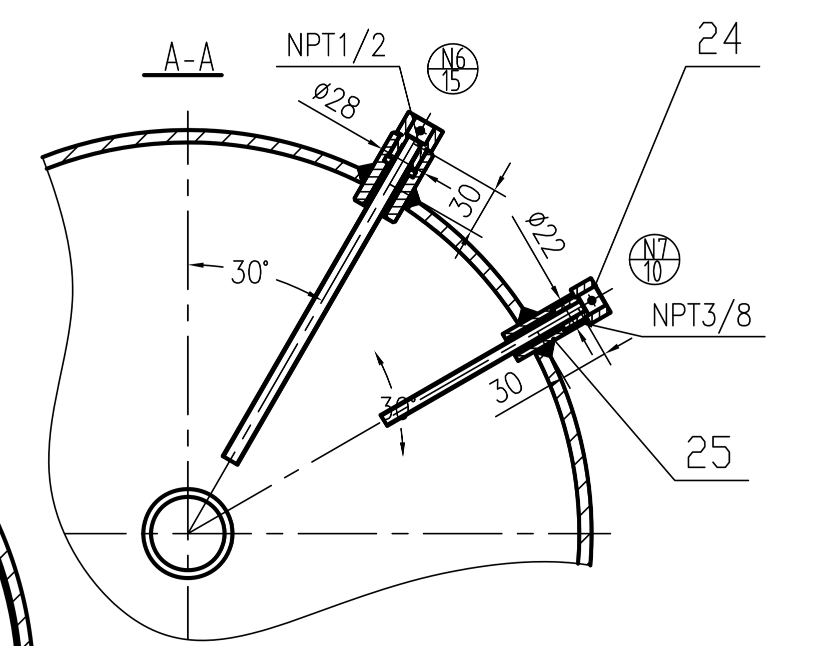
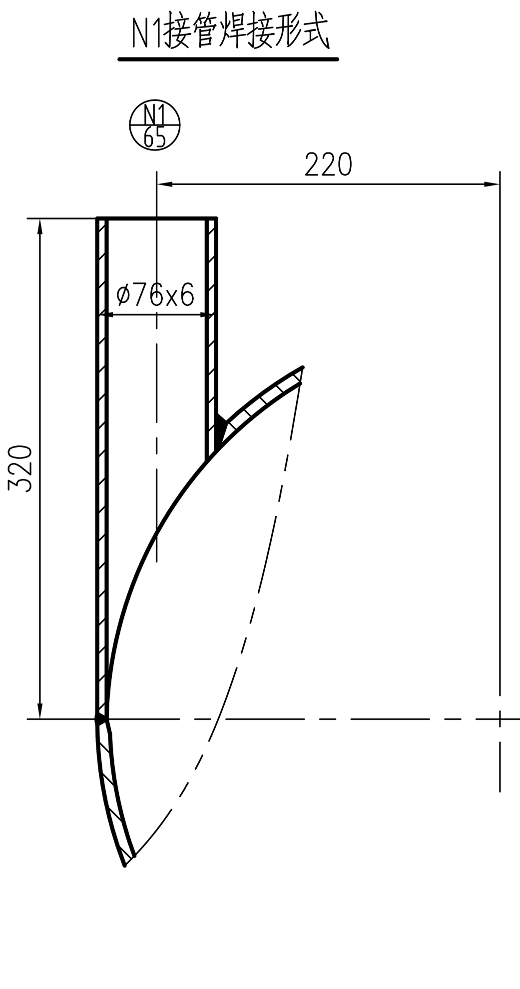


A-A



N1接管焊接形式



设计.制造与检验主要数据表

设计.制造与检验所遵循的规范标准	
	TSG R0004-2009《固定式压力容器安全技术监察规程》
	NB/T47012《制冷装置用压力容器》

设计参数		制造与检验要求				
容器类别	II类	通用要求	1.除注明外,焊接接头采用全焊透结构并符合HG/T20583-2011中有关规定,角焊缝焊脚尺寸按较薄钢板的厚度,法兰的焊接按相应法兰标准. 2.油漆,包装和运输按JB/T4711-2003《压力容器涂敷与运输包装》规定.			
设计压力 (MPa)	2.0					
工作压力 (MPa)	1.7					
设计温度 (°C)	120					
工作温度 (°C)	110					
介质名称	R717 润滑油	焊接规程: NB/T47015-2011				
介质特性	低毒	焊材	母材	焊条牌号		
主要受压元件材料	Q245R,Q345R		碳钢与碳钢之间	J427		
主要材料标准	GB713		不锈钢与不锈钢之间	A102		
腐蚀裕度 (mm)	1		碳钢与低合金钢之间	J507		
焊接接头系数	1	无损检测	检测标准: NB/T47013.2			
全容积 (m^3)	0.3		焊接接头类别 / 检测方法 / 检测比例 / 技术等级 / 合格级别			
安全阀启跳压力 (MPa)	1.8		A,B / RT / 100% / AB / II			
安全阀型号	A62H20-25		C,D / / / / / / / /			
设计预期使用年限 (年)	20	试验	气压试验压力 (MPa)	2.3		
管口及支座方位	按本图		气密性试验压力 (MPa)			
铭牌方位	按本图	热处理要求		不需要		

其它要求

1.设备检验合格后，对外所有开口均封闭，以防异物进入，筒体内部保留0.05MPa的干燥高纯度氮气保压。

2.设备制造完成后，外表面应进行抛丸处理，再喷涂底漆、面漆各二道，颜色按合同要求规定。

3.钢材切割周边 50/▽。

注：三电加热器接口的安装尺寸以电加热棒护套尾部不相碰为准。

管 口 表

符号	公称尺寸	公称压力	连接标准	法兰型式	连接面型式	用途或名称	接管外伸长度
N1	65				焊接	进气口	见图
N2	50				焊接	出气口	100
N3	50				焊接	出油口	100
N4	25				焊接	安全阀口	见图
N5a~b	50		M52×2		螺纹	视液镜口	50
N6	15		NPT1/2		螺纹	加热器接口	30
N7	10		NPT3/8		螺纹	温控器接口	30
N8	15		NPT1/2		螺纹	排气温度检测口	30
N9	15		NPT1/2		螺纹	排气压力检测口	20
N10	15		NPT 1/2		螺纹	导气口	30
N11	15		NPT 1/2		螺纹	回油口	30
N12	15		NPT 1/2		螺纹	检修口	30
N13	15		NPT 1/2		螺纹	加油口	30
N14	15		NPT 1/2		螺纹	油位传感器	30

序号	代号	名称	数量	材料	单件重量	总计重量	备注
25	GB/T14383	螺纹接头NPT3/8	1	20		0.3	L=50
24	YF500K-2	温度控制器护套	1	焊接件		0.8	
23	GB/T8163	接管φ57X5	1	20		0.8	
22	YF500K-2	电加热棒护套	1	焊接件		1.1	
21	GB/T14383	螺纹接头NPT1/2	1	20		0.3	L=50
20		视液镜接头M52X2	2	20	0.5	1	
19	YF500K-2	挡板II	1	Q235B		8.9	
18		铭牌座	1	组合件		/	
17	YF500K-2	安全阀接管φ32x3.5	1	20		0.6	
16	GB/T3452.1	O型密封圈(φ425X7)	1	硅橡胶		/	
15	YF500K-3	上端盖	1	Q345R		73.6	
14	GB/T8163	接管φ57X5	1	20		1.1	
13	GB/T825	吊环螺钉M12	2	A2-70	0.8	1.6	
12	GB/T70.1	内六角螺钉M20X55	20	8.8级	0.15	3	
11	YF500K-3	凸缘	1	Q345R		28.5	
10	YF500K-3	滤芯安装架	1	组合件		21	
9	GB/T14383	螺纹接头NPT1/2	6	20	0.2	1.2	L=40
8	YF500K-2	隔板	1	Q235B		3.3	
7	YF500K-2	滤芯	1	06Cr19Ni10		/	
6	YF500K-2	固定架	2	Q235A	1.75	3.5	
5	YF500K-2	挡板I	1	Q235B		2.5	
4	YF500K-2	进气管φ76X6	1	20		3.3	
3	GB713	筒体φ516X8	1	Q245R		140	L=1390
2	GB/T25198	椭圆封头EHA500X8	1	Q245R		19.6	
1	YF500K-2	支座	2	焊接件	12.6	25.2	

设备净质量 (kg)		330
其中	不锈钢质量 (kg)	
空质量 (kg)		
操作质量 (kg)		
最大可拆件质量 (kg)		

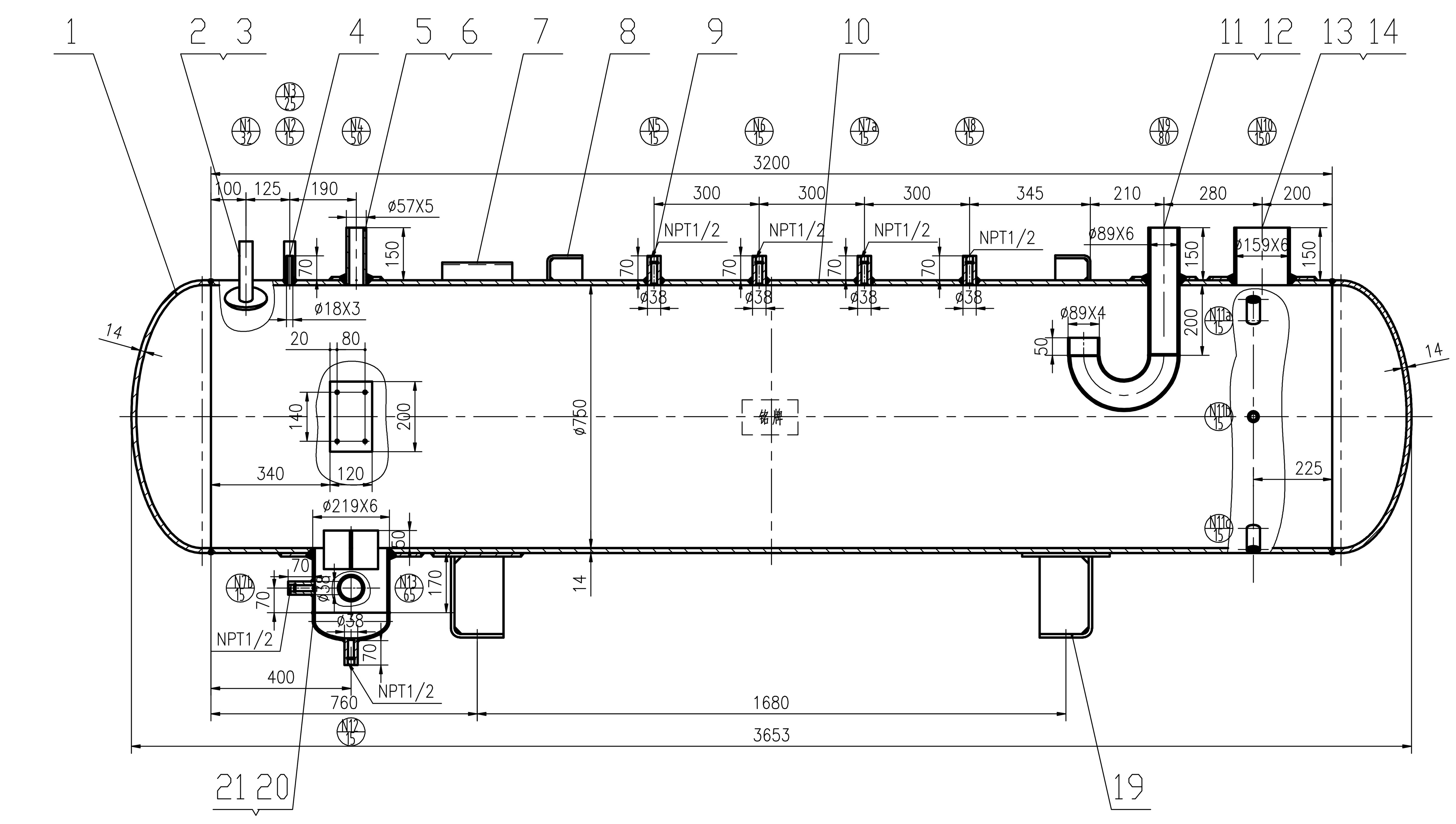
图纸目录：

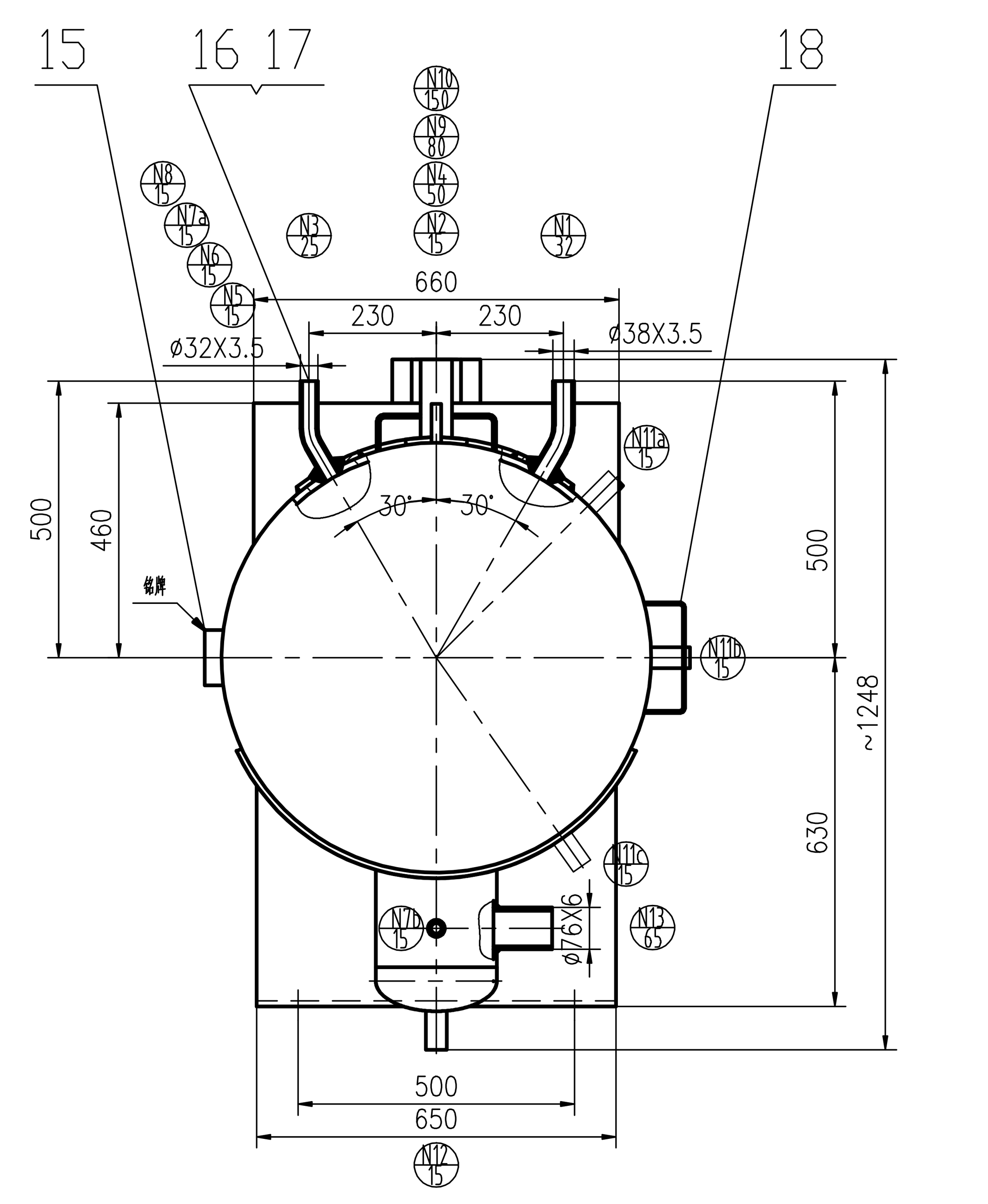
1.YF500K-1，油分离器装配总图，A1一张

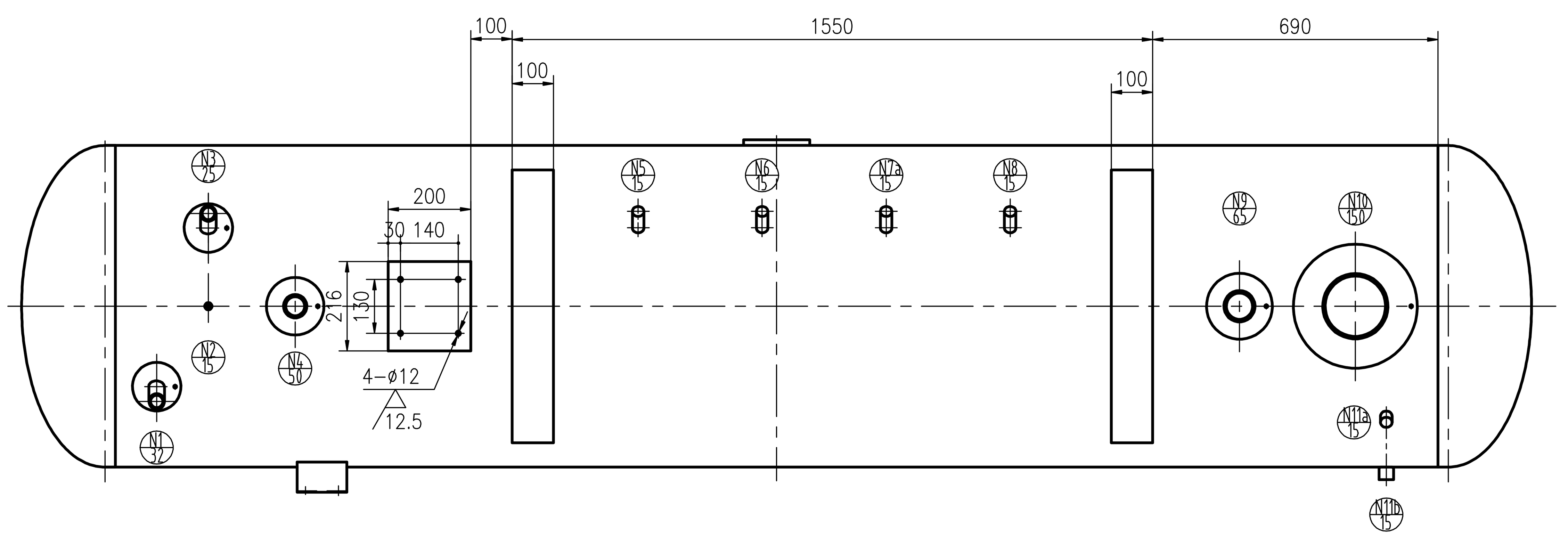
2.YF500K-2，油分离器零部件图，A1一张

3.YF500K-3，油分离器零部件图，A1一张

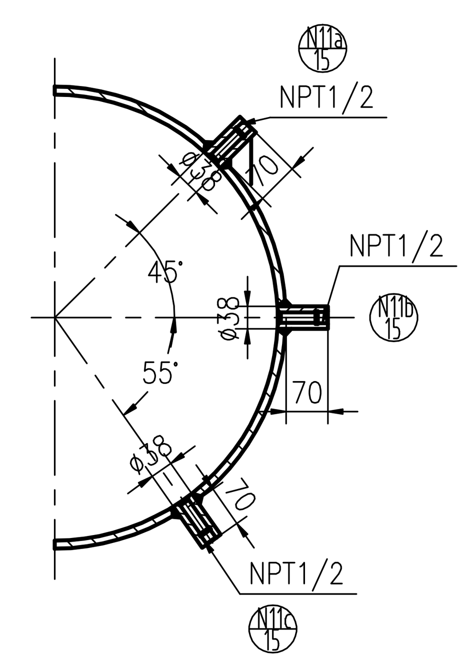
Snowkey® 福建雪人股份有限公司	油 分 离 器 DN500 V=0.3m^3 装 配 总 图	设计项目	
		设计阶段	加工图
设计 / 标准化		YF500K-1	
绘图 / 工艺			
校核			
审核 / 批准	比例 1:4 / 第 1 张	共 3 张	2016年 0版



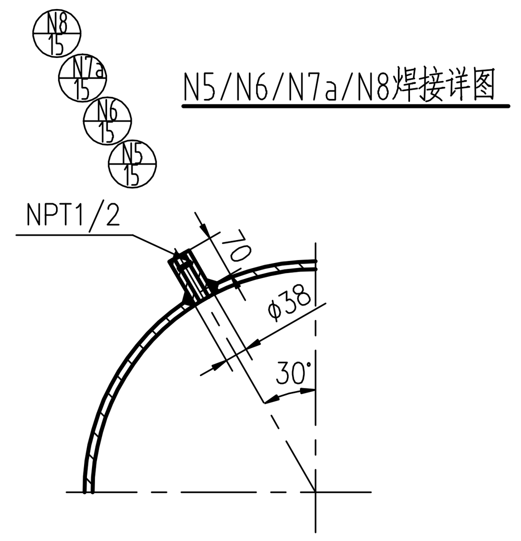


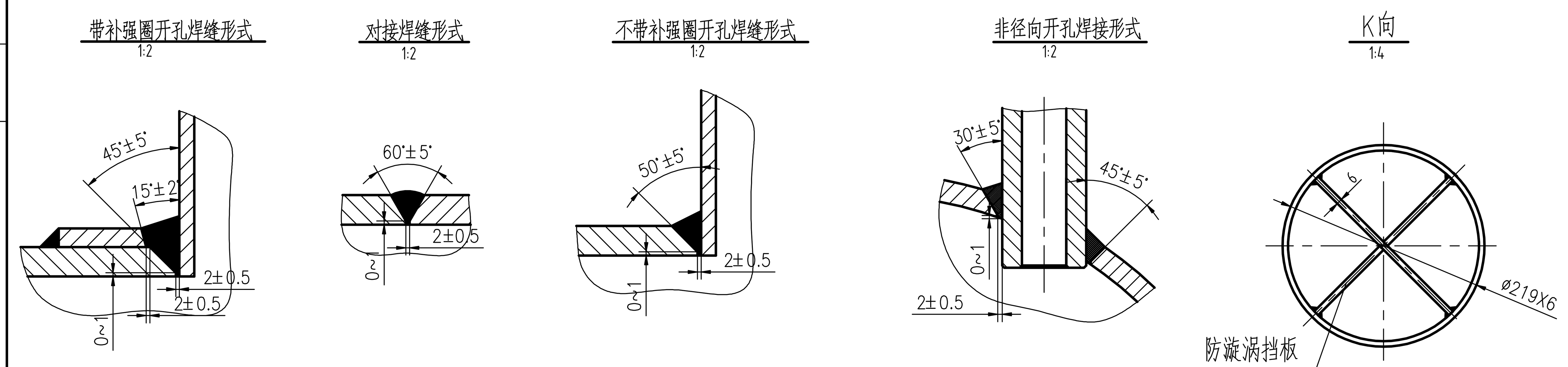


N11abc焊接详图



N5/N6/N7a/N8焊接详图





图纸目录

1.WZE1540-1，CO2储罐装配总图 A1一张；

2.WZE1540-2，CO2储罐零部件图A1一张；

3.WZE1540-3，CO2储罐零部件图A2一张.

设计.制造与检验主要数据表

设计.制造与检验所遵循的标准规范	GB150.1~150.4-2011《压力容器》
	TSG R0004-2009《固定式压力容器安全技术监察规程》

设计参数		制造与检验要求	
容器类别	II类	通用要求	1.除注明外,焊接接头采用全焊透结构并符合HG/T20583-2011中有关规定,角焊缝焊脚高度按较薄钢板的厚度,法兰的焊接按相应法兰标准. 2.油漆,包装和运输按JB/T4711-2003《压力容器涂敷与运输包装》规定.
设计压力 (MPa)	4.5		
工作压力 (MPa)	4.0		
设计温度 (°C)	-39		
工作温度 (°C)	-38		
物料名称	二氧化碳	焊材	焊接规程: NB/T47015-2011
物料特性	无毒		母材 / 焊条牌号
主要受压元件材料	16MnDR		碳钢与低合金钢之间的焊接 / J507RH
主要材料标准	GB3531		低合金钢之间的焊接 / J507RH
腐蚀裕度 (mm)	1		低合金钢与不锈钢之间 / A302
焊接接头系数	1		
全容积 (m^3)	1.54	无损检测	检测标准: NB/T47013.2
安全阀开启压力(MPa)	4.2		焊接接头类别 / 检测方法 / 检测比例 / 技术等级 / 合格级别
安全阀型号	A62H32-63		A,B / RT / 100% / AB / II
设计预期使用年限(年)	10		C,D
保温层材料	橡塑	试验	气压试验压力 (MPa) 4.95
保温层厚度 (mm)	65		气密性试验压力(MPa) /
管口及支座方位	按本图	热处理要求	不需要

其它要求

1. 设备检验合格后，对外所有开口均封闭，以防异物进入，筒体内部保留0.05MPa的干燥高纯度氮气保压；
2.设备制造完成后，外表面应进行抛丸处理，再喷涂底漆、面漆各二道，颜色按压缩机组技术部要求；
3.钢材切割周边 25▽。

管口表　　安全阀口

符号	公称尺寸	公称压力	连接标准	法兰型式	连接面型式	用途或名称	接管外伸长度
N1	32	/	/	/	焊接	安全阀口	见图
N2	15	/	/	/	焊接	回液口	70
N3	25	/	/	/	焊接	放气口	见图
N4	50	/	/	/	焊接	进气口	150
N5	15	/	NPT1/2	/	内螺纹	检修口	70
N6	15	/	NPT1/2	/	内螺纹	测压口	70
N7ab	15	/	NPT1/2	/	内螺纹	测温口	70
N8	15	/	NPT1/2	/	内螺纹	冲注口	70
N9	80	/	/	/	焊接	进液口	150
N10	150	/	/	/	焊接	出气口	150
N11abc	15	/	NPT1/2	/	内螺纹	液位控制器口	70
N12	15	/	NPT1/2	/	内螺纹	排污口	70
N13	65	/	/	/	焊接	出液口	100

序号	代号	名称	数量	材料	单件重量	总计重量	备注
21	WZE1540-2	补强圈DN200X10-C	1	16MnDR		6.8	
20	WZE1540-2	出液包	1	焊接件		15.08	
19	WZE1540-3	支座	2	焊接件	36.46	72.92	
18	WZE1540-3	油回热器支架	1	Q235B		1.2	
17	WZE1540-2	补强圈DN25X10-C	1	16MnDR		0.6	
16	WZE1540-2	排气口接管ø32X3.5	1	16Mn		0.5	
15		铭牌座	1	组合件		/	
14	WZE1540-2	补强圈DN150X10-C	1	16MnDR		3.3	
13	GB6479	接管ø159X6	1	16Mn		3.74	
12	WZE1540-2	补强圈DN80X10-C	1	16MnDR		0.86	
11	WZE1540-2	进液口接管	1	焊接件		5.42	
10	GB3531	筒体ø778X14	1	16MnDR		844.03	
9	WZE1540-2	接头NPT1/2(6000级)	9	06Cr19Ni10	0.39	3.51	
8	WZE1540-2	冷凝蒸发器支架	1	焊接件		7.6	
7	WZE1540-3	经济器支架	1	Q235B		3.26	
6	WZE1540-2	补强圈DN50X10-C	1	16MnDR		0.8	
5	GB6479	无缝管ø57X5	1	16Mn		1.05	
4	GB6479	接管ø18X3	1	16Mn		0.09	
3	WZE1540-2	补强圈DN32X10-C	1	16MnDR		0.69	
2	WZE1540-2	安全阀接管ø38X3.5	1	16Mn		0.6	
1	GB/T25198	椭圆封头EHA750X14	2	16MnDR	74.4	148.8	

设备净质量	(kg)	1125
其中 不锈钢质量	(kg)	3.5
空质量	(kg)	
操作质量	(kg)	
最大可拆件质量	(kg)	

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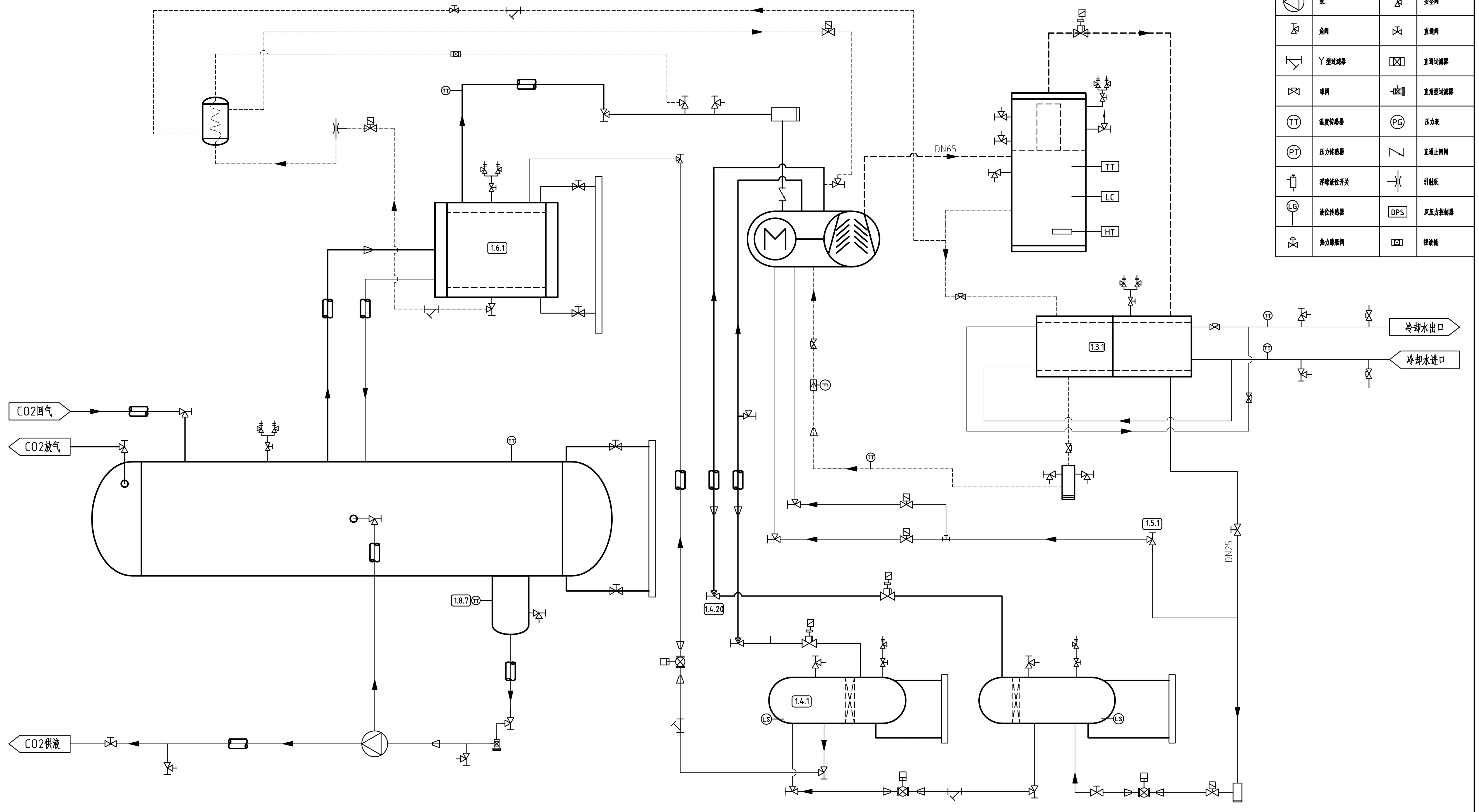
设计		标准化		CO_2储罐 DN750 V=1540L 装配总图	设计项目
绘图		工艺			设计阶段 加工图
校对					WZE1540-1
审核		批准			

比例 1:10　第 1 张　共 3 张　2016年　0版



图例

图例	名称	图例	名称
M	电机		电磁阀
	泵		安全阀
	角阀		直通阀
	Y型过滤器		直通过滤器
	球阀		直角型过滤器
TT	温度传感器	PG	压力表
PT	压力传感器		直通止回阀
	浮球液位开关		引射泵
LG	液位传感器	DPS	双压力控制器
	热力膨胀阀		视液镜

技术要求：

1、制冷剂低温段（经济器、回气管、经济器后供液管、经济器回气管路）保温，厚度为25mm；

2、CO2储罐、CO2冷凝蒸发器保温厚度为64mm，CO2管路保温厚度为25mm。

油管 排气管 吸气管 液体管

标记	处数	分区	更改文件号	签名	年月日	系统流程图	福建雪人股份有限公司 FUJIAN SNOWMAN CO., LTD. Http://www.snowkey.com Email:info@snowkey.com
设计			标准化			阶段标记 重量 比例	SSSCA210 CO2载冷机组
校对							
审核							IRE-20160218-E2 PID-SSSCA210
工艺			批准			共 张 第 张	

Appendix 1

BUSINESS CASE STUDY

TECHNICAL REPORT

District Cooling Development

In Punta Cana

3	2016-08-05	Final Report	L Hargö	P Dalin
2	2016-05-18	First Issue Report	L Hargö	P Dalin
1	2016-04-26	Draft Report	L Hargö	P Dalin
Rev.	**Date**	**Changes**	**Author**	**Approved**

Content

1 Introduction

1.1 Background

During 2015 Devcco performed an initial study on the application of District Cooling system in Punta Cana. The initial study has resulted in a reference case that indicated that such system might be technical and financial feasible. The reference case includes a new centralized absorption cooling plant, located at the PLS plant, using waste heat from the existing waste incineration facility and a lay-out of a new district cooling network in order to connect identified existing and new buildings within the area to the District Cooling system. The reference case was preliminary designed for 2000 TR and to produce approx. 50 GWh cooling energy annually to identified buildings. Existing on-site chiller in, and next to existing buildings, will serve as peak production in the integrated system when needed.

This technical report is a continuation of the initial study performed during 2016.

1.2 Basic project information

Basic project information is result from on-site visits in the Dominican Republic and relevant meetings held with responsible staff within the Punta Cana Group during 2015 and 2016.

1.3 Objective

The expected objectives of the project are:

1) To develop a technical feasibility study on the application of district cooling system in Punta Cana;
2) To identify different technical and financial schemes/options that could be applied to make viable the implementation of the project;
3) Description of the next steps in the development phase, with special focus on the implementation and build-up strategy for Punta Cana District Cooling

This technical report covers item 1 and 2 above.

1.4 Scope

The scope of work is defined in the document Wok Plan, dated 2016-02-20.

2 Market

2.1 Market demand

Within the area owned by the Punta Cana Foundation there are several existing and planned buildings with large cooling demands.

Existing and planned new buildings will result in a growing cooling demand during 2016-2024. The market demand can be summarized as follows:

Existing demand	Installed capacity	Peak	Peak	DC	Duration	Q cool	COP	Q electr.
	TR	TR	MW cool	MW	hours	GWh		GWh
Airport Old + New	1540	1185	4,17	2,92	6000	25,0	2,5	10,0
4 P Sheraton	250	150	0,53	0,37	6000	3,2	3,5	0,9
Blue mall	700	350	1,23	0,86	6000	7,4	2,5	3,0
SUM 1	**2490**	**1685**	**5,9**	**4,15**		**35,6**		**13,9**

Additional demand	Installed capacity	Peak	Peak	DC	Duration	Q cool	COP	Q electr.
	TR	TR	MW cool	MW	hours	GWh		GWh
Airport 3		350	1,23	0,86	6000	7,4	2,5	3,0
4 P Sheraton new		50	0,18	0,12	6000	1,1	3,5	0,3
Hospital		200	0,70	0,49	6000	4,2	2,5	1,7
Supermarket		150	0,53	0,37	6000	3,2	2,5	1,3
Blue mall #2		350	1,23	0,86	6000	7,4	2,5	3,0
SUM 2		**1100**	**3,9**	**2,7**		**23,3**		**9,3**

Grand Total	Installed	Peak	Peak	DC	Duration	Q cool	COP	Q electr.
	TR	TR	MW cool	MW	hours	GWh		GWh
Grand Total		**2785**	**9,8**	**6,85**		**58,9**		**23,2**

During 2016-2024 the total cooling demand will grow to about 2,785 TR peak demand which corresponds to about 10 MW peak cooling demand. The annual consumption of cooling energy demand is calculated to approx. 59 GWh.

The new centralized District Cooling plant is planned for a capacity corresponding to approx. 7 MW cooling capacity. The plant intends to serve as a base load facility with the annual capacity of 45 GWh cooling energy annually. Existing on-site chiller in, and next to existing buildings, will serve as peak production in the integrated system when needed, in total 14 GWh cooling energy per year.

3 Technique

With the absorption chiller technique waste heat from existing sources can be converted into cooling energy with only a small supply of electricity.

Steam and/or hot water replace the usual electrical energy input as the main "fuel" for the chillers.

The District Cooling system consist of four main sub-systems;

- Existing sources of waste heat i.e. the Wartsila engines and the biomass plant
- Absorption chillers (with auxiliaries) for cooling production
- A distribution pipe network.
- Customer building's Energy Transfer Stations (ETS)

3.1 Sourcing

Available sources of waste heat or heat possible to produce at low cost are:

1. The existing biomass steam boiler (7 MW thermal).
2. Heat recovery from the two Wartsila 32 engines for power production.

3.1.1 The biomass steam boiler

Existing biomass steam boiler has a capacity of 700 hp at 100°C which is equal to approx. 6.9 MW. The boiler produces steam at maximum 10 bar/184.1°C for supply to the laundry and to the HFP pre-heater.

Our understanding regarding existing steam demand is summarized in the table below, see also comments under chapter 3.1.3.

Source		**Steam lb/hr**	**Steam lb/day**
Boiler capacity at 100°C	6.9 MW	24,250 lb/hr	194,000 lb/day*
Consumption			
Laundry steam demand (8 bar)	1.8 MW	6,250 lb/hr	50,000 lb/day
HFO pre-heater demand	0.7 MW	2,430 lb/hr	19,440 lb/day
Available for cooling			
Capacity available for cooling production	4.4 MW	15,570 lb/hr	124,560 lb/day

* 8 hours = 1 day

Information received indicates that today, the yearly biomass consumption varies from 12 - 22 tons per day and 6,000 tons per year. Maximum consumption is 40 tons per day and 15,000 tons per year.

With maximum utilization of the biomass boiler, shut-down hours due to maintenance and repair will increase, in this study 4 weeks of stops per year is calculated.

Biomass, fuel - costs and logistics

Cost of biomass fuel is today rather low, approx. USD $15 per TN. On the other side, a higher future demand will also result in a higher price per TN.

For calculations are a price of USD $38 per TN used, as indicated by Punta Cana Foundation's representative. Heat value of the fuel and efficiency of the biomass boiler is not known; based on information that 20 TN biomass is consumed to produce 50´000 lb steam per day the net production cost can be calculated to **USD $0.015 per lb of steam.**

3.1.2 The Wartsila type 32 engines for power generation

The first Wartsila 16 cyl. type 32 engine was installed at site in 2004, the engine generates 7.2 MW of electrical power and was followed by a second unit of the same type and size in 2013.

In accordance with information given in the Wartsila type 32 Product Guide the engine's energy balance is presented below:

Energy source	Temperature	Portion of fuel energy
Exhaust gas	~ 350 °C	~ 30%
Jacket water	~ 85 °C	~ 6,5%
HT charge air	~ 90 °C	~ 9%
Lubricating oil	~ 70 °C	~ 5,5%
LT charge air	~ 40 °C	~ 4%
Generator cooling	~ 35 °C	~ 1,3%
Engine radiation	~ 35 °C	~ 1,5%

Typically, all the heat from HT (high temperature) charge air and jacket cooling circuits and about half of the heat from exhaust gases can be recovered. In many cases, the heat from lubrication oil can also be recovered, fully or partly. These sources add up to 35% of fuel power.

The following heat balance figures are taken from the Product Guide:

16V32, 720 rpm

Load	%	100	90	75	50
Rated output	kW	7200			
Engine output	kW	7200	6480	5400	3600
HT-circuit total	kW	2200	1787	1267	833
HT jacket water	kW	1067	933	800	653
HT charge air	kW	1133	853	467	180
LT-circuit total	kW	1853	1720	1460	1309
LT charge air	kW	1000	893	727	616
LT lubricating oil	kW	853	827	733	693
Exhaust gases	kW	4480	4147	3672	2644
Radiation	kW	225	225	225	225
Exhaust gas flow	kg/s	13,3	12,2	10,4	7,1
Exh. gas temp after TC	°C	345	348	360	380

Heat recovery - Hot water

Accessible sources for heat recovery of hot water, as marked above, are:

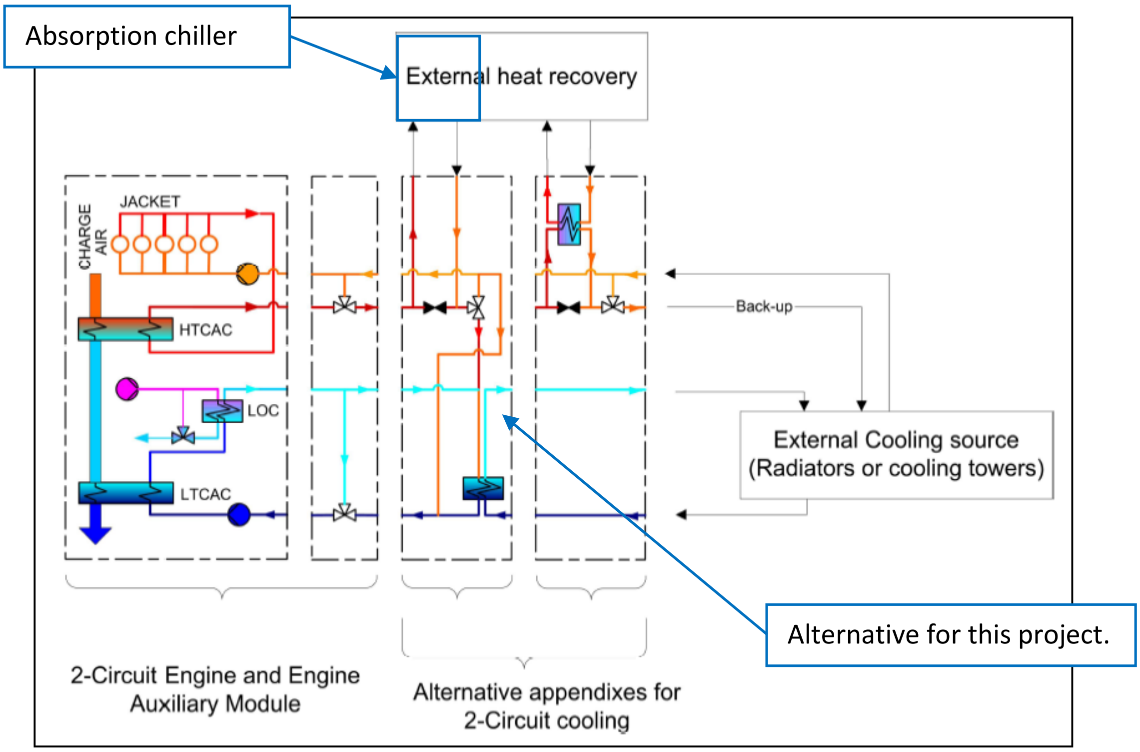
Source	Temp.	Load 100 %	Load 90 %	Load 75 %	Load 50 %
HT jacket water, kW	85°C	1067	933	800	653
HT charge air, kW	90°C	1133	853	467	180
HT-circuit total, kW	**87°C**	**2200 kW**	**1786 kW**	**1267 kW**	**833 kW**
Total for both Wartsila units	**87°C**	**4400 kW**	**3572 kW**	**2534kW**	**1666 kW**

Engine's cooling circuit circulation pump capacity is 135 m3/h, with a temperature drop of 14°C corresponds this flow with 2,200 kW of heat recovery.

There are two alternatives of cooling systems for the Wartsila 32 engine; 1 circuit system and 2 circuit system.

It is not known which system is installed in this case, but in accordance with the Product Guide both systems are suitable for heat recovery.

In the 1 circuit system are the HT-circuit and the LT-circuit connected in serial giving a maximal output heat recovery temperature of 86°C, while in the 2 circuit system the HT-circuit and the LT-circuit are connected in separate circuits giving am maximal output heat recovery temperature of 91°C.



The scheme above shows a 2-circuit system with two alternative appendixes for heat recovery. Our choice for this project is the alternative to the left, without heat exchanger.

Heat recovery - Steam

The second Wartsila 32 engine can be equipped with an exhaust steam boiler, similar as for the first engine.

The exhaust boiler produces 7 bar/170°C steam, capacity 4,695 lb/hr (2,130 kg/hr).

3.1.3 Priority needs of steam, comments

In accordance with received information, prioritized needs of steam are 6'250 + 2,430 = 8,680 lb/hr for supply to the Laundry and the HFO pre-heater. This steam demand is possible to produce via the biomass steam boiler, via the Wartsila 32 engine exhaust steam boiler or via the oil boilers. The exhaust steam boiler has a capacity of 4,695 lb/hr which is about 55 % of the capacity required.

At our latest visit (February 2016) was the biomass boiler not in operation, this indicates that prioritized needs of steam are possible to produce in an economical way without the biomass boiler. This is of course because of the current low world market oil prices but also due to a lower steam demand from the Laundry. If this lower demand from the Laundry is temporarily or not, is not known.

One reflection is that, in a future District Cooling system, it would be better to use the existing first Wartsila exhaust boiler for supply of steam to the absorption chiller instead of to the HFO pre-heater. The HFO pre-heater function could be handled via hot water recovery from one of the Wartsila engines. As described in chapter 3.2, steam absorption chillers are much more efficient than hot water absorption chillers, the difference between steam and hot water heaters (heat exchangers) are not that significant.

However, available steam volumes for supply to a steam absorption chiller is calculated in accordance with chapter 3.1.1 and 3.1.2, which can be regarded as somewhat conservative.

3.1.4 Sourcing - Summary

Available sources for supply to absorption chillers can be summarized to:

1. Steam 7-10 bar; 15,570 + 4,695 = 20,265 lb/hr.

The biomass boiler is in place and the investment costs for supply of 15,570 lb/hr steam to the chiller is very low.

Investments for an exhaust boiler is required for supply of the extra 4,690 lb/hr of steam.

2. Hot water 87°C; 2 x 135 m3/h => 4,400 kW

An extra heat exchanger circuit is required and the investment costs for supply of 4,400 kW of hot water are low.

3.2 Production

3.2.1 Steam driven absorption chillers

In this case; with steam 7-10 bar available both from the biomass boiler and an exhaust boiler, it will be possible to install the more efficient 2-stage type of absorption chiller.

Typical key figures for 2-stage steam driven absorption chillers are listed in the table below:

2-stage steam driven	Source available, exhaust boiler only	Source available, biomass only	Source available, total
Steam consumption	4,695 lb/hr	15,570 lb/hr	20,265 lb/hr
Chilled water, cooling capacity	546 TR / 1,916kW	1,810 TR / 6,354 kW	2,356 TR / 8,270 kW
Condenser cooling, required capacity	3,330 kW	11,070 kW	14,400 kW

The biomass "fuel" cost for steam is assumed to USD $0.015 per lb of steam, as calculated in chapter 3.1.1. The cost figure for steam is then equal to **USD 0.037 per kWh** of cooling energy.

The exhaust boiler "fuel" cost for steam is equal to USD 0.0 per kWh, in comparison.

Assumed that investment costs for the exhaust boiler is USD 350,000 higher, compared to investment costs for the biomass alternative this is equal to a difference USD 183 per kW of cooling capacity. A simple 15 year Present Value calculation is presented:

WACC = 5.0%, 15 years		Biomass boiler	Exhaust boiler
Investment cost	1,000 kW	USD 0	USD 183,000
Fuel cost per year	7,000,000 kWh	USD 259,000	USD 0
Present Value, year 1		**USD 2,688,000**	**USD 183,000**

The conclusion is that the financially most attractive cooling production will be based on steam from the exhaust boiler; a possible cooling capacity of **546 TR / 1,916 kW** will be used in the calculations.

Steam from the biomass boiler is more expensive and therefore this will be the alternative for future expansion, it may also work as a back-up resource. In a comparison with traditional electrical chillers, the steam fired absorption chiller is still more economical.

Type of chiller	Cost of "fuel" per MWh of cooling
Exhaust boiler steam fired absorption chiller	USD 0/MWh
Biomass steam fired absorption chiller	USD 37/MWh
Heat recovery Hot Water driven absorption chiller	USD 0/MWh
Electrical chiller, COP = 2.5. Electricity cost, USD 0.15/kWh	USD 60/MWh
Electrical chiller, COP = 2.5. Electricity cost, USD 0.25/kWh	USD 100/MWh

3.2.2 Hot water driven absorption chillers

Minimum hot water supply temperature for hot water driven absorption chillers, in practical, is 75°C. In this case we have access to 87°C hot water which means some increased chiller capacity.

Typical key-figures for hot water driven absorption chillers are listed in the table below:

Hot water driven	Source, available	Source, approx. 50 %
Hot water capacity	4,400 kW	2,200 kW
Chilled water, cooling capacity	926 TR / 3,250 kW	460 TR / 1,625 kW
Condenser cooling, required capacity	7,650 kW	3,825 kW

Cooling production based on heat recovery from the Wartsila engine is financial attractive too; a possible cooling production capacity of **926 TR / 3,250 kW** will be used in the calculations.

3.2.3 Cooling production - Summary

Chilled water based on the two "free" sources in terms of costs for fuel are the financially most attractive and their total capacity also correspond well with the demand of existing buildings.

