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EXECUTIVE COMMITTEE OF
THE MULTILATERAL FUND FOR THE
IMPLEMENTATION OF THE MONTREAL PROTOCOL
Ninety-fifth Meeting
Montreal, 4-8 December 2024
Item 9(d) of the provisional agenda[1]

Addendum

PROJECT PROPOSALS: CHINA

This document is issued to add an additional project proposal for consideration below.

<u>Energy efficiency</u>

• Pilot project to enhance the energy efficiency of cooling technologies in data centres through the demonstration of single-phase immersion cooling system in a data centre	UNDP	Individual consideration

[1] UNEP/OzL.Pro/ExCom/95/1

PROJECT EVALUATION SHEET – NON-MULTI-YEAR PROJECT

China

PROJECT TITLE	BILATERAL/IMPLEMENTING AGENCY
•Pilot project to enhance the energy efficiency of cooling technologies in data centres through the demonstration of single-phase immersion cooling system in a data centre	UNDP

PROJECT OBJECTIVE

1. To demonstrate the use of single-phase immersion cooling systems in data centres using a new environmentally friendly proprietary coolant "Bing Yi 797" which has no ODP and with zero GWP eliminating the need for new HFC-based cooling equipment in data centres
2. To integrate a waste-heat recovery system and mixed power supply for a stable and energy-efficient data centre
3. To disseminate the results and promote use of single-phase immersion cooling systems in new and existing data centres relying on high-GWP HFCs

NATIONAL CO-ORDINATING AGENCY	Foreign Economic Cooperation Office (FECO) / Ministry of Ecology and Environment (MEE)

LATEST ARTICLE 7 DATA (Annex F)	**Year:** 2022	370,903.36 mt	669,563,731 CO_2-eq tonnes

* The consumption data for 2022 was updated to 666,491,379 CO_2-eq tonnes and the consumption data for 2023 was at 769,361,542 CO_2-eq tonnes and posted on the Ozone Secretariat website in November 2024. The Multilateral Fund Secretariat did not have the breakdown of the consumption in mt at the time of posting of this document.

Particular	**Units**	**HFC-410A**
HFC to be avoided through this project:	mt	4,320
	CO_2-eq tonnes	9,020,160
Alternative to be phased in:	A proprietary liquid coolant, Bing Yi 797 owned by the enterprise Tianjin Tier, a subsidiary of Anhui Tier Liquid Cooling Technology Co., Ltd. which developed the immersion cooling technology, and will be leading the implementation of the project. It is a synthetic oil coolant composed mainly of hydrogenated polidocanol (90-99.8 per cent) and compound antioxidants (0.2-0.9 per cent), with no aromatic HCs	
Project duration (months):		24
Initial amount requested (US $):		2,456,900
Final project costs (US $):		
Capital cost:		1,790,800
Contingency (10%):		Not requested
Operating cost:		Not requested
Total project cost:		1,790,800
Local ownership (%):		100
Export component (%):		0
Requested grant (US $):		1,790,800
Implementing agency support cost (US $):		125,356
Total cost of project to Multilateral Fund (US $):		1,916,156
Energy efficiency savings (US $/MWh):		3.55
Status of counterpart funding (Y/N):		Y
Project monitoring milestones included (Y/N):		Y
Minimum energy performance standards available for the relevant sector (Y/N):		Not Available

SECRETARIAT'S RECOMMENDATION	Individual consideration

PROJECT DESCRIPTION

Background

1. On behalf of the Government of China, UNDP has submitted, in line with decision 91/65, a request for a demonstration project for a single-phase immersion cooling system in a data centre in the amount of US $2,456,900, plus agency support cost of US $171,983, as originally submitted.[2] Project preparation for this project was approved at the 94th meeting.

