Cooling the AI Revolution:

Efficiency and Kigali Amendment Pathways for Data Centres

4 November 2025

Room CR-14, UNON compound,
Nairobi, Kenya

Panel 1: Powering AI Responsibly — Industry Pathways to Sustainable Cooling

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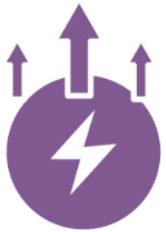
Cooling the AI Revolution

Data Centers impact and benefits from regulation

Impacts



In 2022, estimations revealed that global data centres used 460 TWh—approximately **2% of global electricity use**. This demand could double by 2026 without urgent efficiency action [1].

Many data centres use significant volumes of water: 1 megawatt (MW) data centre can consume as much as **25.5 million litres of water each year only for cooling**, comparable to the daily water use of around 300,000 people [2].

Data centres and data transmission networks were responsible for 330 Mt CO2eq in 2020. This represents about **0.9% of energy-related greenhouse gas emissions**, or 0.6% of total global GHG emissions [3].

Benefits

- **Reduce energy consumption** (-30% approx),

- **Reduction in water usage** by setting specific consumption targets (-90%),

- **Expand internet access** at a reasonable price though local energy efficient data centres and IXPs,

- **Increase the use of renewable energy** by increasing the share used by data centers (+50%),

- **Foster waste heat reuse** by selecting the appropriate cooling technology and providing incentives (+30%),

- **Lower material impact** by increasing the utilization rate of servers, thereby reducing their number,

- **Control the country´s development** by lowering the impact of data centres on the electricity grid and water supply.

[1] International Energy Agency. Electricity 2024, Analysis and Forecast to 2026. https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks

[2]World Economic Forum. https://www.weforum.org/stories/2024/11/circular-water-solutions-sustainable-data-centres/

[3] International Energy Agency. https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks

Procurement Guidelines: Data Centers and Servers

Scope: Data Centers, computer servers and data storage products.

General content: A concise set of recommendations outlining the key performance and operating requirements to consider during any procurement process, ensuring that the product and its installation are sustainable, energy-efficient, and climate-friendly.

PERFORMANCE CRITERIA

- Power usage effectiveness (PUE)
- Water usage effectiveness (WUE)
- Cooling effectiveness ratio (CER)
- IT equipment energy efficiency for servers
- Server efficiency
- Data storage efficiency
- Power supply efficiency (UPS)
- Idle state efficiency

OPERATING CONDITIONS

- Location of data centres
- Renewable energy factor (REF)
- Resilience of data centres
- Modularity
- Cooling design
- Operating temperature and humidity range for servers
- CPU power management criteria
- Utilization rate of IT equipment (ITEUsv)

Intended for: Public Procurers, Technical Personnel, Policy Makers and related officers involved in procurement activities.

Methodology: Developed through a collaborative/consultative approach with key service providers and institutions from the sector:

- *Uptime Institute, France Datacenter, The French Alliance of Digital Industries, EQUINIX, GIMELEC, Google, Microsoft, LBNL, IBM Corporation, etc.*

How to use it? They aim to facilitate the preparation of tender documents issued by governments, state or private enterprises for servers and data storage products. The tender may be issued:

- *Support the **selection and/or approval of data hosting solutions** (e.g., choosing a colocation data centre);*
- *Guide the **development and authorisation of proposals** for the establishment new data facilities;*
- *Serve as a reference when **establishing Minimum Energy Performance Standards** (MEPS).*

Further reading

U4E United for Efficiency

Panel 1: Powering AI Responsibly — Industry Pathways to Sustainable Cooling

- ✓ Where do you see the biggest cooling efficiency wins today?
- ✓ How are refrigerant choices evolving with AI-scale loads?
- ✓ What role do procurement and standards play?
- ✓ What can public and private players do together?