Hot water heat recovery from Wartsila engine no. 1 and 2: 926 TR / 3,250 kW

Steam from the exhaust boiler Wartsila engine no. 2: 546 TR / 1,916 kW
Total chilled water cooling capacity from "free" sources: 1,472 TR / 5,166 kW

This results in following chiller configuration:

- Absorption chiller for hot water: cooling capacity 1 x 926 TR / 3,250 kW.
- Two stage absorption chiller for steam: cooling capacity 1 x 546 TR / 1,916 kW

In addition to the free sources there is also the source of steam from the biomass boiler. With increasing demand due to new buildings steam from the biomass boiler will come to use.

Absorption chillers	**Phase 1**	**Phase 2**
Hot water fired	926 TR / 3,250 kW	
Exhaust steam fired	546 TR / 1,916 kW	
Biomass steam fired		1,810 TR / 6,354 kW*
Total available capacity	**1,472 TR / 5,166 kW**	**3,282 TR / 11,520 kW**

* Available maximum capacity for future demand

3.2.4 Chillers' condenser cooling alternatives

The chillers' condensers need cooling and this can be handled by water or air. For cooling by water resources such as the sea, lakes, rivers or ground wells are usually used.

In this case fresh water from ground wells or the water distribution network could be an alternative for cooling by water. For cooling by air represent cooling towers the most efficient solution.

3.2.5 Fresh water cooling

The cooling systems for Sheraton Four Points and Hotel Westin's are cooled by water from ground wells and the good access to water in this area makes this an interesting alternative. The Westin ground well's water is said to have a very high salinity and it is reason to believe we could have the same situation in the Wartsila plant area.

With a ground water temperature of 15°C (59°F) the water flow demand is 175 liter/sec for the Phase 1 chiller configuration of 1,472 TR / 5,166 kW. The yearly water demand can be estimated to 4.4 million cubic meters.

In accordance with information received there is a cost of approx. USD 50,000 for a 120 GPM ground well. For a flow of 175 liter/sec should 22 boreholes be required to a cost of **USD 1.1 million.** If this larger volume is accessible and how long distance is required between the boreholes is not known.

If water have to be pumped from a depth of 25 meters, the total required pump's pressure head can be estimated to 3.0 bar. Required pumping power approx. 69 kW, annual electrical consumption is 480 MWh. With cost of electricity USD 0.15/kWh, annual cost is USD 72,000.

3.2.6 Cooling towers

Evaporative type of cooling towers is recommended, dimensioned for a wet bulb temperature = 27°C. Air humidity 80 %.

Based on the chiller configuration presented in chapter 3.2.3 (5,166 kW cooling capacity) following condenser cooling capacity is required:

Hot water absorption chiller demand:	7,650 kW
Steam absorption chiller demand:	3,330 kW
Total cooling demand:	10,980 kW
Cooling towers entering temperature:	35°C (95°F)
Cooling towers leaving temperature:	31°C (88°F)
Dimensioning cooling water flow:	655 liter/sec
Pumping power, approx:	80 kW / 560 MWh per year
Cost of electricity, at USD 0.15/kWh:	USD 84,000 per year

Cooling water evaporates continuously and so called blow down is necessary to get rid of scaling and debris in the cooling water circuit. All water contains levels of dissolved solids. When water evaporates from the cooling tower, these solids are left behind causing the cooling water become more concentrated. When this concentration gets too high it is necessary to flush out this water, replacing with fresh water, a so called blowdown. The fresh water is called makeup water.

Cycles of concentration (COC) refers to the concentration ratio between the makeup and the blowdown water. The allowed COC depends of the fresh water quality and most cooling towers operate within a COC range of 3 - 5, a better fresh water quality and cooling towers design results in a higher COC and thereby a lower water consumption. Often is the water's chloride content the limiting factor, too high chloride content causes corrosion in pipes and equipment.

In this case, we have assumed that one new ground well will be needed for supply of water to the cooling towers. With a 120 GPM ground well capacity is more than enough and we do not need to save water.

Evaporating can be calculated to approx.:	4.0 liter/sec.
Blowdown is calculated to:	3.0 liter/sec
COC:	1.3 (low because of suspected high salinity)
Makeup water maximum demand is:	7.0 liter/sec
Makeup water yearly volume, approx:	176,000 m^3
Blow down yearly volume, approx:	76,000 m^3
Electricity to cooling towers fans:	75 kW / 525 MWh per year
Cost of electricity, at USD 0.15/kWh:	USD 78,750 per year

Cooling towers water treatment

Chemicals need to be added into the cooling tower's circuit. Inhibitors to prevent corrosion and scaling and biocides against bacteria and legionella are needed.

In this case with a low COC, the concentration of chemicals can be lower than usually common.

Based on information from the chemical company Ashland, following cost calculation is made:

Chemicals concentration and costs			
Inhibitor	**15**	ml/m^3	USD 13/liter
Biocide Type 1	**200**	ml/m^3	USD 14/liter
Biocide Type 2	**200**	ml/m^3	USD 13/liter

With a yearly makeup water volume of 176,000 m3 the costs for chemicals are estimated to **USD 42,000 per year**.

3.2.7 Condenser cooling - Summary

Assumed that investment costs for the ground wells are USD 1.1 million (as described in chapter 3.2.5) and for the cooling towers are USD 390,000 plus one ground well USD 50,000. Also assuming the difference in operational costs consist of the cooling towers chemical treatment, to a cost of USD 54,000 per year plus fan's electricity to cost. A simple 15 year Present Value calculation can be made:

WACC = 5.0%, 15 years	**Cooling towers**	**Ground wells**
Investment cost	USD 390,000 + 50,000	USD 1,100,000
Pumps op. costs	USD 84,000	USD 72,000
Fans op. costs	USD 78,750	USD 0
Chemicals	USD 42,000	USD 0
Present Value, year 1	**USD 2,565,000**	**USD 1,848,000**

There is a difference in the favor of ground wells but considering the unknown facts about salinity and the possibilities to extract large volumes of ground water in a limited area, this is recommended to further investigations.

3.3 Distribution pipes system

For the distribution system pipes, two different options are available:

- Pre-insulated carbon steel pipes, insulated with PUR-foam and HDPE jacket pipe.
- HDPE pipes; the same type of pipes as generally used for drinking water systems.

Pre-insulated carbon steel pipes main advantage is the insulation, in a hot climate as in Punta Cana the soil temperature is high enough to raise the water temperature inside the pipes before it reaches the customers. With pre-insulated pipes the temperature loss (=gain) is almost zero. Another advantage is the built in leak detection system consisting of two copper wires in the insulating foam. The impedance between the wires is continuously measured and a small leak will be detected before it may cause any harm. If a leak occurs, the location can be identified by the use of an impulse reflectometer.

HDPE-pipes have many advantages when distributing cold water; installation costs are generally lower and the jointing procedure is much faster. Main disadvantage is rather poor pressure rating; high pressure systems require thick wall pipes which are costly. The HDPE material in itself has some insulation capability but this is not enough in hot climates. It is possible to manufacture pre-insulated HDPE-pipes but in other projects these have been shown to be too expensive in large dimensions. A more cost-effective alternative is insulation on site with cellular plastic blocks mounted outside the pipe, in the picture are dim. 355 mm pipes shown:

The distribution network which is presented below has a length of 3.9 km and covers the identified customers. In this case are the calculations based on pre-insulated steel-pipes but in the detailed design phase is it worthwhile to investigate the economic consequences of using HDPE pipes with cellular plastic blocks insulation as an alternative.

Corresponding pipe dimensions are:

Steel pipes 16 bar	HDPE pipes 16 bar	HDPE pipes 10 bar
DN 600	Dim. 710 SDR 11	Dim. 710 SDR 17
DN 500	Dim. 630 SDR 11	Dim. 560 SDR 17
DN 400	Dim. 500 SDR 11	Dim. 450 SDR 17
DN 300	Dim. 355 SDR 11	Dim. 315 SDR 11
DN 200	Dim. 250 SDR 11	Dim. 225 SDR 11

3.3.1 Distribution pipes layout and dimensioning

The overall distribution pipes system layout is presented below:

Pipe dimensioning is dependent of supply and return differential temperatures and these in turn depends on connected buildings' cooling systems design.

Standard design temperatures for chilled water inlet-outlet in buildings' cooling systems are 44-54°F (6.7-12.2°C) but in reality are the differential temperature often less than 10°F. This is because the use of split control valves, low set-points, over sizing, etc.

The Distribution system is designed for a maximum capacity of 7 MW cooling at a differential temperature of 2°C (3.6°F) but we recommend to go through customers' interior cooling systems in order to increase diff. temp. to standard design temperatures, but at least 3°C (5.4°F). This in order to reduce pump sizing and pumping costs, as shown in the table:

Pump dimensioning, system capacity 7 MW	**Diff. temp. 5.5°C (10°F)**	**Diff. temp. 3°C (5.4°F)**	**Diff. temp. 2°C (3.6°F)**
Pump's design flow	304 liter/sec	548 liter/sec	822 liter/sec
Pump's design pressure head	2.2 bar	4.6 bar	9.3 bar
Pump's, electrical demand, η=0.8	82 kW	309 kW	937 kW
Electrical cost per MWh of cooling (el. = USD 0.15/kWh)	USD 1.8/MWh	USD 6.6/MWh	USD 20/MWh

Please note that the USD/MWh cost figure is only representative for the actual design flow presented in the table's first line. As the pressure head drops quickly when the flow decreases this also has a huge impact on the pumping power required.

Tables for a system with maximum demand 7 MW is presented. The number of hours per year a certain demand occurs are roughly estimated and presented. In the first table is data corresponding with diff. temp. = 2°C presented and in the second table is diff. temp. = 5.5°C.

The DC system with a differential temperature of 2°C (3.6°F)

Demand, kW	**4 000**	**4 500**	**5 000**	**5 500**	**6 000**	**6 500**	**7 000**	**Year**
Hours per year	500	1260	1500	1500	1500	1500	1000	8760
2°C system, liter/sec	477	537	597	656	716	776	822	
Pump power, kW	222	296	388	499	632	789	937	
USD/MWh	8,3	9,9	11,6	13,6	15,8	18,2	20,1	
USD/period	16 676	55 984	87 218	112 222	142 170	177 548	140 550	**732 366**

The DC system with a differential temperature of 5.5°C (10°F)

Demand, kW	**4 000**	**4 500**	**5 000**	**5 500**	**6 000**	**6 500**	**7 000**	**Year**
Hours per year	500	1260	1500	1500	1500	1500	1000	8760
5.5°C system, liter/sec	174	195	217	239	260	282	304	
Pump power, kW	30	36	43	50	61	69	82	
USD/MWh	1,1	1,2	1,3	1,4	1,5	1,6	1,8	
USD/period	2 234	6 786	9 574	11 202	13 658	15 575	12 300	**71 329**

The importance of keeping the differential temperatures as high as possible is obvious. By adjusting set points and eliminating short cuts in the customers' systems the return temperatures will increase to standard levels.

3.3.2 Distribution pipes system - investments

Calculated investment costs are presented in the table below. Ground work costs are based upon information from Punta Cana Foundation. Cost of pipes are bench mark with Devcco data base.

Distribution pipes system Pre-insulated steel pipes			Pipes, works	Ground works	**Total**	
Trench, see map	**meter**	**Dim**	**USD/m**	**USD/m**	**USD/m**	**kUSD**
A - B	1100	DN 600	800	200	1000	1100
B - C	1400	DN 600	800	200	1000	1400
C-TBx	450	DN 500	700	180	880	396
TBx-TA	650	DN 300	350	120	470	305.5
C-4P	100	DN 200	200	100	300	30
TBx-TB	200	DN 300	350	120	470	94
SUM 1	**3900**					**3326**
Crossings						800
Energy Transfer Stations, ETS						343
SUM 2						**4469**

3.3.3 Distribution pipes system - Summary

Normally, it is not wise to invest in oversized District Cooling systems before you have the "extra" cooling demand in place. However, in this case with the Cooling Production plant located at a rather long distance from the customers' area it is necessary. To install another main pipe in the future is not possible of economic reasons, here it is necessary to consider future market expansion when dimensioning pipe section A to C.

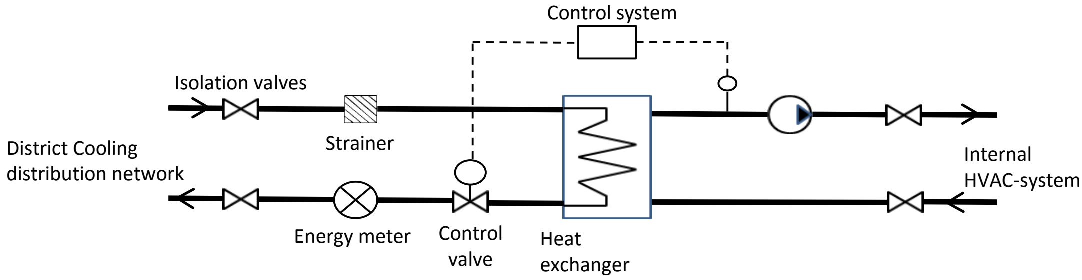
The Distribution pipes system is dimensioned for additional future demand; the new Hospital, Sheraton new building, etc.

The 7 MW maximum capacity is based on a diff. temperature of 2°C (3.6°F) but since this poor diff. temp. causes rather high pumping electrical costs it is worthwhile to go over the customers' internal systems and make the necessary adjustments in order to increase the diff. temperatures.

With at diff. temperature of 3°C (5.4°F) the distribution pipe system capacity will increase to more than 10 MW.

3.4 Energy Transfer Stations, ETS

An Energy Transfer Station (ETS) is installed in each connected building for transfer of cooling from the distribution network into the building's internal cooling system. The ETS includes isolation valves, energy metering equipment, pumps, control valves, automation system, pipes, auxiliaries and normally also a heat exchanger. Standard ETS with a heat exchanger, principal flow schema is shown in the figure below:



Capacity is controlled via a temperature transmitter in the heat exchanger outlet pipe on the secondary side. If the temperature becomes higher than the set-point a signal will go to the control valve in the primary side return pipe, to open the valve and increase the District Cooling flow through the heat exchanger.

Dimensioning temperature for District Cooling supply into the ETS is 5.2°C, this includes set-point = 5°C for the Production plant outlet temperature plus a margin for temperature loss (gain) in the Distribution pipe system.

Heat exchanger

The main reason for installing a heat exchanger in the ETS is to separate the building's internal cooling system from the large Distribution pipe system with its high pressure.
Heat exchanger dimension temperatures are:

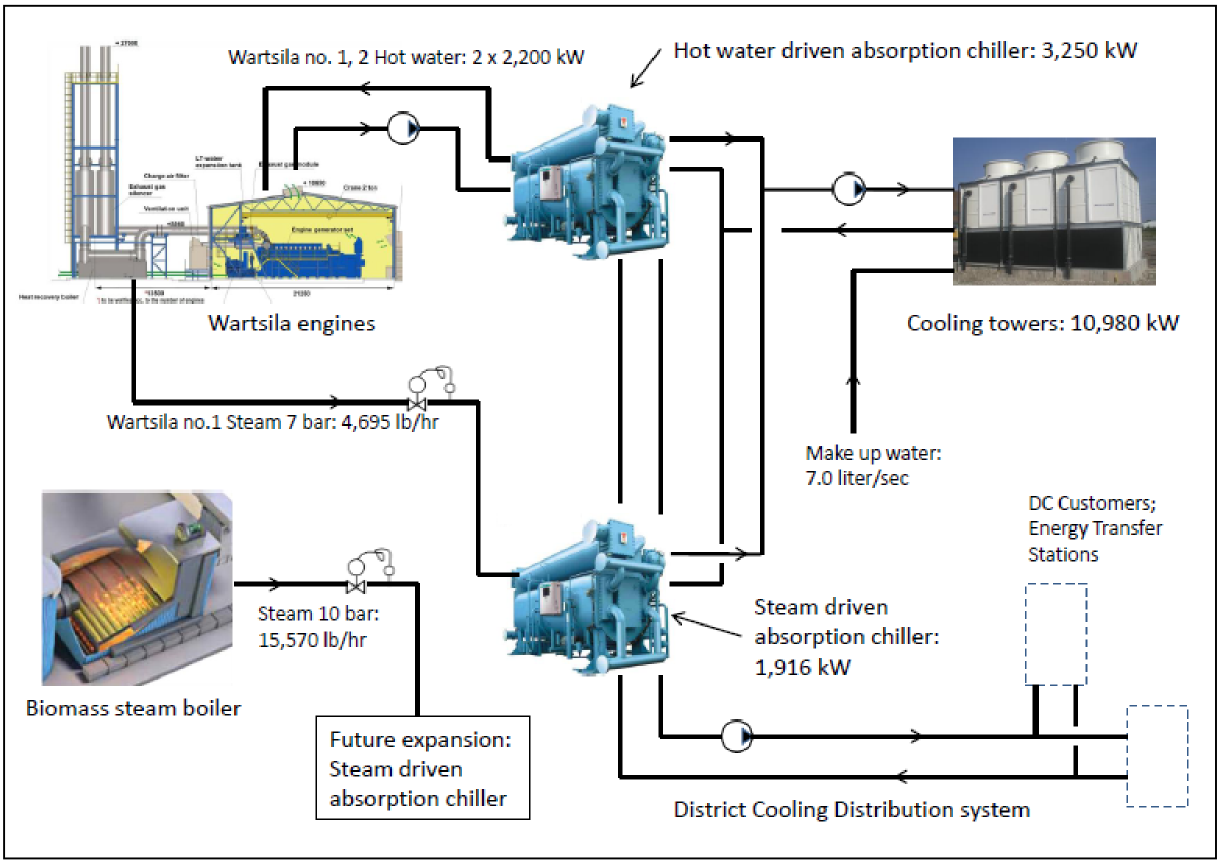
DC Primary side inlet/outlet temp.:	5.2/10.7°C (41.4/51.3°F)
Internal Secondary side inlet/outlet temp.:	12.2/6.7°C (54/44°F)

The DC system in total is not dimensioned for peak load situations but the individual buildings' heat exchangers should be dimensioned for peak load. Before future customers with not yet built buildings are connected it will be some spare capacity in the system, this also applies if different customers not reach their peak load during exactly the same time.

For existing buildings, it is recommended that existing chillers are connected in parallel with the DC heat exchanger on the secondary side, via a 3-way valve function. If the existing chillers are connected in serial after the heat exchanger, peak load situations could result in a "short cut" at the primary side. If the heat exchanger not is able of reaching the set-point temperature at the secondary side a function in the control system should ensure that the primary return temperature not gets too low.

3.5 District Cooling System layout

The system layout can be described as follows:



3.6 Production - investments

The investment for the production plant has been calculated as follows:

Phase 1, Cooling Production plant 5.1 MW	No.	Cost/unit, USD	Summary, USD
Steam fired absorption chiller, 546 TR / 1,916 kW	1	350 000	350 000
Hot water fired absorption chiller, 926 TR / 3,250 kW	1	700 000	700 000
Distribution pumps	2	38 000	76 000
Chillers' internal circuits pumps	4	6 000	24 000
Cooling towers pumps	2	26 000	52 000
Cooling towers	1	390 000	390 000
Ground well	1	50 000	50 000
Pipes, valves and pipe works	1	160 000	160 000
Electrical, I & C	1	60 000	60 000
Building	1	120 000	120 000
Auxiliaries	1	97 000	97 000

Engineering	7%	2 079 000	145 530
Project management	8%	2 079 000	166 320
Unforeseen	12%	2 390 850	288 902
Total, USD			**2 680 000**

Sourcing equipment for 5.1 MW	No.	Cost/unit, USD	Summary, USD
Wartsila exhaust steam boiler	1	*350 000*	*350 000*
Wartsila hot water recovery unit	2	*90 000*	*180 000*
Pipes, valves and pipe works	1	75 000	75 000
Unforeseen	12%	605 000	72 600
Total, USD			**678 000**

Phase 2, New buildings 2 MW	No.	Cost/unit, USD	Summary, USD
Steam fired absorption chiller, 570 TR / 2,000 kW	1	385 000	385 000
Cooling towers and pumps	-	-	260 000
Chillers' internal circuits pumps	2	6 000	12 000
Pipes, valves and pipe works	1	90 000	90 000
Electrical, I & C	1	40 000	40 000
Auxiliaries	1	60 000	60 000
Engineering	7%	847 000	59 290
Project Management	8%	847 000	67 760
Unforeseen	12%	974 050	116 886
Total, USD			**1 090 000**

4 Investments

Total investment for the district cooling system is summarized as follows:

Investments	Phase	Capacity, MW	Summary, USD
Production	1	5,1	2 680 000
Sourcing equipment	1	5,1	678 000
Production	2	2,0	1 090 000
SUM Production + sourcing	**1-2**	**7,1**	**4 448 000**
Distribution	1	7,1	3 326 000
Crossings	1-2	7,1	800 000
SUM Distribution + crossings	**1-2**	**7,1**	**4 126 000**
Energy Transfer Stations	1-2	7,1	343 000
Grand Total	**1-2**	**7,1**	**8 917 000**

5 Profitability analysis

5.1 Business model framework

For the profitability analysis the "Devcco Business Model" with OPEX/CAPEX/Income structure is used in order to establish a baseline and a profitability evaluation tool of the suggested District Cooling system. This model does not consider "how" the project is financed.

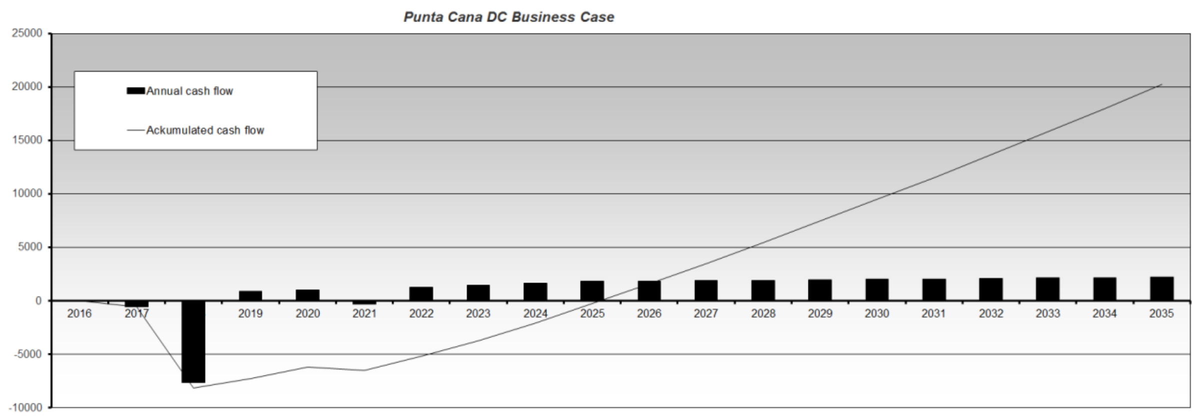
The following framework has been used for the profitability calculations:

Start year	Year	2016
End year	Year	2036
Year of discount (1 jan)	Year	2016
WACC	%	5%
Inflation rate	%	2%
Tax base	%	0%
Depreciation Production	Years	20
Depreciation Distribution	Years	20
Depreciation ETS	Years	20
Cost of Electricity	USD/MWh	150
Cost of Water (TSE/Potable)	USD/m3	0,11
Sewage cost	USD/m3	0,1
Cost of Chemicals	USD/m3	0,3

5.2 Business model summary and project profitability

The results from the business model is summarized in the following project pre-finance cashflow projection table and diagram:

PROJECT BUSINESS MODEL SUMMARY																	
Income		PV	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	....FWD	2028	2029	2030
Capacity/ Effect fee	kUSD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Fee	kUSD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy fee	kUSD	25 914	-	-	1 619	1 619	2 001	2 001	2 192	2 336	2 672	2 672	2 672	2 672	2 672	2 672	2 672
Rest Value from Assets	kUSD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Part Summary	kUSD	25 914	-	-	1 619	1 619	2 001	2 001	2 192	2 336	2 672	2 672	2 672	2 672	2 672	2 672	2 672
Costs		PV	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Project costs	kUSD	438	-	-	40	40	40	40	40	40	40	40	40	40	40	40	40
Administrative costs	kUSD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sales costs	kUSD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electricity costs	kUSD	7 638	-	-	477	477	590	590	646	689	787	787	787	787	787	787	787
Grid Fees	kUSD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Corporate fee	kUSD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fixed O&M	kUSD	1 644	-	-	150	150	150	150	150	150	150	150	150	150	150	150	150
Flexible O&M	kUSD	1 080	-	-	67	67	83	83	91	97	111	111	111	111	111	111	111
Water and Sewage	kUSD	744	-	-	46	46	57	57	63	67	77	77	77	77	77	77	77
Part Summary	kUSD	11 544	-	-	781	781	920	920	990	1 043	1 165	1 165	1 165	1 165	1 165	1 165	1 165
Investments		PV	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Production (Development 2017	kUSD	4 359	-	500	3 430	-	-	1 263	-	-	-	-	-	-	-	-	-
Distribution	kUSD	3 543	-	-	3 991	-	49	-	25	19	43	-	-	-	-	-	-
Sub stations (UC)	kUSD	275	-	-	208	-	49	-	25	19	43	-	-	-	-	-	-
Connection Fee	kUSD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Access Fee	kUSD		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Part Summary	kUSD	8 177	-	500	7 628	-	98	1 263	49	37	86	-	-	-	-	-	-
Project cash flow																	
Cash Flow		PV	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Income	kUSD	32 595	-	-	1 718	1 752	2 209	2 253	2 518	2 737	3 193	3 257	3 322	3 388	3 456	3 525	3 595
Costs	kUSD	(14 482)	-	-	(829)	(845)	(1 016)	(1 037)	(1 137)	(1 222)	(1 393)	(1 421)	(1 449)	(1 478)	(1 508)	(1 538)	(1 568)
EBITDA	kUSD	18 112	-	-	889	907	1 193	1 217	1 380	1 515	1 800	1 836	1 873	1 910	1 948	1 987	2 027
Depreciation	kUSD	(5 469)	-	(26)	(431)	(431)	(436)	(507)	(510)	(512)	(517)	(517)	(517)	(517)	(517)	(517)	(517)
EBIT	kUSD	12 643	-	(26)	458	476	756	709	870	1 003	1 283	1 319	1 355	1 393	1 431	1 470	1 510
Taxes	kUSD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NOPLAT	kUSD	12 643	-	(26)	458	476	756	709	870	1 003	1 283	1 319	1 355	1 393	1 431	1 470	1 510
Depreciation (+)	kUSD	5 469	-	26	431	431	436	507	510	512	517	517	517	517	517	517	517
Change in WC	kUSD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Investments (-)	kUSD	(8 746)	-	(520)	(8 095)	-	(108)	(1 422)	(56)	(43)	(103)	-	-	-	-	-	-
Free Cash Flow	kUSD	9 367	-	(520)	(7 206)	907	1 084	(205)	1 324	1 472	1 697	1 836	1 873	1 910	1 948	1 987	2 027
Acc Free Cash Flow	kUSD		-	(520)	(7 726)	(6 820)	(5 735)	(5 940)	(4 617)	(3 145)	(1 448)	388	2 261	4 171	6 119	8 107	10 134



The net present value (NPV) of the project is calculated to 9 367 000 USD with an expected Internal rate of return (IRR) of 16%.

6 Conclusions and considerations

The technical report shows there are promising opportunities to develop and implement a robust District Cooling system based on several waste heat sources.

The financial projections show an IRR of 16%. Most of the local / international / private or public utility companies utilize a district cooling business model based on long term payback, relatively high dept ratio and cash flow to cover debt by maturity. The return on business is normnally IRR tagrets of 10-12%.

There are a couple of relevant issues identified which we recommend to be investigated further in a coming phase of the project. These are:

- The technical reference solution for phase 1 is now based on hot water recovery from Wartsila engine no. 1 and no. 2 and steam from the exhaust boiler Wartsila engine no. 2. The two engines are primary build for electricity production reasons. By introducing District Cooling in Punta Cana the electrical demand will decrease due to less operation of on-site chillers. To be able to operate the Wartsila engines in line with the District Cooling plans, surplus electricity needs to be delivered to new building demands or to the grid operated by the local utility. The optimization of the solution should be investigated further.
- The existing biomass plant is now only seen as a potential heat source for the phase 2 of the District Cooling project due to the predicted cost of biomass fuel (USD 38 per TN). This in combination with the existing HFO price predicted at USD 45 per barrel makes the Wartsila engines favorable for phase 1. The optimization of a robust technical system in combination with various scenario analysis of fuel price projections should be further investigated.
- Installations of cooling towers at the PLS plant is proposed in the reference solution. The use of fresh water from ground wells instead of cooling towers is treated as an option. Considering the unknown facts about water quality and the possibilities to extract large volumes of ground water in a limited area, this is recommended to further investigations.
- The distribution design temperatures and the possibilities to increase actual operational differential temperatures should be further investigated.
- Redundancy of the proposed reference solution needs to be further developed. The system relies on the two Wartsila engines and/or the biomass boiler. If any planned or un-planned interruptions chilled water needs to be supplied from existing on-site chillers. Today this on-site equipment represents approx. 85% of the phase 1 and 2 capacity demand.
- When planning for the distribution pipes system there is an opportunity to find synergies with other planned installations and utilities such as water and electrical cables in the area. We recommend such synergies opportunities to be investigated further.

COMPREHENSIVE REPORT, NATIONAL TECHNICAL, FINANCIAL/ECONOMIC AND INSTITUTIONAL/REGULATORY FRAMEWORK STUDIES FOR THE DISTRICT COOLING IN EGYPT

FEASIBILITY STUDY FOR NOT-IN-KIND DISTRICT COOLING IN EGYPT

Final Report – Sept 2018

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EXECUTIVE SUMMARY

UNIDO and UNEP have been implementing a demonstration project to undertake a comprehensive feasibility study to assess potential for district cooling in the New Cairo Capital and New El Alamein city to provide technical and economical evidence to be disseminated to government officials as well as private investors. The proposed feasibility study supports the efforts of the Government of Egypt and complements its activities under the HPMP with the overall aim to include district cooling in the planning of the New Cairo Capital and New El Alamein city.

The study comprises three parts: a technical study, a financial study and a proposed institutional regulatory framework study.

The technical study looks at introducing new district cooling techniques for two new cities in Egypt. These new systems possess economic and environmental advantages compared to conventional district cooling systems and are therefore superior to traditional systems. In-Kind (IK) cooling technologies are those techniques utilising primarily electric energy to operate. Not-In-Kind (NIK) cooling techniques are these utilising primarily other forms of energy. NIK cooling technologies were adopted to provide district cooling systems that are energy efficient. Two cities, New El Alamein city and Capital One city were chosen for this study. The study examines the criterion for selecting these cities and compile technical information on NIK technologies. The technical study then prepares basic conceptual designs for district cooling plants for each city separately and calculate the capacity of equipment for this new design.

The technical study examines several NIK cooling technologies and select the most suitable ones for each city. For New El Alamein city, Deep Sea Cooling (DSC) system was chosen. This new technique uses the cold enthalpy of seawater at great depths to cool the chilled water of a district cooling system. The study examines in details the new well boring technique; Horizontal Directional Drilling (HDD) and obtains HDD technical and commercial offers from specialized companies for the location. This was used along with other information to calculate the capital and operating costs of the system.

For the new capital, Capital One, the technical study selects basic conceptual designs for district cooling plants system using NIK cooling assisted by IK cooling technology with NIK producing 60 % of the cooling load capacity. Absorption chillers fired by natural gas was the NIK cooling chosen technology. The technical study assumes all costs required to build and operate the system from first principles, experience and relevant references. The results are used along with other information to calculate the capital and operating costs of the system.

Capital and operating expenditure parameters are calculated for each city system. Those parameters are tabulated.

Distributed chillers system are designed, for each city, in which chillers are installed in buildings in a distributed chillers system approach as opposed to a district cooling approach. For each city, capital and operating parameters for the cooling system are calculated one time for a DC system and another for distributed chillers system. These the two sets of parameters are used in the financial study, for each city, to see which system is economically superior to the other.

The provisional results of the study show that operating expenses of both district cooling using NIK technology systems were economically superior to IK technology using distributed chillers cooling systems.

The financial part of this study uses the parameters obtained in the economic models for each city. This establishes final feasibility of the new techniques through established bankable financial methods.

The purpose of creating a regulatory framework for District Cooling for Egypt is to apply the newly written district cooling code of practice for Egypt on industry and consumers. A comparison of available international District Cooling regulations is made. Analyses of the gaps of the available regulation was also included. This was helpful in developing national institutional and regulatory framework for Egypt. This proposed regulatory framework identifies guidelines and minimum requirements of buildings connected to district cooling systems. This ensure designing and building installations are according to acceptable standards. The proposed regulatory framework also identifies guidelines and minimum requirements for other facilities provided by consumers in buildings. Proposed regulatory framework also provide recommendations on the design of consumer’s air conditioning installation, to ensure such systems are compatible with connected district cooling service. Local institutional and regulatory framework requirements have also been identified and taken into consideration.

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Part 1

The Technical Study

1. The Technical Study

1.1. Introduction

UNIDO and UNEP have been implementing a demonstration project to undertake a comprehensive feasibility study to assess potential for district cooling in the New Cairo Capital and provide technical and economical evidence to be disseminated to government officials as well as private investors. The proposed feasibility study supports the efforts of the Government of Egypt and complements its activities under the HPMP with the overall aim to include district cooling in the planning of the New Cairo Capital.

1.2. Selection Criteria for the Two Cities

A selection criterion was devised and tables were made to assist in selecting cities. The selection was based on a point system followed by tables for technical information survey and financial information survey. However, we could not apply this selection methodology to the project because of the limited city options available at the time of selection. Nevertheless, the criteria devised for this project's NIK technologies can be used for other projects, please see annex (1-1).

The selection process was laborious and time consuming because of the limited choices of suitable cities at the time of selection. Five different cities were studied before selections were made. It was important to obtain plans and schedule of construction for candidate cities to make sure the selection of the cities fulfilled two important conditions:

1- Cities must be vital to the country fast growing economy.
2- Construction plans must be well developed but not too far developed that district cooling cannot be integrated into it.

Of the five cities studied two fulfilled these conditions; new El Alamein and Capital One.

New El Alamein is built on a fast track schedule to be completed in 3 years. It is to replace Alexandria as the traditional second capital of Egypt; the summer seat of government. Its location on the Mediterranean opened up the possibility of using Deep Sea Cooling for its District Cooling system. This important Not-In-Kind (NIK) cooling technology is growing fast. It is not yet available in the Middle East. The city currently has no plans to incorporate district cooling system to its buildings. Introducing NIK cooling technology will help show the economic and ecological benefits of the technology.

The second city Capital One is the most important building project in Egypt today. This is because the government will move there. It is also a fast track project. The Government sector will be completed by 2022. The government district, housing the presidential palace, the cabinet of ministers, the parliament, all ministries and other buildings and services are designed with the concept of district cooling. Although the conceptual design developed provides broad outlines of the system, no design of plants room are made. Introducing the concept of NIK assisted by In-Kind cooling technology will help spread the use of this technology and show its merits.

1.3. Compilation of Technical Information.

The relevant technical solutions chosen for the demonstration of district cooling systems are examined such as fluorocarbon chillers (In- Kind cooling technology), non-fluorocarbon chillers (Not-In-Kind cooling technology), distribution piping network, load interface techniques and energy calculation methods.

The compilation of technical information on relevant technical solutions chosen for the demonstration of district cooling systems encompass the following subjects:

1.3.1. Systems utilizing In-Kind cooling technology or Fluorocarbon chillers.

The definition of Not-In-Kind DC cooling technology is technology that mostly than do not utilize electric power to produce cooling. The aim of this study is the dissemination of Not-In-Kind district cooling technologies, to help introducing these technologies in Egypt.

Fluorocarbon chillers are In-Kind cooling technology, since they are mechanical vapour compression machine operated by electric power. Fluorocarbon chillers have operating costs in Egypt, relatively higher than Not-In-Kind cooling technologies. Therefore, they are not used in this study as the main producers of cooling capacity, but to assist in the cooling process when needed.

Not-In-Kind technologies or non-fluorocarbon chillers are not be able to bring down the chilled water supply temperature to low design levels efficiently and economically. In this case, In-Kind technologies may be needed to assist the cooling process. When design supply chilled water temperatures are set at 3 to 4 °C, In-Kind technology can be included. For this reason, electric chillers are included in the design of DC plants in-series arrangement with non-fluorocarbon chillers such as absorption chillers.

Distribution piping network designed with large delta T requires low supply chilled water temperature. This is to help reduce the diameter of the chilled water piping, thus reducing cost. This is especially important in large and long networks. Those temperatures are not reachable with current commercially available second-generation absorption chillers, since they can provide chilled water temperatures down to 5 to 6 ^{0} C safely. Lower chilled water temperatures, 3 to 4 ^{0} C, are available with new generation absorption chillers expected commercially in the near future. Thus, fluorocarbon chillers are included in-series design arrangement to achieve those low temperatures.

This is also the case in applications when ice or ice-slurry are used for thermal energy storage system (TES), since negative chilled water supply design conditions are required to produce ice or ice- slurry and those temperatures are not achievable with current generations absorption chillers.

However, in all cases the major portion of cooling capacity will be borne by Not-In-Kind cooling technology resulting in low operating costs for the system, while fluorocarbon chillers, electrically operated, will provide a small fraction of the operating costs to achieve lower supply design chilled water temperatures, when needed.

1.3.2. Systems using Not-In-Kind cooling technologies or Non-fluorocarbon Chillers

The main NIK cooling technology systems are:

1.3.2.1. Natural gas fired double effect absorption chillers/heaters systems cooling

This system can be economically advantageous if the price of natural gas in a country is cheaper than that of electric power. The system is not dependent on electric supply irregularities at on-peak periods; hence, it helps shave and stabilizes electric power demand. Furthermore, when it is responsible for taking care of on-peak surges in a system, it limits use of electric power in those peak periods and reduces power demand surcharges. Figure 1.1 shows an 8,000 TR DC plant with gas fired absorption chillers. There are three generations of absorption chillers. The most common are the Double Effect second-generation units with a heat ratio (efficiency) of 1.2 to 1.45.

Figure 1.1: DC plant with 8000 TR gas fired absorption chiller/heaters.

1.3.2.2. Steam or hot water indirect fired absorption systems

Indirect fired absorption systems operate with steam or hot water from industrial processes or from reject heat. Some of the most important examples are Turbine Inlet Cooling System (TIC) used to increase the efficiency of gas turbine power plants. In summer, the turbine efficiency deteriorate due to high ambient temperatures. Cooling combustion air inlet to turbine from ambient conditions to ISO conditions (15 ^{0} C) increases turbine efficiency thus increasing output up to 20%.

Figure 1.2 shows a typical schematic diagram for a TIC system utilizing steam or hot water from the Heat Reject Steam Generators (HRSG) of the power station.

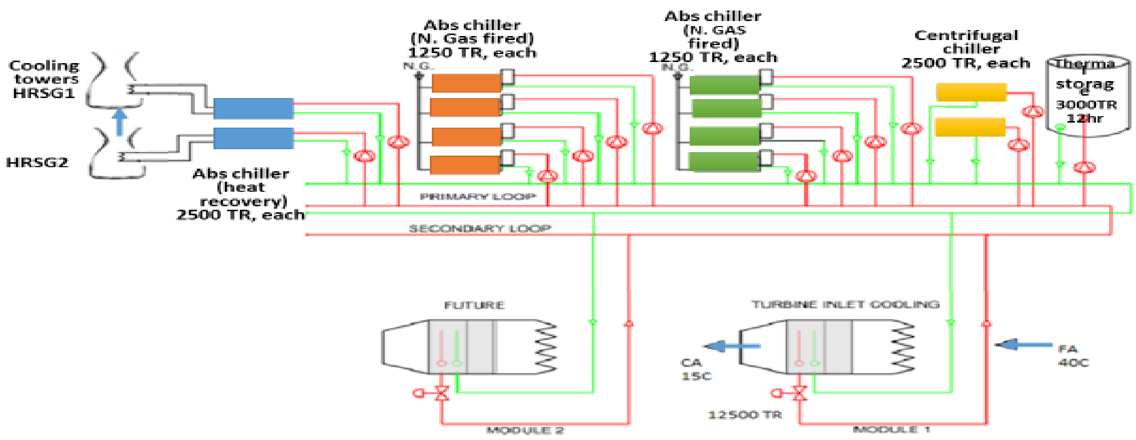

Figure 1.2: Turbine Inlet Cooling -TIC- in a power station using steam or hot water fired absorption chillers.

Figure 1.3 shows the TIC cooling coil installed at air inlet of the gas turbine. Other combination of natural gas fired absorption chillers, electric centrifugal chillers and Thermal Energy Storage (TES) tanks are used to optimize cooling techniques depending on availability of energy at demand.

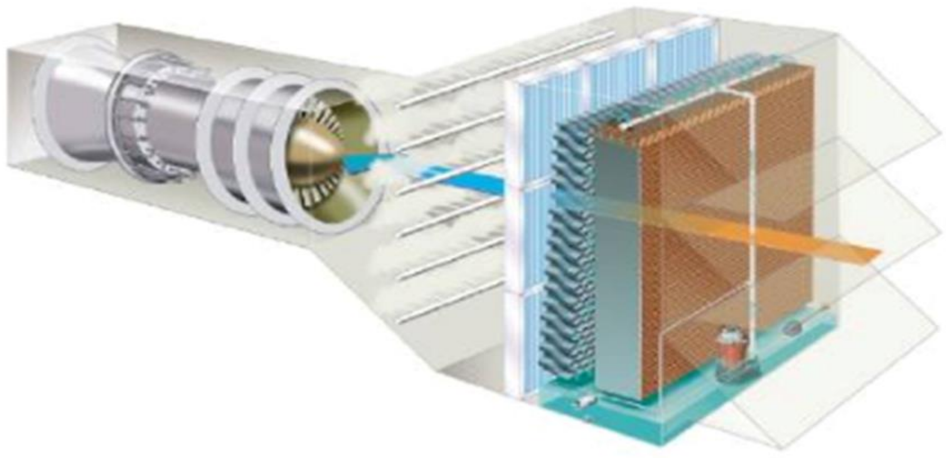

Figure 1.3: TIC cooling coil installed at the air inlet of the gas turbine.

1.3.2.3. Reject exhaust heat or flue gas stream fired absorption systems

Figure 1.4 shows a schematic diagram of exhaust and steam fired absorption chiller. When the exhaust stream is relatively clean, with small amount of Sulphur oxides (SOx) and Nitrogen oxides (NOx) in the stream, it is possible to use the stream to fire directly an exhaust fired absorption chiller. Sulphur oxides and Nitrogen oxides when combined with condensate create acids that attack the generator of the absorption chiller and reduces its lifetime considerably. Therefore direct-fired exhaust absorption chillers have to be used with great caution and only when the exhaust stream composition is relatively free of these oxides. When the stream is not clean, a heat recovery boiler is recommended, either a water tube exhaust type or fire tube exhaust type depending on ease of cleaning the tubes from the inside or the outside. The system economics are excellent because of the negligible cost of the exhaust stream.

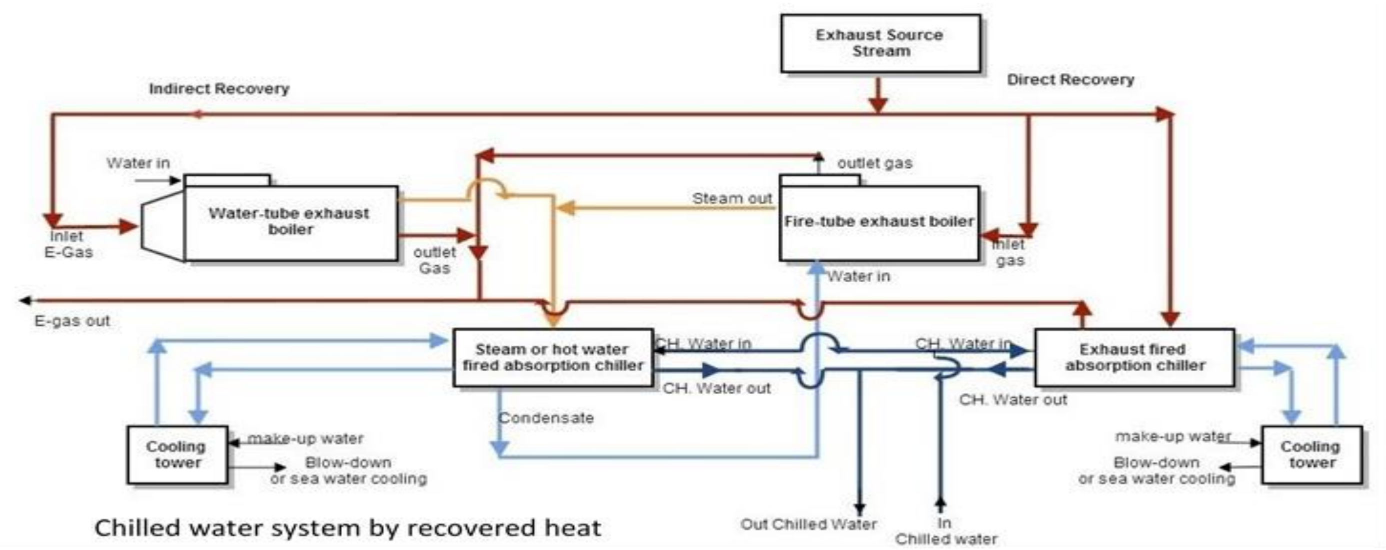

Figure 1.4: Schematic diagram of Exhaust and steam fired absorption chiller.

1.3.2.4. Systems operating by deep sea cooling or cooling/heating

Possibly the best operation economics of a NIK cooling system when exhaust heat or flue gas streams are not available. The system relies on using the low seawater temperature, at deep depths, to cool chilled water used for cooling. Seas and oceans at 1000 m depth have seawater temperatures around 4 ^{0}C [1]. Until recently, getting to those depths by conventional drilling techniques was difficult and extremely costly. The use of modern Horizontal Deep Drilling (HDD) techniques made this cooling technology accessible. In section 3.3, these techniques are shown in detail. This is the chosen cooling technique for the first city.

1.3.3. Distribution Piping Networks Pumping Arrangements

There are five chilled water distribution network-pumping arrangements. Those are

i. Constant Flow Arrangement, Variable flow systems
ii. Variable Speed Primary Pumping.
iii. Primary-Secondary Pumping Arrangement.
iv. Primary-Secondary-Tertiary Pumping Arrangement.
v. Primary-Secondary Distributed Pumping Arrangement.

Pumping arrangements differ depending of the district cooling application chosen. There could be more than one arrangement suitable for a single application, although this is rare, usually one arrangement will be most economical to build and operate for a certain DC system. Chilled water distribution networks may make or break a DC system because its cost can be 50% or more of the overall system cost. Although the distribution chilled water-piping network is the responsibility of the property developer and not the DC provider, nevertheless its cost will be eventually borne by the end user and its implication may make B.O.O. tariffs uneconomical. This is why the design of the chilled water-piping network including its pumping arrangement has to be chosen with great care lest it become too costly from capital cost viewpoint and the all-important operation cost.

The following text is a short description on the suitability of each pumping arrangement:

1.3.4. Load Interface Techniques and Energy Calculation Methods.

District cooling systems are connected to distribution networks through load interfaces. These in turn are connected to end users by one of the two methods: Direct connections and indirect connections.

Both types of connections are used successfully. The type of connection used depends on the nature and application of the district cooling system.

a) Direct connections:

The same chilled water produced circulates in the DC plant and the distribution network. Therefore, there is no interface between the chilled water of the plant and in-building distribution network, and hence no separation of chilled water between the production, distribution, and in-building HVAC system. Some insurance companies' demand that direct connection not be used in large DC systems because of the DC provider liabilities in case flooding occurs due to chilled water leaks, which may result in buildings being flooded.

b) Indirect connections:

In indirect connection, an interface is used, usually a plate heat exchanger. Plate heat exchangers are the preferred heat exchangers in DC systems because traditional shell and tube or shell and coil heat exchangers are bulkier when they are designed to operate at the small approach temperatures in use in DC systems. Those are normally 0.5 to 2°C. In addition, traditional heat exchangers are often more costly. Space is limited in DC buildings' mechanical rooms and is at a premium, especially in commercial and administrative applications. Rent is often considerable.

c) Metering and energy meters:

To measure the energy used by end users, energy meters are installed at the building's mechanical rooms. Energy meters utilize equipment for measuring flow, temperature differences between supply and return of chilled water, time duration between two readings and an energy calculator. There are two types of energy meters: dynamic and static.

d) Collection of DC meter readings:

Collecting energy meter data is done either at the meter or remotely. Local reading of meter uses a handheld terminal that connects to the meter. Remote energy meter reading is made wirelessly by a radio signal from a device in the meter, via the telephone network, or via an Internet connection. In energy meters fitted with radio frequency modules, RF concentrator connected to a central computer uploads the data, and bills can be produced for each end user. In meters connected via the Internet, meters are fitted with a TCP/IP module and can be read by a central computer. Often there is a need for sub-metering, when a building is rented to more than one end user. In this case, a secondary sub meter is needed or the use of water meters at end users to measure flow rates and allocate sub meter reading proportionally according to water flow meter readings. This method is more economical than using sub meters and is cost effective. Another method used by some DC providers is to calculate individual consumption by floor area of the space instead of sub-metering. This method does not provide incentives for end user to conserve energy.

1.3.5. Daily Cooling Load Profile, Diversity Factors and Thermal Energy Storage (TES)

a) Daily Cooling Load Profile:

Several important factors must be clearly defined when designing a district cooling system. Some of the most important factors are the daily cooling load demand curve and peak loads. A customer design engineer or consultant usually defines a building's cooling load. Those buildings could be administrative, shopping malls, hotels, schools, and other types of buildings. Cooling load estimates of those buildings will usually vary a great deal from building to building. An administrative building's cooling load estimate will probably include loads attributed to the prevalent weather, loads of occupants, electrical and electronic appliances, lighting and other loads. Those cooling load estimates will differ from those of a shopping mall, where the occupant's load will probably constitute the major part. The same applies to other buildings as well where the loads will vary a great deal. Shopping mall loads peak at a different time of the day compared to administrative loads or residential loads. Deciding how large also when those loads occur is of crucial importance in calculating the total design load of a district cooling plant. In estimating the cooling load of buildings for a certain district, it is possible to use computerized simulation programs and thus obtain an accurate understanding of peak loads' occurrence and their magnitude.

b) Diversity Factors:

Individual buildings peak at different times. This is why the coincident overall peak demand of a district cooling system depends on the sum of each individual building peak demand at certain time of the day.