Status of implementation of energy efficiency-related activities funded by the Multilateral Fund

2. Under the approved stages of the HCFC phase-out management plan (HPMP) of China, some project components have included the promotion of energy-efficient equipment. The fourth tranche of stage I of the HPMP for the room air-conditioner (AC) manufacturing sector plan included a component to carry out a study on the energy efficiency standards of different refrigerants and research on the environmental impact of appliances. Under stage II of the HPMP, the conversion project in the room AC manufacturing sector plan included dissemination of the results of the project, the benefits of R-290 technology, and the energy efficiency performance of the technology. Under stage II of the HPMP in the servicing sector plan, the component on the standards and codes development for servicing in the industrial and commercial refrigeration and AC sectors included developing technical specification codes to promote good practices, including safety-related skills and knowledge for the new generation of refrigerants, and to enhance/maintain the energy efficiency of the equipment. The conversion project approved at the 82nd meeting to convert from HFC-245fa to HFOs in the manufacture of insulation foam in a domestic refrigerator manufacturer (Hisense Kelon) was funded on the understanding that changes in the energy efficiency of the product would be assessed and reported as well as any related changes in government policies.

Policy, regulatory and institutional framework

3. The Government of China ratified the Kigali Amendment on 17 June 2021. In response to ratifying the Kigali Amendment, China revised the Regulation on Ozone Depleting Substances Management, which was approved in December 2023. The revised regulation, effective from 1 March 2024, included HFCs in the list of controlled substances and implemented quotas on HFC production and imports for 2024. China submitted a request for preparatory funding for stage I for the Kigali HFC implementation plan (KIP) to the 94th meeting. Following bilateral discussions, the Executive Committee agreed to defer consideration of the request to the present meeting.

4. The national standard GB40879-2021 *Maximum allowable values of energy efficiency and energy efficiency grades for data centres* was implemented on 1 November 2022. This regulation specifies the technical standards for an energy efficiency rating, energy consumption measurement, and energy efficiency calculation and assessment of data centres. The energy efficiency rating created for data centres was based on a measure of power usage effectiveness (PUE)[3] and had three levels: level I is less than 1.20 PUE, level II between 1.20-1.30 of PUE, and level III is larger than 1.30 of PUE.[4] In July 2024, the National Development and Reform Commission and the Ministry of Industry and Information Technology released an action plan on the green development of data centres, which defines requirements for data centre equipment, such as the maximum PUE of less than 1.5 PUE from 2025 onward. Renewable

[2] As per the letter of 6 September 2024 from the Ministry of Ecology and Environment of China to UNDP.
[3] PUE is the ratio of the total amount of energy used by a computer data centre facility to the energy delivered to computing equipment.
[4] International Energy Agency report: Policy development on energy efficiency of data centres, Page 44 https://www.iea-4e.org/wp-content/uploads/2024/02/Policy-development-on-energy-efficiency-of-data-centres-draft-final-report-v1.05.pdf

energy must also make up a gradually increasing percentage of total energy consumption of data centres and targets a 10 per cent per year increase in renewable energy use.[5]

HFC and energy consumption in data centres in China

5. Data centres are a rapidly growing sector in China which, due to their high demand for cooling, have led to rapid growth in HFC consumption.[6] In 2024, data centres in China are expected to account for about 10 per cent of the global total. Data centres are significant drivers of growth in electricity demand, globally consuming an estimated 460 terawatt-hours (TWh) in 2022, with electricity consumption projected to potentially reach more than 1,000 TWh in 2026, globally.[7] In China in 2023, data centres were estimated to consume around 267 TWh of electricity.[8]

6. HFCs are widely used in the refrigeration and air-conditioning, and heat pump (RACHP) systems in China. Historically, the cooling method used in data centres in China has been computer room air-conditioning (CRAC), which involves mechanical refrigeration systems using refrigerants to cool air, with air flow then transferring heat away from the IT equipment. The most common refrigerants used in CRAC systems are HFC-134a and R-410A. For example, in a data centre with an IT heat load of 7,200 kW, the typical mechanical refrigeration system would require approximately 4.32 mt (9,020 CO_2-eq tonnes) of R-410A. Moreover, due to the limitations of air's thermal properties, the efficiency of heat exchange of CRAC systems is relatively low. Consequently, the energy consumption of the cooling system typically accounts from 30 to 50 per cent of the total energy use in a traditional data centre. In general, air-cooling technology can only support power consumption per cabinet up to 30kW.[9]

7. China imports and exports R-410A and HFC-134a. Based on Article 7 data the combined consumption of R-410A and HFC-134a in 2022 was negative because of more exports of R-410A than imports that year. In the country programme data for 2022, use for R-410A is reported at 116,711 mt (243,692,067 CO_2-eq tonnes) and accounts for 32 per cent of the reported use of HFCs for that year. As for HFC-134a, use was reported as 72,500 mt (103,674,500 CO_2-eq) tonnes, which is roughly 20 per cent of HFC use reported for that year. For both substances about 30 per cent of the reported use in 2022 was in the refrigeration and air-conditioning (RAC) servicing sector.