Next-Generation Data Centres Cooling Technologies

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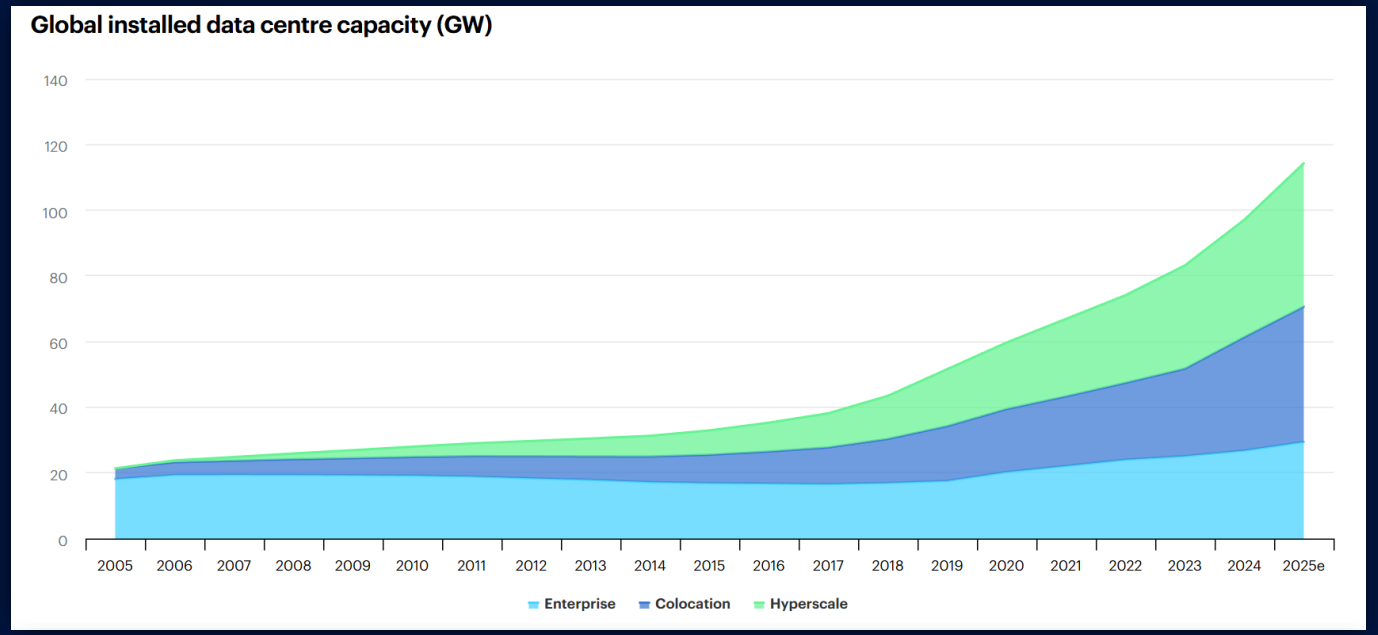
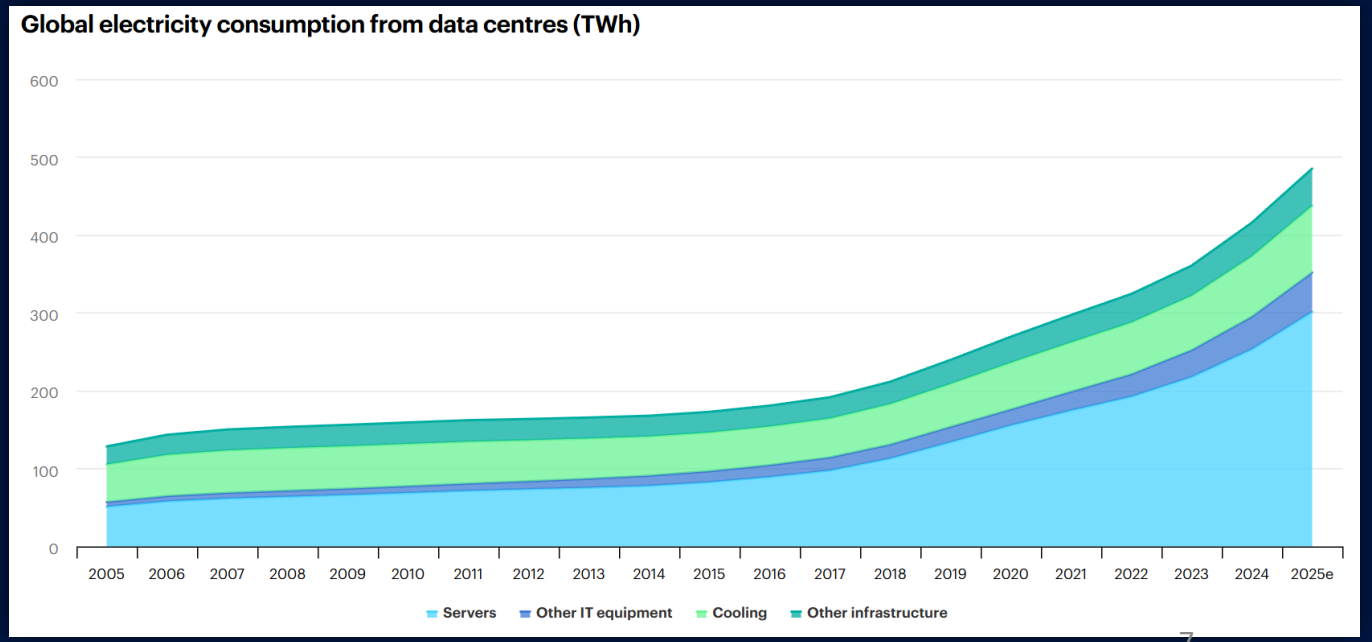
Founder & Principal Consultant, MOGA Consulting Inc.