Diversity factors are used to calculate the overall peak load of a district cooling system. Those diversity factors may be as low as 0.6 or 0.7 of the sum of individual building peak demands, in applications where there is a great diversity of use. There are different types of diversity factors. Diversity factors inside a building are dependent on the actual use pattern of a building. Diversity factors between one building and the other in a district depend on each building's function, orientation, use, and diversity factors between district cooling plants that may be serving a single district's distribution network. Chilled water-piping networks are also subject to diversity factors between distribution loops serving different buildings in parallel. All those diversity factors must be taken into account when calculating the overall peak demand of a district cooling system and when designing chilled water distribution networks.

c) Thermal Energy Storage (TES):

Thermal energy storage (TES) stores cooling enthalpy during off-peak times to use during on-peak times. A specially constructed insulated tank stores the cooling energy at off-peak times and uses it at on-peak times. This technique allows using fewer chillers at on-peak times than those necessary to cope with peaks in the daily cooling load demand curve.

I- New El Alamein City

1.4. Preparing Basic Conceptual Design of District Cooling plant for New El Alamein City

1.4.1. Introduction

Figure 1.5: Location of New El Alamein City

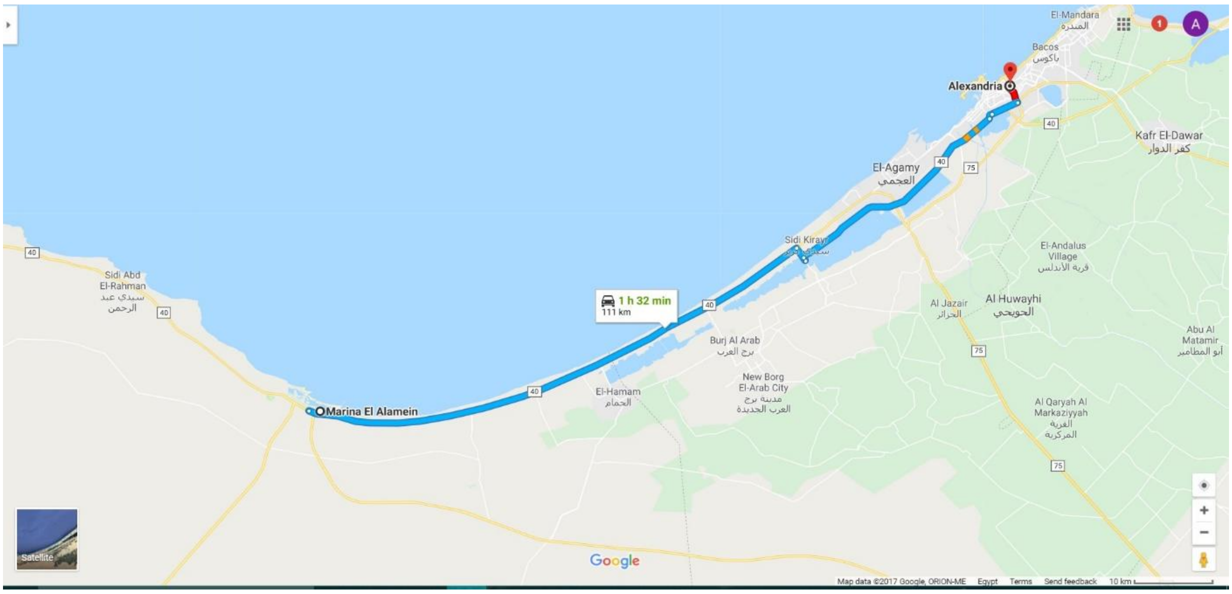

Figure 1.6: Distance between Alexandria and New El Alamein City.

The New El Alamein City is being built to be the modern “summer” capital for Egypt. Located about 110 Km west of Alexandria, next to the resort of Marina El Alamein, with easy access to the Cairo-Alamein highway, Figures 1.5, 1.6 and 1.7. It is about 250 Km away from Cairo. The area is famous because of the WW 2 pivotal battle of Alamein that took place in the vicinity.

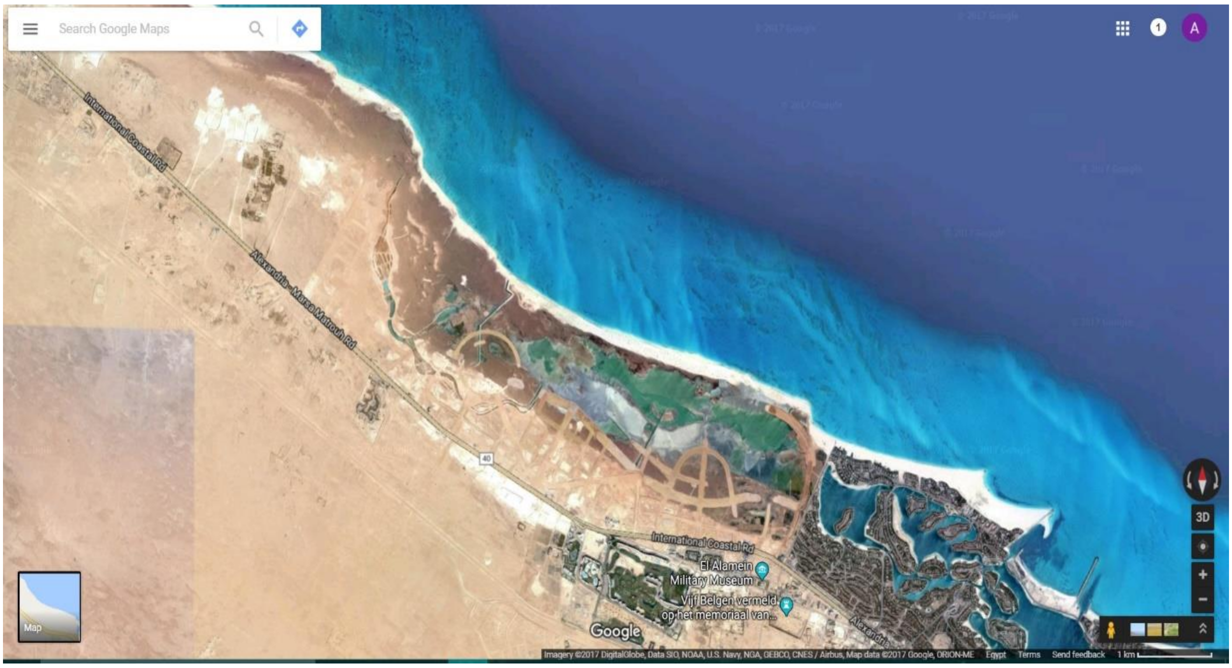

Figure 1.7: Layout of New El Alamein city.

The design drawings of the city are shown below in Figures 1.8, 1.9 and 1.10.

Figure 1.8: Overall perspective of New El Alamein City.

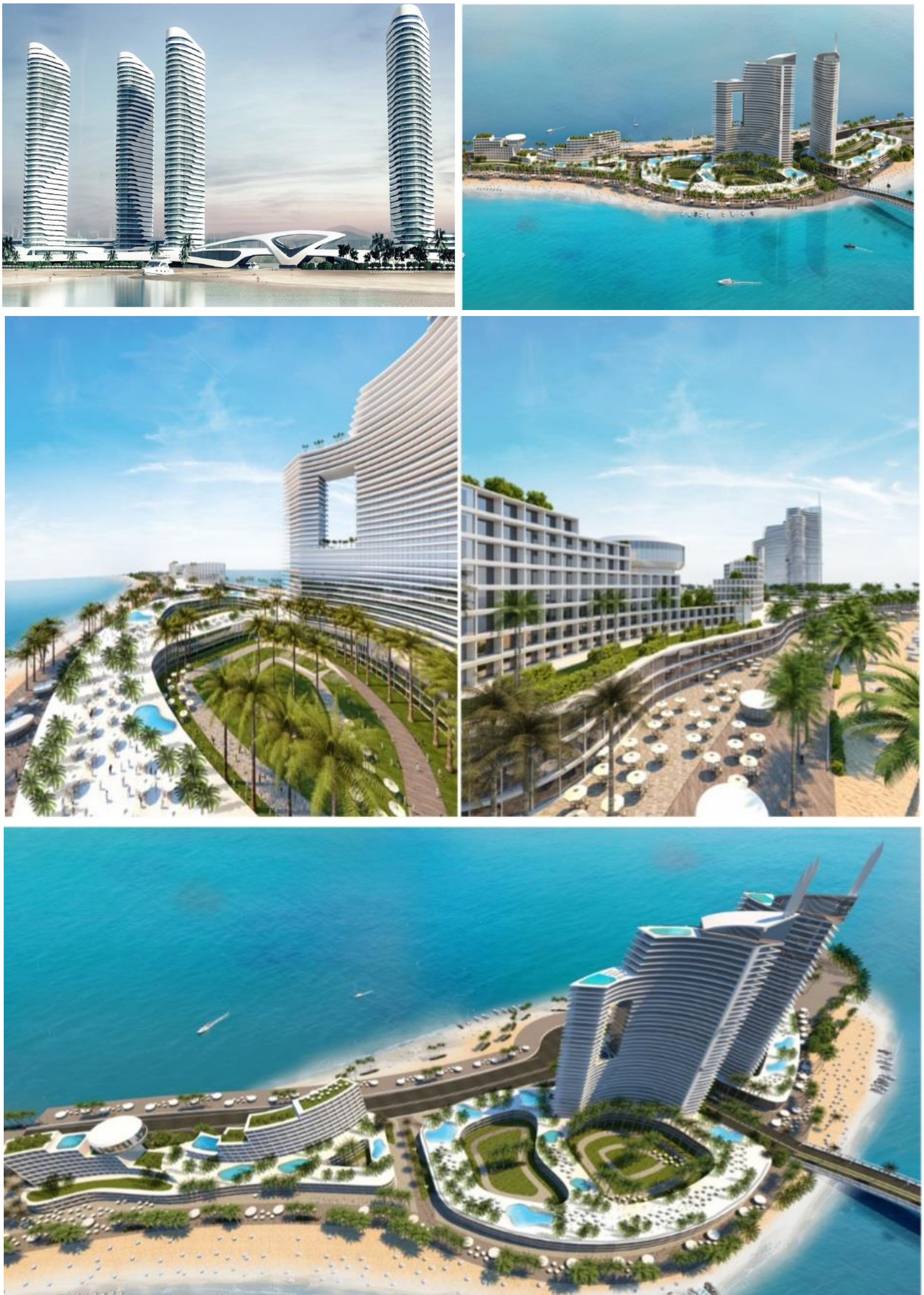

Figure 1.9: Perspective shots of New El Alamein City.

Figure 1.10: Perspective details of New El Alamein City Buildings.

1.4.2. Estimated Cooling Load of Buildings

Cluster buildings that constitute the first stage of the development are as follows:

LD-00, LD-01, LD-04, LD-05, LD-06, LD-07, LD-08, E-001 and E-002. Those clusters are shown in Table 1.1 as well as their air-conditioning estimated cooling load.

Table 1.1: Estimated Cooling Load of Buildings without Diversity-New El Alamein City.

Plot no.	Built area, m²	Usage	Floors no.	A.C area, m²	Total area, m²	Total no. of R. units and H rooms	Area, Hotel & Comm., m²	Hotel & Comm., TR	Residential, TR	Total TR.
LD-00	158,397	Basement* plus 3 towers, residential plus 1 tower hotel.	A2 tower=32 B2 tower=26 C3 tower=23 C4 tower=19	R=119,608 H=12,527 C=26,262	158,397	R units= 636 H rooms=226	38,789	1,600	4,925	6,525
LD-01	158,397	Basement* plus 3 towers, residential plus 1 tower hotel.	A2 tower=32 B2 tower=26 C3 tower=23 C4 tower=19	R=119,608 H=12,527 C=26,262	158,397	R units= 636 H rooms=226	38,789	1,600	4,925	6,525
LD-05	260,000	Basement* plus 1 tower, residential AND Hotel.	1 tower= 4+40	R=116,000 H=15,428 C=18,572	150,000	R units= 634 H rooms=143	34,000	1,400 (H)	4,770	6,170
LD-06	220,115	Basement* plus 1 tower, residential.	1 tower= 4+40	R=130,000 C=11,000	141,000	R units= 639	11,000	500 (C)	5,300	5,800
LD-07	122,780	Basement* plus 2 towers, residential.	2 towers = 3+35	R=130,000 C=11,000	92,390	R units= 492	4,825	200	3,000	3,200
LD-08	191,216	Basement* plus 3 towers, residential.	3 towers = 3+35	R=87,000 C= 4,825	138,223	R units= 751	4,825	200	4,600	4,800
E-001 & E-002	53,540	Commercial and parking lots.	Basement+ ground+ First.	C= 50,890	50,890	R units= 751	50,890	2,100	440	2,550
Total								**7,600**	**27,960**	**35,550**

Notes:

1. *Basement consist of commercial, services and parking lots.
2. R= Residential, H= Hotel, C= Commercial.
3. LD-04 estimated total load 2,700 TR. (not incl. in table.)
   Divided into 730 TR for H &C and 1,970 R.
4. Cooling load factor used 495 B.t.u. /hr. (46 B.t.u./hr.ft²)
5. No diversity factor used
6. & LD-03 not included. Capacity estimated in text.

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1.4.3. Deep Sea Cooling (DSC)

Deep Sea Cooling is a new technology that uses cold-water temperature of the seas, at great depths, to cool chilled water of a district cooling system. The main advantage of this technique is that may consume down to a tenth energy consumption compared to In-Kind technologies.

In preparing the conceptual design of the district cooling project at New El Alamein City, the principle of energy conservation governed the choice of design philosophy. The design uses two types of NIK cooling technologies. Deep Sea Cooling (DSC) technique and natural gas fired absorption chiller/heater. If the system is adopted, it will be the first DSC project in the Region.

This technique is well developed in Scandinavian countries and in island states such as Hawaii and others. Stockholm City (2) has used its unique location on the shore of the Baltic Sea and at the mouth of Lake Malaren (the largest lake in Sweden) to build a deep source cooling system for its downtown buildings. Another large project is planned for Dubai in the United Arab Emirates. Toronto City, Canada has the largest deep-source cooling project yet it is not the first city to plumb the depths of North America's glacial lakes.

Four years ago, Cornell University inaugurated a US $ 57 million lake-source cooling plant. The system cools university buildings and a nearby high school in Ithaca, New York.

The plant draws 3.9 ^{0} C (39 F) water from 70 meters (250 feet) below the surface of Cayuga Lake, a glacially carved lake that is 132.6 meters (435 feet) deep at its lowest point The Natural Energy Laboratory of Hawaii Authority (NELHA), a state research facility located on the Big Island of Hawaii, runs its own deep-source cooling plant. The system cools buildings on the agency's campus, which overlooks the Pacific

Ocean. The plant draws 6 ^{0} C (42.8 F) seawater from depth of 610 meters (2,000 feet). "NELHA saves about US $3,000 a month in electrical costs by using the cold seawater air-conditioning process," said Jan War, an operations manager. Makai Ocean Engineering, a private company based in Honolulu, is also developing plans to cool all of the city's downtown using a similar system.

Figure 1.11 shows how seawater temperature decreases as depths increases. The graph shows the general trend of the downward decrease of seawater temperature as depth increase. This trend differs from summer to winter and with the location of the point where it is measured.

Oceanographers divide the ocean into categories by depth. The broadest category is the upper part of the ocean known as the ―photical zone. This is generally regarded as the upper 200 meters of the ocean where sun light penetrates and photosynthesis takes place. The bottom part of the ocean is called the ―aphotical zone where sunlight does not add heat and cold temperatures are present. Bathymetry and oceanography studies suggest that at an ocean depth of at least 1000 meters, 4°C water temperature is assured. It should be noted that 4^0 C temperature might also be available at depths of 500 to 900 meters. Diligent temperature studies need to be conducted as part of study preceding a proposed project(1).

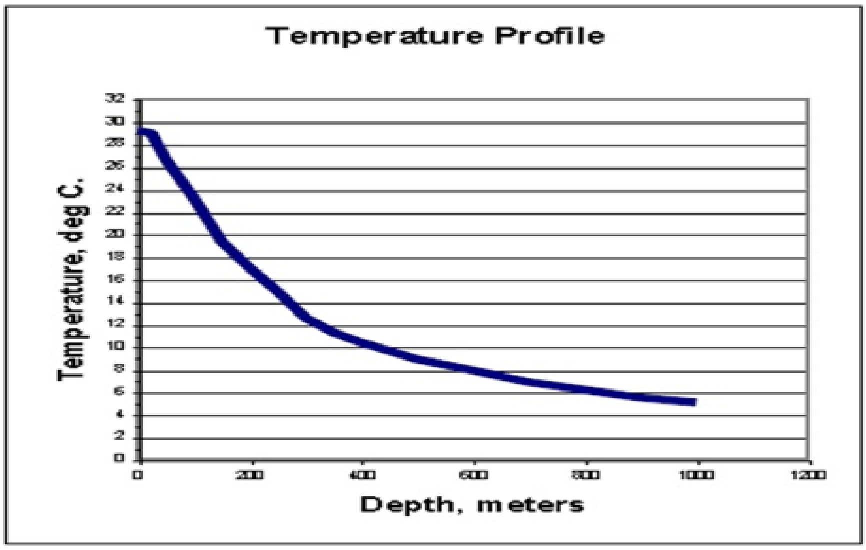


Figure 1.11: Seawater temperature drop versus depths of the

For a specific location, measurements that are more accurate are available at the US National Oceanic and Atmospheric Administration (NOAA). At NOAA, the National Centres for Environmental Information (NCEI) hosts and provides access to one of the most significant archives, with comprehensive oceanic, atmospheric, and geophysical data. NCEI is the US leading authority for environmental information [(3)]. Once the Egyptian government approves the location of the plant, temperatures of the seawater at the location can be assessed.

1.4.3.1. Deep Sea Cooling and Horizontal Directional Drilling (HDD) Techniques

There are a number of problems associated with laying a pipe to access cold water from shore to the required depth. The tide action might dislodge anchoring blocks of the piping, especially with high seas. Coral Reefs and seabed marine life may also be affected. Because of that, environmental permits may be difficult to obtain. Returning seawater to the sea should be made so that it is returned to the depth strata where the seawater temperature is the same as that of the returning water. This assures conservation of the sea microorganisms without disruption.

Horizontal Directional Drilling (HDD) is a mature technology used in the Oil and Gas field. This technique enables directional drilling under the surface to access deep cold water with a horizontal displacement of up to eleven kilometres from shore. A rig could also drill a diagonal tunnel of suitable diameter to bring cold seawater to the surface. Using heat exchangers between the cold seawater and a chilled water system, temperatures of 5.5°C to 6.5°C could be achieved at the fresh chilled water network. Similarly, the rig would also drill suitable tunnel to return heated water to a suitable depth. This is the drilling technique suggested for the study. Figure 1.12 shows the position of the supply and return tunnels and piping and the DC station.

1.4.3.2. The DC Plant, Chilled Water Piping Network and Building plots position

The drawings below show the location of the DC plant Figure 1.13 and 1.14, the chilled water-piping network envisaged and the building plots. In section 1.4.7, more design details are given regarding the chilled water-piping network.

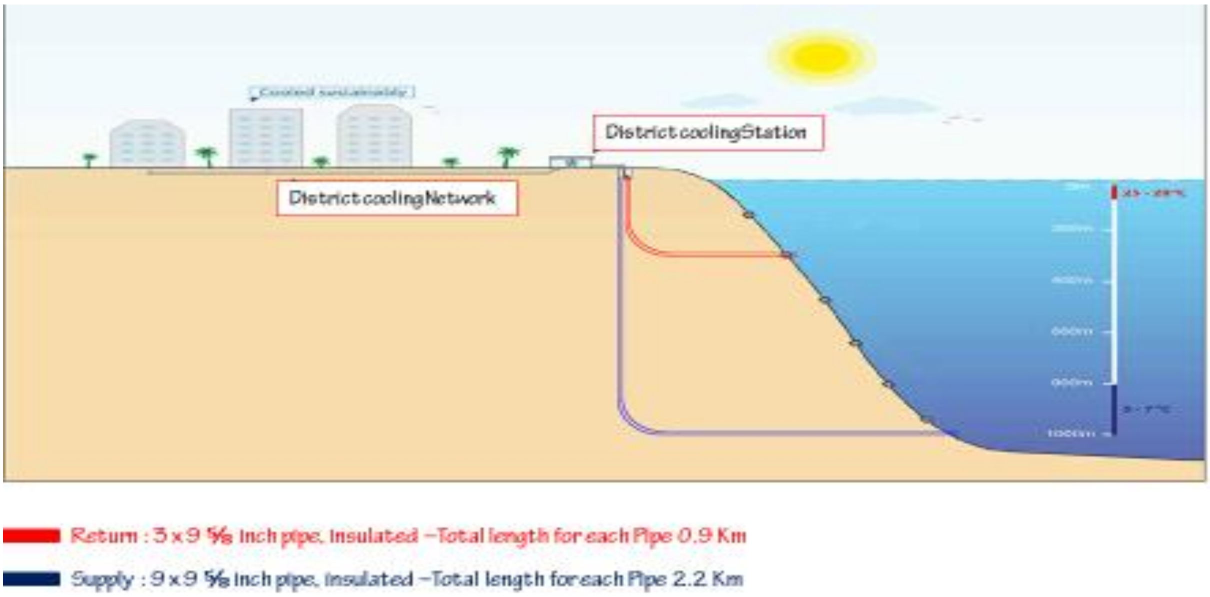


Figure 1.12: District Cooling by Deep Sea Cooling for New El Alamein City.

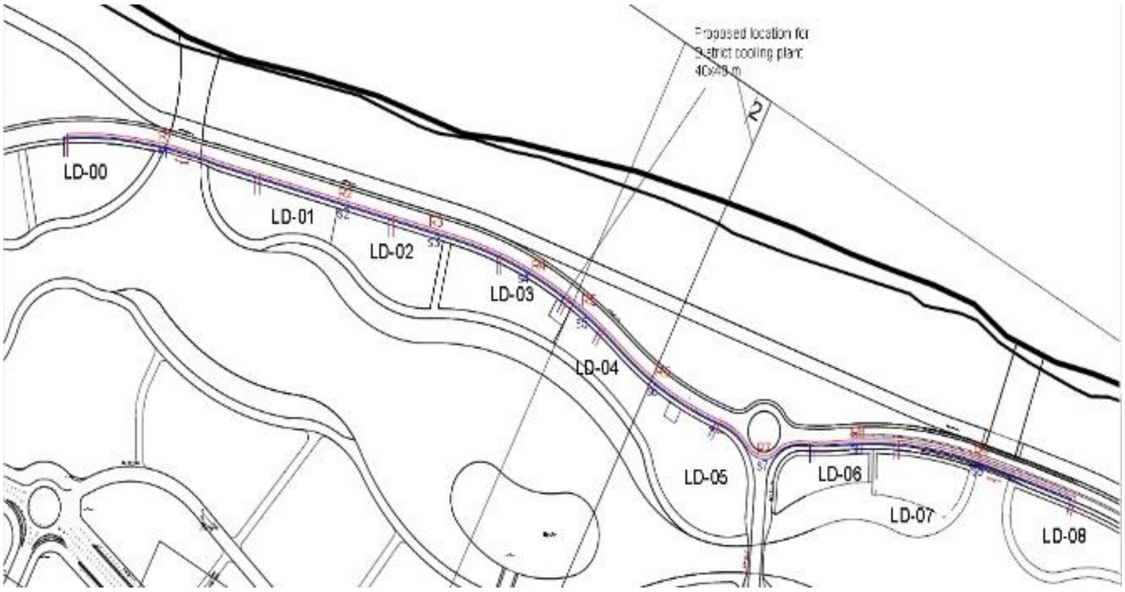


Figure 1.13: Proposed location of district cooling plant for New El Alamein

Figure 1.14: Building cluster locations for the district cooling plant of New El Alamein City.

1.4.4. Daily Cooling Load Demand Profile and Thermal Energy Storage (TES).

According to table 1.1, the estimated cooling load of building, without diversity, is 7,600 TR for Hotel and commercial application. Only hotels and commercial applications were considered here because of the low usability of residences in New Cities.

When LD-04, hotel and commercial is added, the total undiversified load is 8,330 TR. Adding an estimated load for LD-02 and LD-03, which was not designed yet at the time this report was written, an estimated undiversified cooling load of **11,500 TR** is assumed. Considering the diversity in each building (0.7) and the diversity between buildings (0.8), total diversified cooling load estimate is derived 11,500 x.7x.8= **6,440 TR**.

Figure 1.15 shows typical Daily Cooling Load Demand Profiles for several applications. The three bottom applications are hotel/service apartments, shopping and leisure.

The figure shows typical daily cooling demand profiles for typical buildings in a high ambient temperature country. Peaks differ according to the application. Recreational applications tend to have peaks late in the evening, whereas occupation related applications peak in the afternoon. The weekend operational hours are usually much reduced and different from those during the weekend. An aggregate daily cooling load demand curve can thus be made Figure 1.16, which shows the overall daily system load demand curve.

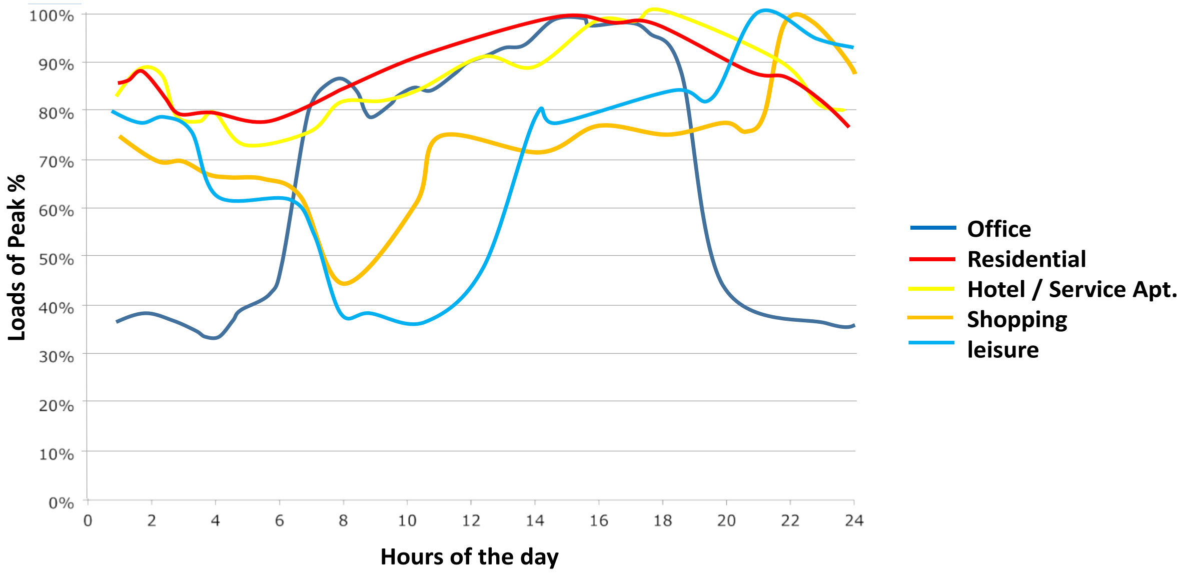


Figure 1.15: Typical daily cooling loads demand profiles for several applications, superimposed.

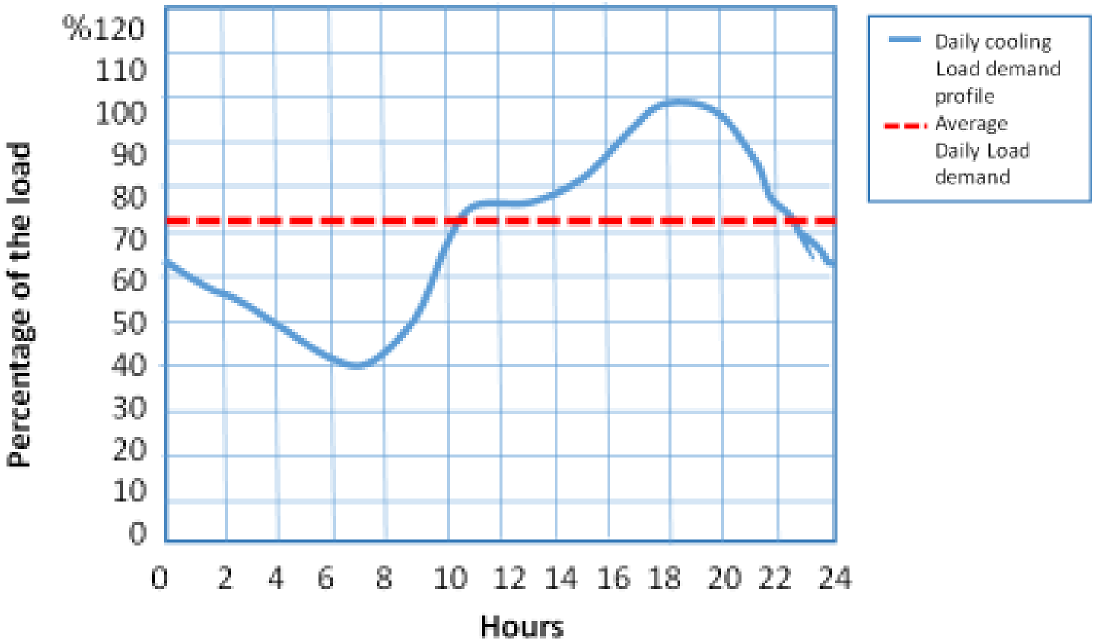


Figure 1.16: Typical aggregated daily cooling load demand profile showing average daily load

Figures 1.17 shows that an average load of about 74% can be considered. Accordingly, the average cooling load would 4,800 TR (6,440 x 0.74 = 4,766 TR). The upper part of the curve would be the Thermal Energy Storage capacity of 1,700 TR for 12 hrs, total 20,400 TR.hrs.

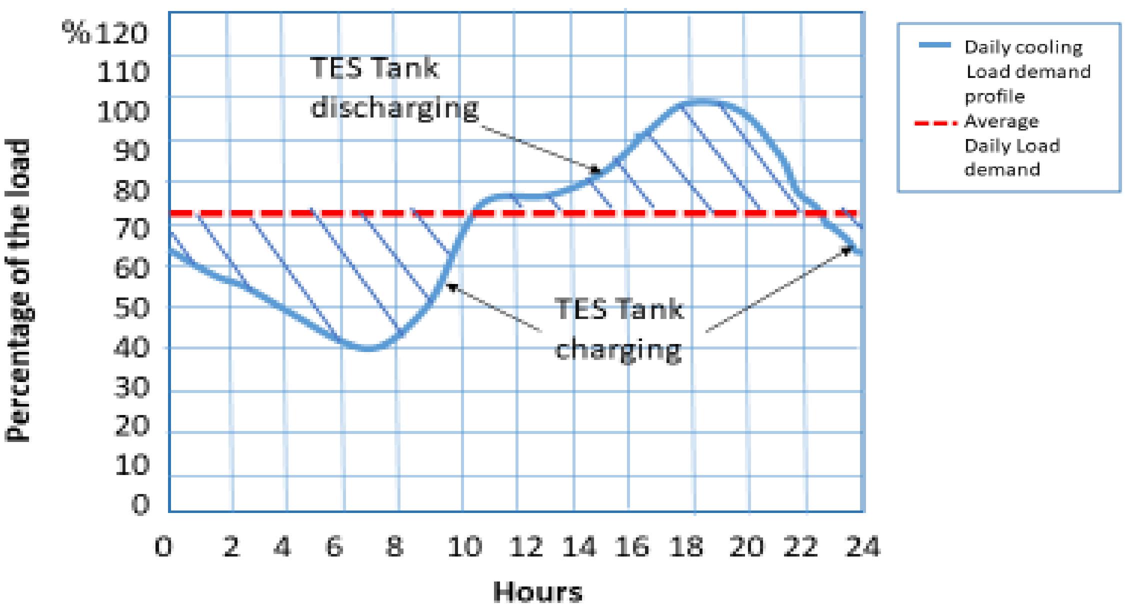


Figure 1.17: Typical daily cooling load demand profile showing average daily load & charging/ discharging loads.

The design is based on the following assumptions:

- Total tonnage, undiversified = 11,500 TR.
- Total tonnage, diversified= 6,440 TR. (D.F.= 0.7 x 0.8 = 0.56)
- Average load= 4,800 TR.
- DSC system producing a total capacity of 4,800 TR
- TES tank with a capacity of 20,400 TR.hr. (@1,700 TR x 12 hrs.).
- Two abs. chiller/heater, N. gas fired, each 800 TR (total 1600 TR) - redundancy and heating.

1.4.5. Design Philosophy of Chilled Water Production

The principle of energy conservation governed the choice of design philosophy for New El Alamein City. This is the reason DSC was adopted as the main cooling system, since it consumes down to a tenth energy compared to mechanical vapour compression [(1)]. However, the principle of redundancy was also observed to reduce breakdown risks.

It should be noted that Thermal Energy Storage (TES) was also adopted, to reduce the size of the DC plant and to provide short time redundancy when needed. This is expounded upon in section 3.7. In this way, the lowest possible operating costs were achieved, as explained in section 4.0.

A NIK absorption chiller system was also incorporated to operate if there were partial breakdown in DSC system or during programmed maintenance. The absorption system will operate also when the TES tank breaks down or during programmed maintenance.

Supply chilled water design temperature were assumed to be 6°C and return chilled water temperatures of 12°C. DSC will always produce the main cooling capacity production.

1.4.6. Basic Design of Deep Sea Cooling plant

A specialised HDD oil and gas service company was introduced to the system envisaged. The HDD company studied the system and came back with a design for the well. The design of the supply well is shown in figures 1.18, 1.19 and 1.20. The figures show the supply horizontal well design in plan, cross section elevation and 3D view respectively. The HDD company produced a Geographic Standard Planning Report of the system. The HDD co made a detailed commercial and technical offer for supply and install of the horizontal wells.

The DSC system will consist of 9 supply pipes for the supply of seawater at 4 ^{0} C. Each pipe is 9 5/8 inch in diameter. Each pipe will be located in a service shaft bored by HDD techniques. The return seawater, at 11.7 ^{0} C, is through 3 return pipes, each 9 5/8 inch diameter.

The total length of each supply pipe is 2200 m while each return pipe is 900 m. Each supply pipe has 1000 of vertical length and 1200 m horizontal length. The length of return pipe is 400 and 500 m vertical and horizontal lengths respectively.

The data was used to design seawater/ chilled water heat exchangers. The cold side would be for seawater while the hot side is chilled water.

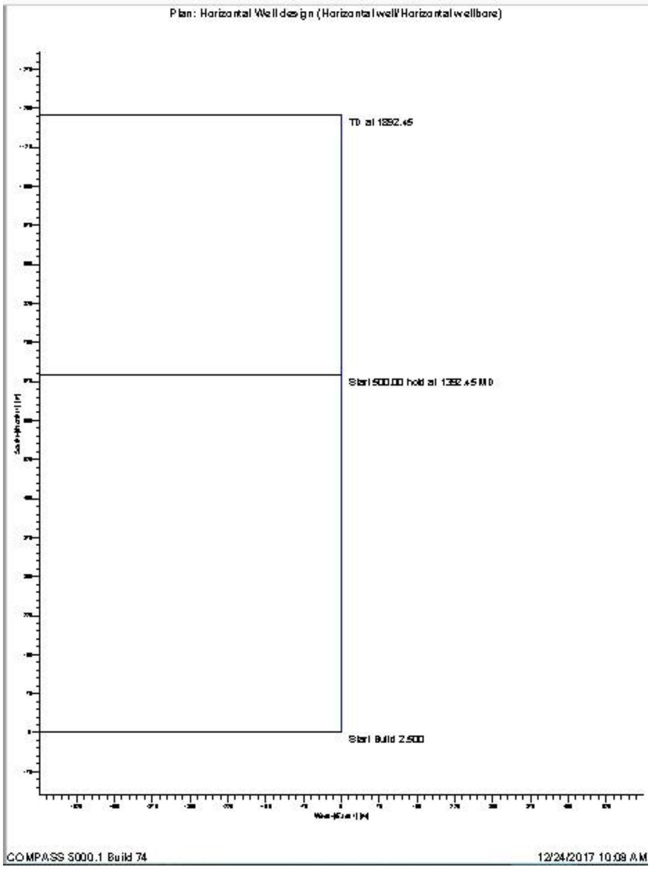


Figure 1.18: HDD horizontal Well Design, plan view.

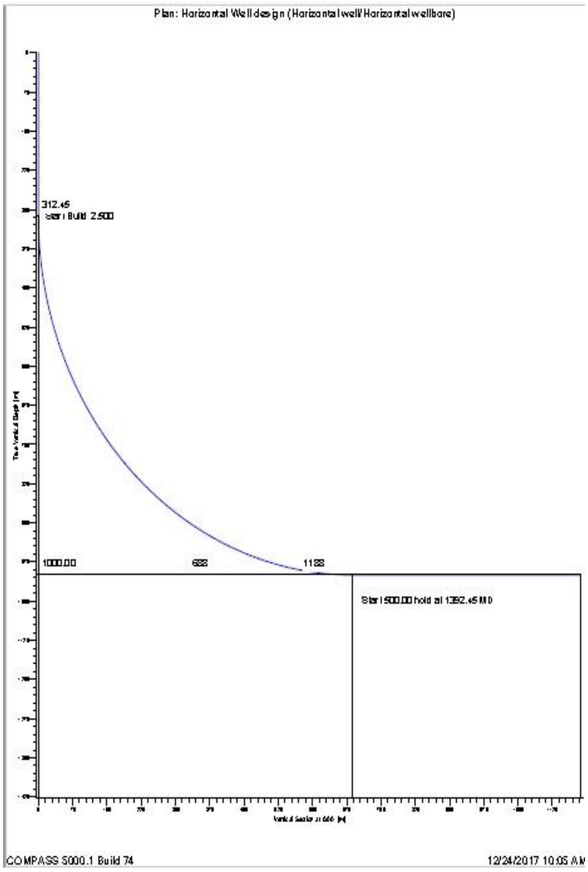


Figure 1.19: HDD horizontal Well Design, cross section

The sizing of the seawater/ chilled water heat exchangers, the seawater pumps and chilled water circuits temperature was calculated. This is indicated in the HDD co. geographic report. The figures 1.18, 1.19 and 1.20 are from the HDD co. geographic report. In this design:

- Four Titanium plate heat exchangers, sweater/ chilled water were used to chill the closed circuit network. Three heat exchanger are on duty while the fourth is for standby.
- Each heat exchanger has a duty of: 1600 TR (5626 kW)
- Seawater temperature, in/out ^{0} C: 4 / 11.7
- Chilled water temperature, in/out ^{0} C: 6 / 12
- Water flow rate, each HX, cold side/hot side, m3/hr: 641.12 / 804.35

The data selection sheet of the heat exchanger is shown in annex (1-3). The data of the heat exchanger selection was used to design the basic schematic diagram for deep sea cooling and chilled water system. This is shown in figure 1.21. The diagram shows also the TES system. The TES is piped directly into an open bridge between the DSC system chilled water return header and the primary chilled water supply header.

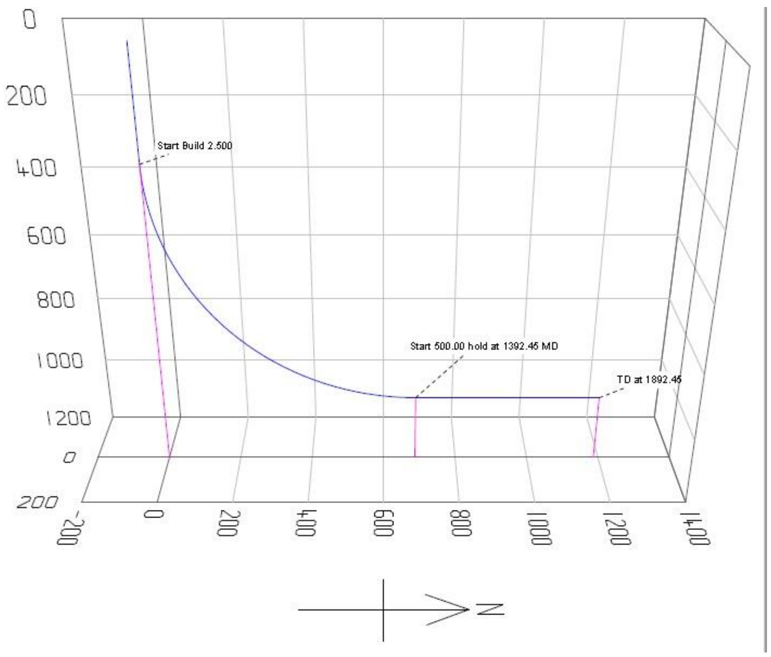


Figure 1.20: HDD horizontal Well Design, New El Alamein, 3D view.

The upper region – warm- return water of the stratified TES tank is connected to the primary chilled water return header as shown in figure 1.22.

The lower region – cool- supply water of the stratified TES tank is connected to the primary chilled water supply header downstream of the primary cooling system, the DSC, upstream of the chilled water secondary pumps.

The TES system works as follows:

- At off-peak periods: the plant primary chilled water flow is higher than the secondary flow:

TES tank automatically recharge, rate of charging = difference between primary and secondary flow.

- At on-peak periods: the plant primary chilled water flow is lower than the secondary flow:

TES tank automatically discharge, rate of discharging = difference between secondary and primary flow.

Figure 1.21 depict the basic schematic diagram for the system, showing the DSC heat exchangers, the TES tank and a seawater tank. The seawater tank is added to mix return seawater with fresh surface seawater to help maintain a constant 11.7 ^{0} C hence return water at specific depth where seawater temperature is the same and preserve the ecology of the sea. The seawater pump calculation was made. This is as follows:

- Flow capacity, each (3+one standby): 2,730 gpm (0.18 m^3/sec).
- Pressure head, m water: 100 m
- Type: split case vertical.
- Material: Titanium.

The pumps are located down a service pit 25 m deeper than the sea level, to overcome cavitation. Annex 6 shows the selection data of the pumps.

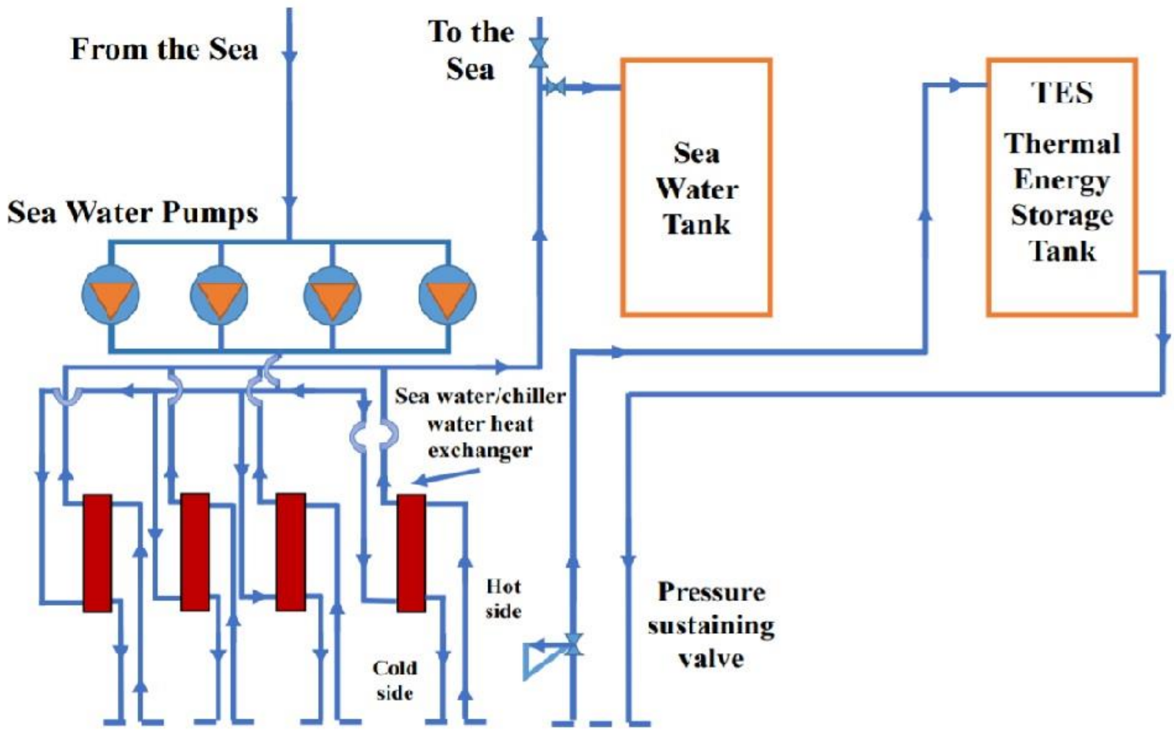


Figure 1.21: Basic schematic Diagram Deep Sea Cooling, Chilled water and TES system

1.4.7. Basic Plant Room Design Arrangement

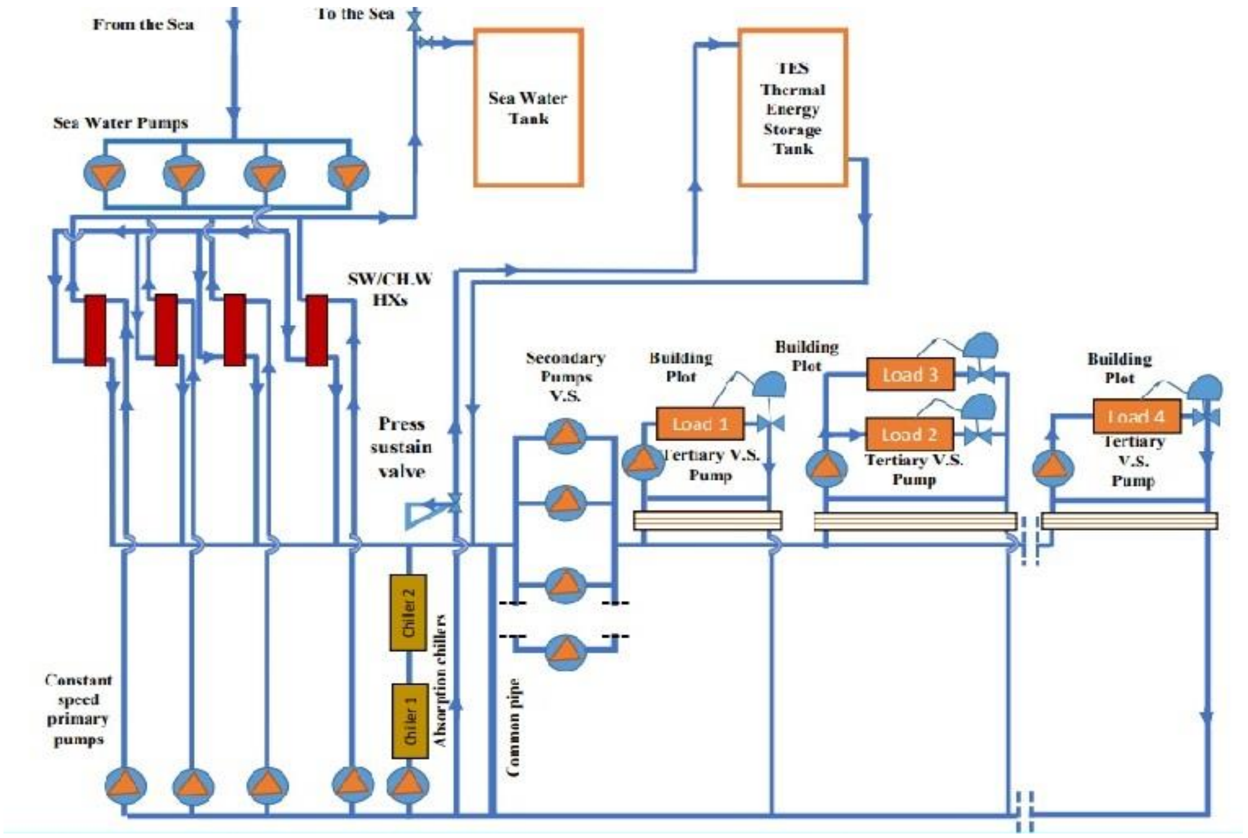


Figure 1.22: Basic chilled water schematic diagram of DSC and chiller system

Figure 1.22 shows the chilled water schematic diagram of the whole system. The DSC system produces the average load of the system. Each seawater/fresh water heat exchanger (HXs) have a capacity of 1,600 TR (5626 kW). Three HXs produce an average load at 4,800 TR (16,900 kW), while the fourth HX is on standby. The four HXs are connected in parallel to the primary chilled water circuit. TES connect in parallel with the circuit. The operation of the TES is described in section 3.6.

The absorption chillers are connected also in parallel, with an in-series arrangement. Each chiller is 800 TR (2,800 kW) so that the total capacity of the branch is also 1,600TR (5,626 kW). In each branch of the primary chilled water circuit 1,600 TR capacity is installed. This help reduce components selection, spares and balancing the system. All primary chilled water pumps are constant speed.

Variable speed secondary pumps serve the secondary chilled water circuit. Three pumps are carrying the load while a fourth pump is on standby.