Table 1. Article 7 and CP data for HFC-134a and R-410A in China (2020-2022)

Substance	GWP	Article 7 (2020)	Article 7 (2021)	Article 7 (2022)	CP (2020)	CP (2021)	CP (2022)
Metric tonnes							
HFC-134a	1,430	89,165	100,729	82,030	n/a	85,625	72,500
R-410A	2,088	-68,464	-74,522	-106,255	n/a	102,538	116,711
Total	**n/a**	**20,700**	**26,206**	**-24,225**	**n/a**	**188,163**	**189,210**
Servicing sector total for HFC-134a	1,430	n/a	n/a	n/a	n/a	34,943	23,920
Servicing sector total for R-410A	2,088	n/a	n/a	n/a	n/a	24,828	35,780

[5] English.gov.cn, the official English-language communication platform of the State Council of the People's Republic of China https://english.www.gov.cn/news/202407/24/content_WS66a0b167c6d0868f4e8e96ba.html
[6] The climate cost of China's digital infrastructure rush, dialogue Earth https://dialogue.earth/en/energy/11960-the-climate-cost-of-china-s-digital-infrastructure-rush/
[7] International Energy Agency (IEA) https://www.iea.org/reports/electricity-2024/executive-summary
[8] In a report by Greenpeace East Asia and the North China Electric Power University https://www.techerati.com/news-hub/data-centres-china-renewables-energy/
[9] Copenhagen Centre on Energy Efficiency, Innovative Data-Centre Cooling Technologies in China – Liquid Cooling Solution, https://c2e2.unepccc.org/kms_object/innovative-data-centre-cooling-technologies-in-china-liquid-cooling-solution/

Substance	GWP	Article 7 (2020)	Article 7 (2021)	Article 7 (2022)	CP (2020)	CP (2021)	CP (2022)
CO_2-eq tonnes							
HFC-134a	1,430	127,505,365	144,041,928	117,302,710	n/a	122,443,664	103,674,500
R-410A	2,088	-142,918,864	-155,565,505	-221,807,965	n/a	214,099,553	243,692,067
Total		**- 15,413,499**	**-11,523,577**	**-104,505,255**	**n/a**	**336,543,217**	**347,366,566**
Servicing sector total for HFC-134a	1,430	n/a	n/a	n/a	n/a	49,967,832	34,205,786
Servicing sector total for R-410A	2,088	n/a	n/a	n/a	n/a	51,839,820	74,709,183

8. The power requirements of general CPUs (central processing units) have been increasing from 100W to around 400W, and the power of a GPU (graphics processing unit) used for AI (artificial intelligence) can be as high as 2.6kW.[10] Traditional air-conditioning systems using air-cooling technology have been unable to meet the cooling requirements of high-density data centres.[11] In response to growing needs, liquid cooling was introduced in China in data centres in 2015, including cold-plate liquid cooling, immersion liquid cooling and spray liquid cooling. There are two main categories of liquid cooling technologies based on how the cooling medium interacts with the heat source: non-contact liquid cooling and contact liquid cooling.

Non-contact liquid cooling

9. Non-contact liquid cooling in data centres includes cold plate cooling and heat pipe cooling:

(a) Cold plate cooling involves liquid cooling plates with a coolant fluid (normally water) to conduct and cool high-temperature components. They are usually made of metal and have numerous small channels through which the cooling liquid can flow and absorb heat, which is then carried away by a circulating system.