October 2025

Global Data Centre Growth

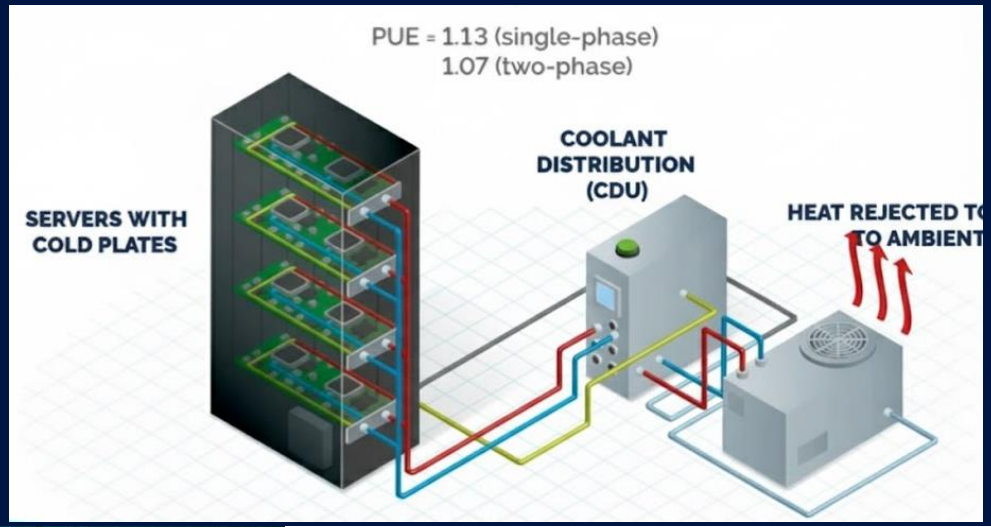
- Data centre (DC) electricity use projected to double to 945 TWh by 2030 (IEA, 2024)
- Driven by AI, cloud, hyperscale growth
- U.S., China, Europe = 85 % of demand
- ➔ burden on cooling (energy, water, and infrastructure) is a major design and operational challenge