1.5. Proposing Capital and Operating Expenditure Parameters for Economic Model

1.5.1. Economic Model Comparison, Capital and Operating Expenditures.

The owner of a development, a property developer or a specialized company, constructs the DC system. The DC system builder usually chose a Build, Own and Operate (BOO) scheme. The DC provider will invest in building and operating the system, in return collect tariff(s) from the users.

The DC provider has to provide economically advantageous tariff(s) to the user compared to expenses incurred had buildings owners/users installed their own chiller system. He also has to make a profit on his investment.

The system therefore has to be economically advantageous to two sides; the user/owner compared to installing his own individual chiller system in each building and the provider by providing him with an attractive Internal Rate of Return (IRR) on his investment.

To perform this comparison, parameters have to be calculated. Financial parameters such as current rates of borrowing, risk levels, discount rates, inflation rates and others establish the comparison financially. Other parameters are engineering derived parameters that help achieve a financial comparison. These are capital and operating expenses, EFLH and other factors. These are calculated by this technical part of the study.

The system therefore has to be economically advantageous to two sides; the user compared to installing its own individual chiller system in each building and the provider by having an attractive Internal Rate of Return (IRR) on his investment.

To do this comparison, parameters have to be calculated. Some of these parameters are financially established according to current rates of borrowing, risk, discount, inflation and others. Other parameters are engineering derived parameters, such as capital and operating expenses, EFLH and others.

Those engineering derived parameters were calculated and slotted in Table 1.2 and used in the financial part to calculate the financial feasibility of the system.

Two points of view govern the economic viability of the system over its lifetime of 20 to 22 years:

First: from the point of view of the user.

The DC system chosen compared with a system using distributed individual chiller plants for each building must have Net Present Value- over its lifetime- less than that of distributed individual building chillers. This means that the DC system is cheaper to the user than distributed chiller system, therefore economically superior and viable.

Second: from the point of view of the DC provider.

The IRR of the system must be high enough to provide a profit to the DC provider. If the IRR is within the expectations of the DC provider, then the system is economically acceptable to the DC provider and viable.

The economic model as well as other economic parameters provide these data and therefore can govern the choice of the system. Part II of the study contains the economic model.

1.5.2. Cost Parameters for use with the Economic Model.

Table 1.2: Cost Parameters for the DC system- New El Alamein City.

S.N	Item	Qt. or US $	US $	Remarks
I	DC using Not-In-Kind Technology.			
	Deep Sea Cooling System and Absorption chillers/heaters.			
1	Capital Expenditure:			
	HDD piping- supply.			
	HDD piping Return.			
	Heat exchangers (HXs), seawater/chilled water.			
	Pumps, seawater.			
	HXs primary chilled water pumps.			
	Thermal Energy Storage (TES) tank.			
	Abs. chillers/heater, gas fired redundancy.			
	Secondary chilled water pumps.			
	Building and sweater pumps pit.			
	Other and contingency			
	Total capital cost			
2	Operating Expenditure:			
a	Equivalent Full Load Hours (EFLH). Commercial areas may need cooling all around the year. Hotels will need cooling and heating across the year and may need cooling for public areas across the year.			
b	Breakdown no. of labour:			
c	Salaries structure / month: Station chief.			1 station chief. Each crew:

S.N	Item	Qt. or US $	US $	Remarks
	Each shift: - HVAC senior graduate engineer. - Skilled technician. - Technician			1 senior graduate engineer. 1 skilled technician. 1 technician.
d	Monthly salaries: 1 Station Chief 3 Senior graduate engineer 3 Skilled technicians 3 technicians Total salaries, monthly. Yearly salaries			For three crews (24 hrs operation).
e	Electric consumption per year			
	Seawater pumps :			
	{no.pumps x (hrs/day) x EFLH x kW/p x ($ / kW)}			
	Secondary chilled water pumps (Used for both Not-In-Kind and In-Kind Technologies.)			
	{No.pumps x (kW/pump) x EFLH x ($/ kW)}			
	Primary chilled water pumps consumption (No. of p. x kW per p x EFLH x $/kW.hr.)			
	Total Yearly electric consumption			
f	Natural Gas Consumption			
	{No. chillers x 800 TR x (m^3/hr/TR) x ((EFLH x 1/4) x ($/$m^3$)}.			
	Total N.gas consumption (4 months) /year.			
g	Yearly spare parts & maintenance- % of capital cost of system.			
	Total yearly operating expenses			
II	Distributed individual building chillers, In-Kind technology:			
1	Capital Expenditure			
	Total undiversified estimated capacity			
	Total capital cost, individual buildings chillers			
2	Operating Expenditure			
	Electric consumption			
	Assuming water-cooled system with 1.0 kW/ TR electric consumption for the system.			Centrifugal chillers, vapour compression, water-cooled.
	Cooling tower water consumption			For evaporation and blow down.
	TR x .012 m^3/TR.hr x $/$m^3$			
	Yearly salary cost			
	Yearly spares and maintenance.			
	% of capital cost of system.			
	Total operating expenses cost			

S.N	Item	Qt. or US $	US $	Remarks
	Rough calculation of return on capital expenditure; DSC compared to distributed chillers: • Yearly saving in operating expenses; • Difference in cost, capital expenditure, DSC vs. distributed chillers: • No. of years payback:			

II- Capital One- New Capital

1.6. Preparation of basic conceptual design of district cooling plants for Capital One – New capital

1.6.1. Introduction.

Figure 1.23: Map of Egypt showing the location of Capital One

Situated 45 Km west of Cairo on the Cairo- Suez highway, Skidmore, Owings & Merrill LLP (SOM) the leading architecture, interior design, engineering, and urban planning firm in the US and the world, has developed the initial framework and core principles of a sustainable new city of Cairo, Egypt [(7)].

The vision for CAPITAL ONE is a product of the collaboration of the Egyptian Ministry of Housing and Capital City Partners Ltd and investors, aided by SOM.

The Egyptian parliament and its government departments and ministries, as well as foreign embassies, would move to the new metropolis. Developers say the new city would include almost 2,000 schools and colleges and more than 600 health care facilities.

The project will create more than a million jobs. It is planned to be built over 700 sq. km (270 sq. miles) and house about five million residents.

The idea is to lure Egyptians away from the chaotic sprawl of Cairo – where congestion and pollution are high. This New Capital will spark a renaissance in the economy. Wadis and a unique topography, which will be preserved and enhanced for future generations, define this unique site. The future city will be compact in urban form and anchored by concentrated development districts, including a central business district, a government administrative district, a cultural district, a knowledge and innovation district, and over 100 diverse residential neighbourhoods.

The city is planned to consist of 21 residential districts and 25 "dedicated districts." Its downtown is to have skyscrapers and a tall monument said to resemble the Eiffel Tower and the Washington Memorial. The city will also have a park double the size of New York City's Central Park, artificial lakes, about 2,000 educational institutions. A technology and innovation park, 663 hospitals and clinics, 1,250 mosques, 40,000 hotel rooms, a major theme park four times the size of Disneyland, 90 square kilometres of solar energy farms, an electric railway link with Cairo.

A new international airport at the site of the pre-existing Wadi al Jandali Airport currently used by the Egyptian Air Force. It will be built as a smart city concept. It is planned that the transfer of parliament, presidential palaces, government ministries and foreign embassies will be completed between 2020 and 2022 at a cost of US $45 billion. Figure 1.23 shows a Map of Egypt and the location of Capital One.

1.6.2. Architectural Conceptual Design of Capital One.

Figures 1.24 shows the proposed location of governmental buildings for phase 1, phase 2, and the parliament.

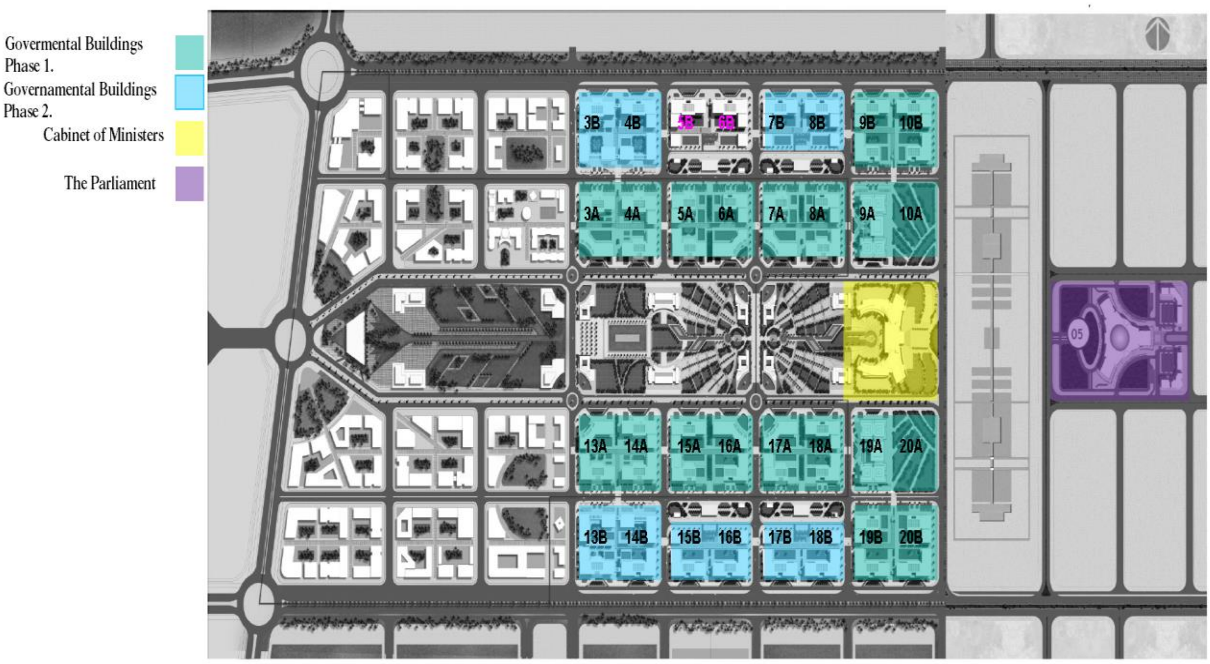


Figure 1.24: Location of Governmental Buildings for phase 1 and 2, and Parliament.

Figure 1.25 shows the services monumental areas for the governmental quarters and figure 1.26 shows details of these services.

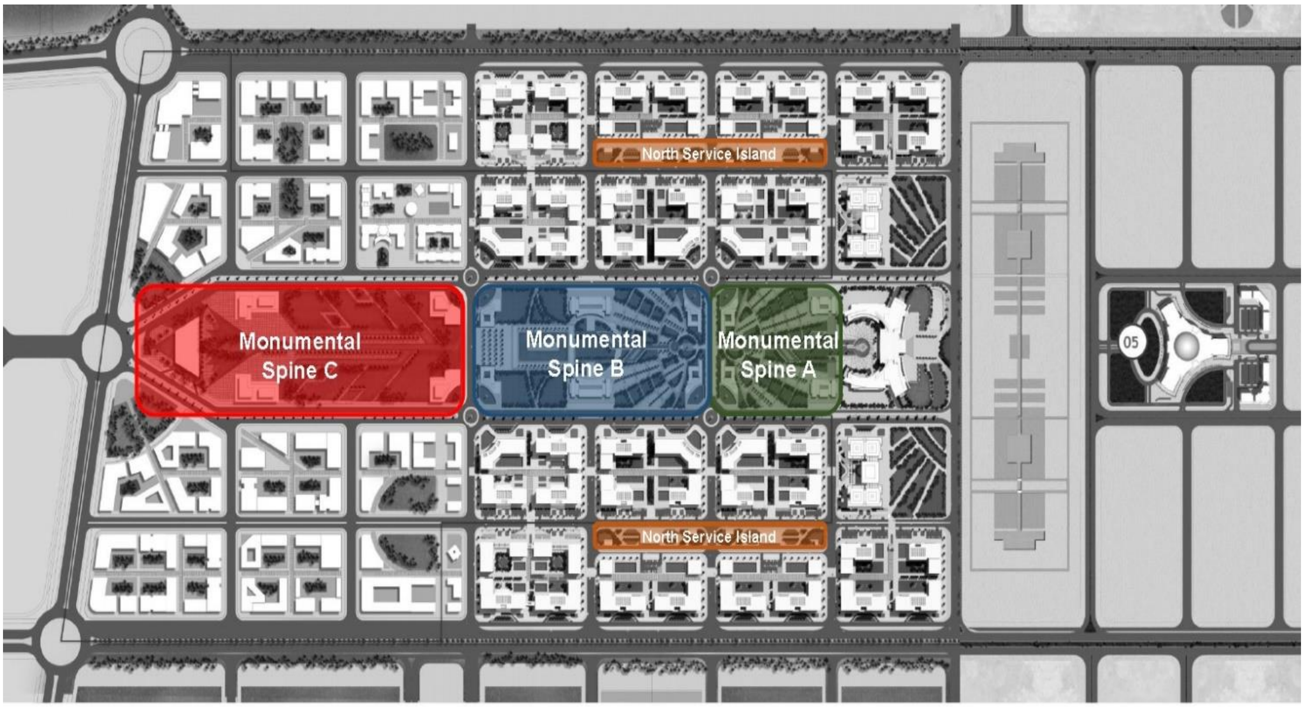


Figure 1.25: Service areas for governmental quarters.

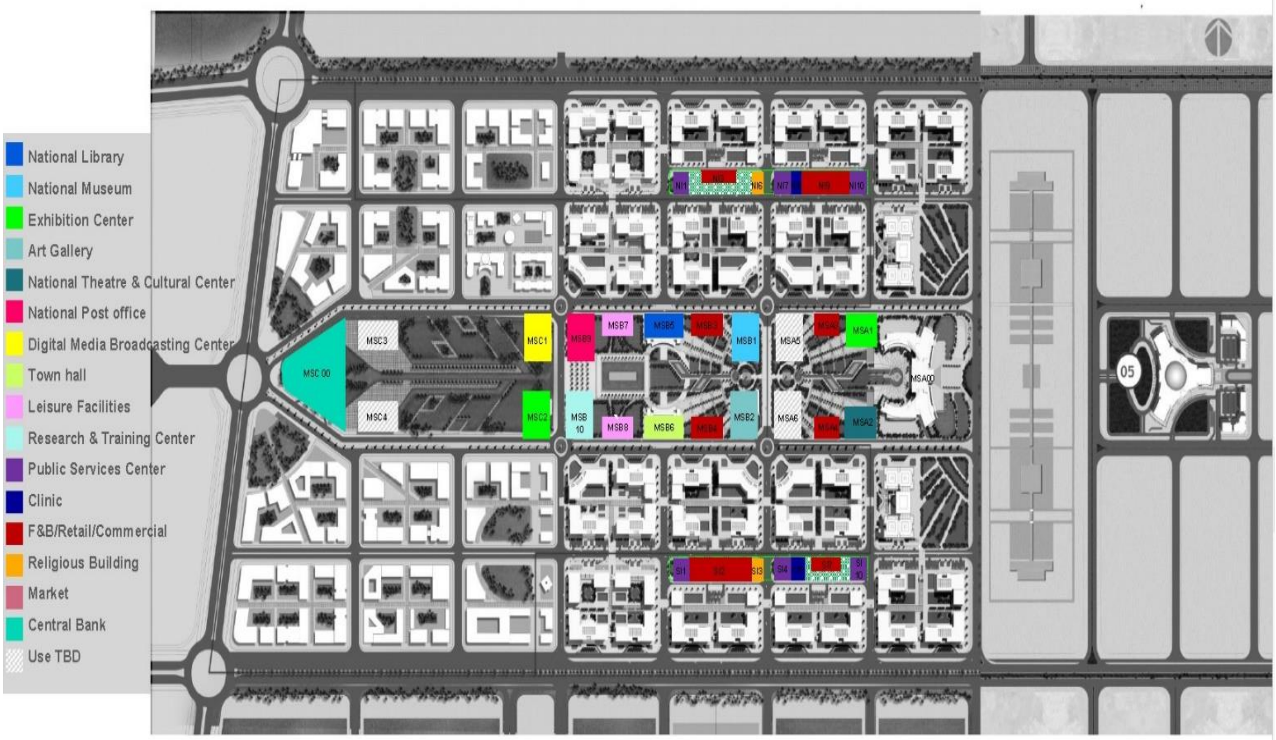


Figure 1.26: Details of Government service areas

The construction plan was phased in 3 phases. Figure 1.27 shows the phases of construction.

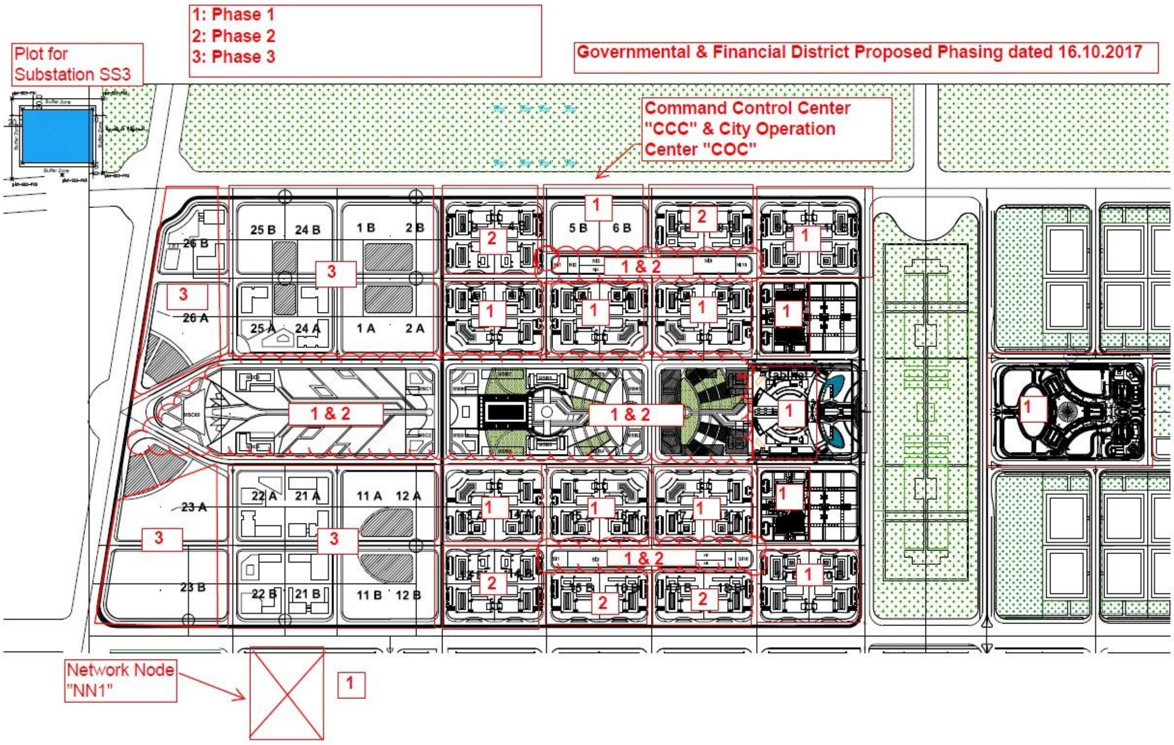


Figure 1.27: The three phases of construction.

1.6.3. Conceptual DC plants locations and Daily Cooling Load Demand Profile.

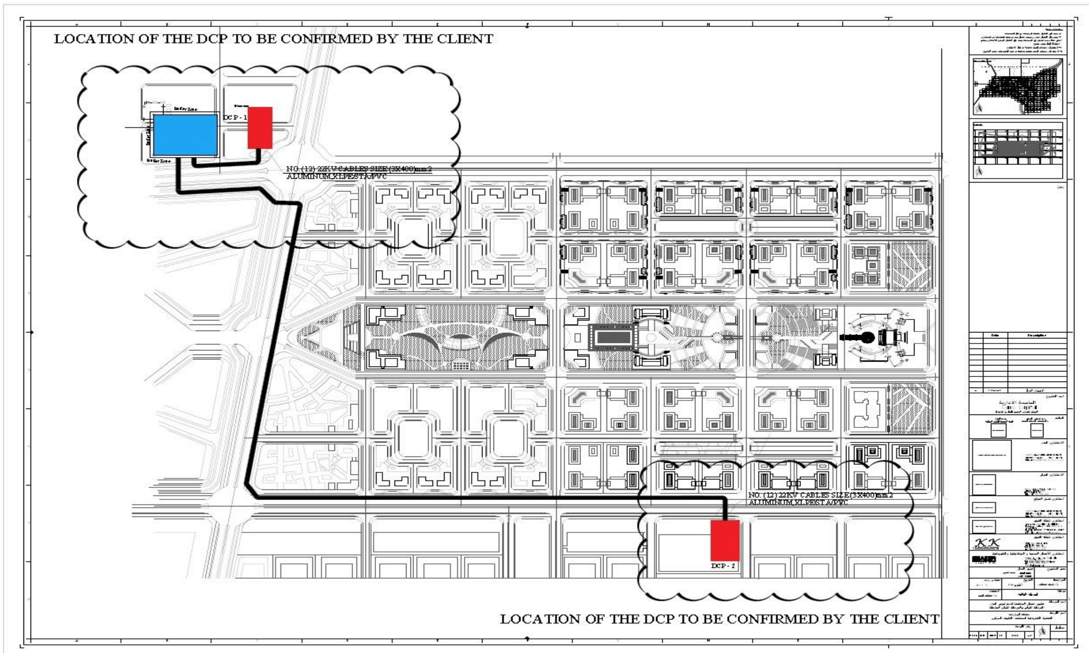
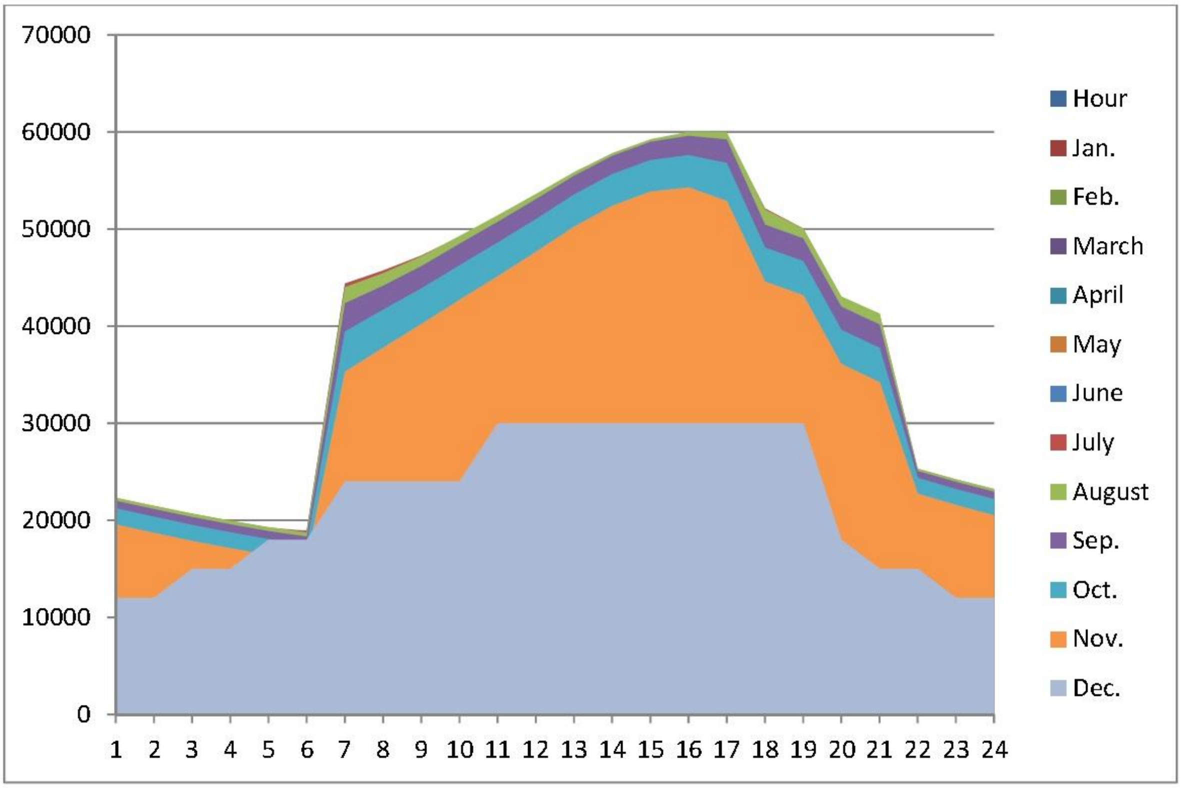


Figure 1.28: Location of DC plants.

Shaker Consultancy Group [8] made the conceptual electro- mechanical design of the city including district cooling plants locations for major government and public service buildings of the city.

The B.O.O design envisaged two DC plants for the governmental district. Figure 1.28 shows the location of DC plants 1 and 2. The refrigeration capacity of each DC plant was estimated to be 60,000 TR. This is shown in figure 1.29 of the Daily Cooling Load Demand Profile (DCLDP) [8].



DCP's .1, 2 - Load Profile for total Estimated Cooling Load of 60,000 T.R.

Figure 1.29: Daily Cooling Load Demand Profile for each DC plant.

Figure 1.29 shows the daily cooling load demand profile (DLDP) across the year. The phases of construction of each DC plant is as follows:

- DC Plant 1, by end of 2018: 25,000 TR.
- DC Plant 2, by end of 2018: 25,000 TR.
- DC Plant 1, by end of 2020: 60,000 TR.
- DC Plant 2, by end of 2020: 60,000 TR

All governmental buildings, offices, parliament and services of phases 1, 2 and 3 are to be housed and operational by the end of 2020.

1.6.4. Design of the Chilled Water Network (8).

Figure 1.30 shows the conceptual design of the chilled water network was made by Shaker Consultant Group [8]**.** Both DC plants are serving the same network. The network is designed as an outer ring in a loop type arrangement. The loop has 15 inside branches serving loads inside the ring and one outside branch serving Parliament.

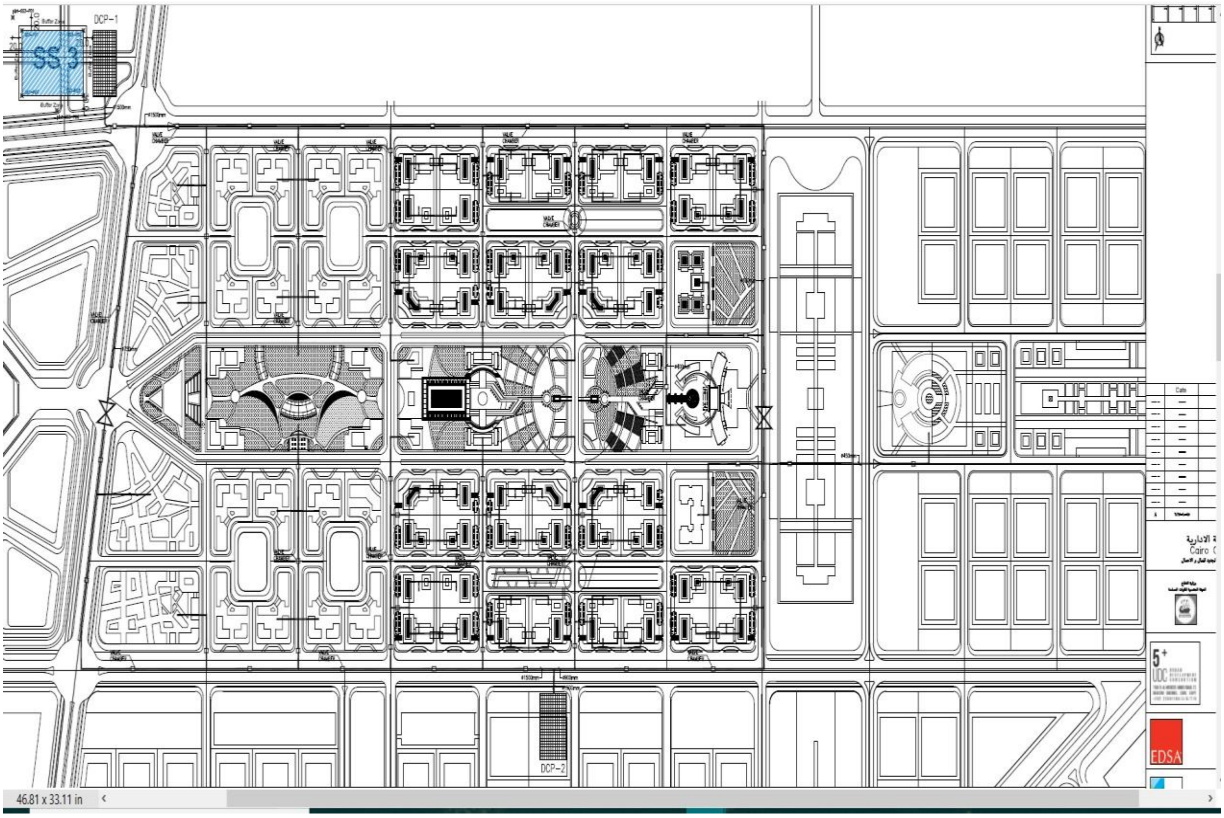


Figure 1.30: The chilled water network.

Several valve chambers are located on the loop and the branches as shown in figure 1.31. Two major manoeuvring shut-off valves are located on the eastern and western sides of loop. The conceptual design made by the consultant (8) for the Government District at New Capital consist of the following documents:

1. Request for Proposal (RFP) for a district cooling project on a Build Own and Operate (BOO) basis for the project, dated October 2017.
2. Guidelines for the design of the plants: General Design criteria and General Specifications for two DC plants and scope of BOO.
3. Appendices A, B and C:

A: contain lists of buildings areas served by be DC stations, details of phase 1, 2 and 3. This is shown in figures 1.24, 1.25, 1.26, and 1.27.

B: contains drawings for the chilled water piping network route including branches serving loads, valve rooms and shut-off diverting valves positions. This is shown in figure 1.31

Two more drawings show the electrical cabling details and routing to and between DCP1 and 2. Also a buffer zone area.

C: contains the DC Plants expected Key Performance Indicators (KPI). These are the chilled water design temperatures required, the chilled water flow required, penalties for diminished flow, chilled water pressure at each ETS room, penalties for changes in flow and number of malfunction hours penalties.

No DC plants design or selection of chillers types or plant room arrangement are made in the conceptual design of the consultant [(8)]. The basic design of the plants is made in this study. This is shown in section 1.6.5.

However, the Daily Cooling Load Demand Profile was provided by the consultant and is shown in figure 1.29.

In section 1.6.5 of this report the plant rooms basic design arrangement is shown, Thermal Energy Storage (TES) selection and primary, secondary- tertiary pumps selection of the chilled water system.

The selection is governed by the rules of NIK cooling technology stated in section 1.3 and the principle of energy conservation. The following section describe the system chosen for the DC plants of the government district of Capital One that have been used in the calculations of section 1.7.

1.6.5. Basic plant rooms design arrangement using Not-In-Kind Cooling Technology assisted by In-Kind.

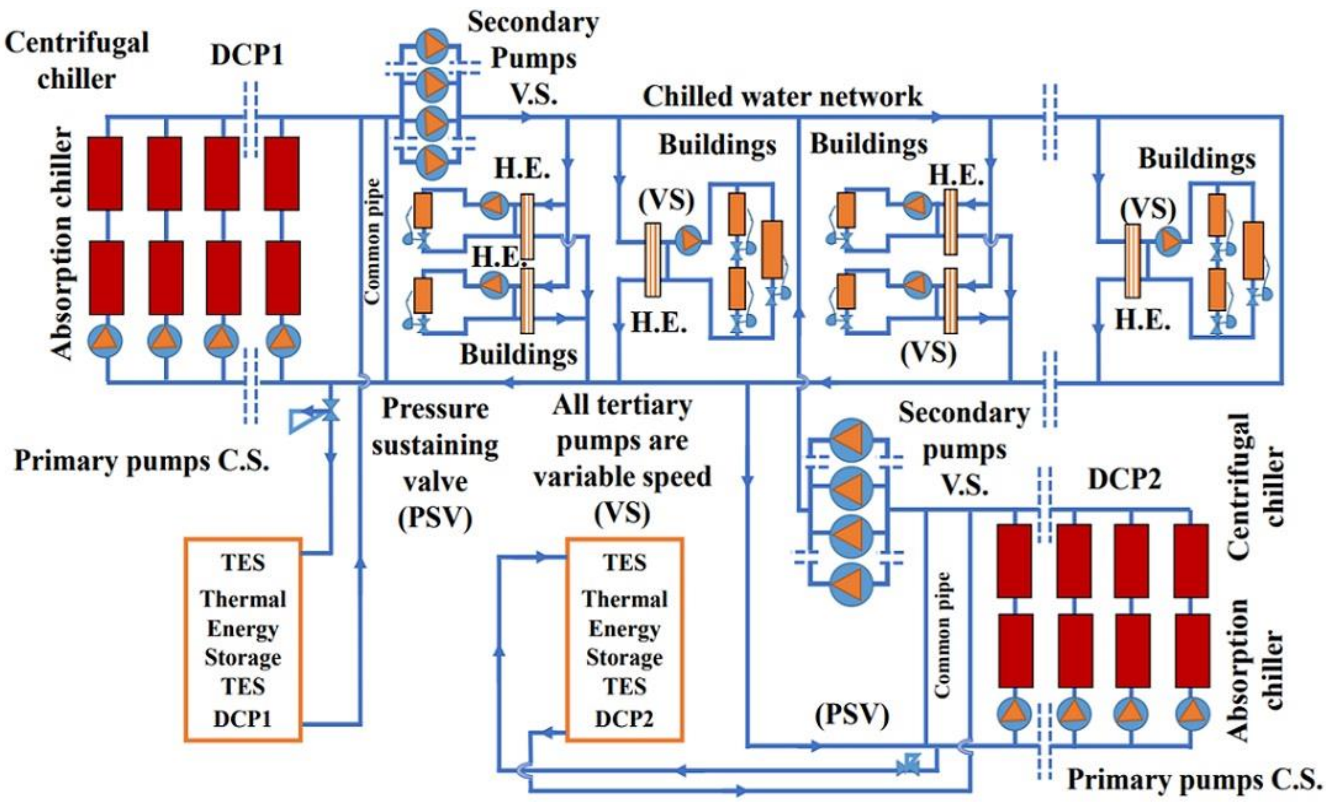


Figure 1.31: Basic schematic diagram of Chilled Water for two DC plants- Capital One.

Key Performance Indicators given by consultant [(8)] in design guidelines and appendix C:

- Chilled water temperature at battery limit, supply/ return, ^{0}C: 4/12.88
- building heat exchangers, chilled water design temperature, cold side, supply/ return, ^{0}C: 5/13.9
- Flow rate, for 22,500 TR, GPM: 36,000, and for 27,500 TR, GPM: 44,000.

The following basic design is proposed:

The first phase of cooling load for each DC plant consist of the following. Pumps data calculations shows:

- 11 branches (one branch for standby), each branch have two chillers connected in series.
- One constant flow primary chilled water pump per branch, capacity 70 kW.
- Downstream of the pump, one absorption chiller, natural gas fired, nominal capacity 1,500 TR (5,280 kW) and one centrifugal chiller capcity 1000 TR (3,520 kW).
- Total capacity per plant 11x 2500 = 27,500 TR (96,800 kW).
- 13 (12 + 1 standby) secondary pumps, variable speed, each 350 kW.
- Two cooling towers serve one branch: capacity 1,800 TR for the absorption chiller and 1000 TR for the centrifugal chiller.
- Cooling tower pumps: for the absorption chiller 140 kW and for the centrifugal chiller 80 kW.

The second phase of cooling load for each DC plant consist of, additionally:

- 7 branches, each branch have two chillers connected in series and one constant flow primary chilled water pump, capacity 70 kW, downstream of the pump one absorption chiller, natural gas fired, nominal capacity 1,500 TR (5,280 kW) and one centrifugal chiller capcity 1000 TR (3,520 kW).
- TES tank, capacity 15,000 TR x 13 hrs. = 195,000 TR.hrs, connected to the primary circuit.
- 13 (12 + 1 standby) secondary pumps, variable speed, each 350 kW.
- Total final capacity per plant, 18 branches: 18 x 1,500 + 15,000 = 60,000 TR (211,200 kW)

Figure 1.31 shows this basic schematic diagram of the chilled water system for two DC plants and connection to the network. More details on the TES are made in section 1.6.6.

The chilled water pumping arrangement system chosen is primary- secondary- tertiary system, with variable speeds pumps for both secondary and tertiary pumps. Primary pumps are constant speed. This type of systems is shown in sections 1.3.3 and 1.4.6.

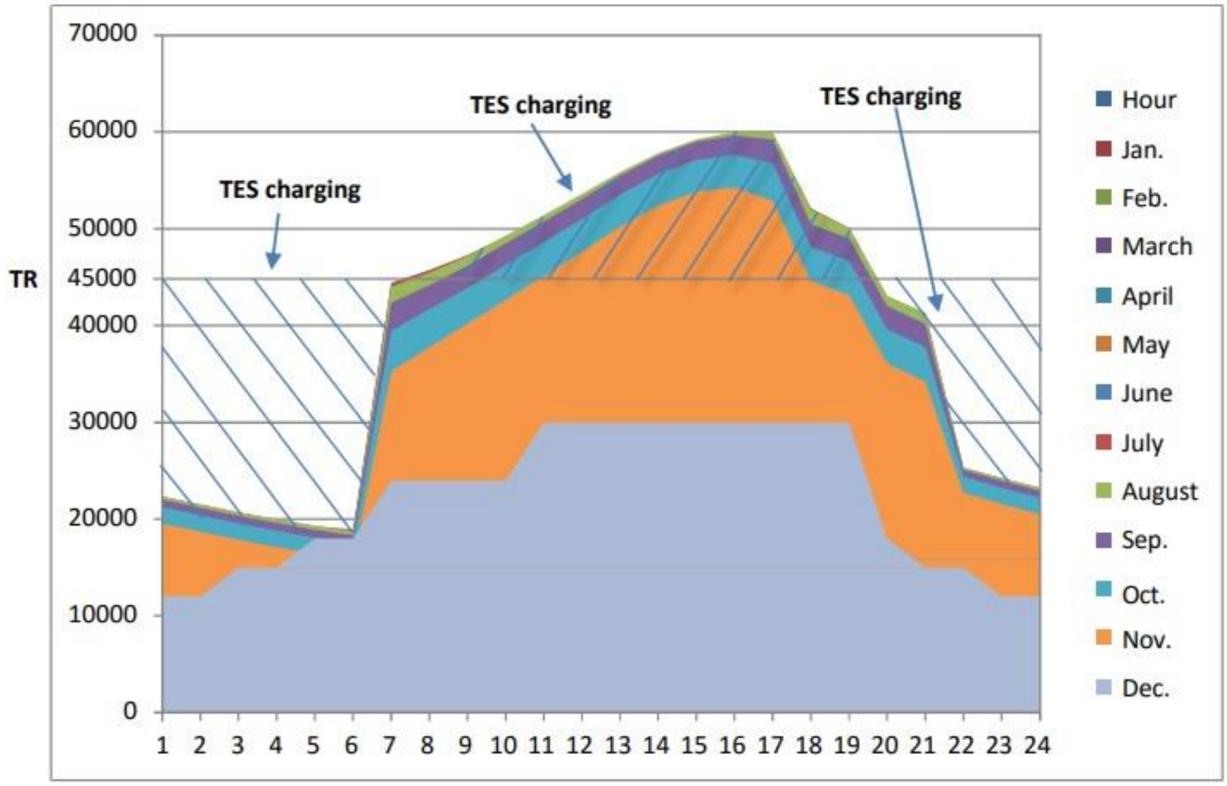
Redundancy is provided in phase 1 by one extra branch for each station with a capacity of 2,500 TR. No redundancy in phase 2 is made since both DC plants are connected to the same chilled water distribution network, saving diversity between the plants of about 20% or 9,000 TR and can be used as redundancy once chillers breakdown until they are repaired.

1.6.6. Thermal Energy Storage (TES) and Energy Transfer Stations (ETS) at buildings

Sections 1.3.5 and 1.4.5 show the importance of the DLDP in establishing the possibility of using Thermal Energy Storage (TES) and thus shifting peak loads to off-peak periods and reducing the installed capacity of a DC plant. This results in avoiding high electrical demand charges. TES was applied to each DC plants at cooling phase 2 (60,000 TR each) by designing TES capacity of 15,000 TR from 07 hrs to 20 hrs as shown in figure 1.32. The peak load between 07 hrs and 20 hrs is served by the TES tank while the TES was charged at the other hours. The continuous average capacity of each plant is 45,000 TR (158,400 kW) and the capacity of each TES is 15,000 TR x 13 hrs = 195,000 TR.hrs.

This is shown in figure 1.32 and connection of each TES is shown in the basic chilled water schematic diagram of the plants, figure 2.31.

The operation of TES tanks is shown in sections 1.3.5 and 1.4.6 also described here:



(by Shaker Consultancy Group)

Figure 1.32: Daily Cooling Load Demand Profile and TES capacity.

Operation of the TES:

The TES is piped directly for each DC plant into an open bridge between the chillers branches and the system chilled water return header and the primary chilled water supply header.

The upper region - warm return water of the stratified TES tank is connected to the primary chilled water return header upstream of the cooling system as shown in figure 1.31.

The lower region- cool supply water of the stratified TES tank is connected to the primary chilled water supply header downstream of the primary cooling system and upstream of the chilled water secondary pumps.

The TES system works as follows:

- At off-peak periods: the plant primary chilled water flow is higher than the secondary flow:

  TES tank automatically recharge, rate of charging = difference between primary and secondary flow.

- At on-peak periods: the plant primary chilled water flow is lower than the secondary flow:

  TES tank automatically discharge, rate of discharging = difference between secondary and primary flow.

1.7. Proposing Capital Expenditure Parameters for the Economic Model.

1.7.1. Economic Model comparison, Capital and Operating Expenditures

As shown in section 1.5.1 the owner of a development, a property developer or a specialized company, constructs the DC system. The DC system consultant [8] specified a Build, Own and Operate (BOO) scheme. The DC provider will invest in building and operating the system, in return collect tariff(s) from the users. Those are defined in annex 8: RFP BOO DC Project, p.33, section 6.4.2 as follows:

Quote

(a) A Monthly Capacity Charge expressed in EGP. /TR to cover the provision of the Plants and related capacity of the Chilled Water Network. The Bidder shall also provide the basis for any upward and downward annual review movement in the Monthly Capacity Charge. Bidders are encouraged to provide in their proposal means to minimize, cap or eliminate the monthly capacity charge.

(b) A Monthly Consumption Charge expressed in EGP. /TR-hr based on the Cooling Load supplied as read by the BTU Meter.

(c) The Bidder must submit in its Proposal its own detailed financial model (the Financial Model) for the Project. The Financial Model must be capable of generating all calculations required by this RFP. The Financial Model should faithfully reflect the terms of the Project Agreements. It should also reflect any technical assumptions and cost estimates stated in the Bidder's Proposal.

(d) The projections should be supplied both in hard copy and CD-ROM form using Microsoft Excel. The Financial Model is required to adhere to best practice standards and techniques. Failure to adhere to best practice standards in respect of the Financial Model may render a Proposal to be deemed non-compliant

(e) The Bidder shall provide the capital cost for each Plant.

(f) The Bidder shall provide the O&M cost over the terms of the Offtake Agreement of operation for each Plant.

(g) The Bidder shall also provide the energy costs for electricity, natural gas, make up water and fuel oil and the chemical costs upon which its Proposal is based.

(h) Completeness of the scope of supply and services; cover DCP and coordination scope for chilled piping distribution network to ETS inside buildings).

(i) Energy utilities consumable values or any other efficient energy criteria could be proposed by bidders.

(j) *The Bidder shall provide the O&M cost over the terms of the Offtake Agreement of operation for Chilled Water Network, in a separate agreement as described in the RFP."*

Unquote

The DC provider has to provide economically advantageous tariff(s) to the user compared to expenses incurred had buildings installed their own chiller system. He also have to make a profit on his investment.

The system therefore has to be economically advantageous to two sides; the user/owner compared to installing his own individual chiller system in each building and the provider by providing him with an attractive Internal Rate of Return (IRR) on his investment.

To perform this comparison parameters have to be calculated. Financial parameters such as current rates of borrowing, risk levels, discount rates, inflation rates and others establish the comparison. Other parameters are engineering derived parameters that help achieve a financial comparison. These are capital and operating expenses, EFLH and other factors. These are calculated by this technical part of the study.

Two points of view govern the economic viability of the system over its lifetime of 20 to 22 years:

First*:* from the point of view of the user.

The DC system chosen compared with a system using distributed individual chiller plants for each building must have Net Present Value- over its lifetime- less than that of distributed individual building chillers. This means that the DC system is cheaper to the user than distributed chiller system, therefore economically superior and viable.

Second*:* from the point of view of the DC provider.

The IRR of the system must be high enough to provide a profit to the DC provider. If the IRR is within the expectations of the DC provider, then the system is economically acceptable to the DC provider and viable.

The economic model as well as other economic parameters provide these data and therefore can govern the choice of the system. Part II of the study contains the economic model.

Capital and operating expenditures, Equivalent Full Load Hours (EFLH) number of hours of the DC system are shown in section 1.7.2. The table 1.3 is a summary of all cost parameters that are used in the economic model.

Table 1.3: Cost of Chiller Plant, Thermal Energy Storage (TES) Chilled water TES, Ice TES and LTF TES.

S.N	System	US $	Remarks
1	Chiller Plant to be added for TES	1,800 to 3,500/TR	Include installation of chillers, cooling towers, pumps, instrumentation, controls, electrical, building.
2	Ice TES	100 to 150 / TR. hr	Installed without chillers, pumps, controls, etc. ($800 to 1,200 per TR for eight hours discharge of TES).
3	Ice TES	225 to 475/ TR.hr	Installed with chillers, pumps, controls, etc. ($1,800 to 3,800 per TR for eight hours discharge of TES).
4	CHW TES- large capacity.	30 to 85/ TR.hr	Installed, above ground, large capacity- over 20,000 TR.hr. ($240 t0 860 per TR for eight hours discharge of TES).
5	CHW TES- medium capcity.	60 to 170/ TR.hr	Installed, above ground, medium capacity- 10,000 to 20,000 TR.hr. ($240 to 860 per TR for eight hours discharge of TES).
6	CHW TES- small capcity.	80 to 200/ TR.hr	Installed, above ground, small capacity- 5,000 to 10,000 TR.hr. ($640 t0 1,600 per TR for eight hours discharge of TES).
7	LTF TES	Similar to CHW cost	Installed, above ground- very similar to CHW TES (as smaller and less expensive tank is offset roughly by added cost of the chemical additives in the fluid).
8	Hydraulic Integration of TES to Balance the system.	100 to 250 / TR	

1.7.2. Cost Parameters for use with the Economic Model.

Table 1.4: Cost Parameters for the DC system- Capital One.

S.N	Item	Qt. or US $	US $	Remarks
I	DC using Not-In-Kind and In-Kind Technologies.			
	Absorption chillers and electrical centrifugal chillers.			
1	Capital Expenditure:			
	Total tonnage, both cooling phases, per plant:			
	18 branches, each branch consist of one 1500 TR abs. chiller, Natural gas fired plus one 1000 TR centrifugal chiller, electric. Total per branch 2,500 TR.			
	18 abs Chiller and 18 cent. Chiller, per plant			
	36 abs Chiller and 36 cent. Chiller, for two plants			
	Total tonnage: 45,000 x 2 TR (without TESs.)			
	Additionally:			
	Two TES tank systems			
	Total tonnage per plant with TES: 45,000 + 15,000 = 60,000 TR, Total installed, two plants: 120,000 TR.			
	Capacity per TES: 15,000 x 13 = 195,000 TR.hr			
	TES cost : 2 x 195, 000 TR.hrs			
	Hydraulic Integration to the balance of the system			
	Total capital cost			
2	Operating Expenditure:			
a	Equivalent Full Load Hours (EFLH). Commercial areas may need cooling all around the year. Hotels will need cooling and heating across the year and may need cooling for public areas across the year.			
b	Breakdown no. of labours: 1 Stations Chief 3 HVAC senior graduate engineer, 3 Skilled technician 3 Technician			24 hrs operation. For each plant: Three crews: One working in 1st shift, one for the 2nd and one on leave. The third shift substitute the first and so on.
c	Salaries structure / month: Station chief (one for two plants). Each shift: - HVAC senior graduate engineer. - Skilled technician. - Technician			1 stations chief- for both plants Each crew: 1 senior graduate engineer. 1 skilled technician. 1 technician.
d	Monthly salaries (without stations chief): 3 Senior graduate engineer 3 Skilled technicians 3 technicians Total salaries, monthly. Yearly salaries per plant, without stations chief.			For each plant: Three crews (24 hrs operation).