(b) Heat pipes consist of copper tubes, aluminum fins, and a working fluid that changes phase passively to move heat. As air passes over the warm side (hot air aisle from data centre return air) of the heat pipe, the refrigerant vaporizes, absorbing energy, then travels to the cold side (outside air) where it condenses, releasing energy and then flows back to the warm side. These systems are efficient heat transfer devices; however, these still rely on fluorocarbon-based refrigerants.

10. Non-contact liquid cooling is well suited for high-heat flux components like CPUs and GPUs, where efficient heat dissipation is critical. However, it is used in conjunction with other cooling systems such as CRAC systems, to manage lower-heat areas across the entire data centre.

Contact liquid cooling

11. Contact liquid cooling in data centres includes two-phased immersion cooling and single-phase immersion cooling:

(a) Two-phase immersion cooling systems use a fluorocarbon, which boils at around 50°C. The heat generated by the servers causes this dielectric liquid to boil, turning it into vapor that passively handles the transfer. The vapor then condenses back into liquid form through a condensing coil, after which the chilled liquid is reintegrated into the cycle. This simple cycle eliminates the need for cooling hardware like fans.

[10] Ibid.
[11] Ibid.

(b) Single-phase immersion cooling is a method where the cooling medium does not undergo a phase change during heat exchange. In this technology, servers are immersed in a non-conductive cooling liquid, and the heat generated by the servers is removed through the forced flow of this liquid. The heat is then transferred to the external environment via a plate heat exchanger.

12. Two-phase immersion cooling demonstrates higher heat exchange performance; however, during operation, the data centre essentially functions as a pressure vessel. Thus, maintenance on any specific server requires shutting down the entire system, which is the primary reason why this technology has not seen widespread adoption. In single-phase immersion cooling, a refrigerant is required but the use of a plate heat exchanger reduces the amount of refrigerant needed and can work with various refrigerants, including ammonia, carbon dioxide, and hydrocarbons.[12] Due to the physical properties of the cooling medium compared to air, this technology enables higher temperature delivery without the need for additional mechanical refrigeration equipment across the entire data centre cooling system.

13. Currently, there are two primary types of coolant liquids used in single-phase immersion cooling systems: fluorinated liquids and synthetic oils. Table 2 presents the properties of the currently used coolants, highlighting the differences in their environmental impact, thermal conductivity, and other key characteristics.

(a) Fluorinated liquids are composed of fluorocarbon compounds, such as perfluorocarbon (PFC) and perfluorinated polyether (PFPE). These coolants are effective but have environmental concerns due to their high GWP values.

(b) Synthetic oils are primarily composed of hydrocarbons, including polyol esters (POE) and polyalphaolefin (PAO). Unlike fluorinated liquids, synthetic oils do not contribute to greenhouse gas emissions, making them a more environmentally friendly choice. Table 2 presents the properties of the currently used coolants, highlighting the differences in their environmental impact, thermal conductivity, and other key characteristics.

(c) Bing Yi 797, a synthetic oil coolant innovated and registered by Tianjin Tier, is composed mainly of 90-99.8% hydrogenated polidocanol and 0.2%-0.9% compound antioxidants, with no aromatic hydrocarbons. This composition is designed to maximize cooling performance and environmental friendliness. The demonstration project would validate the effectiveness of the single-phase immersion cooling system in data centre using Bing Yi 797.

Table 2. Coolants used in single-phase immersion cooling

Coolant		**Thermal performance**				**Environmental impact**		**Safety performance**	
		Thermal conductivity W/(m·°C)	Heat capacity kJ/(kg·°C)	Density kg/m^3	Dynamic viscosity mm^2/s	ODP	GWP	Flash point °C	Ignition point °C
Fluorinated liquid	FC-40	0.065	1.1	1,855	2.2	0	>5,000	/	/
	Novec7500	0.065	1.128	1,614	0.77	0	100	/	/
	SF-10	0.077	1	1,580	0.71	0	2.5	/	/
	HT-135	0.065	0.963	1,720	1	0	>5,000	/	/
Synthetic oil	**Bing Yi 797**	**0.342**	**1.987**	**797**	**13**	**0**	**0**	**175**	**164**
	VP-3	0.117	1.630	930	2.79	0	0	113	104
	EC-110	0.1376	2.155	820	16.94	0	0	>350	203

[12] https://www.hvacinformed.com/news/dfc-explains-advantages-plate-heat-exchangers-in-refrigeration-technology-co-1711435756-ga.1711435878.html; https://www.swep.net/refrigerant-handbook/10.-systems/asdf8/; https://www.alfalaval.us/industries/refrigeration/industrial-refrigeration/

Enterprise information

14. The enterprise Anhui Tier Liquid Cooling Technology Co., Ltd., (Anhui Tier), is a technology enterprise specializing in advanced cooling solutions for data centres. The coolant technology to be used was developed by its subsidiary, Tianjin Tier Technology Co., Ltd, which was founded in 2019. Anhui Tier would lead the pilot project on design, manufacturing, installation, engineering, and maintenance.

15. The project will be implemented in a new data centre; hence, there is no current use of HFCs and energy consumption, but the project would avoid the use of HFCs and would reduce the typical energy requirement of a data centre. The site for this demonstration project is confirmed and comprises more than 20,000 m^2, as well as a 5,000 kVA dual-power supply, water supply, and bandwidth network for operational requirements in Wuhu City.

Project overview and funding request

16. The pilot project is being submitted in line with decision 91/65(c).

Project objective

17. The project proposes to begin with the design, construction, and operation of the data centre, including upgrading the servers and designing six liquid cooling cabinets with a total capacity of 7,200 kW integrating 10 GRP computing cards into a single server followed by the design, construction and operation of a waste heat recovery system using a R-290 heat pump and a hybrid power supply system and aims for a 50 per cent renewable energy. The project would include a comprehensive assessment and comparative analysis against other air-cooled data centres and measuring energy efficiency, and a review of energy efficiency standards for data centres using the operational data of the demonstration project and promoting the results of the project through different awareness and outreach activities.

Proposed activities

18. There are six main elements in the project, and each element is described below:

(a) *Data centre*: Activities would include the optimisation of the servers to improve the internal flow field and enhance the heat exchange between chips and coolant; system design, assembly, and operation, analysis of the effects of structural parameters, physical properties, and operational parameters of liquid-cooled servers; design of liquid cooling cabinet and analysis of operational parameters such as coolant flow rate and temperature; designing the operational logic for external cooling equipment;

(b) *Wastewater recovery:* The data centre will use wastewater to provide heat for the data centre park, leveraging its high temperature (over 50°C) for efficient energy recovery; this will include the design of a wastewater recovery system, encompassing heat pump devices and pipeline designs; developing an operational logic using AI methods to optimize system performance, ensuring the data centre is efficiently cooled while supplying heat to the park; and processing, assembly, and trial operation;

(c) *Hybrid power supply system*: Introduce two municipal power supply sources, each capable of carrying 50 per cent of the load under normal conditions and 100 per cent if one source fails; assess the supplementary heating requirements; use data collected during the trial operation on the system's heat dissipation and heating supply requirements; determine the heating needs for the data centre park to determine if waste heat recovery system can meet these demands efficiently; develop operational strategies based on data collected;

processing and assembly for mixed power supply; and trial operation for mixed power supply;

(d) *Comparative study:* Conduct an in-depth analysis of single-phase immersion cooling data centres focusing on comparing the performance, energy efficiency, environmental impact, and economic benefits of single-phase immersion cooling with traditional air-cooled data centres; the environmental impact of the coolant's lifecycle and the system's carbon emissions over its lifecycle conducted; energy efficiency and economic aspects, parameters, such as PUE, water usage effectiveness, investment costs, and operating costs for the system analysed; comprehensive research report;

(e) *Standards improvement:* Market assessment of demand for single-phase immersion cooling systems in new and existing facilities that currently rely on HFC-based cooling systems including an analysis of industry trends, potential adoption rates, and the regulatory landscape; national standard for maximum allowable values of energy efficiency and energy efficiency grades for data centres reviewed, including consultation meetings with industry experts and the national standardization committee; a report with recommendations on enhancing the standard prepared; and

(f) *Technology awareness and dissemination:* Including a technical seminar and participation in industry exhibition; and training for designers, technicians, production managers, installation technician, and equipment maintenance personnel.