S.N	Item	Qt. or US $	US $	Remarks
	For two plants:			For two plants; one stations chief and two crew, each crew as above.
	1 Stations Chief: 2,000/ month Yearly - Plant 1. - Plant 2.			
	Yearly salaries cost, both plants			
e	Electric consumption per year			
	Cooling towers pumps: 140 kW each for abs chillers and 80 kW for centrifugal chillers.			
	{no.pumps x (hrs/day) x EFLH x kW/p x ($ / kW)} For abs chillers 18 x 3000 x 80 x 0.084			
	For cent. chillers 18 x 3000 x 140 x 0.084			
	Primary chilled water pumps: 70 kW each			
	{no.pumps x (hrs/day) x EFLH x kW/p x ($ / kW)}			
	36 x 3000 x 70 x 0.084			
	Secondary chilled water pumps: 350 kW each (Used for both Not-In-Kind and In-Kind Technologies.).			
	{No.pumps x (kW/pump) x EFLH x ($/ kW)}			
	Centrifugal chillers electric consumption:			
	{No. of plants x No. chillers per plant x 1,000 TR x consumption (kW/TR) x (EFLH) x ($/$m^3$)}.			
	Total Yearly electric consumption			
f	Natural Gas Consumption of Absorption chillers :			
	{No. of plants x No. chillers per plant x 1,500 TR x consumption (m^3/hr/TR) x (EFLH) x ($/$m^3$)}.			
	Total N.gas consumption /year.			
g	Yearly spare parts & maintenance- 0.123 % of capital cost of system.			
	Total yearly operating expenses			
II	Distributed individual building chillers, In-Kind technology:			
1	Capital Expenditure			
	Total undiversified estimated capacity			
	Total capital cost, individual buildings chillers			
2	Operating Expenditure			
	Electric consumption			
	Assuming water-cooled system with 1.0 kW/ TR.hr overall electric consumption for the system.			
	TR x 1 x EFLH x $/kW.hr			
	Cooling tower water consumption:			
	TR x .012 m^3/TR.hr x EFLH x $/$m^3$			

S.N	Item	Qt. or US $	US $	Remarks
	Yearly salary cost			
	Yearly spares and maintenance.			
	% of capital cost of system.			
	Total operating expenses cost			
	Capital cost of NIK assisted by IK cooling technology is less expensive than IK cooling technology: Capital cost IK/NIK= Capital cost IK= This is in itself a good argument to choose NIK with IK over IK, since usually NIK is dearer than IK but makes up for this difference by lower operating costs. Operating cost: Operating cost IK/NIK= Operating cost IK=			

References:

1 Natural Cold Water District Cooling Plants Enabled by Directional Drilling, ASHRAE CRC, Cairo, October 2010. http://www.cotherma.com/Press%20Release%20-%20Climate%20Change%20with%20Innovation.pdf?Type=fpaper&pcode=1030

2 The AC of Tomorrow? Tapping Deep Water for Cooling. National Geographic, 20 October 2017.

3 US National Oceanic and Atmospheric Administration, NOAA, has National Centres for Environmental Information (NCEI), https://www.ncei.noaa.gov/about.

4 HDD Services Co.

5 Geographic Standard Planning Report, New El Alamein City, North coast, Egypt. Triple L Oil Services, December 2017.

6 Commercial offer, horizontal well, New El Alamein City, North coast, Egypt. Triple L Oil Services, December 2017.

7 Skidmore, Owings & Merrill LLP (SOM), 14.03.2015

http://www.arch2o.com/som-is-leading-the-planning-of-the-capital-cairo/

8 Shaker Consultancy Group.

9 A. A. Olama, District Cooling, theory and practice, Taylor and Francis CRC Press, Boca Raton, USA, 2017. www.CRCpress.com

10 S. Frederiksen, S. Werner, District Heating and Cooling, Studentlitteratur AB Lund, Sweden, 2013. www.studentlitteratur.se

11 ASHRAE District Cooling Guide, ASHRAE Atlanta, Georgia, USA, 2013. www.ashrae.org

12 International District Energy Association IDEA, District Cooling Best Practice Guide, Westborough, MA, USA, 2008. www.distrctenergy.org

Annex (1-1)
Criteria for selecting potential sites for the District Cooling Feasibility Study

NATIONAL COUNTERPART	National Ozone Unit / the Egyptian Environmental Affairs Agency

Points System

No	Item	Criteria	Points	Score
1	New developed city/district.	New City = 20 New District in existing City = 15 Existing District = 5	20	
2	Minimum Cooling Capacity	< 5,000 TR = 5 5,000 – 10,000 TR = 7 10,000 – 30,000 TR = 8 > 30,000 TR = 10	10	
3	Proximity to: a. Sea side b. Waste Heat Source (elect. power station)	Within or less than 5Km = 30 5-10 Km = 20 More than 10 Km = 10	20	
4	Proximity to NG downstream line	Within connected proximity	10	
5	Current status of city/district development	Concept phase = 20 Design phase = 10 Contract phase = 5	20	
6	Type of application (residential, commercial, governmental, industrial, mixed)	Governmental = 20 Residential = 5 Commercial =15 Industrial = 15 Mixed Use = 20	20	
		Total	100	

Technical Information Survey.

No.	Item	Details
1	Sites Parameters:	
A	Sites for District Cooling Plants under consideration.	- Name of sites: - Site 1: --------- - Site 2: ---------- - Site 3: ---------- - Site 4: ---------- (Chose two sites.)
B	Cost of Land: - Purchasing. - Renting.	Site 1: Site 2: Site 3: Site 4:
C	Cost of plant building construction:	For a masonry building: -----/square meter.

No.	Item	Details
		For a steel structure building: ------/square meter.
D	Additional Information you may think is important to list:	
2	Energy and Water.	
A	Electric Power Prices: - Low Voltage. - Medium Voltage. - High Voltage.	Residential: --- Commercial: ---- Industrial: ----- (Link to internet site- prices of electric power cost.)
B	Natural Gas Prices:	Site1: , Site 2: , Site3: , Site 4: Is it piped to site?
C	Is there a source of reject heat near the site? (Refinery, steel mill, glass factory, thermal desalination plant, electric power station, etc.…)	Site 1: Site 2: Site 3: Site 4:
D	- Is there a Refuse Processing Plant near the site? - Is there a Refuse Derive Fuel (RDF) available?	Site 1: Site 2: Site 3: Site 4:
E	Price of fresh water, brackish water and drain:	
F	Additional Information you may think is important to list:	
3	Salaries	
A	Salaries structure for: - Qualified Graduate engineers (5 to 10 years exp.): - Qualified Graduate engineers (1 to 5 years exp.): - Skilled Technician: - Technician: - Labourer:	
B	Additional Information you may think is important to list:	
4	Taxes and Custom Duties	
A	Rate of Income Taxes: - On individuals: - On Corporations:	
B	Taxes on Services: - On electric power supply: - On district Cooling Services. - Other.	
C	Custom Duties on imported Equipment:	
D	Value Added taxes on Imported goods and services:	

Financial Information Survey.

No.	Item	Details
1	Sites Parameters:	
A	Sites for District Cooling Plants under consideration.	- Name of sites: - Site 1: --------- - Site 2: ---------- - Site 3: ---------- - Site 4: ---------- (Chose two sites.)
B	Cost of Land: - Purchasing. - Renting.	Site 1: Site 2: Site 3: Site 4:
C	Cost of plant building construction:	For a masonry building: -----/square meter. For a steel structure building: ------/square meter.
D	Additional Information you may think is important to list:	
2	Energy and Water.	
A	Electric Power Prices: - Low Voltage. - Medium Voltage. - High Voltage.	Residential: --- Commercial: ---- Industrial: ----- (Link to internet site- prices of electric power cost.)
B	Natural Gas Prices:	Site1: , Site 2: , Site3: , Site 4: Is it piped to site?
C	Is there a source of reject heat near the site? (Refinery, steel mill, glass factory, thermal desalination plant, electric power station, etc.…)	Site 1: Site 2: Site 3: Site 4:
D	- Is there a Refuse Processing Plant near the site? - Is there a Refuse Derive Fuel (RDF) available?	Site 1: Site 2: Site 3: Site 4:
E	Price of fresh water, brackish water and drain:	
F	Additional Information you may think is important to list:	
3	Salaries	
A	Salaries structure for: - Qualified Graduate engineers (5 to 10 years exp.):	

No.	Item	Details
	- Qualified Graduate engineers (1 to 5 years exp.): - Skilled Technician: - Technician: - Labourer:	
B	Additional Information you may think is important to list:	
4	Taxes and Custom Duties	
A	Rate of Income Taxes: - On individuals: - On Corporations:	
B	Taxes on Services: - On electric power supply: - On district Cooling Services. - Other.	
C	Custom Duties on imported Equipment:	
D	Value Added taxes on Imported goods and services:	

Annex (1-2)

HDD geographic report

HDD co.

Horizontal

Horizontal
Horizontal
Horizontal

Horizontal

Plan: Horizontal Well

Standard Planning Report - Geographic

04 December, 2017

Database:	TLOS	Local Co-ordinate Reference:	Site Horizontal
Company:	Horizontal	TVD Reference:	Mean Sea Level (System)
Project:	Horizontal	MD Reference:	Mean Sea Level (System)
Site:	Horizontal	North Reference:	Grid
Well:	Horizontal	Survey Calculation Method:	Minimum Curvature
Wellbore:	Horizontal		
Design:	Horizontal Well		

Project	Horizontal		
Map System:	Coordinate Systems of Egypt	System Datum:	Mean Sea Level
Geo Datum:	Old Egyptian 1907 - Egypt		
Map Zone:	Egypt Red Belt		

Site	Horizontal						
Site Position:			Northing:	0.00 m	Latitude:	0° 0' 0.000 N
From:	None		Easting:	0.00 m	Longitude:	0° 0' 0.000 E
Position Uncertainty:		0.00 m	Slot Radius:	335.28 mm	Grid Convergence:	0.00°

Well	Horizontal					
Well Position	+N/-S	0.00 m	Northing:	0.00 m	Latitude:	22° 34' 40.149 N
	+E/-W	0.00 m	Easting:	0.00 m	Longitude:	25° 1' 39.009 E
Position Uncertainty		0.00 m	Wellhead Elevation:	0.00 m	Ground Level:	0.00 m

Wellbore: Horizontal

Magnetics	Model Name	Sample Date	Declination (°)	Dip Angle (°)	Field Strength (nT)
	User Defined	12/4/2017	0.00	0.00	0

Design: Horizontal Well

Audit Notes:					
Version:		Phase:	PROTOTYPE	Tie On Depth:	0.00

Vertical Section:	Depth From (TVD) (m)	+N/-S (m)	+E/-W (m)	Direction (°)
	0.00	0.00	0.00	0.00

Plan Sections

Measured Depth (m)	Inclination (°)	Azimuth (°)	Vertical Depth (m)	+N/-S (m)	+E/-W (m)	Dogleg Rate (°/30m)	Build Rate (°/30m)	Turn Rate (°/30m)	TFO (°)	Target
0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.00	
112.45	0.00	0.00	112.45	0.00	0.00	0.000	0.000	0.000	0.00	
1,192.45	90.00	0.00	800.00	687.55	0.00	2.500	2.500	0.000	0.00	
1,692.45	90.00	0.00	800.00	1,187.55	0.00	0.000	0.000	0.000	0.00	

Database:	TLOS	Local Co-ordinate Reference:	Site Horizontal
Company:	Horizontal	TVD Reference:	Mean Sea Level (System)
Project:	Horizontal	MD Reference:	Mean Sea Level (System)
Site:	Horizontal	North Reference:	Grid
Well:	Horizontal	Survey Calculation Method:	Minimum Curvature
Wellbore:	Horizontal		
Design:	Horizontal Well		

Planned Survey

Measured Depth (m)	Inclination (°)	Azimuth (°)	Vertical Depth (m)	+N/-S (m)	+E/-W (m)	Map Northing (m)	Map Easting (m)	Latitude	Longitude
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22° 34' 40.149 N	25° 1' 39.009 E
30.48	0.00	0.00	30.48	0.00	0.00	0.00	0.00	22° 34' 40.149 N	25° 1' 39.009 E
60.96	0.00	0.00	60.96	0.00	0.00	0.00	0.00	22° 34' 40.149 N	25° 1' 39.009 E
91.44	0.00	0.00	91.44	0.00	0.00	0.00	0.00	22° 34' 40.149 N	25° 1' 39.009 E
112.45	0.00	0.00	112.45	0.00	0.00	0.00	0.00	22° 34' 40.149 N	25° 1' 39.009 E
121.92	0.79	0.00	121.92	0.07	0.00	0.07	0.00	22° 34' 40.151 N	25° 1' 39.008 E
152.40	3.33	0.00	152.38	1.16	0.00	1.16	0.00	22° 34' 40.186 N	25° 1' 39.007 E
182.88	5.87	0.00	182.76	3.60	0.00	3.60	0.00	22° 34' 40.265 N	25° 1' 39.004 E
213.36	8.41	0.00	213.00	7.39	0.00	7.39	0.00	22° 34' 40.388 N	25° 1' 38.998 E
243.84	10.95	0.00	243.04	12.52	0.00	12.52	0.00	22° 34' 40.554 N	25° 1' 38.991 E
274.32	13.49	0.00	272.83	18.97	0.00	18.97	0.00	22° 34' 40.762 N	25° 1' 38.982 E
304.80	16.03	0.00	302.30	26.73	0.00	26.73	0.00	22° 34' 41.013 N	25° 1' 38.971 E
335.28	18.57	0.00	331.40	35.79	0.00	35.79	0.00	22° 34' 41.306 N	25° 1' 38.958 E
365.76	21.11	0.00	360.07	46.14	0.00	46.14	0.00	22° 34' 41.641 N	25° 1' 38.944 E
396.24	23.65	0.00	388.25	57.74	0.00	57.74	0.00	22° 34' 42.016 N	25° 1' 38.928 E
426.72	26.19	0.00	415.89	70.58	0.00	70.58	0.00	22° 34' 42.431 N	25° 1' 38.910 E
457.20	28.73	0.00	442.93	84.64	0.00	84.64	0.00	22° 34' 42.885 N	25° 1' 38.890 E
487.68	31.27	0.00	469.33	99.87	0.00	99.87	0.00	22° 34' 43.378 N	25° 1' 38.869 E
518.16	33.81	0.00	495.02	116.27	0.00	116.27	0.00	22° 34' 43.908 N	25° 1' 38.846 E
548.64	36.35	0.00	519.96	133.78	0.00	133.78	0.00	22° 34' 44.474 N	25° 1' 38.821 E
579.12	38.89	0.00	544.10	152.39	0.00	152.39	0.00	22° 34' 45.076 N	25° 1' 38.795 E
609.60	41.43	0.00	567.40	172.04	0.00	172.04	0.00	22° 34' 45.711 N	25° 1' 38.768 E
640.08	43.97	0.00	589.80	192.71	0.00	192.71	0.00	22° 34' 46.379 N	25° 1' 38.739 E
670.56	46.51	0.00	611.26	214.35	0.00	214.35	0.00	22° 34' 47.079 N	25° 1' 38.709 E
701.04	49.05	0.00	631.74	236.92	0.00	236.92	0.00	22° 34' 47.809 N	25° 1' 38.677 E
731.52	51.59	0.00	651.20	260.38	0.00	260.38	0.00	22° 34' 48.567 N	25° 1' 38.644 E
762.00	54.13	0.00	669.60	284.67	0.00	284.67	0.00	22° 34' 49.353 N	25° 1' 38.610 E
792.48	56.67	0.00	686.91	309.76	0.00	309.76	0.00	22° 34' 50.164 N	25° 1' 38.575 E
822.96	59.21	0.00	703.08	335.59	0.00	335.59	0.00	22° 34' 50.999 N	25° 1' 38.539 E
853.44	61.75	0.00	718.10	362.11	0.00	362.11	0.00	22° 34' 51.856 N	25° 1' 38.502 E
883.92	64.29	0.00	731.93	389.27	0.00	389.27	0.00	22° 34' 52.735 N	25° 1' 38.464 E
914.40	66.83	0.00	744.54	417.02	0.00	417.02	0.00	22° 34' 53.632 N	25° 1' 38.425 E
944.88	69.37	0.00	755.91	445.29	0.00	445.29	0.00	22° 34' 54.546 N	25° 1' 38.386 E
975.36	71.91	0.00	766.01	474.05	0.00	474.05	0.00	22° 34' 55.476 N	25° 1' 38.346 E
1,005.84	74.45	0.00	774.83	503.22	0.00	503.22	0.00	22° 34' 56.419 N	25° 1' 38.305 E
1,036.32	76.99	0.00	782.35	532.76	0.00	532.76	0.00	22° 34' 57.374 N	25° 1' 38.263 E
1,066.80	79.53	0.00	788.55	562.60	0.00	562.60	0.00	22° 34' 58.338 N	25° 1' 38.222 E
1,097.28	82.07	0.00	793.42	592.68	0.00	592.68	0.00	22° 34' 59.311 N	25° 1' 38.180 E
1,127.76	84.61	0.00	796.96	622.95	0.00	622.95	0.00	22° 35' 0.290 N	25° 1' 38.137 E
1,158.24	87.15	0.00	799.15	653.35	0.00	653.35	0.00	22° 35' 1.273 N	25° 1' 38.095 E
1,188.72	89.69	0.00	799.99	683.82	0.00	683.82	0.00	22° 35' 2.258 N	25° 1' 38.052 E
1,192.45	90.00	0.00	800.00	687.55	0.00	687.55	0.00	22° 35' 2.378 N	25° 1' 38.047 E
1,219.20	90.00	0.00	800.00	714.30	0.00	714.30	0.00	22° 35' 3.243 N	25° 1' 38.009 E
1,249.68	90.00	0.00	800.00	744.78	0.00	744.78	0.00	22° 35' 4.229 N	25° 1' 37.967 E
1,280.16	90.00	0.00	800.00	775.26	0.00	775.26	0.00	22° 35' 5.214 N	25° 1' 37.924 E
1,310.64	90.00	0.00	800.00	805.74	0.00	805.74	0.00	22° 35' 6.200 N	25° 1' 37.881 E
1,341.12	90.00	0.00	800.00	836.22	0.00	836.22	0.00	22° 35' 7.185 N	25° 1' 37.839 E
1,371.60	90.00	0.00	800.00	866.70	0.00	866.70	0.00	22° 35' 8.170 N	25° 1' 37.796 E
1,402.08	90.00	0.00	800.00	897.18	0.00	897.18	0.00	22° 35' 9.156 N	25° 1' 37.754 E
1,432.56	90.00	0.00	800.00	927.66	0.00	927.66	0.00	22° 35' 10.141 N	25° 1' 37.711 E
1,463.04	90.00	0.00	800.00	958.14	0.00	958.14	0.00	22° 35' 11.127 N	25° 1' 37.668 E
1,493.52	90.00	0.00	800.00	988.62	0.00	988.62	0.00	22° 35' 12.112 N	25° 1' 37.626 E
1,524.00	90.00	0.00	800.00	1,019.10	0.00	1,019.10	0.00	22° 35' 13.098 N	25° 1' 37.583 E
1,554.48	90.00	0.00	800.00	1,049.58	0.00	1,049.58	0.00	22° 35' 14.083 N	25° 1' 37.540 E
1,584.96	90.00	0.00	800.00	1,080.06	0.00	1,080.06	0.00	22° 35' 15.069 N	25° 1' 37.498 E

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Database:	TLOS	Local Co-ordinate Reference:	Site Horizontal
Company:	Horizontal	TVD Reference:	Mean Sea Level (System)
Project:	Horizontal	MD Reference:	Mean Sea Level (System)
Site:	Horizontal	North Reference:	Grid
Well:	Horizontal	Survey Calculation Method:	Minimum Curvature
Wellbore:	Horizontal		
Design:	Horizontal Well		

Planned Survey

Measured Depth (m)	Inclination (°)	Azimuth (°)	Vertical Depth (m)	+N/-S (m)	+E/-W (m)	Map Northing (m)	Map Easting (m)	Latitude	Longitude
1,615.44	90.00	0.00	800.00	1,110.54	0.00	1,110.54	0.00	22° 35' 16.054 N	25° 1' 37.455 E
1,645.92	90.00	0.00	800.00	1,141.02	0.00	1,141.02	0.00	22° 35' 17.040 N	25° 1' 37.412 E
1,676.40	90.00	0.00	800.00	1,171.50	0.00	1,171.50	0.00	22° 35' 18.025 N	25° 1' 37.370 E
1,692.45	90.00	0.00	800.00	1,187.55	0.00	1,187.55	0.00	22° 35' 18.544 N	25° 1' 37.347 E

Annex (1-3)

Data sheet selection: Plate Heat Exchanger- Seawater/ chilled water

SONDEX®
by Danfoss

	Att:	Item: 23	V1240ASI
Quotation no. : 001	Ref:		Jary 17, 2018

PHE-Type	A188-IS25-610-TLXA		Hot side	Cold side
Flowrate	(m3/h)		804.35	641.12
Inlet temperature	(°C)		12.00	4.00
Outlet temperature	(°C)		6.00	11.70
Pressure drop	(bar)		0.73	0.51
Heat exchanged	(kW)		5626	
Thermodynamic properties:			Water	Sea Water
Density	(kg/m³)		999.60	1,020.33
Specific heat	(kJ/kg*K)		4.20	4.02
Thermal conductivity	(W/m*K)		0.58	0.58
Mean viscosity	(mPa*s)		1.36	1.32
Wall viscosity	(mPa*s)		1.41	1.32
Fouling factors	(m²*K/kW)		0,0003	0,0003
Dimensioning factor	(%)		0.3	
Inlet branch			F1	F3
Outlet branch			F4	F2

Design of Frame / Plates:		
Plate arrangement (passes*channel)		1 × 305 + 0 × 0
Plate arrangement (passes*channel)		1 × 304 + 0 × 0
Number of plates		610
Effective heat surface	(m²)	1,193.81
Overall K-value Duty/Clean	(W/m²*K)	5259 / 5276
Plate material		0.7 mm TITAN
Gasket material / Max. temp.	(°C)	NITRIL SONDER LOCK (S) / 110
Max. design temperature	(°C)	100.00
Max. Working/test pressure	(bar)	20,00 / 26,00
Max. Differential pressure	(bar)	20.00
Frame type / Paint Specification		IS / Category C2L BLUE RAL 5010
Connections HOT side		DN 300 Flange cladded with Titan PN25
Connections COLD side		DN 300 Flange cladded with Titan PN25
Liquid volume	(liter)	4446
Frame length	(mm)	5270 Max. No. of Plates 737
Net / Operating weight	(kg)	10825 / 15315
PRICE EACH	**EUR**	

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This Heat exchanger is certified by the AHRI Liquid to Liquid Heat Exchangers Certification Program, based on AHRI standard 400. AHRI certified units are subject to rigorous and continuous testing, have performance ratings independently measured and are third party verified. Certified units may be found in the AHRI Directory at www.ahridirectory.org

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Part 2

The Economic and Financial Study

2. The Economic and Financial Study

2.1. The Economic Section (New Alamein City)

2.1.1. Introduction

The economic and financial study for New Alamein City has taken into consideration the technology proposed which is based on calculated estimates of the capacity loads. Thus, the study proposes the optimal capacity that results in an economically feasible project.

The estimated load capacity was built based on 10,863 ToR stations that includes a mix use of absorption chillers and a large thermal storage unit, in addition to the use of thermal storage for more energy efficiency. The total investment cost including the construction of the civil and electromechanical works reached USD 53,322,500 Million (the equivalent of EGP 0.95 Billion).

It is worth noting that the piping distribution network was not included in the study because it is beyond the scope of the B.O.O. developer.

The tariff structure was based on industry norm in similar B.O.O. projects which are divided into 3 main divisions:

1. ***Connection charge*** which is mainly payable once and upfront upon contracting with the contracted customer of energy which is was estimated at 10% of the total investment cost of the station.
2. ***Capacity charge*** which is calculated based on a minimum capacity dedicated to each specific customer multiplied by the set tariff.
3. ***Consumption charge*** which is the actually consumed energy per ton per hour.

The suggested tariff of EGP 9.4/TR/hr, takes into account the market rates and the breakeven point of the plant.

The financing scheme of the project was assumed based on the following structure:

Source of Funding	%	Amount	
		USD	EGP
Connection Charge – Advance Payment	10%	5,132,250	91,354,050
Equity	30%	18,404,068	327,592,406
Debt	60%	30,793,500	548,124,300

The assumed interest rate for the debt is 18% fixed rate (the current prevailing rates are corridor which is equivalent to 19% +2% and the corridor rate is forecasted to drop further to reach 14% during 2018) The debt tenor period is estimated to be 10 years with 2 years grace period with interest capitalized during this period.

The annual revenues starting the 1st year of operation shall be EGP 355.4 Million, then reach EGP 467.3 Million in 8th year then stabilizes onwards.

The net profit after taxes in 1st year of operation is EGP 190.8 million and escalates to reach EGP 300.1 Million in the 12th year and stabilizes onwards.

All the operating expenses were based on the technical data provided in the technical study and using their current rates and fixed through the projection period as per the industry norm all increases in the utilities and operation expenses are passed through to the end consumer.

The resulted returns of the project is as follows

Project IRR	**28.5%**
NPV	**EGP 392,871,741**
Payback period (Years)	**4.0**
Discounted Payback period (Years)	**7.2**
Breakeven point in ToR	**29,762,952**
Breakeven point in Amount	**EGP 278,283,601**

2.1.2. Basic Assumptions

2.1.2.1. Investment Cost

The main equipment needed in this plant to produce a total of TOR 60,000 are 36 electric centrifugal chillers, 36 absorption chillers and 2 thermal storage tanks which a total investment cost of USD 158.7 Million (equivalent to EGP 2.825 Billion) which its breakdown as follows:

Major Equipment	Quantity	Cost per Unit		Total Cost	
		USD	EGP	USD	EGP
Absorption Chillers	4	1,200,000	21,360,000	4,800,000	85,440,000
Thermal Storage Tank	2	2,040,000	36,312,000	4,080,000	72,624,000
Seawater Pumps	6	400,000	7,120,000	2,400,000	42,720,000
Primary chilled water pump	6	500,000	8,900,000	3,000,000	53,400,000
Secondary chilled water pumps	8	100,000	1,780,000	800,000	14,240,000
Others Equipment (HDD supply/return/misc				21,356,000	472,946,000
Subtotal				**32,770,000**	**583,306,000**

The total estimated budget for the construction cost for the plant erection is estimated at USD 1.25 million (equivalent to EGP 27.8 Million)

Due to the nature of the uncertainty of the estimated cost, the study took into consideration a higher contingency budget of 25% of the total equipment and construction costs which is translated to an amount of USD 8.1 Million (the equivalent of EGP 144.3 Million)

This resulted in a total station cost of USD 51.3 Million (the equivalent of EGP 0.9 Billion)

The station land area requirement is estimated at 2000 m^2 with an estimated cost per sqm of USD 1000 giving a total land cost of USD 2 Million (the equivalent of EGP 35.6 Million)

Considering the above capital expenditure, the total investment cost of the project shall be around USD 53.3 Million (the equivalent of EGP 0.95 Billion)

The estimated construction period is 2 years.

The depreciation and interest capitalization schedule assumed is as follows:

Depreciation Schedule	Depreciation Rate	Depreciation Period in years
Construction & Installations	2.0%	50
Equipment	4.0%	25

2.1.2.2. Sources and Usage of Funds

The study has calculated the sources and usage of the projects as per the following table:

Sources of Funds			Usage of Funds	
Loans	**60%**	**548,124,300**	Land	**35,600,000**
			Construction &	
Year 0		548,124,300	Installations	**172,170,500**
Year 1		-	Equipment	**741,370,000**
Year 2			Network Installation	-
			Working Capital	-
Advanced Payment	**10%**	**91,354,050**		
Year 0		91,354,050	Year 0	-
Year 1			Year 1	-
Year 2			Year 2	-
Equity Injection	**30%**	**327,592,406**	Pre-operating Expenses	**2,350,037**
Year 0		327,592,406	OPEX for 1st Year	**15,580,219**
Year 1		-	Cash Buffer	-
Year 2				
TOTAL		**967,070,756**	**TOTAL**	**967,070,756**

Notably, the study has assumed the connection charge to be one of the funding sources to reduce the cost of finance constituting 10% of the funding requirements reaching an amount of EGP 91.3 Million

The bank debt was assumed at 60% of the needed funding amounting to EGP 548.1 Million and the remaining of 30% shall be covered by equity funding of EGP 327.5 Million.

2.1.2.3. Financial Highlights

a) Revenues

The revenues were assumed based on the assumed capacity loads of the plant of 10,863 ToR as illustrated in the following table:

Installed Capacity	ToR	No. of Units
Operation Capacity per Absorption Chillers	1,116	4
Operation Capacity per Thermal Storage	3,200	2

Basic operating Assumptions

	% split of Daily productio
Daily Production for Commercial use	50.00%
Daily Production for Hotels use	30.00%
Daily Production for Public areas use	20.00%
Months Operating	12
Days Operating	365
Yearly working hours	8,760
EFLH per year @ 34%	**4,800 hrs**
Min Take in ToR	**18,000,000**

The Minimum Charge Breakdown

Capacity Charge (Minimum charge) in ToR		
Commercial	9,000,000	
Hotels	5,400,000	
public areas	3,600,000	
Total Load Capacity in Hrs	**18,000,000**	
Price per Tariff TR/Hour	**USD**	**EGP**
Commercial	0.53	9.4
Administrative	0.53	9.4
Residential	0.53	9.4
Capacity Charge (Minimum charge) in EGP		
Commercial	84,150,000	
Administrative	50,490,000	
Residential	33,660,000	
Total Minimum Charge in EGP	**168,300,000**	

b) Breakeven Analysis

In calculating the breakeven point, the study assumed the Profit-volume analysis approach which resulted in the following analysis table:

Volume in Units	52,144,000	
Price per Tariff TR/Hour	5.62	
Total Sales	293,161,244	1
Connection Charge	91,354,050	2
Total In cash from selling	384,515,294	3 = (1+2)
Variable Costs		
Total Electricity Cost	11,999,877	
Total Natural Gas Cost	3,346,322	
Total Water Cost	-	
General & Administrative	350,000	

Other Operating Expenses	18,966,155	
Total Variable Costs	**34,662,354**	**4**

Contribution Margin	**349,852,940**	**3-4**

Fixed Costs	
Direct Manpower Costs	1,510,686
Total Electricity Cost	2,999,969
Total Natural Gas Cost	371,814
Total Water Cost	-
General & Administrative	150,000
Insurance	27,406,215
Depreciation	56,640,303
Loan Repayment	169,419,903
Total Fixed Costs	**258,498,890**

Total Cost	**293,161,244**

Profits	**91,354,050**

Unit selling price	9.35
unit variable costs	0.7
Unit contribution margin (UCM)	8.69
contribution margin Ratio (CMR)	93%
Fixed costs (Min. Take In Capacity)	258,498,890

Breakeven point in units	**29,762,952**
Breakeven point in Value	**278,283,601**

Target unit Value	278,283,601
Target Price	9.35

Min Take in ToR	**23,241,521**

c) Cost of Operations

The main costs incurred for producing the required energy is illustrated in the table below:

A	**Electricity Cost**	
	Seawater pumps	
	Average electricity consumption in Kw per TR	240 (Kw per TR)
	No. of pumps	6

	Primary chilled water pumps	
	Average electricity consumption in Kw per TR	35 (Kw per TR)
	No. of pumps	6
	Secondary chilled water pumps	
	Average electricity consumption in Kw per TR	100 (Kw per TR)
	No. of pumps	8
	Average Cost per Kwh	1.50 (EGP)
	Total Electricity Cost in EGP	**14,999,846**

B	**Natural Gas**	
	Average natural gas consumption in Cubic Meter per TR	0.30 (M3 per TR)
	Average Cost per Cubic Meter	2.31 (EGP)
	Total Cost of Natural Gas in EGP	**3,718,135**

C	**Water**	
	Average Water Cubic Meter consumed per TR per Hr	0.00 (M3 per TR)
	Average Cost per Cubic Meter	8.90 (EGP)
	Total Cost of Water in EGP	**0**

D	**Direct Manpower Costs**	**1,510,686**

	TOTAL Cost of Production (COGS)	**20,228,668**
	Average Production Cost per hrs in EGP	**0.94**

d) Gross Profit Margin

The gross profit margin after deducting the cost of operations has shown improvement from 94.3% in Year 3 of operation to reach 95.9% in year 8 onwards.

e) Operating Expenses & profit

The main operating indirect expenses items are chemicals for the network, spare parts for overhauling and maintenance and finally general and admin expenses. All the said items were assumed as a percentage of total investment cost as per ASHRAE standards which is reflected in the following table:

Item	%
Chemicals	**1.0%**

Spare Parts, Overhauling & Maintenance (Machinery)	**0.123%**
Secondary Spare (Bearing, Belts, etc)	**1.0%**
Insurance	**3.0%**
General & Administrative	

f) EBITDA

The project should healthy earnings before interest, taxes, depreciation and amortization (EBITDA), as it achieved EGP 298.4 Million in year 1 of operations and stabilized on EGP 430.3 Million in year 8 of operation.

2.1.2.4. Net Profit

The project should healthy net profit after taxes, as it achieved EGP 250.9 Million in year 1 of operations and stabilized on EGP 307.8 Million in year 12 of operation.

2.1.2.5. Investment Cost

All figures assumed in this project were based on budgetary prices were provided by the technical team who obtained such information from various local and international vendors, suppliers and contractors. The total investment cost of the project was calculated based on the following:

A	**Major Equipment**	**Quantity**	
	Absorption Chillers	4	
	Thermal Storage Tank	2	
	Seawater pumps	6	
	Primary chilled water pumps	6	
	Secondary chilled water pumps	8	
	Cost per Unit	**USD**	**EGP**
	Absorption Chillers	$ 1,200,000	21,360,000
	Thermal Storage Tank	$ 2,040,000	36,312,000
	Major Equipment Costs	**USD**	**EGP**
	Absorption Chillers	4,800,000	85,440,000
	Thermal Storage Tank	4,080,000	72,624,000
	Subtotal Equipment		**158,064,000**
B	Other Equipment	**USD**	EGP
	Seawater pumps	$ 400,000	42,720,000
	Primary chilled water pumps	$ 500,000	53,400,000
	Secondary chilled water pumps	$ 100,000	14,240,000
	HDD piping , supply	$ 17,775,000	395,493,750
	HDD piping, return	$ 3,081,000	68,552,250
	Misc. Mechanical	$ 500,000	8,900,000

		USD	EGP
	Contingency		-
	Subtotal Other Equipment		**583,306,000**
C	**Construction Cost**	**USD**	**EGP**
	General Construction	$ 1,250,000	27,812,500
	Controls (BMS - Instrumentals - Startups - Commissioning)		-
	Contingency	$ 8,110,000	144,358,000
	Construction Fees		-
	Subtotal Construction Cost	**9,360,000**	**172,170,500**
	Total Station Cost	**51,322,500**	**913,540,500**
F	**Land**	**USD**	**EGP**
	Overall Size of Land (sq. mt.)	*2,000*	
	Cost Per sq. mt.	1,000	17,800
	Subtotal Land Cost	**2,000,000**	**35,600,000**
	Total Investment Cost	**53,322,500**	**949,140,500**

2.1.2.6. Sources and Usage of Funds Highlights

Sources and Usage of Funds			
Sources of Funds	**In EGP**	**Deployment of Funds**	**In EGP**
Loans	**2,403,000,000**	Land	**35,600,000**
Year 0	1,201,500,000	Construction & Installations	**1,180,140,000**
Year 1	-	Equipment	**2,824,860,000**
Year 2	1,201,500,000	Network Installation	**-**
		Working Capital	**-**
Advanced Payment	**400,500,000**		
Year 0	400,500,000	Year 0	
Year 1		Year 1	
Year 2		Year 2	
Equity Injection	**1,294,612,277**	Pre-operating Expenses	**2,448,293**
Year 0	693,862,276	OPEX for 1st Year	**55,063,984**
Year 1	-		
Year 2	600,750,000		
TOTAL	**4,098,112,277**	**TOTAL**	**4,098,112,277**

2.1.2.7. Project Returns

Project IRR	***29%***
Equity IRR	***35.8%***
Terminal Growth Rate	***0.00%***
WACC	***19.71%***
NPV	***EGP 417,772,618***
NPV (w/o Terminal Value)	***EGP 378,208,989***
Payback period (Years)	***4.0 years***
Discounted Payback period	***7.0 years***
P/E	***7.00***
Cost of Equity	***21.00%***

The table above, the project shows favourable equity IRR of 29% and project IRR of 36% with a payback period of 4.0 years.

2.1.2.8. Scenarios

The study conducted scenario analyses to stand on the factors affecting the operations of the DC plant. The resulted showed the following:

Sensitivity analysis w.r.t. Price per Tariff TR/Hour	Base Case	Price Down by 5%	Price Down by 10%	Price Down by 15%
Decrease in Price of TR/Hour (% of Base Case)		*5.0%*	*10.0%*	*15.0%*
IRR	29.00%	29.00%	29.00%	29.00%
NPV	417,772,618	417,772,618	417,772,618	417,772,618
Discounted Payback	6.99	6.99	6.99	6.99

Rest all parameters remaining constant;

Sensitivity analysis w.r.t. Cost of Electricity & Natural gas	Base Case	Cost up by 5%	Cost up by 10%	Cost up by 15%
Increase in Price of Electricity & Natural gas (% of Base Case)		*5.0%*	*10.0%*	*15.0%*
IRR	29.00%	28.93%	28.87%	28.80%
NPV	417,772,618	414,880,278	411,987,918	409,095,538
Payback	6.99	7.02	7.05	7.08

Rest all parameters remaining constant;

Sensitivity analysis w.r.t. Equity Finance	Base Case	Equity up by 5%	Equity up by 10%	Equity up by 15%
Equity Finance (% of Total investment costs)		*5.0%*	*10.0%*	*15.0%*
IRR	29.00%	28.84%	28.68%	28.52%
NPV	417,772,618	403,028,535	388,686,040	374,704,090
Payback	6.99	7.11	7.24	7.36

Rest all parameters remaining constant;

From the tables above, it is evident that the project is less sensitive to tariffs reduction, yet opex increases mildly affects its returns as well as the increase in equity portion in the funding scheme of the project.

THE MAIN NOTE IN THIS PROJECT IS THE IMPORTANCE TO OPTIMIZE THE INFRASTRUCTURE OF SEAWATER PUMPS AND THEIR ASSOCIATED EXCAVATION COSTS VERSUS THE INSTALLED

CAPACITY OF THE CHILLERS TO PRODUCE THE MOST OUTPUT REQUIRED TO ACHIEVE THE MENETIONED CAPACITY.

2.1.2.9. Comparison between District Cooling Plant and Individual Cooling System

The study has conducted a comparative study for a typical user/client to compare between installing Central Chilled Water system in the individual buildings of the Project namely, mixed use between Residential Buildings, hotels and Commercial Building.

The essence of the comparison investigates the Capital Expenditure on the Equipment and network installations with its associated financing cost in addition to its operation expenses, versus paying for a service provided by District Cooling Plant that involves paying Connection, Capacity and Consumptions charges only.

After calculating the cost incurred by the user in both scenarios, we calculate their Net Present Value to reach a conclusion on the saving achieved.

The end result showed positive results in favour of the district cooling plant with an NPV of EGP 1.5 billion versus an NPV of EGP 1.7 billion for individual building chillers, making the DC plant less costly than the individual building chillers.

2.2. The Economic Section (Capital One – New Capital)

2.2.1. Introduction

The economic and financial study was built based on 60,000 ToR stations that includes a mix use of electric and absorption chillers, in addition to the use of thermal storage for more energy efficiency. The total investment cost including the construction of the civil and electromechanical works reached USD 230 Million (the equivalent of EGP 4.1 Billion).

It is worth noting that the piping distribution network was not included in the study because it is beyond the scope of the B.O.O. developer.

The tariff structure was based on industry norm in similar B.O.O. projects which are divided into 3 main division:

1. ***Connection charge*** which is mainly payable once and upfront upon contracting with the contracted customer of energy which is was estimated at 10% of the total investment cost of the station.
2. ***Capacity charge*** which is calculated based on a minimum capacity dedicated to each specific customer multiplied by the set tariff.
3. ***Consumption charge*** which is the actually consumed energy per ton per hour.

The suggested tariff of EGP 7/TR/hr, takes into account the market rates and the breakeven point of the plant.

The financing scheme of the project was assumed based on the following structure:

Source of Funding	%	Amount	
		USD	EGP
Connection Charge – Advance Payment	10%	22,500,000	400,500,000
Equity	30%	72,731,027	1,294,612,277
Debt	60%	135,000,000	2,403,000,000

The assumed interest rate for the debt is 18% fixed rate (the current prevailing rates are corridor which is equivalent to 19% +2% and the corridor rate is forecasted to drop further to reach 14% during 2018) The debt tenor period is estimated to be 10 years with 2 years grace period with interest capitalized during this period.

The annual revenues starting the 3rd year of operation shall be EGP 1.5 Billion, then reach EGP 2 Billion in 10th year then stabilizes at EGP 2.4 Billion in the 14th year.

The net profit after taxes in 3rd year of operation is EGP 570 million and escalates to reach EGP 997 Million in the 10th year, and peaks to EGP 1.461 Billion in year 14th year of operation.

All the operating expenses were based on the technical data provided in the technical study and using their current rates and fixed through the projection period as per the industry norm all increases in the utilities and operation expenses are passed through to the end consumer.

The resulted returns of the project is as follows

Project IRR	**30%**
NPV	**EGP 1,697,260,318**
Payback period (Years)	**4.8**
Discounted Payback period (Years)	**7.4**
Breakeven point in ToR	**132,387,063**
Breakeven point in Amount	**EGP 926,709,440**

1.1.1. Basic Assumptions

1.1.1.1. Investment Cost

The main equipment needed in this plant to produce a total of TOR 60,000 are 36 electric centrifugal chillers, 36 absorption chillers and 2 thermal storage tanks which a total investment cost of USD 158.7 Million (equivalent to EGP 2.825 Billion) which its breakdown as follows:

Major Equipment	Quantity	Cost per Unit		Total Cost	
		USD	EGP	USD	EGP
Electrical Centrifugal Chillers	36	1,687,500	30,037,500	60,750,000	1,081,350,000
Absorption Chillers	36	1,687,500	30,037,500	60,750,000	1,081,350,000
Thermal Storage Tank	2	18,600,000	331,080,000	37,200,000	662,160,000
Subtotal				**158,700,000**	**2,824,860,000**

The total estimated budget for the construction cost for the plant erection is estimated at USD 45 million (equivalent to EGP 801 Million)

The study took into consideration a contingency budget of 10% of the total equipment and construction costs which is translated to an amount of USD 21.3 Million (the equivalent of EGP 379.1 Million)

This resulted in a total station cost of USD 225 Million (the equivalent of EGP 4 Billion)

The station land area requirement is estimated at 2000 m^2 with an estimated cost per sq.m of USD 1000 giving a total land cost of USD 2 Million (the equivalent of EGP 35.4 Million)

Considering the above capital expenditure, the total investment cost of the project shall be around USD 230 Million (the equivalent of EGP 4.147 Billion)

The estimated construction period is 2 years.

The depreciation and interest capitalization schedule assumed is as follows:

Depreciation Schedule	Depreciation Rate	Depreciation Period in years
Construction & Installations	2.0%	50
Equipment	4.0%	25

1.1.1.2. Sources and Usage of Funds

The study has calculated the sources and usage of the projects as per the following table:

Sources of Funds			Usage of Funds	
Loans	**60%**	**2,403,000,000**	Land	**35,600,000**
Year 0		1,201,500,000	Construction & Installations	**1,180,140,000**
Year 1		-	Equipment	**2,824,860,000**
Year 2		1,201,500,000	Network Installation	**-**
			Working Capital	**-**
Advanced Payment	**10%**	**400,500,000**		
Year 0		400,500,000	Year 0	**-**
Year 1			Year 1	**-**
Year 2			Year 2	**-**
Equity Injection	**30%**	**1,294,612,277**	Pre-operating Expenses	**2,448,293**
Year 0		693,862,276.50	OPEX for 1st Year	**55,063,984**
Year 1		-	Cash Buffer	**-**
Year 2		600,750,000.00		
TOTAL		**4,098,112,277**	**TOTAL**	**4,098,112,277**

Notably, the study has assumed the connection charge to be one of the funding sources to reduce the cost of finance constituting 10% of the funding requirements reaching an amount of EGP 0.4 billion

The bank debt was assumed at 60% of the needed funding amounting to EGP 2.403 billion and the remaining of 30% shall be covered by equity funding of EGP 1.294 billion.

1.1.1.3. Financial Highlights

a) Revenues

The revenues were assumed based on the assumed capacity loads of the plant of 60,000 ToR as illustrated in the following table:

Installed Capacity	ToR	No. of Units
Operation Capacity per Electrical Centrifugal Chillers	1,000	36
Operation Capacity per Absorption Chillers	1,500	36
Operation Capacity per Thermal Storage	15,000	2

Basic operating Assumptions		The Minimum Charge Breakdown		
	% split of daily production	**Capacity Charge (Minimum charge) in ToR**		
		Commercial	57,500,000	
		Hotels	34,500,000	
Daily Production for Commercial use	50.00%	public areas	23,000,000	
Daily Production for Hotels use	30.00%	**Total Load Capacity in Hrs**	**115,000,000**	
Daily Production for Public areas use	20.00%			
Months Operating	12	**Price per Tariff TR/Hour**	**USD**	**EGP**
Days Operating	365	Commercial	0.39	7.0
Yearly working hours	8,760	Administrative	0.39	7.0
		Residential	0.39	7.0
		Capacity Charge (Minimum charge) in EGP		
EFLH per year @ 34%	**3,000 hrs**	Commercial	02,500,000	
Min Take in ToR	**115,000,000**	Administrative	41,500,000	
		Residential	161,000,000	
		Total Minimum Charge; EGP	**805,000,000**	

b) Breakeven Analysis

In calculating the breakeven point, the study assumed the Profit-volume analysis approach which resulted in the following analysis table:

Volume in Units	360,000,000	
Price per Tariff TR/Hour	1.73	
Total Sales	623,966,385	1
Connection Charge	400,500,000	2
Total In cash from selling	1,024,466,385	3= (1+2)
Variable Costs		
Total Electricity Cost	40,478,054	
Total Natural Gas Cost	42,172,650	
Total Water Cost	14,097,600	
General & Administrative	350,000	
Other Operating Expenses	57,517,250	
Total Variable Costs	**154,615,554**	**4**
Contribution Margin	**869,850,831**	**3-4**
Fixed Costs		
Direct Manpower Costs	2,923,116	
Total Electricity Cost	10,119,514	
Total Natural Gas Cost	4,685,850	
Total Water Cost	3,524,400	
General & Administrative	150,000	

Insurance	60,075,000
Depreciation	119,903,363
Loan Repayment	668,469,588
Total Fixed Costs	**869,850,831**

Total Cost	1,024,466,385

Profits	**-**

Unit selling price	7.00
unit variable costs	0.4
Unit contribution margin (UCM)	6.57
contribution margin Ratio (CMR)	94%
Fixed costs (Min. Take In Capacity)	869,850,831

Breakeven point in units	**132,387,063**
Breakeven point in Value	**926,709,440**

Target unit Value	926,709,440
Target Price	**7.00**

Min Take in ToR	**114,138,355**

c) Cost of Operations

The main costs incurred for producing the required energy is illustrated in the table below:

A	**Electricity Cost**	
	Cooling towers pumps Electrical Centrifugal Chillers	
	Average electricity consumption in Kw per ToR	140 (Kw per ToR)
	No. pumps	18
	Annual electricity consumption	3,780,000
	Cooling towers pumps Absorption Chillers	
	Average electricity consumption in Kw per ToR	80 (Kw per ToR)
	No. pumps	18
	Annual electricity consumption	2,160,000
	Primary chilled water pumps	
	Average electricity consumption in Kw per ToR	70 (Kw per ToR)
	No. pumps	36
	Annual electricity consumption	3,780,000
	Secondary chilled water pumps	
	Average electricity consumption in Kw per ToR	350 (Kw per ToR)
	No. pumps	12
	Annual electricity consumption	6,300,000
	Centrifugal chillers electric consumption	
	Average electricity consumption in Kw per ToR	0.33 (Kw per ToR)
	Annual electricity consumption	17,820,000
	Average Cost per Kwh	1.50 (EGP)
	Total Electricity Cost	**50,597,568**

B	**Natural Gas**	
	Average natural gas consumption in Cubic Meter per ToR	0.25 (M3 per ToR)
	Annual natural gas consumption	20,250,000
	Average Cost per Cubic Meter	2.31 (EGP)
	Total Natural Gas Cost	**46,858,500**

C	**Water**	
	Average Water Cubic Meter consumed per ToR per Hr	0.06 (M3 per ToR)
	Annual Water consumption	7,615,385
	Average Cost per Cubic Meter	2.31 (EGP)
	Total Water Cost	**17,622,000**

D	**Direct Manpower Costs**	**2,923,116**

TOTAL Cost of Energy Produced in EGP	**118,001,184**
Average Production Cost per hrs in EGP	**0.87**

d) Gross Profit Margin

The gross profit margin after deducting the cost of operations has shown improvement from 85% in Year 3 of operation to reach 90% in year 14.

e) Operating Expenses & profit

The main operating indirect expenses items are chemicals for the network, spare parts for overhauling and maintenance and finally general and admin expenses. All the said items were assumed as a percentage of total investment cost as per ASHRAE standards which is reflected in the following table:

Item	%
Chemicals	**1.0%**
Spare Parts, Overhauling & Maintenance (Machinery)	**0.123%**
Secondary Spare (Bearing, Belts, etc)	**1.0%**
Insurance	**3.0%**
General & Administrative	

f) EBITDA

The project should healthy earnings before interest, taxes, depreciation and amortization (EBITDA), as it achieved EGP 1.1 billion in year 3 of operations and stabilized on EGP 2.0 billion in year 14 of operation.

1.1.1.4. Net Profit

The project should healthy net profit after taxes, as it achieved EGP 0.5 billion in year 3 of operations and stabilized on EGP 1.46 billion in year 14 of operation.