19. The project will be implemented between December 2024 and December 2026.

<u>Total cost of the pilot project</u>

20. The total cost for the pilot project as submitted is summarized in table 3.

Table 3. Estimated costs for the pilot energy efficiency project at a data centre, as submitted (US $)

Itemized costs		**Total project cost**	**Co-financed by China**	**MLF funds**
Physical infrastructure	Land separation	1,540,000	1,540,000	0
	Civil construction of site	400,000	400,000	0
	Subtotal	**1,940,000**	**1,940,000**	**0**
Design	Development of immersed liquid cooling package component	65,000	32,500	32,500
	Development of immersed liquid cooling motherboard	120,000	60,000	60,000
	Development of immersed liquid control algorithm	195,000	97,500	97,500
	Development of heat sink and server structure	150,000	75,000	75,000
	Design of liquid cooling tank	55,000	27,500	27,500
	Design of coolant circulation	20,000	10,000	10,000
	Design of waste heat recovery	70,000	35,000	35,000
	Development of infrastructure management platform software	88,500	44,250	44,250
	Development of AI algorithm	100,000	50,000	50,000
	CFD software engineer	80,000	40,000	40,000
	Design of overall data centre system	55,000	38,500	16,500
	Subtotal	**998,500**	**510,250**	**488,250**
Process and assembly	Glass for data centres	59,040	59,040	0
	Container production and assembly	520,000	520,000	0
	Liquid cooling cabinet	1,285,000	642,500	642,500
	Liquid cooling motherboard	1,714,000	1,199,800	514,200

Itemized costs		Total project cost	Co-financed by China	MLF funds
	Liquid cooling shell of servers	342,800	171,400	171,400
	Liquid cooling special package components	342,000	171,000	171,000
	Chip module	24,000,000	24,000,000	0
	Memory, CPU, network card	1,650,000	1,650,000	0
	Coolant	857,000	728,500	128,500
	Intelligent computing centre infrastructure management platform deployment and commissioning	142,500	99,750	42,750
	AI self-tuning platform	66,000	46,200	19,800
	Hydrodynamic module	250,000	250,000	0
	Dry cooler	500,850	500,850	0
	Uninterrupted hybrid power supply system (mixed power supply system)	1,141,800	1,141,800	0
	Heat pump (wastewater recovery system)	120,000	120,000	0
	Subtotal	**32,990,990**	**31,300,840**	**1,690,150**
Trial operation[13]	Installation and commissioning costs	30,000	15,000	15,000
	Administrative cost	12,000	6,000	6,000
	Subtotal	**42,000**	**21,000**	**21,000**
System operation[14]	Maintenance cost	45,000	22,500	22,500
	Power cost	852,700	852,700	0
	Subtotal	**897,700**	**875,200**	**22,500**
Comparative research	Data processing and analysis	15,000	7,500	7,500
	Comprehensive assessment- environment impact	10,000	5,000	5,000
	Comprehensive assessment- energy efficiency and economic analysis	10,000	5,000	5,000
	Comparative research- investigation for the air-based cooling data centre	15,000	7,500	7,500
	Comparative research- performance comparison between air-based and the project	10,000	5,000	5,000
	Research report	10,000	5,000	5,000
	Subtotal	**70,000**	**35,000**	**35,000**
Standards improvement	Market assessment	50,000	25,000	25,000
	Standard improvement	50,000	25,000	25,000
	Subtotal	**100,000**	**50,000**	**50,000**
Awareness and dissemination	Technology dissemination-Technical seminar	50,000	25,000	25,000
	Technology dissemination-Case sharing	50,000	25,000	25,000
	Technology dissemination-Participation in industry exhibitions	50,000	25,000	25,000
	Training to related designers, technicians	50,000	25,000	25,000
	Training to production management persons, manufacturing workers	50,000	25,000	25,000
	Training to equipment maintenance personnel	50,000	25,000	25,000
	Subtotal	**300,000**	**150,000**	**150,000**
	Total	**37,339,190**	**34,882,290**	**2,456,900**

[13] This relates to operations of the data centre on a trial basis to collect data for optimising system performance relating to temperature, heat transfer aspects that affect temperature fluctuations and impact on energy consumption.
[14] This relates to costs for technical and maintenance personnel for onsite operation of the equipment.

SECRETARIAT'S COMMENTS AND RECOMMENDATIONS

COMMENTS

21. The Secretariat has reviewed the project proposal in light of decision 91/65 and the project preparation that was provided for this project at the 94th meeting.

Technical and cost-related issues

Validation of the technology

22. The Secretariat noted from the submission that Bing Yi 797, a synthetic oil coolant innovated and registered by Tianjin Tier, is composed mainly of 90-99.8 per cent hydrogenated polidocanol and 0.2-0.9 per cent compound antioxidants, with no aromatic hydrocarbons. Regarding testing of the performance of this product on safety and product performance, UNDP explained that this has been vetted by independent laboratories.

Status of adoption of Bing Yi 797

23. The Secretariat requested additional information on the status of adoption of the proposed technology. UNDP explained that this technology has been validated in laboratory settings and adopted in small-scale data centres in China. Initially, it was implemented in a university data centre with only one cabinet, and later it was expanded to a commercial data centre with six cabinets. These applications handle relatively low heat loads and are primarily used for basic computing services. Further, customer feedback has been positive, with users appreciating the technology's cleanliness, compact design, reduced noise levels, and manageable energy costs. UNDP also explained that compared to traditional systems, this solution has been well-received for its efficiency and operational advantages in smaller-scale data centres. UNDP also clarified that single-phase immersion cooling could be used in other applications, such as battery thermal management systems for both electric vehicles (EV) and battery energy storage systems (BESS) and charging piles for EVs. Such technology mainly addresses the heat dissipation for high heat-flux scenarios, avoiding the use of air-conditioning systems.

Heat recovery process

24. The Secretariat requested clarifications relating to the heat recovery process, noting that this is not directly a part of the system used for cooling the centre. UNDP explained that to ensure high cooling efficiency and effective waste heat recovery in data centres, it is crucial that the parameters of both systems—such as temperature, flow rate, and heat transfer capacities—are precisely aligned; mismatches result in efficiency loss and would affect the performance of the system as a whole. In addition, they also mentioned that an imbalance in matching heat flows would result in thermal imbalance affecting coolant performance, excessive energy consumption in different unit operations, higher wear and tear of components, system instability contributing to downtime risks, and lower levels of heat recovery which indirectly would result in inefficiency. Based on consultations, UNDP agreed to remove the costs relating to this component from the proposal.

Supplementary cooling needs

25. On supplementary cooling needs, UNDP explained that based on laboratory testing data, such systems do not need supplementary cooling. The server could normally operate even if the coolant inlet[15]

[15] The temperature of the coolant at the point where it enters a system

temperature is as high as 50°C. Correspondingly, the coolant outlet temperature[16] could be around 60°C; thus, this technology could be applied in both hot and cold climates around the world.

Information sharing upon project completion

26. The Secretariat requested information on what would be shared with the clients after the successful demonstration of the technology. UNDP explained that the overall system information covering details on the system setup (such as the setup for servers and cabinets); operating parameters (covering key operational data such as server temperature variations and including GPUs and CPUs); system temperature and flow rate measurements at critical points; and operational data analysis, including a comparative study with HFC-based systems, energy consumption metrics, and an economic analysis, would be made available to the Multilateral Fund and other interested parties. Certain aspects of the technology will remain proprietary, including the system design process which will be retained as proprietary information, and the coolant-related information since this is a proprietary chemical it would be provided directly to customers by Tier. Further, Tier guarantees the coolant's functionality for up to 10 years (exceeding the average data centre lifespan of about 8 years) and will handle coolant recycling at the end of the data centre's life.

Development of standards for data centres based on the results

27. On standards development, the Secretariat had discussions on the time taken to implement such standards, noting that standards development can be an important output for improving the energy efficiency of data centres. UNDP explained that reviewing the minimum energy performance standards (MEPS) is a crucial aspect for projects under the energy efficiency funding window. This not only facilitates the dissemination of green technology but also establishes a benchmark for energy-efficient and related practices[17] in data centres that would result in "green data centres". Keeping in view the time taken for the implementation of standards, it was agreed to remove this component from the project, noting that the energy performance-related results from the project would contribute to the development of standards for data centres only after the completion of the project.