1.1.1.5. Investment Cost

All figures assumed in this project were based on budgetary prices were provided by the technical team who obtained such information from various local and international vendors, suppliers and contractors. The total investment cost of the project was calculated based on the following:

Major Equipment	Quantity	
Electrical Centrifugal Chillers	36	
Absorption Chillers	36	
Thermal Storage Tank	2	

Cost per Unit	USD	EGP
Electrical Centrifugal Chillers	1,687,500	30,037,500
Absorption Chillers	1,687,500	30,037,500
Thermal Storage Tank	18,600,000	331,080,000

Major Equipment Costs	USD	EGP
Electrical Centrifugal Chillers	60,750,000	1,081,350,000

	USD	EGP
Absorption Chillers	60,750,000	1,081,350,000
Thermal Storage Tank	37,200,000	662,160,000
Subtotal Equipment	**158,700,000**	**2,824,860,000**

Construction Cost	**USD**	**EGP**
General Construction	45,000,000	801,000,000
Contingency	21,300,000	379,140,000
Construction Fees		-
Subtotal Construction	**66,300,000**	**1,180,140,000**
Total Station Cost	**225,000,000**	**4,005,000,000**

Land	**USD**	**EGP**
Overall Size of Land (sq. mt.)	2,000	
Cost Per sq. mt.	$ 1,000	17,800
Subtotal Land Cost	**2,000,000**	**35,600,000**
Total Investment Cost	**227,000,000**	**4,040,600,000**

1.1.1.6. Sources and Usage of Funds Highlights

Sources and Usage of Funds			
Sources of Funds	**In EGP**	**Deployment of Funds**	**In EGP**
Loans	**2,403,000,000**	Land	**35,600,000**
Year 0	1,201,500,000	Construction & Installations	**1,180,140,000**
Year 1	-	Equipment	**2,824,860,000**
Year 2	1,201,500,000	Network Installation	-
		Working Capital	-
Advanced Payment	**400,500,000**		
Year 0	400,500,000	Year 0	
Year 1		Year 1	
Year 2		Year 2	
Equity Injection	**1,294,612,277**	Pre-operating Expenses	**2,448,293**
Year 0	693,862,276	OPEX for 1st Year	**55,063,984**
Year 1	-		
Year 2	600,750,000		
TOTAL	**4,098,112,277**	**TOTAL**	**4,098,112,277**

1.1.1.7. Project Returns

Project IRR	***30.48%***

Equity IRR	*42.66%*
Terminal Growth Rate	*0.00%*
WACC	*19.48%*
NPV	*EGP 1,697,260,318*
NPV (w/o Terminal Value)	*EGP 1,501,784,359*
Payback period (Years)	*4.8 years*
Discounted Payback period	*7.40 years*
P/E	*7.00*
Cost of Equity	*21.00%*

The table above, the project shows favourable equity IRR of 42% and project IRR of 30% with a payback period of 4.8 years.

1.1.1.8. Scenarios

The study conducted scenario analyses to stand on the factors affecting the operations of the DC plant. The resulted showed the following:

Sensitivity analysis w.r.t. Price per Tariff TR/Hour	Base Case	Price Down by 5%	Price Down by 10%	Price Down by 15%
Decrease in Price of TR/Hour (% of Base Case)		*5.0%*	*10.0%*	*15.0%*
IRR	30.48%	28.90%	27.31%	25.72%
NPV	1,697,260,318	1,459,659,144	1,221,656,458	983,228,902
Discounted Payback	7.40	8.01	8.79	9.78

Rest of all parameters remaining constant;

Sensitivity analysis w.r.t. Cost of Electricity & Natural gas	Base Case	Cost up by 5%	Cost up by 10%	Cost up by 15%
Increase in Price of Electricity & Natural gas (% of Base Case)		*5.0%*	*10.0%*	*15.0%*
IRR	30.48%	30.29%	30.11%	29.93%
NPV	1,697,260,318	1,671,521,466	1,645,781,610	1,620,040,774
Payback	7.40	7.47	7.54	7.62

Rest of all parameters remaining constant;

Sensitivity analysis w.r.t. Equity Finance	Base Case	Equity up by 5%	Equity up by 10%	Equity up by 15%
Equity Finance (% of Total investment costs)	*0.0%*	*5.0%*	*10.0%*	*15.0%*
IRR	30.48%	30.29%	30.11%	29.93%
NPV	1,697,260,318	1,636,465,134	1,577,573,702	1,520,390,034
Payback	7.40	7.52	7.64	7.76

From the tables above, it is evident that the project is most sensitive to tariffs reduction, comes next the utility cost increases and the increase in equity portion in the funding scheme of the project.

1.1.1.9. Comparison between District Cooling Plant and Individual Cooling System

The study has conducted a comparative study for a typical user/client to compare between installing Central Chilled Water system in the individual buildings of the Project namely, mixed use between Residential Buildings and Commercial Building.

The essence of the comparison investigates the Capital Expenditure on the Equipment and network installations with its associated financing cost in addition to its operation expenses, versus paying for a service provided by District Cooling Plant that involves paying Connection, Capacity and Consumptions charges only.

After calculating the cost incurred by the user in both scenarios, we calculate their Net Present Value to reach a conclusion on the saving achieved.

The end result showed positive results in favor of the district cooling plant with an NPV of EGP 5.9 billion versus an NPV of EGP 9.3 billion for the individual building chillers, making the DC plant less costly than the individual building chillers.

Part 3

National Institutional and Regulatory Framework for District Cooling in Egypt

3. National Institutional and Regulatory Framework for The District Cooling in Egypt

2.1. Introduction

This project was approved for implementing by UNIDO, as lead agency, and UN-Environment, as cooperating agency, and aims to provide a detailed technical, financial as well as environmental and energy assessment / Roadmap for the government of Egypt, in the development of district cooling systems. Issuing the regulatory and institutional framework in Egypt is also focused.

The project had been managed by a National Steering Committee, led by the Ministry of Environment, with representation from NOU/EEAA (Egyptian Environmental Affairs Agency), Ministry of Housing, Utilities and Urban Communities, The Housing & Building National Research Center (HBRC) and local experts as well as UNEP and UNIDO as advising members. The Committee decided that the Housing & Building National Research Center (HBRC) of Egypt, which is a government entity the Ministry of Housing, Utilities and Urban Communities of Egypt; is the best positioned regional body to undertake the development of the institutional and regulatory framework component of the project due its technical resources as well as being responsible for issuing the national buildings and engineering codes including the codes of refrigeration and air-conditioning and the code of district cooling.

The project aims to provide a detailed technical, financial as well as environmental and energy assessment in the development of district cooling systems in Egypt. The feasibility study will focus on new cities being built in Egypt with specific attention to the new capital (exact venues to be selected), which in total will have a span of 700sq km and have 21 residential districts and 25 dedicated districts. The project will develop, technical and financial feasibility studies for the selected locations, for utilizing district cooling facilities that operate with not-in-kind technologies i.e. non-vapour compression systems. The new El Alamein city is the second site that selected by the committee for developing the district cooling system with the deep sea cooling technique as the suitable not-in-kind technology for this project.

The committee is responsible for the followings:
Managing the two projects in all its stages including agreement on the project plan.
Selecting and setting criteria for evaluating the locations.
Checking the technicalities for every site where the district cooling systems will be applied.
Setting the TORs for the technical and financial feasibility.
Managing the process of drafting the regulatory and institutional framework as well as advocate the final results amongst decision makers and respective authorities in Egypt.
Considering of the proposed suggestions from the possible financial partners that can support the after-study stage.
Inviting the experts/authorities for consultation during the implementation of the project.
Revising the progress reports regularly and giving advice for the project coordinators.
Revising, commenting and confirmation on the final report for the study of this project.

Proposal for the plan:

- Setting the implementation steps and standards for choosing the sites
- Setting the technicalities for testing the feasibility study and its implementation
- The completion from terms of reference for the study of the institutional regulatory framework
- Workshop and a top official meeting for the stakeholders and the investors and technology presenters to represent the project.
- First draft for the technicalities used in each site
- First draft for the institutional regulatory framework in each site
- Final draft for the institutional organizational framework
- Workshop and a consultation meeting for the stakeholders to present their notes on the project
- Final report for the whole project
- Workshop and top official meeting for the decision makers for the awareness of the test results.

The objective of the current report is to benefit from the technical expertise of HBRC and the formed technical committee to develop the final report for national regulatory and institutional framework for district cooling in Egypt of the project of Feasibility Study **Not-In-Kind** for district cooling in Egypt.

2.2. Compilation and analyses of local and international relevant codes and regulations

This includes the followings:

- Compilation of local and international codes/regulations.
- Analyzing the gaps of the existing framework.
- Identification of requirements for local institutional & regulatory framework.

2.2.1. Compilation of local and international codes and regulations

This includes collecting all relevant local and international district cooling codes as well as relevant regulatory frameworks that governs the buildings and construction sectors from A5 and non-A5 countries. It also includes compile technical information on relevant technical solutions chosen for the demonstration of district cooling systems such as fluorocarbon chillers, not-in-kind cooling, distribution-piping network, load interface techniques, energy calculation method, etc.
Technical data from regulatory framework of district cooling in Singapore, Hong Kong and Egypt had been gathered as described in details hereinafter.

2.2.1.1. Regulatory framework of Singapore district cooling

The District Cooling Act was legislated in 2002.

- **Price of the new utility service**

The legislation, administered by the Energy Market Authority of Singapore, requires that the new utility service be priced at a level no higher than the equivalent costs of chilled water production in conventional in building plants employing similar technology.

- **Costs of the service connection facilities**

The costs of the service connection facilities, which include the heat exchangers, metering/control equipment and connection pipes to the Chilled Water Piping Network, are borne directly by the customer but the installation and maintenance of the facilities are undertaken by SDC. SDC bears the costs of upstream piping network and the district cooling plants as infrastructure costs which are translated into recurring monthly Contract Capacity Charges levied on the customers.

- **Responsibility of the Service Provider**

The Service Provider shall, at its own costs, be responsible for planning, designing, constructing, installing, testing, commissioning, operating and maintaining the District Cooling System and Service Connection Facilities (but without prejudice to the Consumer's payment obligations). The Service Provider shall notify the Consumer immediately if there is any unexpected significant change in the operating status of the District Cooling System or if any interruption is expected to occur. The Service Provider shall secure that the District Cooling System is fully operational to provide the Supply in accordance with the Supply Agreement by the Target Supply Date and will provide the Supply to the Consumer throughout the Contract Duration in accordance with the terms of the Supply Agreement.

- **Responsibility of the Consumer**

The Consumer shall not install any independent chilled water production facilities in the Premises for the purpose of space cooling at the Premises unless otherwise agreed to in writing.
The Consumer shall not supply the Service to any building Other than agreed buildings. the consumer may notify the service provider in writing to increase the contract capacity to the amount mentioned in this notice and the service provider shall do its best to accommodate the consumer's request provided that:

a- The amount of the increase in the nodal capacity shall not exceed 10% of the prevailing decimal capacity without the consent of the service provider.

b- If the increase in the nodal capacity requires the modernization of service delivery facilities, the consumer must pay the cost of this upgrade work.

The Service Provider shall make available to the Consumer the increased capacity requested by the Consumer within 12 months of the request being made.
Chilled water supply temperature is regulated at 6.0ºC +0.5ºC. The customer is required to adopt "variable flow" design for its downstream reticulation so as to achieve a return temperature higher than 14ºC. If the hourly average supply temperature exceeds 6.5ºC, SDC pays a rebate that is twice the equivalent hourly rate for Contract Capacity Charge. Similarly, if the monthly average return temperature falls below 14 ºC, the customer pays a surcharge on the Usage Charge, also a filtration system for the return water to the Heat Exchanger with a minimum filtration performance of 200 microns, and a pressure relief device at the interfacing connection set to operate at a pressure at or below 16 bar.
The chilled water tariffs are regulated by Energy Market Authority (EMA) and the tariff rates are reviewed at half-yearly intervals. There are five components as follows:

(Contract Capacity Charge, Usage Charge, Capacity Overrun Charge, Return Temperature Adjustment and Supply Deficiency Rebate)

The Consumer shall provide and construct the Intake Station in accordance with the plans and specifications agreed by the Parties. The Consumer shall maintain the Intake Station inclusive of the building structure, infrastructure, mechanical and electrical services within the Intake Station and general cleanliness of the Intake Station.

The District Cooling Service shall be measured by metering equipment of a type approved by the Authority. The metering equipment shall be supplied, installed, calibrated and maintained by the Service Provider,

- **Testing of meter**

The metering equipment shall at all times be accurate to a tolerance of ± 3% and its accuracy shall be verified at periodic intervals not exceeding five years. In case of inaccurate meter, the Service Provider shall repair, re-calibration or replacement of such meter. The costs of any testing of any meter requested by the Consumer shall be borne by the Consumer unless such testing reveals that the meter is inaccurate beyond the permitted tolerance of error in which case the costs shall be borne by the Service Provider. The Service Provider shall make a fair and reasonable estimate of the amount of District Cooling Service provided to the Consumer during the period when the meter was faulty or inaccurate.

- **The provisions of this Act**

(a) Exercise licensing ,

(b) To protect the interests of consumers in respect of: (the prices charged and other terms of supply of district cooling services; the quality of district cooling services and the continuity reliability of district cooling services).

(c) No person shall provide district cooling services to any service area unless he is authorized to do so by a license.

(d) The license may be granted to any person, class of persons or a particular person (to deal with any public emergency; to pay to the Authority a fee for the grant of the license or to pay to it periodic fees for the duration of the license, or both, of such amount as may be determined by or under the regulations or license;)

(E) Provisions regulating the prices to be charged by the licensee including (fixing of prices or the rate of increase or decrease in prices).

(f) Provisions for the periodic disclosure of information, by way of an information memorandum, including: (reports on the management, asset management, on price comparison with the conventional systems; financial matters and accounts of the license of the district cooling services).

(g) It shall be the duty of a licensee to: maintain a reliable, efficient, co-ordinated and economical district cooling system and ensure public safety in relation to the provision of district cooling services. No licensee shall do or omit to do any act which will adversely affect, directly or indirectly, the reliability and stability of district cooling services provided to consumers.

(h) Where it is necessary to do inspecting, maintaining or repairing any part of a district cooling system the authorized person may giving 7 days prior notice to the owner, on the occurrence of any emergency the licensee may forthwith discontinue the provision of services.

(i) Where any owner of any land desires to use his land for the purposes of development and he considers it necessary that any part of a district cooling system that has been laid, placed, carried or erected on his land should be removed therefrom, he may request the licensee to remove that part from his land.

(j) Any developer or owner of a building who requires any district cooling services from a licensee shall provide at his expense such space and facility within or on the building and such access thereto as may be necessary for the operation of the district cooling system.

(k) Any person who provides district cooling services to any service area without a license shall be guilty of an offence and shall be liable on conviction to a fine not exceeding $50,000.

2.2.1.2. Regulatory framework of Hong Kong district cooling

- **Provision of District Cooling Services:**

Any of the following persons may apply to the Director in a specified form for approval as the consumer of district cooling services for a building—

a- an owner, a person responsible for the management of the building,

b- the specified form (the estimated maximum cooling capacity;the intended starting date for the provision, pay any charge, fee or deposit payable; to be responsible for, and to bear the cost of, the design, provision, construction, installation and maintenance)

c- If the Director decides to reject the applicant, he must notify the applicant of the decision and the reasons for the decision.

- **Suspension or termination of district cooling services:**

The Director may suspend or terminate district cooling services to a building if: there is no approved consumer; the approved consumer fails to: fulfil, or is in breach of, the undertaking given by the approved consumer, complying with a direction contained in an improvement notice.

- **Application for resumption of suspended district cooling services:**

The Director may resume district cooling services to the building if the approved consumer demonstrates to the satisfaction of the Director, the benefit of the treatment of the failure that led to the suspension of the service.

- **Charges for district cooling services**

The approved consumer must pay to the Government the following charges: a capacity charge for the month, if the highest actual cooling capacity in the month exceeds the contract cooling capacity extra fees must be paid; The Director must inform the approved consumer of the rates of primary charge applicable to the building for each subject period.

- **Determination of actual cooling capacity and actual cooling energy consumption**

They are to be measured by a meter owned by the Government and maintained by the Director or in the manner the Director thinks fit.

- **Testing of meter**

The consumer who doubts the accuracy of a meter that measures the actual cooling capacity and actual cooling energy consumption may apply to the Director in a specified form to have the meter tested and if the inaccuracy does not exceed 3% above or below the correct amount. then no fee for testing is payable by the consumer.

- **Deposit**

The Director may require the consumer to pay a deposit to cover any charge or fee that is or may be payable in respect of the building, and in a particular cases, he can reduce, waive or refund, in whole or in part, a deposit payable or paid

- **Calculation of charges for district cooling services**

Capacity Charge = C × CR

Where: C; contract cooling capacity of the building; and CR capacity charge rate applicable to the building.

Capacity Overrun Charge = (AC – C) × CR × 110%

Where: AC; highest actual cooling capacity of the building in the month, C; contract cooling capacity of the building and CR; capacity charge rate applicable to the building.

Consumption Charge = AE × ER

Where: AE; actual cooling energy consumption of the building in the month and ER; consumption charge rate applicable to the building.

Surcharge = (PC – PCP) × 5%

Where: PC; the primary charge or fee that is payable as at the due date and PCP; the part of the primary charge or fee that has been paid, if any, as at the end of the due date.

Further Surcharge = (PCS – PCSP) × 10%

Where: PCS; the primary charge, fee or surcharge that is payable as at the due date and PCSP; the part of the primary charge, fee or surcharge that has been paid, if any, as at the expiry of the period of 6 months beginning on the day after the due date.

- **Calculations of Capacity charge rate and consumption charge rate for Kai Tak**

Capacity Charge Rate (CR)

- for the initial period CR= $112.11 per kilowatt refrigeration (kWr);
- for each subject period $CR = CR_{n-1} \times (1 + CCPI_r)$

where: CR_{n-1}; capacity charge rate applicable immediately before the subject period and $CCPI_r$ rate of change in CCPI applicable for the subject period.

Consumption Charge Rate (*ER*)

- for the initial period ER= $0.19 per kilowatt-hour refrigeration (kWrh)
- for each subject period $ER = ER_{n-1} \times (1 + ET_r)$

Where: ER_{n-1}; consumption charge rate applicable immediately before the subject period and ET_r rate of change in electricity tariff applicable for the subject period.

2.2.1.3. Egyptian district cooling code

- The method of calculating the usage tariff is as follows:
  1. Connection charge has a fixed value per ton of refrigeration TR or equivalent paid when contracting.
  2. Capacity charge is related to the cooling capacity that the building is designed on the basis of it (TR or equivalent). It is usually paid each month regardless of what is consumed monthly.
  3. Consumption charge is related to the quantity of consumption (TR.hr).
- A good financial model should be used and consider the following:
  1. Accurate estimation of capital expenditure
  2. Accurate estimation of the fixed and variable operating expenditure.
  3. Estimating the depreciation rate of the fixed assets (Buildings 40 years, Distribution network 30 years, Equipment and machinery 20 years, Cars, Furniture and Computers 5 years) and preparing a table for the amortization value throughout the life of the project.
  4. Build an appropriate financing structure that takes into account the principle of dept to equity and maintains an acceptable level of financial leverage and financial risks.
  5. Calculate the cost of money and rate of return IIR required for investment.
  6. Calculate the cooling / heating energy tariff that achieves the required rate of return.
  7. Calculation of the equation of the adjustment of the cooling / heating energy tariff in case of changes in input prices of electricity, natural gas, water or other energy sources.
- The Building, Ownership and Operation Agreement (B.O.O) and the appropriateness of investment should be formulated in a manner consistent with the gradual expansion of station and network power capacity.
- The annual rate of increase in the sale price of TR.hr (cooling / heating) should not be installed but preferably linked to the annual inflation rate declared.
- It should be reviewed periodically (every three years, for example) in the rate of annual increase in the sale price of one TR.hr (cooling / heating) in case of using a constant annual increase rate.
- Preparation of the Load Demand Curves of the thermal load throughout day, month and year should be prepared.
- Refrigerants compatible with the environment should be used.
- Water must be treated to solve sedimentation, corrosion and microbiological activity throughout the chilled water system and cooling water.
- The designer should define the temperature difference (ΔT) between supply and return of the chilled / hot water.
- The control and measuring devices in the pumping system of the chilled water plant shall be of a high degree of accuracy and precision.
- A service vehicle equipped with the following shall be provided: (movable generator - one or more pumps with connections - ventilation fan with connections - electric or pneumatic hand tools - electric welding and oxy-acetylene - fire extinguishers - first aid kit for valve room service.

2.2.2. Analyses the gaps of the available regulations

The Housing & Building National Research Centre (HBRC) established a National Steering Committee to propose institutional and regulatory framework for the project. HBRC is responsible for issuing national building and engineering codes for EGYPT including the codes for refrigeration and air-conditioning and district cooling code. This study looks at introducing new component to manage the process of developing the national regulatory and institutional framework, for building and operating district cooling facilities in Egypt. Results proposed will be publicly debated with decision makers and respective authorities in Egypt. HBRC compiled local and international codes/regulations that governs buildings and construction sectors in addition to relevant international District Cooling codes and regulations from A5 and non-A5 countries. Inputs from regulatory framework of district cooling and district cooling codes for Singapore, Hong Kong and Egypt had been gathered and reported. Hong Kong data were most comprehensive. Analysis of the gaps in available existing regulation framework were also included.

Hereinafter the Table 3.1 that contains a comparison between all the available relevant international District Cooling regulations over the world. Analyses the gaps of the available regulation is included in this table. It will be helpful in developing national institutional and regulatory framework for Egypt.

Table 3.1 Comparison between all the available relevant international District Cooling regulations

Item	Hong Kong	Singapore	Egypt
Part 1 Preliminary			
1. Short title	I	N/I	
2. Interpretation	I	N/I	I
3. District cooling system in relation to which this Ordinance applies	I	N/I	N/I
Part 2 Provision of District Cooling Services			
4. Approval of consumer of district cooling services	I	N/I	N/I
5. Contract cooling capacity	I	N/I	N/I
6. Provision of district cooling services	I	N/I	N/I
7. Suspension or termination of district cooling services	I	N/I	N/I
8. Application for resumption of suspended district cooling services	I	N/I	N/I
9. Ceasing to be approved as consumer of district cooling services	I	N/I	N/I
Part 3 Charges for District Cooling Services			
10. Charges for district cooling services	I	N/I	I
11. Determination of actual cooling capacity and actual cooling energy consumption	I	N/I	I
12. Testing of meter	I	N/I	N/I
13. Deposit	I	N/I	N/I
14. Due date for charge, fee and deposit	I	N/I	N/I
15. Reduction etc. of charge, fee and deposit	I	N/I	N/I
16. Recovery of charge and fee	I	N/I	N/I
17. Application of charge and fee received etc.	I	N/I	N/I

Part 4 Administration of District Cooling Services			
18. Improvement notice	**I**	**N/I**	**N/I**
19. Authorized officers	**I**	**N/I**	**N/I**
20. Access for inspection and maintenance	**I**	**I**	**N/I**
21. Offences	**I**	**N/I**	**N/I**
Part 5 Appeal			
22. Appeal to appeal board	**I**	**N/I**	**N/I**
23. How to lodge an appeal	**I**	**N/I**	**N/I**
24. Appeal board panel	**I**	**N/I**	**N/I**
25. Appeal board	**I**	**N/I**	**N/I**
26. Proceedings of appeal board	**I**	**N/I**	**N/I**
27. Hearing of appeal	**I**	**N/I**	**N/I**
28. Reappointment of appeal board in case of certain vacancies	**I**	**N/I**	**N/I**
29. Appeal board may authorize inspection of installation etc.	**I**	**N/I**	**N/I**
30. Determination of appeal	**I**	**N/I**	**N/I**
Part 6 Miscellaneous Matters			
31. Presumptions and evidence in writing	**I**	**N/I**	**N/I**
32. Delegation by Director	**I**	**N/I**	**N/I**
33. Director may specify forms	**I**	**N/I**	**N/I**
34. Secretary may amend Schedules	**I**	**N/I**	**N/I**

2.2.3. Identification of requirements for local institutional & regulatory framework

The purpose of creating a regulatory framework for District Cooling for Egypt is to apply the newly written district cooling code of practice for Egypt on industry and consumers.

This proposed regulatory framework identifies guidelines and minimum requirements of buildings connected to district cooling systems. This ensure designing and building installations are according to acceptable standards. The proposed regulatory framework also identifies guidelines and minimum requirements for other facilities provided by consumers in buildings. Proposed regulatory framework also provide recommendations on the design of consumer's air conditioning installation, to ensure such systems are compatible with connected district cooling service. Local institutional and regulatory framework requirements have also been Identified and taken into consideration.

In this regulatory framework the following **definitions** can be used

Concept a **,**central plant has the capability of generating coolant (usually chilled water) using high capacity chiller and supplied via pipes to more than one building in a service area in order to air-conditioning those buildings. or
District cooling system (DCS) distributes cooling energy in the form of chilled water or other medium from a central source to multiple buildings through a network of underground pipes for use in space and process cooling. or
District cooling service means the sale of coolant (chilled water or any other medium used for the purpose of providing district cooling) for space cooling in a service area by a licensee operating a central plant capable of supplying coolant via piping to more than one building in the service area

Design, groups of large and energy-efficient chillers are usually installed in a central chiller plant to take advantage of the economy of scale and the cooling demand diversity between different buildings within a district.

License, the approval given by the authority to allow person, entity, or agency providing district cooling services to any service area, and without the license no person, entity, or agency shall provide district cooling services to any service area unless he is authorized to do so by a license.

Contract Template, documented formal agreement between the district cooling service provider and the customer receiving the service, contract shall specify the duties and rights of the two contract party

Constructions, the facility used for or in connection with the provision of district cooling services comprising the district cooling plant, one or more chillers or similar cooling units, district cooling pipes and other apparatus including metering equipment including the preparation of civil facilities required for the system installation.

Commissioning, the consumer's cooling system up to the connection point where it is connected to the district cooling system.

Operation, installing the metering equipment and starting to release the district cooling coolant to air condition so as to control simultaneously its temperature, humidity, cleanliness and distribution to meet the requirements of the conditioned space.

Disputes, disputes between the parties they shall be judging by, a District Court and a Magistrate's Court shall have jurisdiction to try any offence under this Act and shall have power to impose the full penalty or punishment in respect of any offence under this Act

Actual Cooling Capacity, in relation to a building to which district cooling services are provided by a district cooling system, means the rate of heat removal, in the unit of kilowatt refrigeration (kWr), that is actually demanded by the building for the system to generate the chilled water supplied to the building for the services.

Actual Cooling Energy Consumption, in relation to a building to which district cooling services are provided by a district cooling system, means the cooling energy, in the unit of kilowatt-hour refrigeration (kWrh), that is actually used by the building for the system to generate the chilled water supplied to the building for the services.

Agreed Starting Date, in relation to a building for which a person is an approved consumer, means the intended starting date for the provision of district cooling services to the building as agreed by the Director of the DC committee when approving the person as the consumer.

Charge, means a primary charge, surcharge or further surcharge;

Contract Cooling Capacity, in relation to a building, means the contract cooling capacity as provided or revised for the building;

Director, means the director of the DC committee Services;

District Cooling Services, means the supply of chilled water for air-conditioning purposes by a district cooling system owned by the DC provider, and other related services;

District Cooling System, means a system in which chilled water is supplied from one or more central chiller plants to user buildings within the area served by the system through a network of pipes for air-conditioning in the buildings;

Estimated Maximum Cooling Capacity, in relation to a building to which district cooling services are intended to be provided by a district cooling system, means an estimation of the maximum rate of heat removal, in the unit of kilowatt refrigeration (kWr), that would be demanded by the building for the system to generate the chilled water to be supplied to the building for the services;

Primary Charge, means a capacity charge, a capacity overrun charge or a consumption charge;

As per the follows, the recommended proposed procedures for a DC project in Egypt follows in Table 3.2. The table list these procedures, identifies whether it is voluntary or mandatory and suggest responsible authorities for implementation of each stage. Reference to the district cooling code is also included.

Table 3.2 Recommended procedures for DC projects in Egypt

No.	Item	Suggested Responsible Authority(s)	Reference at DC Code	Remarks
1	Concept	DC Committee	Chapter 1	Mandatory
2	Design	Owner Consultant	Chapter 1 ,2,3,4,5,6,7	Optional
3	License	DC Committee & Authorized Entities	Chapter 1	Mandatory
4	Contract Template	DC Committee	Chapter 1	Mandatory
5	Constructions	DC Provider & Utilities	Chapter 3	Optional
6	Commissioning	Owner Consultant	Chapter 1	Optional
7	Operation	Owner Operator	Chapter 1,5	Optional
8	Disputes	DC committee	-	Mandatory

Hereinafter The following flow chart in Figure 3.1 explain the recommended procedures to be followed for district cooling projects in Egypt and identifies the responsibilities and the suggested responsible authority for the implementation of each stage separately.

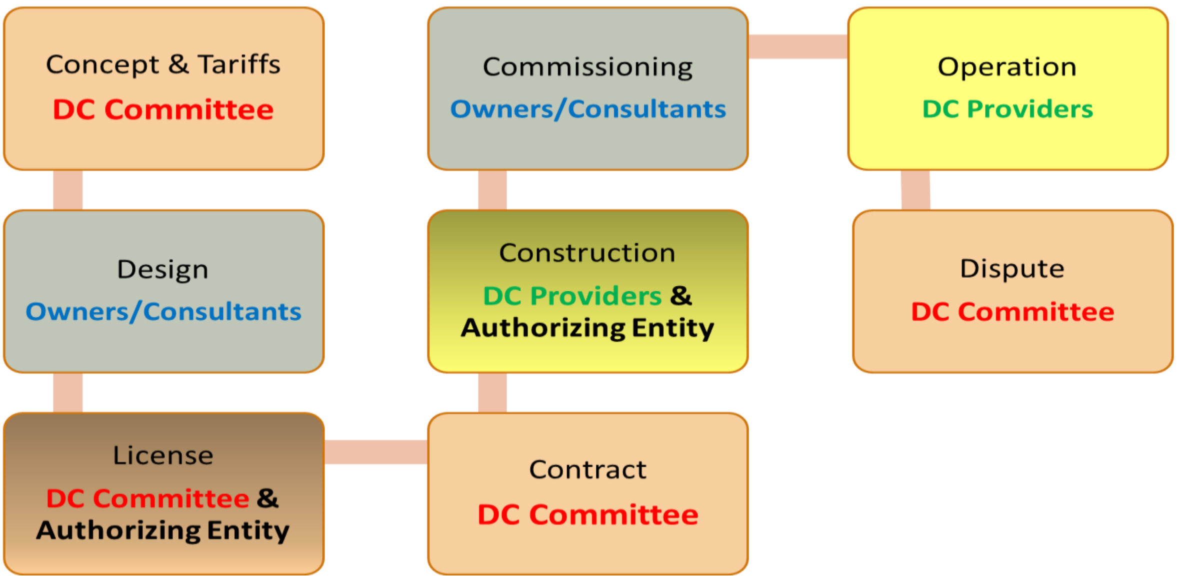

Figure 3.1 Flow chart for the recommended procedure for DC projects in Egypt

2.3. Development of local institutional & regulatory framework

Based on the gap analysis between the available regulations and the requirements identified for local institutional & regulatory framework for Egypt, the proposed institutional and regulatory framework has been developed as follows in Table 3.3.

Table 3.3 Proposed Institutional and Regulatory Framework for DC Projects in Egypt

No.	Item	Suggested Approach
A. Concept		
1	A.1. Forming a DC committee.	• Issuing Ministerial Decree forming the DC committee • HBRC to form and appoint members to DC committee. • Members to DC committee invited from HBRC, New Urban Communities Authority, Ministry of Housing, Ministry of Environment, and other related entities. • The DC committee shall suggest what it deems necessary to complete the work.
2	A.2. Calculating the usage tariffs.	The method of calculating the usage tariffs is as follows: • Connection charge: has a fixed value per ton of refrigeration (TR or equivalent) paid when contracting. • Capacity charge: related to the design cooling capacity of the building (TR or equivalent). Paid each month, usually, regardless of what is consumed monthly. • Consumption charge is the quantity of consumption per month (TR.hr).
3	A.3. Paying the fees for reviewing the DC project.	Fees for reviewing and approving the project may be paid to the DC committee by the service provider upto 0.1% from the estimated budget of the project.
4	A.4. Linking the annual rate of increase in the sale price of TR.hr to the annual inflation rate declared.	The annual rate of increase in the sale price of TR.hr (cooling / heating) should not be installed but preferably linked to the annual inflation rate declared. It should be reviewed periodically (every three years, for example) in the rate of annual increase in the sale price of one TR.hr (cooling / heating) in case of using a constant annual increase rate.
5	A.5. Formulation of the B.O.O.	The Building, Ownership and Operation Agreement (B.O.O) and the appropriateness of investment should be formulated in a manner consistent with the gradual expansion of station and network power capacity.
6	A.6. Using of purpose made financial model	An adequate purpose made financial model should be used and include the following: 1. Accurate estimation of capital expenditure.

No.	Item	Suggested Approach
		2. Accurate estimation of the fixed and variable operating expenditure. 3. Estimating the depreciation rate of the fixed assets (i.e.: Buildings - 40 years, Distribution network - 30 years, Equipment and machinery - 20 years, Cars, Furniture and Computers - 5 etc.…) including table for the amortization value throughout the life of the project. 4. Build an appropriate financing structure that takes into account the principle of debt to equity ratio, maintains an acceptable level of financial leverage and financial risks. 5. Calculate the cost of money and rate of return IIR required for investment. 6. Calculate the cooling / heating energy tariffs that achieves the required rate of return. 7. Calculation of the equation of the adjustment of the cooling / heating energy tariffs in case of changes in input prices of electricity, natural gas, water, drain or other energy sources. 8. Calculate the EFLH (Equivalent Full Load Hours) of the project.
	B. Design	
7	B.1. Revising the contract cooling capacity.	The approved consumer for a building or his consultant may revise the contract cooling capacity of the building only if the DC committee has agreed to the revision.
8	B.2. Preparation of the Load Demand Curves, daily, monthly and yearly.	Preparation of Load Demand Curves throughout the day, month and year should be made by the owner consultant.
9	B.3. Using of refrigerants that comply with Montreal Protocol and its amendments.	Refrigerants that comply with Montreal Protocol and its latest amendments.
10	B.4. Treatment of Water.	Water must be treated to solve sedimentation, corrosion and microbiological activity throughout the chilled water system and cooling water.
11	B.5. Defining the chilled water temperature difference.	The designer should define the temperature difference (ΔT) between supply and return of the chilled / hot water.
	C. License	
12	C.1. Getting the licence.	Getting the licence from the authorized entities based on the approval by the DC committee.

<table>
<tr><th>No.</th><th>Item</th><th>Suggested Approach</th></tr>
<tr><td colspan="3">D. Contract Template</td></tr>
<tr><td>13</td><td rowspan="3">D.1. Templet of the application form for approval</td><td>Templet of the application form for approval is a specified form prepared by the DC committee.</td></tr>
<tr><td>14</td><td>The specified form for approval to the DC committee may applied by any owner or occupier of the building and the person responsible for the management of the building as the approved consumer of district cooling services for a building.</td></tr>
<tr><td>15</td><td>The applicant must include in the specified form (template of the application form for approval):
- The estimated maximum cooling capacity of the building;
- The intended starting date for the provision of district cooling services to the building; and
- the undertaking to be given by the applicant is to:
○ Pay the charges, fee or deposit applicable in respect of the district cooling services provided to the building.
○ Be responsible for, and to bear the cost of, the design, provision, construction, installation and maintenance of the facilities for the building to receive district cooling services as specified by the DC committee.
○ Comply with any other conditions required by the DC committee relating to proper running of the system.</td></tr>
<tr><td colspan="3">E. Interference Items (Constructions, Commissioning and Operation)</td></tr>
<tr><td>16</td><td rowspan="2">E.1. Necessary actions to protect life, or property, or the performance of an installation for the building, made by the consumer that is jeopardizing or could jeopardize the operation or reliability of the DC services.</td><td>The DC committee may refuse to provide DC services to a building if the approved consumer for the building fails to fulfil, or is in breach of, the undertaking given by the owner or the approved consumer in respect of the building.</td></tr>
<tr><td>17</td><td>The DC committee may suspend or terminate district cooling services to the building in the following cases and the DC committee must notify the consumer for the building of the decision and the reasons for the decision:
- There is no approval for the consumer of a building;
- The approved consumer for the building fails to fulfil, or is in breach of, the undertaking given.
- The approved consumer for the building fails to comply with a directive contained within an improvement notice;
- Work is required to be carried out for the installation,</td></tr>
</table>

No.	Item	Suggested Approach
		inspection, testing, operation, maintenance, regulating, alteration, repair, replacement or removal of any part of the district cooling system; - Work is required to be carried out in the event of an operational emergency arising from a fault in the DC system.
18	E.2. Paying the connection, capacity and consumption charges.	The approved consumer for a building must pay to the DC provider the connection charge at contract signing. Also, the capacity charge and the consumption charge for the district cooling services provided to the building during a month must paid monthly. If the highest actual cooling capacity of the building in the month exceeds the contract cooling capacity of the building, a capacity overrun charge for the month must be paid.
19	E.3. Metering system for cooling capacity	The actual cooling capacity and actual cooling energy consumption of a building are to be measured by a meter owned by the DC provider.
20	E.4. Meter calibration	An approved consumer for a building who doubts the accuracy of a meter that measures the actual cooling capacity and actual cooling energy consumption of the building may apply to the DC committee in a specified form to have the meter tested. If the result of the test is that the meter is registering correctly, the approved consumer must pay to the accredited testing laboratory the cost for testing else however, if the result is that the meter is not registering correctly, the DC provider must pay the fee for testing. The meter is regarded as registering correctly despite any inaccuracy found in its measurement if the inaccuracy does not exceed 3% above or below the correct amount.
21	E.5. Improvement notice	The DC committee may issue an improvement notice to the approved consumer for a building if the DC committee is of the opinion that the behaviour of, an installation of the building by the approved consumer, is jeopardizing or will jeopardize the operation or reliability of district cooling services. The improvement notice issued to an approved consumer must specify the approved consumer's behaviour or installation that is jeopardizing or will jeopardize the operation or reliability of district cooling services; and direct the approved consumer to remedy the behaviour or installation within a certain period specified in the notice.

No.	Item	Suggested Approach
22	E.6. Inspection of installation for determination of an appeal.	If the DC committee reasonably believes that an installation or facility is relevant to the determination of an appeal, the committee may inspect the installation or facility in situ.
23	E.7. Pumping system requirements.	The control and measuring devices in the pumping system of the chilled water plant shall be of a high degree of accuracy and precision.
24	E.8. Valve room requirements.	A service vehicle equipped with the following shall be provided: (movable generator - one or more pumps with connections - ventilation fan with connections - electric or pneumatic hand tools - electric welding and oxy-acetylene - fire extinguishers - first aid kit for valve room service.
F. Disputes		
25	F.1. Refusing to provide DC services to a building.	If the DC committee decides to refuse to provide DC services to a building, the DC committee must notify the approved consumer for the building of the decision and the reasons for the decision.
26	F.2. A person obstructs an authorized officer.	A person commits an offence if the person obstructs an authorized officer, during the officer's performance of a function under this Ordinance; or tampers with a facility owned and maintained by the DC provider for any purpose relating to the provision of district cooling services. The person who commits an offence is liable to be convicted and fined.
27	F.3. Notice of appeal.	A person who is aggrieved by any of the following decisions and directives may appeal to the DC committee against the decision or directives: - A decision not to approve a person as the consumer of district cooling services for a building; - A decision to refuse to provide district cooling services to a building; - A decision to suspend or terminate district cooling services to a building; - A decision not to resume district cooling services to a building where the services were suspended; - A decision to refuse an application for the cessation of the approval of a person as the consumer of district cooling services for a building; - A decision to issue or amend an improvement notice; - A direction contained in an improvement notice. - A decision denoting the start date of the service.

No.	Item	Suggested Approach
28		An appeal against a decision or direction does not suspend the decision or direction unless the DC committee decides otherwise.
29		A person may lodge an appeal by giving a notice of appeal to the DC committee.
30		The notice of appeal must be given within 14 days after the date on which the person is notified of the decision or direction appealed against. The notice of appeal must be in a specified form and be accompanied by a copy of any document on which the person intends to rely.
31		As soon as reasonably practicable after receiving a notice of appeal, the DC committee must deliver it to the DC provider.

Annex (3-1)
Regulatory framework of Singapore district cooling (SDC)

Regulatory framework of Singapore district cooling (SDC[1])

The authorities in Singapore accepted the submission for district cooling to be made a mandated utility service in order to mitigate the start-up commercial risks. Accordingly, the District Cooling Act was legislated in 2002 to provide the necessary regulatory framework.

The legislation, administered by the Energy Market Authority of Singapore, requires that the new utility service be priced at a level no higher than the equivalent costs of chilled water production in conventional in building plants employing similar technology. Over time, the district cooling operator is allowed to earn a baseline return based on its invested assets. When the operator has recovered its start-up losses after achieving the critical mass of demand for efficient operation, any efficiency gain above the baseline return shall be shared equally by the operator and customers. Customers are thus assured of long-term savings and the start-up demand risk for the operator is also mitigated.

Chilled water supply to a customer is provided via heat exchangers as a connection interface in an Intake Station (or energy transfer station) located within the customer's development.

The building space for the Intake Station is provided and maintained by the customer. The Intake Station also accommodates the downstream pumps for distribution of chilled water within the development.

The costs of the service connection facilities, which include the heat exchangers, metering/control equipment and connection pipes to the Chilled Water Piping Network, are borne directly by the customer but the installation and maintenance of the facilities are undertaken by SDC[1]. SDC bears the costs of upstream piping network and the district cooling plants as infrastructure costs which are translated into recurring monthly Contract Capacity Charges levied on the customers.

The Supply shall be provided at all times during the Contract Duration on a 24 hourly basis.The Service Provider shall use its best efforts to prevent any interruption in the provision of the Supply and to minimize the duration of any such interruption. The Service Provider shall notify the Consumer immediately if there is any unexpected significant change in the operating status of the District Cooling System or if any interruption is expected to occur.

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[1] Singapore Power and Dalkia went on to form Singapore District Cooling (SDC) as a joint-venture to implement the pilot system.

The Service Provider shall, in scheduling any maintenance, repair, connection, disconnection, extension and other work in the District Cooling System ("Planned Works"), endeavour so far as is reasonably practicable to:

i. consult with the consumer as to the scheduling of the execution of the Planned Works;
ii. coincide the execution of the Planned Works outside the Normal Usage Hours; and
iii. stagger the execution of the Planned Works,

Such that there shall not be any interruption in the provision of the Supply at the Premises or if an interruption cannot reasonably be avoided, the duration and extent of the interruption is minimized. The Service Provider shall in any event give the Consumer at least 14 days prior written notice of the execution of any Planned Works, and such notice shall state the dates on, and times at which the Planned Works will be executed, and the extent to which the provision of the Supply at the Premises will be interrupted.

Nothing shall restrict the Service Provider from taking immediate action to avoid injury to persons or significant damage to property on the occurrence of any emergency, provided that the Service Provider shall give the Consumer as much prior notice as possible.

The Service Provider shall, at its own costs, be responsible for planning, designing, constructing, installing, testing, commissioning, operating and maintaining the District Cooling System and Service Connection Facilities (but without prejudice to the Consumer's payment obligations).

The Service Provider shall secure that the District Cooling System is fully operational to provide the Supply in accordance with the Supply Agreement by the Target Supply Date and will provide the Supply to the Consumer throughout the Contract Duration in accordance with the terms of the Supply Agreement.

The Consumer shall make the connection of Consumer Installation to the secondary side of the Heat Exchangers, subject to the Consumer Installation having been completed and tested by the Consumer's competent person to the reasonable satisfaction of the Service Provider.

The Consumer shall use the District Cooling Service of the Service Provider for the purpose of space cooling at the Premises throughout the Contract Duration on the terms of the Supply Agreement unless exempted by the Authority from doing so.

The Consumer shall not install any independent chilled water production facilities in the Premises and cause such facilities to operate in parallel with the District Cooling System for the purpose of space cooling at the Premises unless otherwise agreed to in writing by the Service Provider Provided That the Consumer may at its sole discretion install and operate at its own costs such backup or standby systems and facilities for the purpose of space cooling at the Premises in the event of any interruption in the Supply.

The Consumer shall not under any circumstances supply District Cooling Service received from the Service Provider to any building or premises other than the Premises.

The Contract Capacity shall be fixed for the duration of the Initial Contract Period. However, if the Consumer's requirements for District Cooling Service at the Premises exceed the Contract Capacity, the Consumer may by notice in writing to the Service Provider request that the Contract Capacity be increased to the amount stated in such notice and the Service Provider shall use its best efforts to accommodate the Consumer's request Provided That:

i. The quantum of the increase in the Contract Capacity shall not exceed 10% of the prevailing Contract Capacity without the Service Provider's consent;
ii. The increase in the Contract Capacity shall be subject to there being available capacity in the District Cooling System; and
iii. If the increase in Contract Capacity necessitates upgrading of the Service Connection Facilities, the Consumer shall pay for the costs of such upgrading work.

Subject to the aforesaid provisos, the Service Provider shall make available to the Consumer the increased capacity requested by the Consumer within 12 months of the request being made.

In the event that the Consumer’s (kW.hr) maximum demand exceeds the Contract Capacity, the Service Provider shall endeavour to provide additional supply capacity on a short-term basis subject to payment of Capacity Overrun Charge by the Consumer. Whenever the Service Provider is of the reasonable opinion that the Consumer’s (kW.hr) maximum demand, where it exceeds the Contract Capacity, will or is likely to, interfere with the efficient and reliable supply of district cooling service to other consumers, the Service Provider shall be entitled to limit the Supply to the Consumer up to the Contract Capacity. The Consumer shall immediately, upon request by the Service Provider, limit the (kW.hr) maximum demand to its Contract Capacity.

Chilled water supply temperature is regulated at 6.0ºC +0.5ºC. The customer is required to adopt “variable flow” design for its downstream reticulation so as to achieve a return temperature higher than 14ºC. If the hourly average supply temperature exceeds 6.5ºC, SDC pays a rebate that is twice the equivalent hourly rate for Contract Capacity Charge. Similarly, if the monthly average return temperature falls below 14ºC, the customer pays a surcharge on the Usage Charge.

The chilled water tariffs are regulated by Energy Market Authority (EMA) and the tariff rates are reviewed at half-yearly intervals. There are five components as follows:

vi. Contract Capacity Charge
vii. Usage Charge
viii. Capacity Overrun Charge
ix. Return Temperature Adjustment
x. Supply Deficiency Rebate

The Consumer shall arrange for a competent person to design and install the Consumer Installation in accordance with the technical guidance provided by the Service Provider and which shall incorporate the following minimum requirements:

i. A control arrangement, via a variable flow system or otherwise, to maintain the Return Temperature at or higher than 14ºC;

ii. A filtration system for the return water to the Heat Exchanger with a minimum filtration performance of 200 microns; and
iii. A pressure relief device at the interfacing connection set to operate at a pressure at or below 16 bar.

The Consumer shall at its own cost provide and construct the Intake Station in accordance with the plans and specifications agreed by the Parties. Such plans and specifications shall not be altered without the agreement in writing of the Parties. The Consumer shall ensure that the Intake Station shall be used for plant and equipment linked to the provision of District Cooling Service at the Premises.

The Consumer shall at its own cost maintain the Intake Station inclusive of the building structure, infrastructure, mechanical and electrical services within the Intake Station and general cleanliness of the Intake Station.

The Consumer shall pay for the cost of the Service Connection Facilities, which is the amount stated in the Supply Agreement. Notwithstanding such payment by the Consumer, the Service Connection Facilities shall be the property of the Service Provider, and the Service Provider shall be responsible for the operation, maintenance and repair of the Service Connection Facilities.

The Consumer shall not operate any device of the Service Connection Facilities nor carry out any work on the Service Connection Facilities.

The Consumer shall provide the Service Provider with reasonable quantities of electricity (for the purpose of operating the control and instrumentation panels of the Service Connection Facilities) and water (for general cleaning purposes) at the Intake Station. Save as aforesaid, the Service Provider shall be responsible for arranging for and procuring all electricity, water and any other utilities and consumables as may be required for the operation of the District Cooling System.

The District Cooling Service delivered to the Consumer shall be measured by metering equipment of a type approved by the Authority. The metering equipment shall be supplied, installed, calibrated and maintained by the Service Provider.

The Service Provider shall ensure that the metering equipment shall at all times be accurate to a tolerance of ±3% of the nominal flow of coolant. The accuracy of the meter(s) shall be verified upon its installation and thereafter at periodic intervals not exceeding five years (or such other periods as the Parties may agree in writing) by an independent testing laboratory approved by the Authority.

If the meter(s) shall for any reason become faulty or inaccurate beyond the required tolerance of error, the Service Provider shall as soon as possible procure the service, repair, re-calibration or replacement of such meter(s) as appropriate. The Consumer may at any time by written notice to the Service Provider request that the accuracy of any meter(s) be tested. The Service Provider shall forthwith upon receipt of the Consumer's request arrange for the testing and calibration of such meter(s). The costs of any testing of any meter requested by the Consumer shall be borne by the Consumer unless such testing reveals that the meter is inaccurate beyond the permitted tolerance of error in which case the costs shall be borne by the Service Provider.

Where any meter is found to be inaccurate beyond the permitted tolerance of error, the Service Provider shall make a fair and reasonable estimate of the amount of District Cooling Service provided to the Consumer during the period when the meter was faulty or inaccurate. The Service Provider shall, if appropriate, make retrospective adjustment to the bills previously rendered by the Service Provider with respect to the District Cooling Service based on the readings of such meter for the period since the meter was last inspected and tested and found to be accurate within the permitted tolerance of error.

The Authority shall be charged with the general administration of the local Act and the exercise of the functions and duties imposed on the Authority by this Act.

The Authority may authorize any person to assist it in the exercise of its functions and duties under this Act, either generally or in a particular case.

Subject to the provisions of this Act, it shall be the function and duty of the Authority:

(a) to exercise licensing and regulatory functions in respect of the provision of district cooling services;
(b) to protect the interests of consumers in respect of:
    i. The prices charged and other terms of supply of district cooling services;
    ii. The quality of district cooling services;
    iii. The continuity and reliability of district cooling services; and
(c) To issue or approve and from time to time review codes of practice and other standards of performance in connection with the provision of district cooling service

No person shall provide district cooling services to any service area unless he is authorized to do so by a license. The license may be granted to any person, class of persons or a particular person, and may include conditions requiring the licensee

(a) To prepare itself to deal with any public emergency;
(b) To pay to the Authority a fee for the grant of the license or to pay to it periodic fees for the duration of the license, or both, of such amount as may be determined by or under the regulations or license;

Conditions included in a license may contain all or any of the following:

(a) provisions regulating the prices to be charged by the licensee including:
    i. the fixing of prices or the rate of increase or decrease in prices;
    ii. the fixing of an average price or an average rate of increase or decrease in the average price;
    iii. the setting of prices with reference to a general price index, the cost of production, a rate of return on assets employed or any other specified factors; and
    iv. the setting of prices with reference to the quantity, location, period, temperature of coolant, or other specified factors relevant to the provision of district cooling services;
(b) provisions for the periodic disclosure of information, by way of an information memorandum, including:
    i. reports on the management of the district cooling services;
    ii. reports on asset management of the district cooling system;
    iii. reports on price comparison of the district cooling service with the conventional air-conditioning systems;

iv. reports on performance comparison of the district cooling services with the conventional air-conditioning systems;
v. security measures; and
vi. reports on financial matters and accounts of the licensee; and

(c) Provisions requiring the licensee to provide a sinking fund for asset management.

A license shall not be transferable and any purported transfer of any license shall be void. It shall be the duty of a licensee to: maintain a reliable, efficient, co-ordinated and economical district cooling system in accordance with such codes of practice or other standards of performance as may be issued or approved by the Authority; and ensure public safety in relation to the provision of district cooling services.

No licensee shall do or omit to do any act which will adversely affect, directly or indirectly, the reliability and stability of district cooling services provided to consumers. The prices to be charged by a licensee and to be paid by consumers for the provision of district cooling services shall be in accordance with such prices as may be fixed from time to time by the licensee in accordance with the conditions of its license.

In fixing prices of district cooling services, a licensee shall neither show undue preference as between persons similarly situated nor exercise undue discrimination as between persons similarly situated, having regard to the place and time of supply and the quantity supplied.

Where it is necessary to do so for the purpose of inspecting, maintaining or repairing any part of a district cooling system or for the purpose of carrying out any function conferred on a licensee under this Act or under any granted license, a licensee or any person authorized by the licensee may, after giving 7 days prior notice to the owner or occupier of any land.

(a) at any reasonable time, enter upon any land or building within the service area, whether or not such part of the district cooling system has been laid, placed, carried or erected on, under, upon or over the land or building;
(b) carry out all necessary inspection, maintenance or repair; and
(c) in the course thereof, fell or lop trees, remove vegetation and do all other things necessary for the purpose,

Causing as little damage as possible and paying compensation to any person adversely affected for any damage that may be caused thereby. Where any owner of any land desires to use his land for the purposes of development and he considers it necessary that any part of a district cooling system that has been laid, placed, carried or erected on his land should be removed therefrom, he may request the licensee to remove that part from his land.

Any developer or owner of a building who requires any district cooling services from a licensee shall provide at his expense such space and facility within or on the building and such access thereto as may be necessary for the operation of the district cooling system.

Where a licensee is of the opinion that immediate action is necessary on the occurrence of any emergency, in the interests of public safety or in order to avoid undue interference with the efficient provision of district cooling services to other consumers or for such other reasons affecting the public interest, the licensee may forthwith discontinue the provision of district cooling services to any consumer.

The licensee shall immediately thereafter give notice in writing of the discontinuance to the Authority and the affected consumer, and shall restore district cooling services to that consumer as soon as is reasonably practicable. A licensee shall not be liable for any loss or damage caused to any person resulting from such discontinuance in the provision of district cooling services.

Any person who provides district cooling services to any service area without a license shall be guilty of an offence and shall be liable on conviction to a fine not exceeding $50,000.

Annex (3-2)

Regulatory framework of Hong Kong district cooling

District Cooling Services Ordinance

An Ordinance to provide for matters relating to district cooling services provided by the Government, including the imposition of charges for the services; and to provide for other related matters.

Part 1
Preliminary

1. Short title

This Ordinance may be cited as the District Cooling Services Ordinance.

2. Interpretation

In this Ordinance—

Actual Cooling Capacity, in relation to a building to which district cooling services are provided by a district cooling system, means the rate of heat removal, in the unit of kilowatt refrigeration (kWr), that is actually demanded by the building for the system to generate the chilled water supplied to the building for the services.

Actual Cooling Energy Consumption, in relation to a building to which district cooling services are provided by a district cooling system, means the cooling energy, in the unit of kilowatt-hour refrigeration (kWrh), that is actually used by the building for the system to generate the chilled water supplied to the building for the services.

Agreed Starting Date, in relation to a building for which a person is an approved consumer, means the intended starting date for the provision of district cooling services to the building as agreed by the Director under section 4(4)(b)(ii) when approving the person as the consumer under section 4(4).

Appeal Board, means a District Cooling Services Appeal Board appointed under section 25.

Appeal Board Panel means the appeal board panel referred to in section 24.

Approved Consumer, in relation to a building, means a person who is approved under section 4(4) as the consumer of district cooling services for the building;

Authorized Officer, means a public officer authorized under section 19;

Building, includes part of a building;

Capacity Charge, means the capacity charge referred to in section 10(1)(a);

Capacity Overrun Charge, means the capacity overrun charge referred to in section 10(1)(b);

Charge, means a primary charge, surcharge or further surcharge;

Consumption Charge, means the consumption charge referred to in section 10(1)(c);

Contract Cooling Capacity, in relation to a building, means the contract cooling capacity as provided or revised under section 5 for the building;

Deposit, means a deposit payable under section 13;

Director, means the Director of Electrical and Mechanical Services;

District Cooling Services, means the supply of chilled water for air-conditioning purposes by a district cooling system owned by the Government, and other related services;

District Cooling System, means a system in which chilled water is supplied from one or more central chiller plants to user buildings within the area served by the system through a network of pipes for air-conditioning in the buildings;
Due Date —see section 14;
Estimated Maximum Cooling Capacity, in relation to a building to which district cooling services are intended to be provided by a district cooling system, means an estimation of the maximum rate of heat removal, in the unit of kilowatt refrigeration (kWr), that would be demanded by the building for the system to generate the chilled water to be supplied to the building for the services;
Fee, means the fee for testing referred to in section 12(4);
Function, includes a power and a duty;
Further Surcharge, means the further surcharge referred to in section 10(2)(b);
Improvement Notice, means an improvement notice issued or amended under section 18;
Primary Charge, means a capacity charge, a capacity overrun charge or a consumption charge;
Secretary means the Secretary for the Environment;
Specified Form, means a form specified by the Director under section 33;
Surcharge, means the surcharge referred to in section 10(2)(a).

3. District cooling system in relation to which this Ordinance applies

This Ordinance applies in relation to a district cooling system specified in Schedule 1.

Part 2

Provision of District Cooling Services

4. Approval of consumer of district cooling services

(1) Any of the following persons may apply to the Director in a specified form for approval as the consumer of district cooling services for a building—

(a) An owner or occupier of the building;

(b) A person responsible for the management of the building.

(2) The applicant must include in the specified form—

(a) The estimated maximum cooling capacity of the building;

(b) The intended starting date for the provision of district cooling services to the building; and

(c) An undertaking given by the applicant in accordance with subsection (3).

(3) The undertaking to be given by the applicant under subsection (2)(c) is an undertaking—

(a) To pay any charge, fee or deposit payable in respect of the district cooling services provided to the building in accordance with this Ordinance;

(b) To be responsible for, and to bear the cost of, the design, provision, construction, installation and maintenance of the facilities for the building to receive district cooling services as specified by the Director; and

(c) To comply with any other conditions imposed by the Director relating to the provision or use of district cooling services.

(4) The Director may approve the applicant as the consumer of district cooling services for a building if—

(a) The application complies with subsections (1) and (2); and

(b) The Director agrees to—

(i) The estimated maximum cooling capacity provided under subsection (2)(a) or otherwise by the applicant; and

(ii) The intended starting date provided under subsection (2)(b) or otherwise by the applicant.

(5) If the Director approves the applicant as the consumer of district cooling services for a building under subsection (4), the applicant becomes, or is taken to have become, the approved consumer for the building on the agreed starting date.

(6) If the Director decides not to approve the applicant as the consumer of district cooling services for a building under subsection (4), the Director must notify the applicant of the decision and the reasons for the decision.

5. Contract cooling capacity

(1) If the Director approves a person as the consumer of district cooling services for a building under section 4(4), the estimated maximum cooling capacity agreed by the Director under section 4(4)(b)(i) becomes, or is taken to have become, the contract cooling capacity of the building on the agreed starting date.

(2) The approved consumer for a building may revise the contract cooling capacity of the building only if the Director has agreed to the revision.

6. Provision of district cooling services

(1) If the Director approves a person as the consumer of district cooling services for a building under section 4(4), the Director may provide district cooling services to the building from—

(a) The agreed starting date; or

(b) A later date as proposed by the approved consumer and agreed by the Director.

(2) Nevertheless, the Director may refuse to provide district cooling services to a building from the date specified in subsection (1) if the approved consumer for the building fails to fulfil, or is in breach of, the undertaking given by the approved consumer under section 4(2)(c) in respect of the building.

(3) If the Director decides to refuse to provide district cooling services to a building under subsection (2), the Director must notify the approved consumer for the building of the decision and the reasons for the decision.

7. Suspension or termination of district cooling services

(1) The Director may suspend or terminate district cooling services to a building if—

(a) There is no approved consumer for the building;

(b) The approved consumer for the building fails to fulfil, or is in breach of, the undertaking given by the approved consumer under section 4(2)(c) in respect of the building;

(c) The approved consumer for the building fails to comply with a direction contained in an improvement notice;

(d) In the Director’s opinion, work is required to be carried out for the installation, inspection, testing, operation, maintenance, regulating, alteration, repair, replacement or removal of any part of the district cooling system;

(e) In the Director’s opinion, work is required to be carried out in the event of an operational emergency arising from a fault in the district cooling system;

(f) In the Director’s opinion, it is necessary to do so to protect life or property; or

(g) In the Director’s opinion, the behaviour of, or an installation of the building by, the approved consumer for the building is jeopardizing or will jeopardize the operation or reliability of the district cooling services.

(2) If the Director decides to suspend or terminate district cooling services to a building under subsection (1)(b), (c), (d), (e), (f) or (g), the Director must notify the approved consumer for the building of the decision and the reasons for the decision.

8. Application for resumption of suspended district cooling services

(1) If the Director has suspended district cooling services to a building under section 7(1)(b), (c), (d), (e), (f) or (g), the approved consumer for the building may apply to the Director for the services to be resumed.

(2) On an application under subsection (1), the Director may resume district cooling services to the building if the approved consumer demonstrates to the satisfaction of the Director that the ground on which the services were suspended no longer exists.

(3) If the Director decides not to resume district cooling services to a building under subsection (2), the Director must notify the approved consumer for the building of the decision and the reasons for the decision.

9. Ceasing to be approved as consumer of district cooling services

(1) A person who is the approved consumer for a building may apply to the Director for the cessation of the approval.

(2) The application must—

(a) State the intended date of the cessation; and

(b) Be made at least 1 month before that date.

(3) The Director must allow the application if—

(a) The application complies with subsection (2); and

(b) All outstanding charges and fees payable by the approved consumer in respect of the district cooling services provided to the building have been settled before the intended date of the cessation.

(4) If the Director allows the application, then, on the intended date of the cessation—

(a) The person ceases to be approved as the consumer of district cooling services for the building; and

(b) The undertaking given by the person under section 4(2)(c)in respect of the building ceases to be in force.

(5) If the Director decides to refuse the application, the Director must notify the person of the decision and the reasons for the decision.

Part 3

Charges for District Cooling Services

10. Charges for district cooling services

(1) The approved consumer for a building must pay to the Government the following charges for the district cooling services provided to the building during a month—

(a) A capacity charge for the month, calculated according to section 2(1) and (3) of Schedule 2;

(b) If the highest actual cooling capacity of the building in the month exceeds the contract cooling capacity of the building—a capacity overrun charge for the month, calculated according to section 2(2) and (3) of Schedule 2; and

(c) A consumption charge for the month, calculated according to section 3 of Schedule 2.

(2) The approved consumer for a building must also pay to the Government the following charges for an outstanding charge or fee—

(a) If a part of a primary charge or fee payable in respect of the building is not paid on or before its due date—a surcharge for the unpaid primary charge or fee, calculated according to section 4(1) of Schedule 2; and

(b) If a part of a primary charge, fee or surcharge payable in respect of the building remains unpaid as at the expiry of the period of 6 months beginning on the day after its due date—a further surcharge for the unpaid primary charge, fee or surcharge, calculated according to section 4(2) of Schedule 2.

(3) The Director must inform the approved consumer for a building, by notice in writing, of the rates of primary charge applicable to the building for each subject period.

(4) In addition, the Director must publicize the rates of primary charge applicable for each subject period by—

(a) Publishing a notice that is accessible through the Internet; or

(b) Placing a notice in any daily newspaper in circulation in Hong Kong.

(5) In this section—

Rates of Primary Charge mean the capacity charge rate and consumption charge rate within the meaning of section 5 of Schedule 2;

Subject Period has the meaning given by section 5(2) of Schedule 2.

11. Determination of actual cooling capacity and actual cooling energy consumption

(1) The actual cooling capacity and actual cooling energy consumption of a building are to be measured by a meter owned by the Government and maintained by the Director in the building.

(2) However, if the Director is of the opinion that it is impracticable or inappropriate to rely on a measurement under subsection (1) for a period, the actual cooling capacity and actual cooling energy consumption of the building for that period may be determined in the manner the Director thinks fit.

12. Testing of meter

(1) An approved consumer for a building who doubts the accuracy of a meter that measures the actual cooling capacity and actual cooling energy consumption of the building may apply to the Director in a specified form to have the meter tested.

(2) After receiving the application, the Director must arrange for the meter to be tested in the manner the Director thinks fit.

(3) A meter is regarded as registering correctly despite any inaccuracy found in its measurement if the inaccuracy does not exceed 3% above or below the correct amount.

(4) If the result of the test is that the meter is registering correctly, the approved consumer must pay to the Director a fee for testing in an amount equivalent to the cost involved in testing the meter.

(5) However, if the result is that the meter is not registering correctly, no fee for testing is payable by the approved consumer.

13. Deposit

(1) The Director may require the approved consumer for a building to pay a deposit, in the amount and by the date specified in a demand note issued to the approved consumer, to cover any charge or fee that is or may be payable in respect of the building.

(2) Without limiting any other power under this Ordinance, the Director may apply a deposit paid in respect of a building to the payment of a charge or fee payable in respect of the building.

(3) A deposit paid under this section—

(a) Does not bear interest; and

(b) Is not transferable.

(4) Subject to subsection (2), a deposit paid by a person as the approved consumer for a building must be refunded to the person if—

(a) The person has ceased to be approved as the consumer of district cooling services for the building; and

(b) The Director is of the opinion that the deposit is no longer required for satisfying any liability owed by the person as the approved consumer to the Government in connection with the services.

14. Due date for charge, fee and deposit

(1) The due date for a charge or fee is—

(a) For a primary charge or fee—the date by which the charge or fee must be paid as specified in a demand note issued by the Director for the charge or fee;

(b) For a surcharge payable in respect of a primary charge or fee—the due date of the primary charge or fee; and

(c) For a further surcharge payable in respect of a primary charge, fee or surcharge—the date on which the period of 6 months beginning on the day after the due date of the primary charge, fee or surcharge expires.

(2) The due date for a deposit is the date by which the deposit must be paid as specified in a demand note issued for the deposit under section 13(1).

(3) A charge, fee or deposit must be paid—

(a) For a primary charge, fee or deposit—on or before the due date; or

(b) For a surcharge or further surcharge—immediately after the due date.

15. Reduction etc. of charge, fee and deposit

(1) The Director may, in a particular case, reduce, waive or refund, in whole or in part, a charge or fee payable or paid under this Ordinance.

(2) The Director may, on the application by the approved consumer for a building in a particular case, reduce, waive or refund, in whole or in part, a deposit payable or paid in respect of the building.

16. Recovery of charge and fee

A charge or fee payable under this Ordinance is recoverable as a civil debt due to the Government.

17. Application of charge and fee received etc.

(1) Subject to the approval of the Financial Secretary, those parts of the charges and fees received by the Government under this Ordinance that are required for either of the purposes specified in subsection (2) do not form part of the general revenue and may be applied for those purposes.

(2) The purposes are—

(a) Settling a payment that a person who has entered into an agreement with the Government for the management, operation and maintenance of a district cooling system is entitled to receive under the agreement; and

(b) Settling any other expenses arising from or in connection with the provision of district cooling services.

Part 4

Administration of District Cooling Services

18. Improvement notice

(1) The Director may issue an improvement notice to the approved consumer for a building if the Director is of the opinion that the behaviour of, or an installation of the building by, the approved consumer is jeopardizing or will jeopardize the operation or reliability of district cooling services.

(2) An improvement notice issued to an approved consumer must—

(a) State the Director's opinion referred to in subsection (1);

(b) Specify the approved consumer's behaviour or installation that is jeopardizing or will jeopardize the operation or reliability of district cooling services; and

(c) Direct the approved consumer to remedy the behaviour or installation within the period specified in the notice.

(3) The Director may amend or withdraw an improvement notice by issuing a notice to the approved consumer.

(4) An improvement notice issued to a person as the approved consumer for a building ceases to have effect if the person is no longer the approved consumer for the building.

(5) Subsection (4) applies regardless of whether the person has complied with the direction contained in the improvement notice.

19. Authorized officers

(1) The Director may, in writing, authorize a public officer attached to the Electrical and Mechanical Services Department to be an authorized officer for the purposes of this Ordinance.

(2) An authorized officer must, if so requested, produce written proof of that officer's authorization before performing a function under this Ordinance.

20. Access for inspection and maintenance

(1) An authorized officer may, at all reasonable times, enter a building to do any or all of the following—

(a) To inspect the building for the purposes of verifying information that is needed in determining a charge payable in respect of the building;

(b) To install, inspect, test, operate, maintain, regulate, alter, repair, replace or remove any part of the district cooling system in the building;

(c) To suspend or terminate district cooling services to the building.

(2) Subsection (1) does not empower an authorized officer to enter a part of the building that is for residential use without the consent of the occupier of that part.

(3) An authorized officer may exercise any power under this section with the assistance of any other person the officer thinks fit.

21. Offences

(1) A person commits an offence if the person—

(a) Obstructs an authorized officer, or a person assisting the officer under section 20(3), in the officer’s performance of a function under this Ordinance; or

(b) Tampers with a facility owned and maintained by the Government for any purpose relating to the provision of district cooling services.

(2) A person who commits an offence under subsection (1) is liable on conviction to a fine at level 3 and to imprisonment for 6 months.

Part 5
Appeal

22. Appeal to appeal board

(1) A person who is aggrieved by any of the following decisions and direction made in respect of the person may appeal to an appeal board against the decision or direction—

(a) A decision not to approve a person as the consumer of district cooling services for a building under section 4(4);

(b) A decision to refuse to provide district cooling services to a building under section 6(2);

(c) A decision to suspend or terminate district cooling services to a building under section 7(1)(b), (c), (d), (e), (f) or (g);

(d) A decision not to resume district cooling services to a building under section 8(2) where the services were suspended under section 7(1)(b), (c), (d), (e), (f) or (g);

(e) A decision to refuse an application for the cessation of the approval of a person as the consumer of district cooling services for a building under section 9;

(f) a decision to issue or amend an improvement notice under section 18;

(g) A direction contained in an improvement notice.

(2) An appeal under subsection (1) against a decision or direction does not suspend the decision or direction unless the Director decides otherwise.

23. How to lodge an appeal

(1) A person may lodge an appeal under section 22(1) by giving a notice of appeal to the Director.

(2) A notice of appeal must be given within—

(a) 14 days after the date on which the person is notified of the decision or direction appealed against; or

(b) A longer period that the Director may allow.

(3) A notice of appeal must—

(a) Be in a specified form;

(b) Be accompanied by a copy of any document on which the person intends to rely;

(c) Contain the particulars of any witness that the person intends to call at the hearing of the appeal.

(4) as soon as reasonably practicable after receiving a notice of appeal, the Director must deliver it to the Secretary.

24. Appeal board panel

(1) The Secretary is to appoint members to an appeal board panel consisting of the following numbers and categories of members—

(a) Not more than 4 members, each of whom is—

(i) A barrister qualified to practise as such under the Legal Practitioners Ordinance (Cap. 159); or

(ii) A solicitor qualified to act as such under that Ordinance;

(b) Not more than 4 members, each of whom is a corporate member of The Hong Kong Institution of Engineers in one or more of the electrical, mechanical and building services disciplines;

(c) Not more than 4 members, each of whom is a corporate member of The Hong Kong Institution of Engineers in a discipline other than those mentioned in paragraph (b); and

(d) Not more than 4 members, each of whom is not, in the Secretary's opinion, from the engineering profession.

(2) For an appointment under subsection (1) (b) or (c)—

(a) A person is ineligible if the person has less than 10 years' experience of practice in the engineering profession in Hong Kong; and

(b) If a person is a corporate member of The Hong Kong Institution of Engineers in more than one discipline, the person's membership is, for the purposes of subsections (1) and (6)(d), to be regarded as being only in the discipline designated by the Secretary for the appointment.

(3) A public officer is ineligible for an appointment under subsection (1).

(4) A member of the appeal board panel is to be appointed for a term of 3 years and may be reappointed where each reappointment is for a term of 3 years.

(5) A member of the appeal board panel may, at any time, resign from his or her office by issuing a notice in writing to the Secretary.

(6) The Secretary may terminate the office of a member of the appeal board panel if the Secretary is satisfied that the member—

(a) Has become a public officer;

(b) Has become bankrupt or has entered into a voluntary arrangement within the meaning of section 2 of the Bankruptcy Ordinance (Cap. 6) with the member's creditors;

(c) Is incapacitated by physical or mental illness;

(d) Has ceased to be of the capacity by virtue of which the member was appointed; or

(e) Is otherwise unable or unfit to perform the functions of a member of the appeal board panel.

(7) The Secretary must give notice in the Gazette of any appointment, reappointment, resignation or termination of office under this section.

25. Appeal board

(1) Within 21 days after receiving a notice of appeal delivered under section 23(4), the Secretary must appoint from among the members of the appeal board panel a District Cooling Services Appeal Board to hear the appeal.

(2) An appeal board is to consist of 5 members—

(a) One of whom is the Chairperson of the board, who must be appointed from the category of members specified in section 24(1)(a); and

(b) The remaining 4 members must be appointed from all of the 3 categories of members specified in section 24(1)(b), (c) and (d).

(3) If a vacancy occurs in an appeal board before the hearing of the appeal begins, the Secretary must, as soon as reasonably practicable, make an appointment from among the members of the appeal board panel to fill the vacancy so that the board is composed in accordance with subsection (2).

(4) The members of an appeal board may be paid out of the general revenue any remuneration the Financial Secretary determines.

26. Proceedings of appeal board

(1) The quorum for a meeting of an appeal board is 3 members, one of whom must be the Chairperson of the board.

(2) A question before an appeal board must be determined by a majority of those members present at the meeting at which the question is to be determined.

(3) If there is an equality of votes in respect of a question before an appeal board, the Chairperson of the board has a casting vote in addition to his or her original vote.

(4) An appeal board may perform any of its functions, and its proceedings are valid, despite—

(a) Subject to section 28, a vacancy in the board; or

(b) A defect in the appointment or qualification of a person purporting to be a member of the board.

(5) In performing their functions under this Ordinance, the members of an appeal board have the same privileges and immunities as a judge of the Court of First Instance has in civil proceedings in that Court.

(6) A person appearing before an appeal board as a witness, a party to an appeal or a representative of a party to an appeal is entitled to the same privileges and immunities as he or she would have in civil proceedings in the Court of First Instance.

(7) Subject to this Part, an appeal board may determine its own procedure.

(8) In this section—

Meeting includes a meeting to hear an appeal.

27. Hearing of appeal

(1) The Chairperson of an appeal board must notify the appellant and the Director of the date, time and place of the hearing of the appeal at least 14 days before the hearing.

(2) At the hearing of an appeal—

(a) The appellant may be represented by—

(i) A barrister or solicitor; or

(ii) (if the appellant is a body corporate) an individual authorized by the appellant; and

(b) The Director may be represented by—

(i) A barrister or solicitor; or

(ii) A public officer.

(3) An appeal board may engage a barrister or solicitor to attend the hearing of an appeal to advise it on any matter relating to the appeal.

(4) The hearing of an appeal must be open to the public unless the appeal board determines that there is a good reason for it to be held in camera.

(5) An appeal board may, by a notice signed by the Chairperson of the board and issued to a person—

(a) Direct the person to attend before the board and to give evidence; or

(b) Direct the person to produce documents.

(6) No person to whom a direction is given under subsection (5) is required to give any evidence, or produce any document, that tends to incriminate the person.

(7) A person who fails to comply with a direction under subsection (5) commits an offence and is liable on conviction to a fine at level 3.

28. Reappointment of appeal board in case of certain vacancies

(1) Subsection (2) applies if, after the hearing of an appeal has begun, a vacancy occurs in an appeal board and—

(a) As a result, fewer than 3 members of the board remain in office; or

(b) The vacancy is that of the Chairperson of the board.

(2) On the occurrence of the vacancy—

(a) The appeal board is dissolved; and

(b) the Secretary must appoint an appeal board under section 25(1) as if the Secretary had received, on the date on which the vacancy occurred, the notice of appeal delivered under section 23(4) in relation to the subject matter of the appeal again.

29. Appeal board may authorize inspection of installation etc.

(1) If an appeal board reasonably believes that an installation or facility is relevant to the determination of an appeal, the board may, by an authorization signed by the Chairperson of the board—

(a) Authorize a person to inspect the installation or facility; and

(b) Authorize the person to enter a building, except a part of the building that is for residential use, for the purposes of the inspection.

(2) A person who obstructs a person authorized under subsection (1) in the inspection commits an offence and is liable on conviction to a fine at level 3 and to imprisonment for 6 months.

30. Determination of appeal

(1) An appeal board may—

(a) Confirm, vary or revoke the decision or direction appealed against; or

(b) Substitute its own decision or direction for the decision or direction appealed against.

(2) An appeal board may make any order that it thinks fit with regard to the payment of—

(a) Costs and expenses of the appeal proceedings; or

(b) Costs and expenses of the Director or any other person in the proceedings.

(3) The costs and expenses ordered to be paid under subsection (2) are recoverable as a civil debt.

(4) An appeal board must issue to the appellant and the Director a notice of its determination and the reasons for the determination.

Part 6

Miscellaneous Matters

31. Presumptions and evidence in writing

(1) In any civil proceedings for the recovery of an unpaid charge or fee payable under this Ordinance, a document to which this subsection applies is admissible in evidence on production without further proof.

(2) Subsection (1) applies to a document that—

(a) Purports to be signed by the Director or an authorized officer; and

(b) States—

(i) The name of the person liable to pay the charge or fee;

(ii) The amount of the charge or fee;

(iii) The nature and other particulars of the charge or fee; and

(iv) That the charge or fee remains unpaid.

(3) If a document is admitted in evidence under subsection (1)—

(a) The court must, in the absence of evidence to the contrary, presume—

(i) That it was signed by the Director or the authorized officer as stated in the document;

(ii) That the facts referred to in subsection (2)(b) as stated in the document are true; and

(iii) That the record of the facts stated in the document was made and compiled at the time stated in it; and

(b) The document is evidence of all other matters contained in it.

(4) If a document is admitted in evidence under subsection (1), the court may, if it thinks fit, on its own motion or on the application of a party to the proceedings—

(a) Summon the person who signed the document; and

(b) Examine that person as to the subject matter of the document.

32. Delegation by Director

The Director may, in writing, delegate any of his or her functions under this Ordinance to a public officer attached to the Electrical and Mechanical Services Department.

33. Director may specify forms

(1) The Director may specify a form to be used for the purposes of any provision of this Ordinance.

(2) If the Director specifies a form under subsection (1), the Director must make copies of the form available—

(a) At the office of the Electrical and Mechanical Services Department during normal office hours; and

(b) In any other manner the Director thinks fit.

34. Secretary may amend Schedules

The Secretary may, by notice published in the Gazette, amend Schedule 1 or 2.

Schedule 1

[ss. 3 & 34]

District Cooling System in relation to which this Ordinance Applies

1. Kai Tak District Cooling System, which serves the area that is delineated and edged red on Plan No. KM9180 signed by the Director of Lands on 12 August 2014 and deposited in the office of the Director of Electrical and Mechanical Services.

Schedule 2

[ss. 10 & 34]

Charges for District Cooling Services

1. Calculation of charges for district cooling services

(1) This Schedule applies to the calculation of the following charges for a district cooling system—

(a) Capacity charge and capacity overrun charge (see section 2 of this Schedule);

(b) Consumption charge (see section 3 of this Schedule);

(c) Surcharge and further surcharge (see section 4 of this Schedule).

(2) Section 5 of this Schedule sets out the following rates that are applicable to a building to which district cooling services are provided by a district cooling system referred to in that section—

(a) Capacity charge rate;

(b) Consumption charge rate.

2. Capacity charge and capacity overrun charge

(1) The amount of capacity charge payable under section 10(1)(a)in respect of a building for a month is to be calculated according to the following formula—

Capacity Charge = C × CR

Where; C contract cooling capacity of the building; and CR capacity charge rate applicable to the building.

(2) The amount of capacity overrun charge, if payable under section 10(1)(b) in respect of a building for a month, is to be calculated according to the following formula—

Capacity Overrun Charge = (AC – C) × CR × 110%

Where; AC highest actual cooling capacity of the building in the month; C contract cooling capacity of the building; and CR capacity charge rate applicable to the building.

(3) If district cooling services are provided to a building in a month for a period of less than 1 month, the amount of capacity charge, and that of any capacity overrun charge, payable for that month are to be calculated on a pro-rata basis according to the number of days for which the services are provided to the building in that month.

3. Consumption charge

The amount of consumption charge payable under section 10(1)(c) in respect of a building for a month is to be calculated according to the following formula—

Consumption Charge = AE × ER

Where; AE actual cooling energy consumption of the building in the month; and ER consumption charge rate applicable to the building.

4. Surcharge and further surcharge

(1) The amount of surcharge, if payable under section 10(2)(a) in respect of a primary charge or fee, is to be calculated according to the following formula—

Surcharge = (PC – PCP) × 5%

Where; PC the primary charge or fee that is payable as at the due date; and PCP the part of the primary charge or fee that has been paid, if any, as at the end of the due date.

(2) The amount of further surcharge, if payable under section 10(2)(b) in respect of a primary charge, fee or surcharge, is to be calculated according to the following formula—

Further Surcharge = (PCS – PCSP) × 10%

Where; PCS the primary charge, fee or surcharge that is payable as at the due date; and PCSP the part of the primary charge, fee or surcharge that has been paid, if any, as at the expiry of the period of 6 months beginning on the day after the due date.

5. Capacity charge rate and consumption charge rate

(1) For a building to which district cooling services are provided by a district cooling system specified in column 1 of the following table;

(a) The capacity charge rate applicable is specified in paragraph (a) in column 2 opposite that system; and

(b) The consumption charge rate applicable is specified in paragraph (b) in column 2 opposite that system.

Table

District cooling system	Rate of charge
1. Kai Tak District Cooling System	(a) **Capacity charge rate (*CR*)—** (i) for the initial period— CR = \$112.11 per kilowatt refrigeration (kWr); (ii) for each subject period— CR = $CR_{n-1} \times (1 + CCPI_r)$ Where; CR_{n-1} capacity charge rate applicable immediately before the subject period; and $CCPI_r$ rate of change in CCPI applicable for the subject period. (b) **Consumption charge rate (*ER*)—** (i) for the initial period— ER = \$0.19 per kilowatt-hour refrigeration (kWrh); (ii) for each subject period— ER = $ER_{n-1} \times (1 + ET_r)$ Where; ERn-1 consumption charge rate applicable immediately before the subject period; and ETr rate of change in electricity tariff applicable for the subject period.

(2) In this section—

Initial Period, for the Kai Tak District Cooling System, means the period beginning on the commencement date# of this Ordinance up to and including the first 31 March that follows;

Rate of Change In CCPI, in relation to a subject period beginning in a year, means the annual rate of change in the Composite Consumer Price Index recorded for the preceding year, after removing the effects of all one-off relief measures of the Government, if any, as compiled and published by the Commissioner for Census and Statistics;

Rate of Change In Electricity Tariff, in relation to a subject period beginning in a year, means the annual rate of change in electricity tariff applied to the year, as announced by the supplier of electricity to the district cooling system and publicized through the Internet by the Director;

Subject Period, for the Kai Tak District Cooling System, means any 12-month period beginning on 1 April of a year up to and including 31 March in the following year that is after the initial period.

Editorial Note:

[#] Commencement date: 27 March 2015

Annex (3-3)
Regulatory framework of Egypt district cooling

When designing district cooling / heating plants, the electrical consumption of the plant equipment shall be between 0.25 kW / TR in absorption stations to 0.9 kW / TR in conventional stations.

Chilled / Hot water pipe networks shall be within the planning of utilities for new areas and the urban planning shall comply with the enactment of regulations for the sale of land.

The method of calculating the usage tariff is as follows:

1 - Connection charge has a fixed value per ton of refrigeration TR or equivalent paid when contracting.

2. Capacity charge is related to the cooling capacity that the building is designed on the basis of it (TR or equivalent). It is usually paid each month regardless of what is consumed monthly.

3. Consumption charge is related to the quantity of consumption (TR.hr).

A good financial model should be used and consider the following:

1. Accurate estimation of capex - capital expenditure

2- Accurate estimation of the fixed and variable Opex-operating expenditure.

3. Estimating the depreciation rate of the fixed assets and preparing a table for the amortization value throughout the life of the project.

4 - Build an appropriate financing structure that takes into account the principle of dept to equity and maintains an acceptable level of financial leverage and financial risks.

5 - Calculate the cost of money and rate of return IIR required for investment.

6. Calculate the cooling / heating energy tariff that achieves the required rate of return.

7- Calculation of the equation of the adjustment of the cooling / heating energy tariff in case of changes in input prices of electricity, natural gas, water or other energy sources.

It is recommended that:

1. Using the discounted cash flow approach to build the Financial model.

2 - Calculate the cost of money using the weighted average cost of capital model, which at the same time represents the discount rate.

3 - Calculate the rate of return required on the invested money using the capital asset pricing model.

4. It is recommended that energy costs be separated from annual operating costs. It includes the cost of inputs as gas, electricity and water (feed and exchange), which are covered directly by the consumption charge.

Depreciation rates are recommended for the following assets:

- Buildings 40 years
- Distribution network 30 years
- Equipment and machinery 20 years
- Cars, Furniture and Computers 5 years

The appropriateness between cost and benefit should be taken into account when constructing the financial model, as well as the nature of district cooling / heating projects in terms of the productive life of the plant and the distribution network / networks.

The Building, Ownership and Operation Agreement (B.O.O) and the appropriateness of investment should be formulated in a manner consistent with the gradual expansion of station and network power capacity.

The annual rate of increase in the sale price of TR.hr (cooling / heating) should not be installed but preferably linked to the annual inflation rate declared.

It should be reviewed periodically (every three years, for example) in the rate of annual increase in the sale price of one TR.hr (cooling / heating) in case of using a constant annual increase rate.

When selecting chilled water units for central cooling stations:

1 - Preparation of the Load Demand Curves of the thermal load throughout the day and month and year

2. Economic trade-offs and the degree of reliability among the available sources of energy, whether electricity, gas or other heat source (eg, solar energy, waste energy).

3 - Preparation of the preliminary financial feasibility study including costing and the principles and mechanisms of financing.

4. Use of refrigerants compatible with the environment according to the recommendations of the Montreal Protocol and its amendments.

Water must be treated to solve sedimentation, corrosion and microbiological activity throughout the chilled water system and cooling water.

When selecting thermal energy storage systems, consider preparing and training highly qualified operators, studying the impact of different options on public utilities and conducting detailed feasibility studies of these different methods available.

The chilled / hot water distribution Network shall be designed as closed type when a service is required for a specified number of users with cooling / heating loads previously known before the installing grid and as open type when there are no laws forcing users to be connected to Distribution Network.

Computer modelling must be used to estimate expectations for future network installations. The designer must use the hydraulic model to determine the size of the main lines of the distribution network based on the Load Diversity, while the size of the connection lines for each user is determined by its maximum load.

The designer must consider the possibility of introducing new subscribers to any point in the network without cutting the service or emptying the network of water inside.

The designer should initially define a clear strategy for the temperature difference (ΔT) between supply and return of the chilled / hot water. It must be adhered to by all the parties used for district cooling / heating system.

License donors should be involved early in the Piping Layout process when extend in roads or public places to coordinate with other infrastructure networks, ensure the lowest depth for buried pipes and thus reduce cost. The hydraulic model is then used to determine the sizes of pipes and substitutes Possible for the layout of the distribution network, the pumping system and possible future changes to the network.

The control and measuring devices in the pumping system of the chilled water plant shall be of a high degree of accuracy and precision, and the operating crew shall be good trained in order to handle operating conditions changes.

It is recommended to use high efficiency End Suction water distribution pumps at small capacities less than 60 l / s (1000 gallons / min)

The number of valves rooms should be minimizing to as few as possible and a good ventilation system must provide within them and quick couplings shall be provided for drainage pipes outside the room that allow the connection of a pump to drain the water from the room if necessary.

A service vehicle equipped with the following shall provided: (movable generator - one or more pumps with connections - ventilation fan with connections - electric or pneumatic hand tools - electric welding and oxy-acetylene - fire extinguishers - first aid kit for valve room service.

The operator of the chilled water service provider shall work with the service users to achieve the best design, operation and performance of the plant as well as the building systems required to be adapted to avoid inefficient and expensive performance.

The service provider shall supply the buildings required to be adapted with the appropriate cooling / heating energy, whether directly or indirectly. Also, ensure that the water temperature return from the buildings to the station is identical to the design, to avoid symptoms such as low ΔT syndrome.

The design principles and operating limits of the building must be observed to achieve the design temperature difference of the external distribution network (Reticulation System) in order to support the active and energy efficient performance of the station, where the performance of the station depends on these factors.

Industrial pressure control valves (pressure independent control valve PICV industrial type) shall be installed at the entrances of energy transfer stations to control the supply temperature of the chilled water entering the building.

The speed of the building pumps must be controlled either by the owner of the building or by the service provider by maintaining the pressure loss at the farthest point of the system, ensuring the water access to all the points of the system and in different loads.

In general, energy meters shall be used to measure the amount of energy transferred from the central station to the buildings. In general, the quality of the meters must be selected, installed and maintained under the supervision of the company responsible for the public chilled water supply station and according to its specifications and the requirements of the plant. The same company should be responsible for understanding the nature of buildings type and knowing the nature of the thermal loads of the buildings at the highest and least load for each building so that the type of meter can be chosen to be appropriate to the nature of each building.

The cooling capacity of the plant shall be sufficient and not overpriced with a precise distribution capacity for loads of the chilled water system.

The station must be operated with high economic efficiency even at partial thermal loads throughout the day or in different seasons.

It should be kept in mind that the energy tanks cover the total combined load and not just the peak load, so peak loads must be calculated according to the total cohort of the daily load. It is recommended that the storage capacity range from 25% to 33% of the total peak load.

An economic study based on good expectations and principles must be conducted to ensure the validity of operating income

The licensing requirements vary considerably according to the plant location but need to be coordinated with the competent authorities to locate the station and the chilled water distribution systems as well as the condenser water system. Therefore, it is necessary to start early to contact the competent authorities for obtaining licenses. Energy and environment. It is also necessary to establish channels of communication with road and fire-fighting bodies and other facilities.

National Ozone Unit (NOU) at Environment Public Authority (EPA) of Kuwait

In cooperation with

UNIDO & UNEP

Comparative analysis of three not-in-kind technologies for use in central air-conditioning

Final Draft Report

September 2018

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Project Coordinators:
UNIDO: Fukuya Iino
UNEP: Ayman Eltalouny

Comparative analysis of three not-in-kind technologies for use in central air-conditioning in Kuwait

Table of Content

Introduction

At the 75th EXCOM, UNIDO resubmitted requests for this proposal for feasibility studies, in line with decision 74/29 (originally 72/40), to develop a business model for district cooling in Kuwait and Egypt. UNIDO is the lead implementing agency and UNEP is the cooperating agency for both studies.

The feasibility study objective is to provide a detailed technical, financial as well as environmental and energy assessment / road map for the government of Kuwait, in the development of Central A/C systems. The focus of the feasibility study will be a full comparative analysis of three not-in-kind technologies namely:

I. Deep Sea Water free cooling.
II. Waste heat absorption and
III. Solar assisted chilled water absorption systems

Being considered the most promising for Kuwait.

The deliverables of the feasibility study will be:

1. Assessment of the most suitable not-in-kind technology for Central AC systems
2. Assessment of available renewable energy sources,
3. Assessment of legalization barriers,
4. Assessment of energy saving mechanisms,
5. Assessment of environmental benefits
6. Development of a financial structure and financial scheme for both, governmental co-financing mechanisms, including the possibility of providing incentives for private companies.

The project was approved by the 75th EXCOM in accordance to the following decision:

> *20. For Kuwait, the focus of the feasibility study will be a full comparative analysis of three not-in-kind technologies: deep sea water free cooling, waste heat absorption and solar assisted chilled water absorption systems, to determine which may be the most promising option for central air-conditioning systems.*
>
> *21. The following activities will be implemented:*
>
> *(a) A literature review on the current status of deep sea water free cooling, waste heat absorption, and solar assisted chilled water absorption systems;*
>
> *(b) Analysis of renewable energy sources, legal barriers, energy saving mechanisms, environmental benefits; and*
>
> *(c) Development of a financial structure and financial scheme for both the Government, co-financing mechanisms (including the possibility of reducing energy subsidies), and private energy providers.*

Project Objectives

The focus of the feasibility Study is to comparatively assess three not-in-kind technologies for central AC and DC; and provide technical and economical evidence to be disseminated to government officials as well as private investors. This feasibility study will address:

- Use of not-in-kind technologies
- Central A/C technology options;
- Legalization Barriers;
- Energy saving mechanisms;
- Governmental co-financing mechanisms

Project Context

UNIDO and UNEP have been implementing a demonstration project for a detailed technical, financial as well as environmental and energy assessment / road map for the government for Kuwait, in the development of Central A/C systems. The focus of the feasibility study will be a comparative analysis of three not-in-kind technologies namely deep-sea water free cooling, waste heat absorption and solar assisted chilled water absorption systems that are being considered the most promising for Kuwait.
In addition, the most suitable Not-In-Kind (NIK) cooling technology will be selected to air condition two sites, a school and a mosque. Conceptual designs are prepared, each design shall be governed by the principle of energy conservation, adopting together with conventional In-Kind (IK) cooling other suitable techniques NIK cooling techniques to provide substantial savings in operating costs.

1.0 Selection Criteria for the Two Sites

Questionnaires were prepared, see annex 1, based on a point system to help evaluate selection of the best sites/buildings suitable for application of NIK cooling technologies. Unfortunately, this selection process did not provide tangible results because the best sites selected were not assessable to a deep-seawater source, reject heat sources or downstream natural gas piping network (solar assisted absorption cooling). Eventually, general construction plans were obtained for candidate sites that are to be built by “Kuwait Public Authority for Housing Welfare (KPAHW)” and those satisfied one important NIK cooling technology; Two Stage Direct Indirect (TSDI) evaporative cooling.
Sites that are in the planning stage were preferred also buildings designs that are to be repetitively for constructed in future at other sites.
In total four different candidate building were proposed by KPAHW.
Those are:

1. A school for boys/girls. The school central air-conditioning system, utilising 5 air cooled chillers, each 200 TR refrigeration capacity, total capacity 1000 TR. The school air conditioning design IK design was provided.
2. A Medical Centre. Comprising small operating theatres, emergency units and other medical facilities. The Medical Centre has a designed IK central air conditioning system using DX units. Unfortunately, the design documents were not complete, and it proved impossible to obtain enough data to form an accurate idea on refrigeration loads, schedule of equipment and other vital design data on time to consider this selection seriously.
3. A small mosque. Although the mosque architectural and civil design data were complete, no central air conditioning system was provided. This excluded the use of this mosque because of the time needed to estimate cooling loads and create a central air conditioning design.
4. An impressive central mosque, with a complete IK central air conditioning IK design was provided. The air conditioning IK design documents were complete and were enough to get a complete and full picture on the IK design.

It was decided to select site 1 and 4 as the two designated sites for changing their air conditioning design from IK to NIK or NIK assisted by IK.
It is important to note that the selection of the sites fulfilled two important criteria:

I. Sites are important to the country's construction policy represented by Kuwait Public Authority for Housing Welfare (KPAHW) building program.
II. Construction plans are well developed but not too far developed that NIK cooling cannot be integrated into it.

The two buildings selected were ideally suited for Two Stage Direct Indirect (TSDI) evaporative cooling. This is especially important given the importance of the recommendations of increasing fresh air (outdoor air) in those applications of schools and public gathering areas.

2.0 Compilation of Technical Solutions

The relevant technical solutions chosen for the demonstration of cooling systems are examined such as fluorocarbon chillers (In- Kind cooling technology), non-fluorocarbon chillers (Not-In-Kind cooling technology), distribution piping network, load interface techniques and energy calculation methods.
The compilation of technical information on relevant technical solutions chosen for the demonstration of NIK cooling systems encompass the following solutions compiled:

- Systems utilising In-Kind cooling technologies or fluorocarbon chillers.
- Systems using Not-In-Kind cooling technologies or non-fluorocarbon chillers.
    - Systems operating by deep sea cooling or cooling/heating.
    - Reject exhaust heat or flue gas streams fired absorption systems.
    - Solar assisted chilled water absorption systems.
    - Natural gas fired double effect absorption chillers/heaters systems.
    - Steam or hot water indirect fired absorption systems.
- Distribution piping networks pumping arrangements.
- District cooling for a city using reject heat in power stations
- Load interface techniques and Energy calculation methods.
- Daily cooling load profile curves, diversity factors and Thermal Energy Storage (TES).

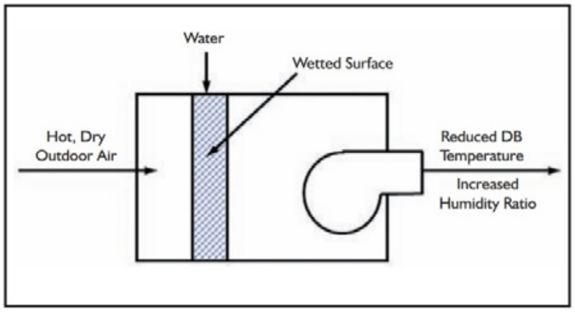
Details on each solution and suitability for the case is described in detail in Annex-2

3.0 Two-stage Direct/Indirect (TSDI) evaporative cooling systems and Kuwait Climatological Conditions.

The two sites suggested by "Kuwait Public Authority for Housing Welfare (KPAHW)" were not within easy access to the Gulf for a Deep-Sea Cooling system use, nor were they near an exhaust heat source or a downstream natural gas pipeline to use with a solar assisted cooling system. The two sites were however most suited for using an NIK system, a two stage direct/indirect evaporation system. Kuwait being a low humidity country, especially in summer, makes it ideal for using the system at high efficiency when most needed. The system was adopted for both sites, as shown later.

3.1 The Concept of Two Stages direct/Indirect (TSDI) evaporative cooling

Direct evaporative cooling is an old technology, useful in low wet bulb ambient temperature regions, since it relies on reducing the conditioned air temperature by evaporating water in the stream and using the water latent heat to reduce its temperature. Indirect evaporative cooling allows cooling the air stream without raising its humidity and allow using the system in hybrid arrangements with other cooling systems. This expands the use of indirect evaporative cooling; improve its efficiency while reducing water consumption



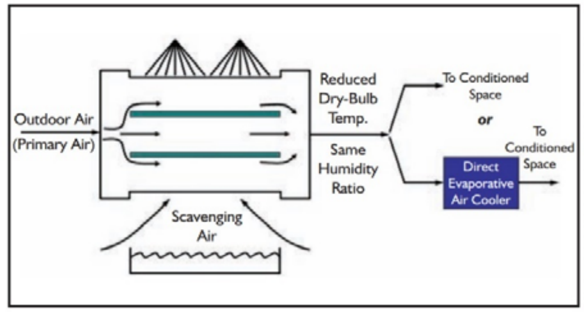


Figure 3.1: Basic direct evaporative cooler Indirect or indirect-direct evaporative cooler.

Figure 3.1 shows a schematic diagram of both systems. Indirect evaporative cooling using a secondary stream, not in directly contact with the primary stream, cools the outdoor air. The humidity of the primary stream thus does not rise. By combining both direct and indirect evaporative cooling air cooling quality improves.

In figure 3.1 the primary air is cooled in the first stage using an air heat exchanger. Primary air, which flows inside the heat exchanger, is cooled without raising its humidity. It is then cooled again by direct evaporative cooling in the second stage and its humidity is raised. Another direct/ indirect cooling system cools the water (not the primary air) in the first stage. The cooled water flows to a fin and tube heat exchanger cooling another stream of outdoor air reducing its temperature and humidity. The second stage cools the air by evaporative cooling.

Figure 3.2: An Indirect Evaporative Cooling module.

In Figure 3.2, shows a modular indirect evaporative cooling module comprising the heat exchanger section. Figure 3.3 shows the airflow pattern in and around the heat exchanger.