Awareness and outreach programmes

28. On awareness and outreach programmes on the results of the project, UNDP explained that Tier would undertake a range of awareness and outreach activities relating to product performance and project outcomes and target audiences including industry representatives, designers and technicians of similar applications, maintenance personnel, and other relevant stakeholders. They would also share the results of this project and other green technology developments in RACHP equipment which could be presented at international meetings such as Montreal Protocol-related meetings.

Agreed cost of the pilot project

29. The Secretariat had discussions on the costs for different components related to this project noting that some of the costs are based on estimates made by the enterprise with inputs from their technical experts. The Secretariat had detailed consultations on the different project cost components keeping in view that there were some cost elements which were not directly related to cooling and noting that some of the costs pertained to technical designs (e.g., costs relating to process and assembly) that are specific to the proposed project. Based on the consultations, costs related to design were adjusted to 74 per cent of the original request; costs for process and assembly relating to the liquid cooling cabinet, liquid cooling motherboard, liquid cooling shell of servers, and liquid cooling special package components were adjusted to 77 per cent of the original request; costs for trials, systems operation, and comparative research were adjusted to 60 per

[16] The temperature of the coolant at the point where it exits a system

[17] Other parameters for efficiency would be Water Usage Effectiveness (WUE), Renewable Energy Factor (REF), partial Power Usage Effectiveness (PPUE); these indicators would also be calculated for assessing project performance.

cent of the original request; the costs for standards improvements were removed from the request; and costs for awareness and information dissemination were adjusted to 50 per cent of the original request. Table 4 below presents the proposal as submitted and the agreed costs.

Table 4. Agreed costs for pilot demonstration of single-phase immersion cooling in a data centre

Particulars	**As submitted (US $)**	**Agreed costs (US $)**
Design	488,250	362,500
Process and assembly	1,690,150	1,306,200
Trial operation	21,000	12,600
System operation	22,500	13,500
Comparative research	35,000	21,000
Standards improvement	50,000	-
Awareness and information dissemination	150,000	75,000
Total	**2,456,00**	**1,790,800**

<u>Avoidance of emissions</u>

30. Compared to R-410A-based air-conditioning systems catering to a 7,200 kW heat load and taking into account a waste heat recovery level of 40 per cent, and an indirect greenhouse gas emission level of electricity of 0.997 kg CO_2/kWh, the direct and indirect emissions savings over the life of the data centre (i.e., 20 years) are 9,020 CO_2-eq tonnes and 1.17 million CO_2-eq tonnes, respectively.

<u>Sustainability, replicability of the pilot project and assessment of risks</u>

31. The project is expected to demonstrate the results of the use of single-phase immersion cooling systems in data centres using a new environmentally friendly proprietary coolant, “Bing Yi 797”. It would also provide information on the performance of the technology in terms of impact on potential HFC consumption reduction that would be avoided and overall energy consumption levels compared to a traditional HFC-based cooling system for a similar data centre. The project is also expected to provide results relating to how the climate impact can be maximized through waste heat recovery and possible use of renewable energy sources with traditional power to create a stable, reliable, and energy efficient power supply for the data centre. The project would also have a significant investment on different components from the beneficiary (Anhui Tier) demonstrating their commitment to project implementation. The Government will comply with the conditions specified in paragraph b(iv) of decision 91/65. This project will also provide information on performance of this technology, which can help in the future development and strengthening of energy efficiency standards and performance parameters for data centres.

RECOMMENDATION

32. The Executive Committee may wish to consider approving the pilot project to enhance the energy efficiency of cooling technologies in data centres through the demonstration of single-phase immersion cooling system in a data centre in the amount of US $1,790,800, plus agency support costs of US $125,356 for UNDP, noting:

(a) The expected direct emission reduction of 9,020 CO_2-eq tonnes over the estimated life of 20 years; and

(b) That the project would be completed no later than 31 December 2026 and a detailed project report would be submitted to the Executive Committee within six months of the date of completion of the project.