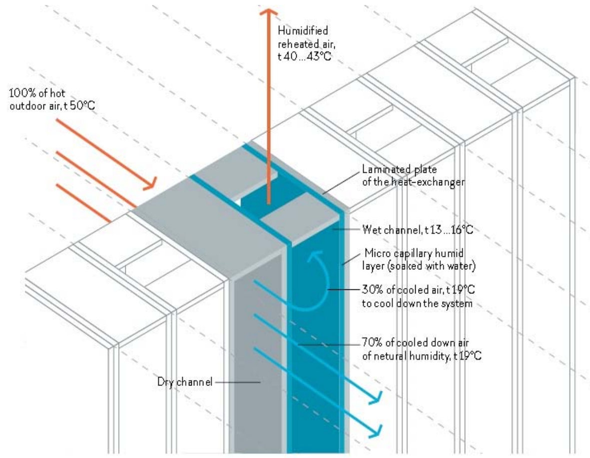


Figure 3.3: Details of air flow in and around an indirect evaporative cooling heat exchanger

Manufacturers of commercially available units claim to provide supply air at the following temperatures at 50º C conditions:

	Ambient Conditions	
	Condition 1 **50ºC dry bulb/28ºC wet bulb**	**Condition 2** **50ºC dry bulb/19ºC wet bulb**
Supply air		
Achieved conditions:		
Dry bulb, ºC	25.7	13.8
Wet bulb, ºC	21.7	3.8

The higher wet bulb temperature in the initial condition one (t db= 50 ºC, t wb=28 ºC), resulted in supply air at a higher t db (25.7 ºC) compared to initial condition 2 (t db= 50 ºC, t wb=19 ºC) where supply air t db dropped to 13.8 ºC.
Water consumption at those conditions is about 1.2 l/hr per kW. Water consumption may rise to about 2.5 l/hr per kW at maximum elevated dry bulb temperatures at Kuwait extreme summer conditions, when outdoor wet bulb temperatures are over 28ºC, in certain climate zones, a hybrid system is used utilizing a mechanical vapour compression, an IK system to assist until those harsh conditions are not prevailing. The system then switches back to Indirect Evaporative Cooling.

3.2 Kuwait Climatological Conditions.

Kuwait enjoys low humidity conditions during summer, which makes it ideally suited for the use of TSDI evaporative cooling. Table 3.1 below shows basic Climatological readings in Kuwait, for 2002. The year was arbitrally chosen according to information made available. The date stated is the one at which the highest dry bulb temperature occurred for the designated month. Coincident dew point, wet bulb and relative humidity are shown.

Table 3.1 Kuwait Highest monthly dry bulb, coincident dew point, wet bulb and relative humidity.

Kuwait Date, 2002	Hour	Highest T_{db}, °C	Coincident		
			Dew point, °C	T_{wb}, °C	Relative Humid. %
09.01	14:00	23.5	6.6	13.970	33.652
14.02	15:00	25.6	-0.3	12.499	18.154
31.03	15:00	31.8	3.5	15.975	16.691
22.04	15:00	36	13.8	21.298	26.537
22.05	15:00	44.2	1.8	19.663	7.56
29.06	15:00	47.9	4.7	21.513	7.684
06.07	16:00	45.7	3.8	20.624	8.066
14.08	15:00	49.7	4	21.851	6.686
02.09	14:00	46.6	4.5	21.079	8.093
01.10	15:00	38.8	11.2	20.997	19.213
06.11	15:00	32.5	14.3	20.492	33.302
14.12	15:00	21.9	10.3	14.983	47.663

The table shows that during November, December and January the high humidity ratio shall not provide enough TSDI cooling, if needed, and IK cooling may be needed. Otherwise, in March, April May, June, July, August, September and October TSDI cooling will operate well because of the low relative humidity (19.2 % to 6.7 %). This study is base on this criterion.

The two sites/buildings are redesigned to operate primarily on TSDI evaporative units with IK chilled water or DX units assisting in times when humidity is highest, providing a maximum of 20 to 30 % of the cooling capacity when needed during those eight months.

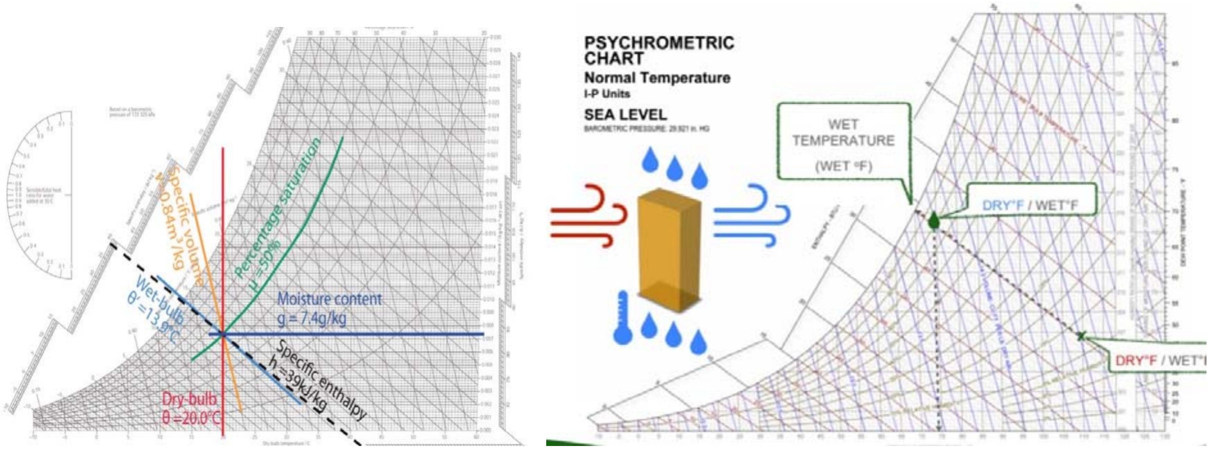
Furthermore, Thermal Energy Storage (TES) tanks of the stratified type were added to the system in order to reduce further the installed IK capacity. TES tanks stores cooling enthalpy at off-peak times and release it at on-peak time. This helps reducing installed capacity because energy is produced at night-time, when climatic temperatures are milder, saving energy further in the order of 10 to 20 %.

3.3 Expected operational Savings of a 5000 cfm (30 TR, 106 kW) TSDI evaporative cooling unit

In sections 4.0 and 5.0 it is shown that the saving in operational cost for the two-sited selected. To demonstrate these savings, the following case study was made:

Two Stage Evaporative Cooling:

A 5000 cfm 100% outside air (Full Fresh Air) air handling unit is considered, the refrigeration capacity saving using a NIK evaporative system assisted by an IK system is calculated and compared to a full IK mechanical DX vapour compression system. Figures 3.4 and 3.5 shows the thermodynamic processes on a psychometric chart. Figure 3.6 and 3.7 shows an isometric view of the unit, a cross section plan and the thermodynamic processes on a psychometric chart. Figure 3.8 and 3.9 shows energy saving for Kuwait conditions in August, see table 3.1, the highest dry bulb temperature during the whole year.



Figures 3.4 and 3.5: Thermodynamic processes on psychometric chart.

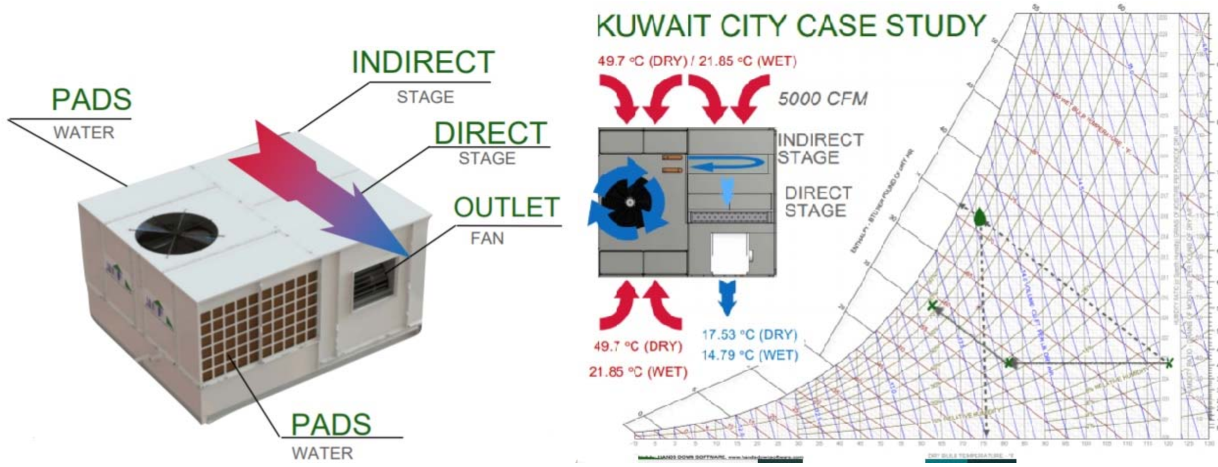


Figure 3.6 and 3.7: Isometric view of TSDI evaporative cooler and the thermodynamic processes on the psychometric chart

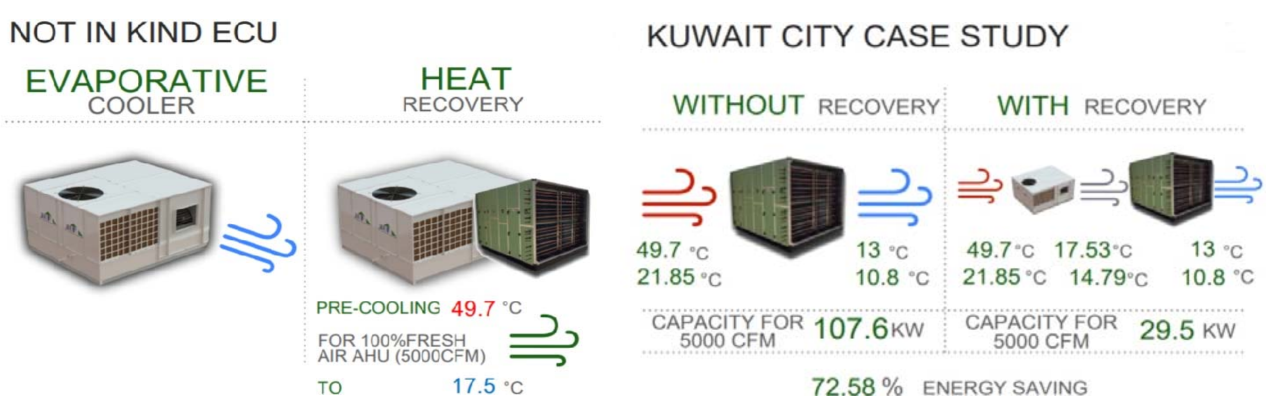


Figure 3.8 and 3.9: Energy saving for Kuwait maximum summer conditions, August 2002.

In this TSDI evaporative cooling system the first stage cools water located in the LHS of the unit in figure 3.6. Cooled water flows to the indirect stage, the RHS of the unit, in turn cools outdoor air passing through this second stage. Evaporative cooling then cools the air at the last stage. Figures 3.8 and 3.9 show the outdoor air conditions:

- Initial Kuwait conditions, August 14^{th} at 15:00: t db= 49.7 °C, t wb= 21.851 °C and RH= 6.686 %.
- Conditions exiting NIK TSDI unit : t db= 17.53 °C, t wb= 14.79 °C
- Conditions exiting IK DX unit : t db= 13 °C, t wb= 10.8 °C.
- Refrigeration capacity saved by using TSDI evap. Cooling: 78.1 kW or 72.58 % saving.

Savings for a 5000 cfm DX unit, with a refrigeration capacity of 107.6 kW (30.6 TR) are calculated to be about 73 % compared to a full IK cooling system. Refrigeration capacity of the IK DX unit drops to 29.5 kW (8.5 TR) or about 27.5 % of original IK capacity.
Total water Consumption is 178.16 l/hr total or 178.17/ 78.58 = 2.28 l/hr per kW at maximum dry bulb conditions of the year, 14th of August 2002.

The First Site

4.0 TSDI evaporative cooling system for a Chilled Water system air conditioning of a School.

The first site selected is a school. The school air conditioning design was completed and utilised a chilled water system connected by a chilled water-piping network to air handling units and fan coil units. The system incorporates a small number of split units (3) and one packaged unit.

4.1 Estimated Cooling Load of the system.

About 1000 TR.

4.2 Modified Conceptual Design of the Plant Incorporating TSDI evaporative cooling system.

Conceptual design under review currently.

4.3. Operational savings of the Hybrid NIK assisted by IK system.

Results are being rechecked and verified and should be ready to publish before the end of October

The Second Site

5.0 TSDI evaporative cooling system for a Direct Expansion (DX) air conditioning of a Mosque

5.1 Estimated cooling load.
5.2 Modified Conceptual Design of the Plant Incorporating TSDI evaporative cooling system.
5.3 Operational savings of the Hybrid NIK assisted by IK system.

As above, conceptual design is finalised, and results are being rechecked and verified and should be ready to publish before the end of October.

References

1 Natural Cold Water District Cooling Plants Enabled by Directional Drilling, ASHRAE CRC, Cairo, October 2010. http://www.cotherma.com/Press%20Release%20-%20Climate%20Change%20with%20Innovation.pdf?Type=fpaper&pcode=1030

2 The AC of Tomorrow? Tapping Deep Water for Cooling. National Geographic, 20 October 2017.

3 US National Oceanic and Atmospheric Administration, NOAA, has National Centres for Environmental Information (NCEI), https://www.ncei.noaa.gov/about.

4 UNEP, 2015: District Energy in Cities—Unlocking the Potential of Energy Efficiency and Renewable Energy.

5 A. A. Olama, District Cooling, theory and practice, Taylor and Francis CRC Press, Boca Raton, USA, 2017. www.CRCpress.com

6 S. Frederiksen, S. Werner, District Heating and Cooling, Studentlitteratur AB Lund, Sweden, 2013. www.studentlitteratur.se

7 ASHRAE District Cooling Guide, ASHRAE Atlanta, Georgia, USA, 2013. www.ashrae.org

8 International District Energy Association IDEA, District Cooling Best Practice Guide, Westborough, MA, USA, 2008. www.distrctenergy.org

Annex-1

Criteria and Questionnaire for sites locations -Kuwait NIK Project

No	Item	Criteria	Points	Score
1	New developed city/district.	New City = 20 New District in existing City = 15 Existing District = 5	20	
2	Minimum Cooling Capacity	< 5,000 TR = 5 5,000 – 10,000 TR = 7 10,000 – 30,000 TR = 8 > 30,000 TR = 10	10	
3	Proximity to: a. Sea side b. Waste Heat Source (elect. power station)	Within or less than 5Km = 30 5-10 Km = 20 More than 10 Km = 10	20	
4	Proximity to NG downstream line	Within connected proximity	10	
5	Current status of city/district development	Concept phase = 20 Design phase = 10 Contract phase = 5	20	
6	Type of application (residential, commercial, governmental, industrial, mixed)	Governmental = 20 Residential = 5 Commercial =15 Industrial = 15 Mixed Use = 20	20	
		Total	100	

Technical Information Survey

No.	Item	Details
1	Sites Parameters:	
A	Sites for District Cooling Plants under consideration.	- Name of sites: - Site 1: --------- - Site 2: ---------- - Site 3: ---------- - Site 4: ---------- (Chose two sites.)
B	Cost of Land: - Purchasing. - Renting.	Site 1: Site 2: Site 3: Site 4:
C	Cost of plant building construction:	For a masonry building: -----/square meter.

No.	Item	Details
		For a steel structure building: ------/square meter.
D	Additional Information you may think is important to list:	
2	Energy and Water.	
A	Electric Power Prices: - Low Voltage. - Medium Voltage. - High Voltage.	Residential: --- Commercial: ---- Industrial: ----- (Link to internet site- prices of electric power cost.)
B	Natural Gas Prices:	Site1: , Site 2: , Site3: , Site 4: Is it piped to site?
C	Is there a source of reject heat near the site? (Refinery, steel mill, glass factory, thermal desalination plant, electric power station, etc.…)	Site 1: Site 2: Site 3: Site 4:
D	- Is there a Refuse Processing Plant near the site? - Is there a Refuse Derive Fuel (RDF) available?	Site 1: Site 2: Site 3: Site 4:
E	Price of fresh water, brackish water and drain:	
F	Additional Information you may think is important to list:	
3	Salaries	
A	Salaries structure for: - Qualified Graduate engineers (5 to 10 years exp.): - Qualified Graduate engineers (1 to 5 years exp.): - Skilled Technician: - Technician: - Labourer:	
B	Additional Information you may think is important to list:	
4	Taxes and Custom Duties	
A	Rate of Income Taxes:	

No.	Item	Details
	- On individuals: - On Corporations:	
B	Taxes on Services: - On electric power supply: - On district Cooling Services. - Other.	
C	Custom Duties on imported Equipment:	
D	Value Added taxes on Imported goods and services:	

Financial Information Survey

No.	Item	Details
1	Sites Parameters:	
A	Sites for District Cooling Plants under consideration.	- Name of sites: - Site 1: --------- - Site 2: ---------- - Site 3: ---------- - Site 4: ---------- (Chose two sites.)
B	Cost of Land: - Purchasing. - Renting.	Site 1: Site 2: Site 3: Site 4:
C	Cost of plant building construction:	For a masonry building: -----/square meter. For a steel structure building: ------/square meter.
D	Additional Information you may think is important to list:	
2	Energy and Water.	
A	Electric Power Prices: - Low Voltage. - Medium Voltage. - High Voltage.	Residential: --- Commercial: ---- Industrial: ----- (Link to internet site- prices of electric power

No.	Item	Details
		cost.)
B	Natural Gas Prices:	Site1: , Site 2: , Site3: , Site 4: Is it piped to site?
C	Is there a source of reject heat near the site? (Refinery, steel mill, glass factory, thermal desalination plant, electric power station, etc.…)	Site 1: Site 2: Site 3: Site 4:
D	- Is there a Refuse Processing Plant near the site? - Is there a Refuse Derive Fuel (RDF) available?	Site 1: Site 2: Site 3: Site 4:
E	Price of fresh water, brackish water and drain:	
F	Additional Information you may think is important to list:	
3	Salaries	
A	Salaries structure for: - Qualified Graduate engineers (5 to 10 years exp.): - Qualified Graduate engineers (1 to 5 years exp.): - Skilled Technician: - Technician: - Labourer:	
B	Additional Information you may think is important to list:	
4	Taxes and Custom Duties	
A	Rate of Income Taxes: - On individuals: - On Corporations:	
B	Taxes on Services: - On electric power supply: - On district Cooling Services. - Other.	
C	Custom Duties on imported Equipment:	
D	Value Added taxes on Imported goods and services:	

Annex-2

Compilation of Technical Solutions

The relevant technical solutions chosen for the demonstration of cooling systems are examined such as fluorocarbon chillers (In- Kind cooling technology), non-fluorocarbon chillers (Not-In-Kind cooling technology), distribution piping network, load interface techniques and energy calculation methods.
The compilation of technical information on relevant technical solutions chosen for the demonstration of NIK cooling systems encompass the following subjects:

1. Systems utilising In-Kind cooling technology or Fluorocarbon chillers

The definition of Not-In-Kind DC cooling technology is technology that mostly utilize electric power to produce cooling. Not-In-Kind DC cooling technology is technology that mostly do not utilize electric power to produce cooling. The aim of this study is the dissemination of Not-In-Kind cooling technologies, to help introducing these technologies in Kuwait.
Fluorocarbon chillers are In-Kind cooling technology, since they are mechanical vapour compression machine operated by electric power. Fluorocarbon chillers have real (not subsidized) operating costs relatively higher than these of Not-In-Kind cooling technologies. Therefore, they are not used in this study as the main producers of cooling capacity, but to assist in the cooling process when needed.
Sometimes Not-In-Kind technologies or non-fluorocarbon chillers are not able to bring down the chilled water supply temperature to low design levels efficiently and economically. In this case, In-Kind technologies may be needed to assist the cooling process. When design supply chilled water temperatures are set at 3 to 4 °C, In-Kind technology can be included. For this reason, sometimes electric chillers are included in the design of chilled water plants in-series arrangement with non-fluorocarbon chillers such as absorption chillers.
Distribution piping network designed with large delta T requires low supply chilled water temperature. This is to help reduce the diameter of the chilled water piping, thus reducing cost. This is especially important in large and long networks. Those temperatures are not reachable with current commercially available second-generation absorption chillers, since they can provide chilled water temperatures down to 5 to 6 ^{o}C safely. Lower chilled water temperatures, 3 to 4 ^{o}C, are available with new generation absorption chillers expected commercially in the near future. Thus, fluorocarbon chillers can be included in-series design arrangement to achieve those low temperatures.
This is also the case in applications when ice or ice-slurry are used for thermal energy storage system (TES), since negative chilled water supply design conditions are required to produce ice or ice- slurry and those temperatures are not achievable with current generations absorption chillers.
However, when used the major portion of cooling capacity will be borne by Not-In-Kind cooling technology resulting in low operating costs for the system, while fluorocarbon chillers, electrically operated, will provide a small fraction of the operating costs to achieve lower supply design chilled water temperatures, when needed.

2. Systems using Not-In-Kind cooling technologies or Non-fluorocarbon Chillers

The main NIK cooling technology systems are:

A. Systems operating by deep sea cooling (DSC) or cooling/heating

Deep Sea Cooling is a new technology that uses cold-water temperature of the seas, at great depths, to cool chilled water of a district cooling system. The main advantage of this technique is that may consumes down to a tenth energy consumption compared to In-Kind technologies.

This technique is well developed in Scandinavian countries and in island states such as Hawaii and others. Stockholm City has used its unique location on the shore of the Baltic Sea and at the mouth of Lake Malaren (the largest lake in Sweden) to build a deep source cooling system for its downtown buildings. Another large project is planned for Dubai in the United Arab Emirates. Toronto City, Canada has the largest deep-source cooling project yet it is not the first city to plumb the depths of North America's glacial lakes.

Four years ago, Cornell University inaugurated a US $ 57 million lake-source cooling plant. The system cools university buildings and a nearby high school in Ithaca, New York.

The plant draws 3.9 ⁰C (39 F) water from 70 meters (250 feet) below the surface of Cayuga Lake, a glacially carved lake that is 132.6 meters (435 feet) deep at its lowest point The Natural Energy Laboratory of Hawaii Authority (NELHA), a state research facility located on the Big Island of Hawaii, runs its own deep-source cooling plant. The system cools buildings on the agency's campus, which overlooks the Pacific Ocean. The plant draws 6 ⁰C (42.8 F) seawater from depth of 610 meters (2,000 feet). "NELHA saves about US $3,000 a month in electrical costs by using the cold seawater air-conditioning process," said Jan War, an operations manager. Makai Ocean Engineering, a private company based in Honolulu, is also developing plans to cool all of the city's downtown using a similar system.

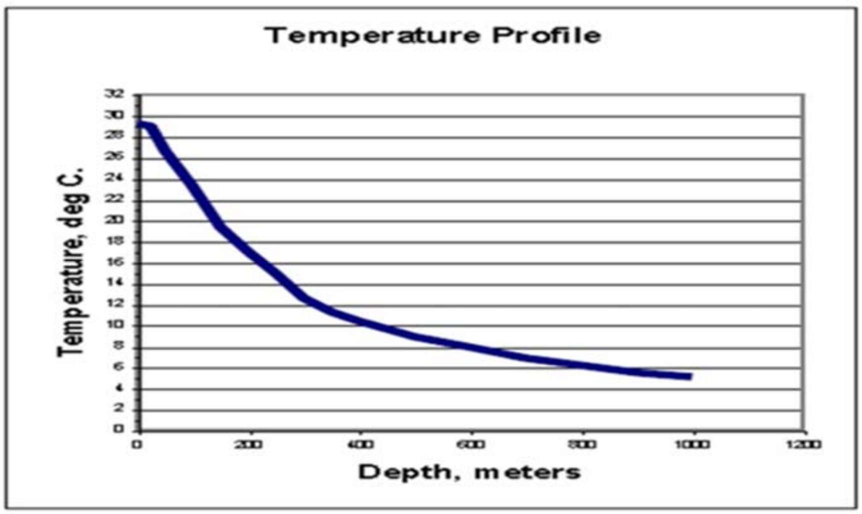


Figure 2.1: Seawater temperature drop versus depths of the Sea.

The graph shows the general trend of the downward decrease of seawater temperature as depth increase. This trend differs from summer to winter and with the location of the point where it is measured.

Oceanographers divide the ocean into categories by depth. The broadest category is the upper part of the ocean known as the —photical zone. This is generally regarded as the upper 200 meters of the ocean where sun light penetrates, and photosynthesis takes place. The bottom part of the ocean is called the —aphotical zone where sunlight does not add heat and cold temperatures are present. Bathymetry and oceanography studies suggest that at an ocean depth of at least 1000 meters, 4°C water temperature is assured. It should be noted that 4⁰C temperature might also be available at depths of 500 to 900 meters. Diligent temperature studies for the Gulf need to be conducted as part of the study preceding a proposed project [(1)].

For a specific location, measurements that are more accurate are available at the US National Oceanic and Atmospheric Administration (NOAA). At NOAA, the National Centres for Environmental Information (NCEI) hosts and provides access to one of the most significant archives, with comprehensive oceanic, atmospheric, and geophysical data. NCEI is the US leading authority for environmental information [(3)]. Once the Egyptian government approves the location of the plant, temperatures of the seawater at the location can be assessed.

Deep Sea Cooling and Horizontal Directional Drilling (HDD) Techniques

There are several problems associated with laying a pipe to access cold water from shore to the required depth. The tide action might dislodge anchoring blocks of the piping, especially with high seas. Coral Reefs and seabed marine life may also be affected. Because of that, environmental permits may be difficult to obtain. Returning seawater to the sea should be made so that it is returned to the depth strata where the seawater temperature is the same as that of the returning water. This assures conservation of the sea microorganisms without disruption.

Horizontal Directional Drilling (HDD) is a mature technology used in the Oil and Gas field. This technique enables directional drilling under the surface to access deep cold water with a horizontal displacement of up to eleven kilometres from shore. A rig could also drill a diagonal tunnel of suitable diameter to bring cold seawater to the surface. Using heat exchangers between the cold seawater and a chilled water system, temperatures of 5.5°C to 6.5°C could be achieved at the fresh chilled water network. Similarly, the rig would also drill suitable tunnel to return heated water to a suitable depth. This is the drilling technique suggested for the study.

Figure 2.2 shows the position of the supply and return tunnels and piping and the DC station.

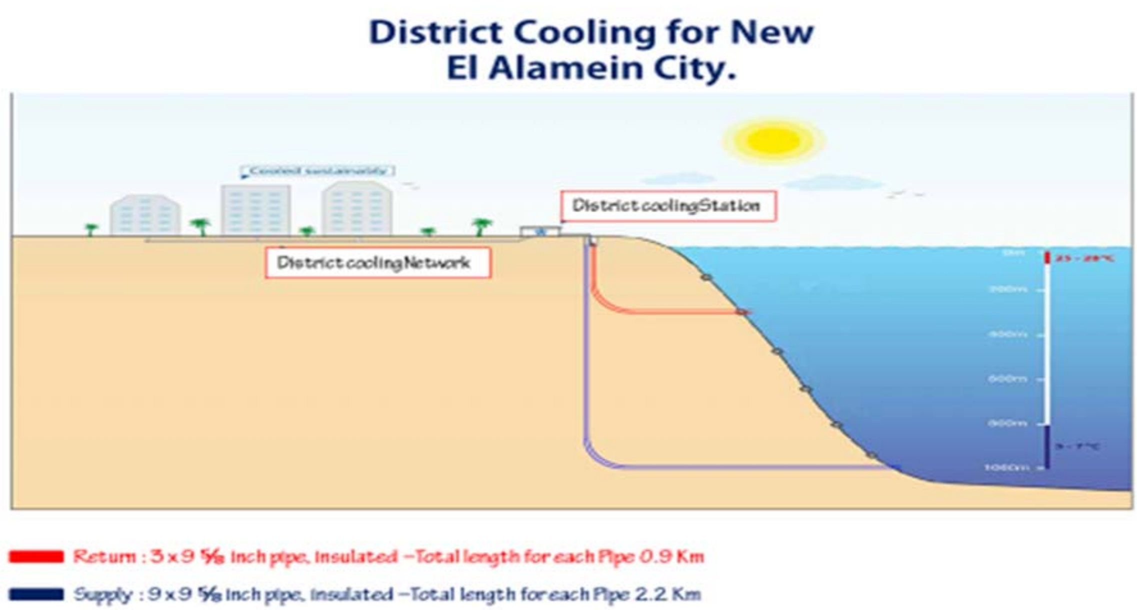


Figure 2.2: Example of Deep Sea Cooling or Free Cooling for a City.

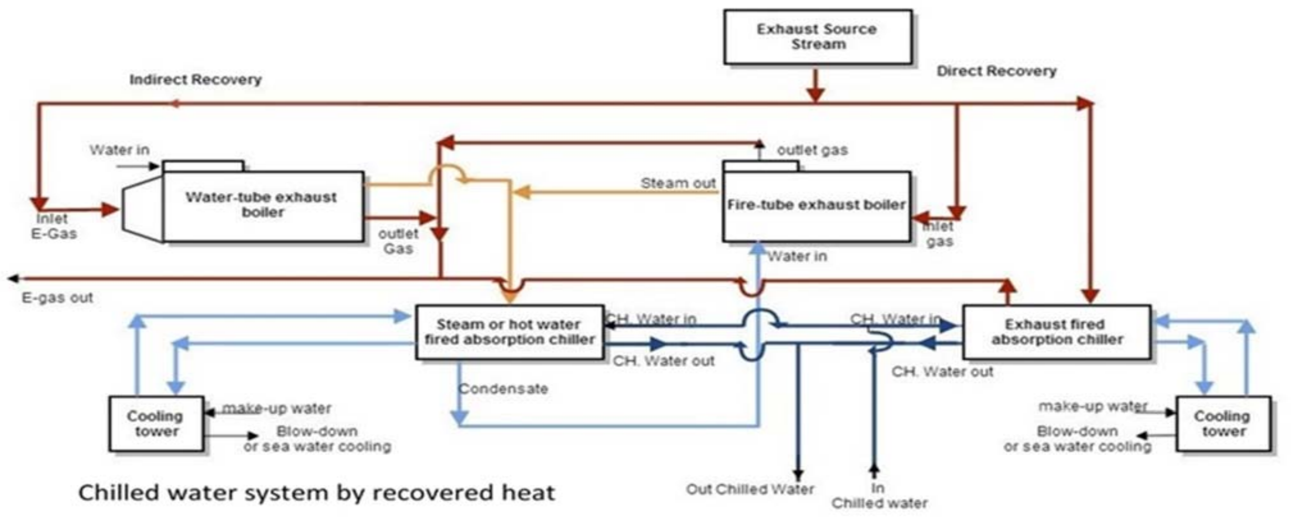


Figure 2.3: Schematic diagram of Exhaust and steam fired absorption chiller.

Figure 2.3 shows a schematic diagram of exhaust and steam fired absorption chiller. When the exhaust stream is relatively clean, with small amount of Sulphur oxides (SOx) and Nitrogen oxides (NOx) in the stream, it is possible to use the stream to fire directly an exhaust fired absorption chiller. Sulphur oxides and Nitrogen oxides when combined with condensate create acids that attack the generator of the absorption chiller and reduces its lifetime considerably. Therefore direct-fired exhaust absorption chillers have to be used with great caution and only when the exhaust stream composition is relatively free of these oxides. When the stream is not clean, a heat recovery boiler is recommended, either a water tube exhaust type or fire tube exhaust type depending on ease of cleaning the tubes from the inside or the outside. The system economics are excellent because of the negligible cost of the exhaust.

B. Solar assisted chilled water absorption cooling systems.

Solar assisted chilled water absorption cooling systems utilises vacuum tube solar collectors or concentrated collectors to heat up water in a closed loop. This heated water fires hot water fired absorption chillers producing chilled water. The capital cost of vacuum or concentrated collectors constitute a large part of the system capital investment. This is why, despite the low operating cost of the system it is not economically feasible to construct the entirety of a chilled water system using solar-fired absorption system. Systems are constructed using 10 to 20 % of the total capacity produced by solar-fired absorption chiller. Systems of total capacities around 500 TR with 50 to 100 TR operating with solar collectors have been constructed and operate successfully. Larger capacities are not be economical. Figure 2.4 shows the schematic diagram of such a system.

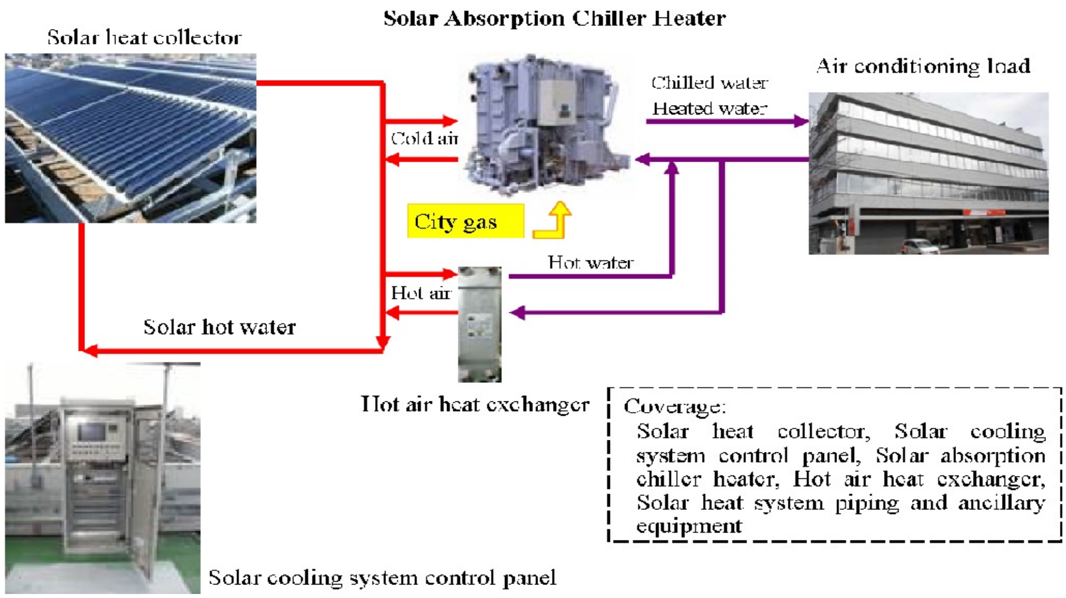


Figure 2.4: Solar assisted chilled water absorption cooling system.

C. Natural gas fired double effect absorption chillers/heaters systems.

This system can be economically advantageous if the price of natural gas in a country is cheaper than that of electric power, which is usually the case. The system is not dependent on electric supply irregularities at on-peak periods; hence, it helps shave and stabilizes electric power demand. Furthermore, when it is responsible for taking care of on-peak surges in a system, it limits use of electric power in those peak periods and reduces power demand surcharges. Figure 2.5 shows an 8,000 TR DC plant with gas fired absorption chillers. There are three generations of absorption chillers. The most common are the Double Effect second-generation units with a heat ratio (efficiency) of 1.2 to 1.45

Figure 2.5: DC plant with 8000 TR gas fired absorption chiller/heaters.

2.2.5 Steam or hot water indirect fired absorption systems.

Indirect fired absorption systems operate with steam or hot water from industrial processes or from reject heat. Some of the most important examples are Turbine Inlet Cooling System (TIC) used to increase the efficiency of gas turbine power plants. In summer, the turbine efficiency deteriorate due to high ambient temperatures. Cooling combustion air inlet to turbine from ambient conditions to ISO conditions (15 ^{o}C) increases turbine efficiency thus increasing output up to 20%**.**

Figure 2.6 shows a typical schematic diagram for a TIC system utilizing steam or hot water from the Heat Reject Steam Generators (HRSG) of the power station.

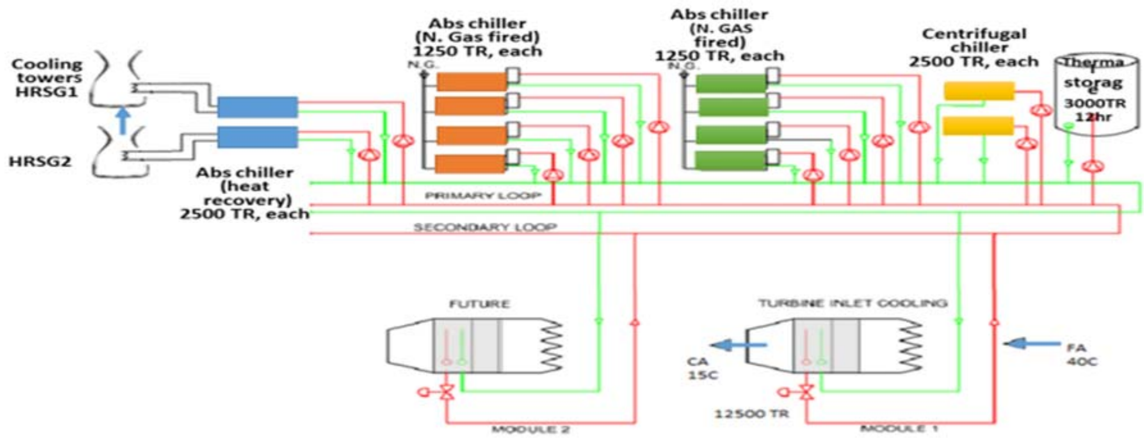


Figure 2.6: Turbine Inlet Cooling -TIC- in a power station using steam or hot water fired absorption chillers.

Figure 2.7 shows the TIC cooling coil installed at air inlet of the gas turbine. Other combination of natural gas fired absorption chillers, electric centrifugal chillers and Thermal Energy Storage (TES) tanks are used to optimize cooling techniques depending on availability of energy at demand.

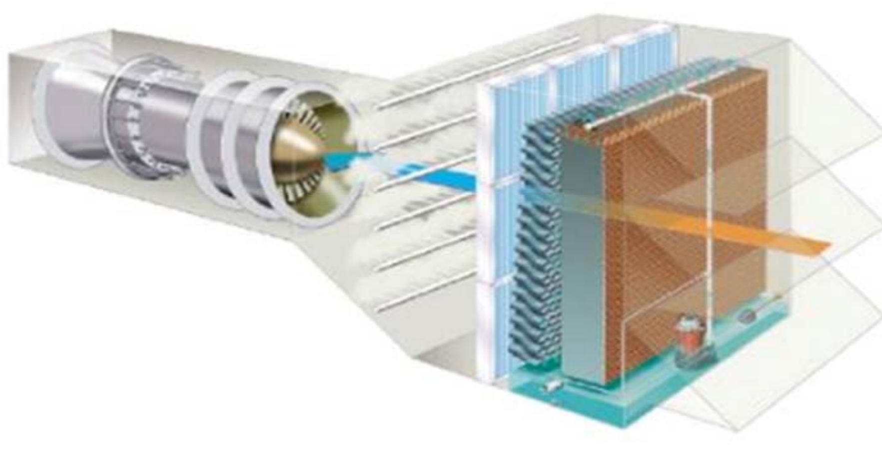


Figure 2.7: TIC cooling coil installed at the air inlet of the gas turbine.

3. Distribution Piping Networks Pumping Arrangements.

There are five chilled water distribution network-pumping arrangements. Those are

A. Constant Flow Arrangement.
B. Variable flow systems
C. Variable Speed Primary Pumping.
D. Primary-Secondary Pumping Arrangement.
E. Primary-Secondary-Tertiary Pumping Arrangement.
F. Primary-Secondary Distributed Pumping Arrangement.

Pumping arrangements differ depending of the cooling application chosen. There could be more than one arrangement suitable for a single application, although this is rare, usually one arrangement will be most economical to build and operate for a certain air conditioning system. The following text is a short description on the suitability of each pumping arrangement:

i. *Constant flow arrangement*

Applied to small capacity district cooling systems where the advantages of variable flow systems are not appreciable. Those advantages are primarily saving in electric energy with frequency inverters.

ii. Variable Flow Arrangements

The primary advantages of those arrangements are their reduced consumption of pumping energy and use of distribution system diversity, saving pumping energy. Those systems are used in relatively larger air conditioning systems.

iii. Variable Speed Primary Pumping

In this system, the primary pumping regulates chilled water flow according to load demand. Pumping energy consumption is reduced compared to constant speed. This system is suitable when the plant pumps can satisfy building's pressure drops, otherwise buildings with larger pressure drops may not be served adequately.

iv. Primary-secondary pumping arrangement.

This system is used when the chilled water distribution system is long, and the variable primary system cannot cope with flows and pressure drops. This arrangement is flexible when an expansion scheme is not clear at inception, and additional buildings may be added at a later stage.

v. Primary-secondary-tertiary pumping arrangement.

It may be necessary, when supply and return chilled water distribution lines become too long with heavy loads in building, to add in-building pumps to provide necessary flow and pressure for each building. These systems are also commonly used in district cooling systems.

vi. Primary-secondary distributed pumping arrangement.

Some systems may have a very large cooling load. It is possible for this system to use a primary-secondary distributed pumping arrangement. This system is probably the most suited system for large applications, because it eliminates secondary pumps in central plants. Reduction in total chilled water pump power of 20%–25% is possible**.** Although this system is highly attractive, it is not suitable when additional buildings may be added at a later stage. The chilled water supply gradient pressure is lower than the return gradient in those systems. Pipes are oversized compared to other systems, which increases the initial capital cost. The operational savings mitigate all those factors in large systems.

4. District Energy for a city using reject heat in power stations.

Figure 2.8 is a Sankey diagram (4) that shows two scenarios to provide heating, cooling, and electricity to a city. One scenario uses a traditional coal-fired power station, business as usual (BAU) scenario, whereas the second scenario uses natural gas in a modern combined heat and power (CHP) station.

In the first scenario with a conventional power station, the typical average thermal efficiency of this simple cycle power station is around 35%. More advanced power stations with combined cycles have thermal efficiencies around 45%. Natural gas-fired CHP stations that recover exhaust gases have overall thermal efficiencies of 80%–90%, and sometimes even higher.

This is why the total primary energy utilized in BAU scenarios shown in Figure 2.6 is 601.6 GWh compared to a primary energy utilization of 308.2 GWh with a CHP station. This is a savings of 293.4 GWh or 48.8% compared to BAU, although in both cases the same energy is produced and taken up by end users: 100 GWh of heat, 100 GWh of cooling, and 100 GWh of electricity.

High thermal efficiencies were obtained because recovered heat was used to fire absorption chillers and assisted by wind and geothermal heat. District heating and cooling technology is utilized with this modern CHP station.

This is why district cooling (5), (6), (7), (8) and heating is such an important technology. It reduces carbon footprint, increases efficiency of power stations especially when coupled with recovered process heat, and makes use of diversity factors in reducing overall heating and cooling needs. However, district cooling and heating can also be applied at a district level, not only at the power station level.

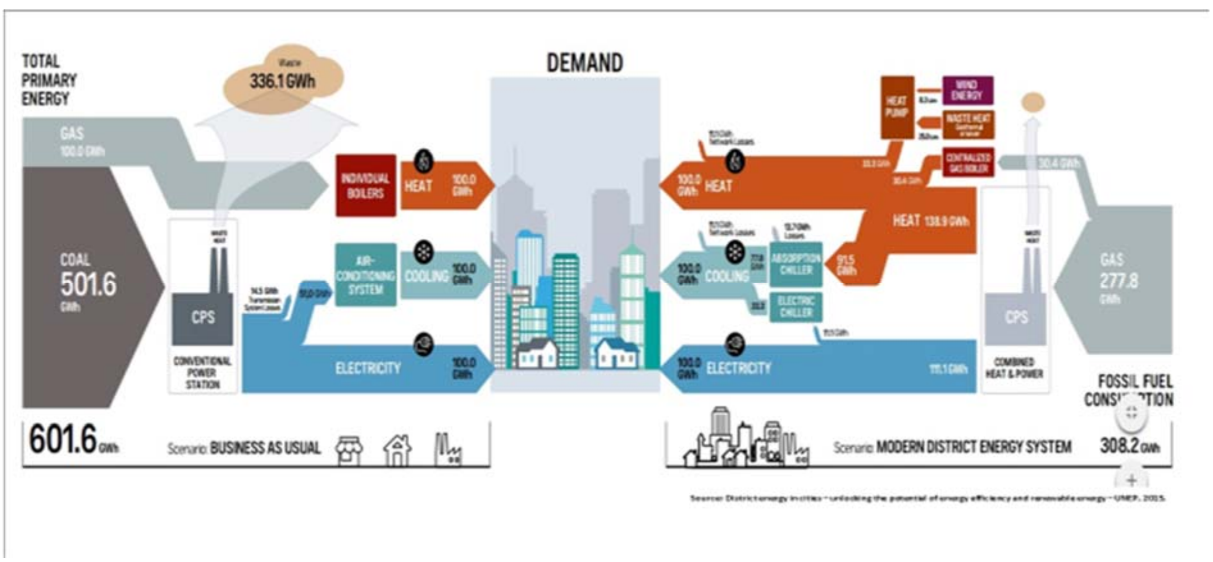


Figure 2.8: The economic and environmental benefits of district cooling in a modern power station for a city.

5. Load Interface Techniques and Energy Calculation Methods.

District cooling systems are connected to distribution networks through load interfaces. These in turn are connected to end users by one of the two methods:

- Direct connections.
- Indirect connections.

Both types of connections are used successfully. The type of connection used depends on the nature and application of the district cooling system.

Direct connections:

The same chilled water produced circulates in the DC plant and the distribution network. Therefore, there is no interface between the chilled water of the plant and in-building distribution network, and hence no separation of chilled water between the production, distribution, and in-building HVAC system. Some insurance companies' demand that direct connection not be used in large DC systems because of the DC provider liabilities in case flooding occurs due to chilled water leaks, which may result in buildings being flooded.

Indirect connections:

In indirect connection, an interface is used, usually a plate heat exchanger. Plate heat exchangers are the preferred heat exchangers in DC systems because traditional shell and tube or shell and coil heat exchangers are bulkier when they are designed to operate at the small approach temperatures in use in DC systems. Those are normally 0.5 to 2°C. In addition, traditional heat exchangers are often more costly. Space is limited in DC buildings' mechanical rooms and
is at a premium, especially in commercial and administrative applications. Rent is often considerable.

Metering and energy meters:

To measure the energy used by end users, energy meters are installed at the building's mechanical rooms. Energy meters utilize equipment for measuring flow, temperature differences between supply and return of chilled water, time duration between two readings and an energy calculator. There are two types of energy meters: dynamic and static.

Collection of DC meter readings:

Collecting energy meter data is done either at the meter or remotely. Local reading of meter uses a handheld terminal that connects to the meter. Remote energy meter reading is made wirelessly by a radio signal from a device in the meter, via the telephone network, or via an Internet connection. In energy meters fitted with radio frequency modules, RF concentrator connected to a central computer uploads the data, and bills can be produced for each end user. In meters connected via the Internet, meters are fitted with a TCP/IP module and can be read by a central computer. Often there is a need for submetering, when a building is rented to more than one end user. In this case, a secondary sub meter is needed or the use of water meters at end users to measure flow rates and allocate sub meter reading proportionally according to water flow meter readings. This method is more economical than using sub meters and is cost effective. Another method used by some DC providers is to calculate individual consumption by floor area of the space instead of submetering. This method does not provide incentives for end user to conserve energy.

6. Daily Cooling Load Profile, Diversity Factors and Thermal Energy Storage (TES).

Daily Cooling Load Profile:

Several important factors must be clearly defined when designing a district cooling system. Some of the most important factors are the daily cooling load demand curve and peak loads. A customer design engineer or consultant usually defines a building's cooling load. Those buildings could be administrative, shopping malls, hotels, schools, and other types of buildings. Cooling load estimates of those buildings will usually vary a great deal from building to building. An administrative building's cooling load estimate will probably include loads attributed to the prevalent weather, loads of occupants, electrical and electronic appliances, lighting and other loads. Those cooling load estimates will differ from those of a shopping mall, where the occupant's load will probably constitute the major part. The same applies to other buildings as well where the loads will vary a great deal. Shopping mall loads peak at a different time of the day compared to administrative loads or residential loads. Deciding how large also when those loads occur is of crucial importance in calculating the total design load of a district cooling plant. In estimating the cooling load of buildings for a certain district, it is possible to use computerized simulation programs and thus obtain an accurate understanding of peak loads' occurrence and their magnitude.

Diversity Factors:

Individual buildings peak at different times. This is why the coincident overall peak demand of a district cooling system depends on the sum of each individual building peak demand at certain time of the day.
Diversity factors are used to calculate the overall peak load of a district cooling system. Those diversity factors may be as low as 0.6 or 0.7 of the sum of individual building peak demands, in applications where there is a great diversity of use. There are different types of diversity factors. Diversity factors inside a building are dependent on the actual use pattern of a building. Diversity factors between one building and the other in a district depend on each building's function, orientation, use, and diversity factors between district cooling plants that may be serving a single
district's distribution network. Chilled water-piping networks are also subject to diversity factors between distribution loops serving different buildings in parallel. All those diversity factors must be taken into account when calculating the overall peak demand of a district cooling system and when designing chilled water distribution networks.

Thermal Energy Storage (TES):

Thermal energy storage (TES) stores cooling enthalpy during off-peak times to use during on-peak times. A specially constructed insulated tank stores the cooling energy at off-peak times and uses it at on-peak times. This technique allows using fewer chillers at on-peak times than those necessary to cope with peaks in the daily cooling load demand curve.
The rating of TES is based on its ability to hold a certain refrigeration capacity for so many hours. For example, a 20,000 TR.h capacity TES will hold 10,000 TR for 2 h or 5,000 TR for 4 h or other combinations totalling 20,000 TR.h. District cooling systems have incorporated successfully TES systems for many years. TES is accepted as an integral part of all air conditioning systems.
Applications range from universities, colleges, airports, museums, sport complexes, and hospitals to leisure centres and administrative buildings; military facilities use TES as do many other applications. The most widely used TES system is the stratified tank type.