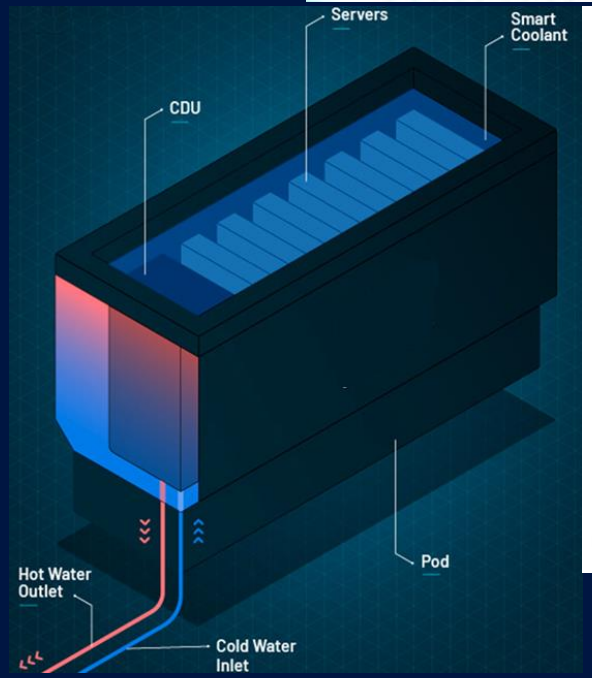


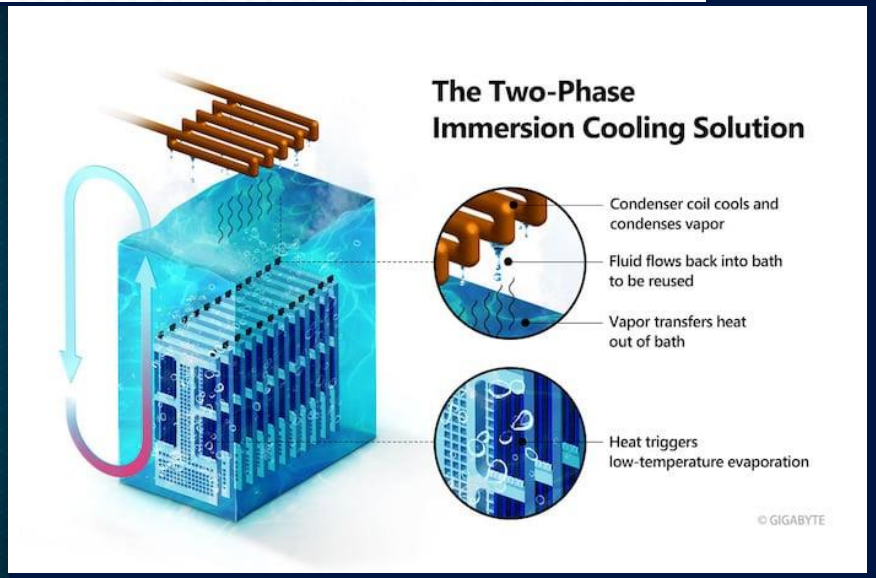


Transition to Next-Generation Cooling – Why Now?

- Increased rack densities with servers, GPUs, and AI accelerators produce more heat per area (200 kW/rack).
- Sustainability goals focus on reducing energy and water use and reusing waste heat.
- Operational needs demand higher performance and reliability, even in tough climates.
- Liquid Cooling is **smaller** and **quieter**!







Panel 2: Country Perspectives — Policies and Practice on the Ground

4 November 2025

Cooling the AI Revolution

Panel 2: Country Perspectives — Policies and Practice on the Ground

- ✓ How are governments preparing for AI-driven energy and cooling demand?
- ✓ How are low-GWP refrigerants being integrated into policy or projects?
- ✓ What are the barriers — cost, awareness, coordination?
- ✓ How is your government working on this topic within the Montreal Protocol on this topic

Green Development of Data Centers in China

Innovation and Pilot of Next-Generation Cooling Technologies

Building sustainable digital infrastructure for the AI era.

Li Xiaoyan
FECO/MEE

Date: November 4, 2025

CHINA

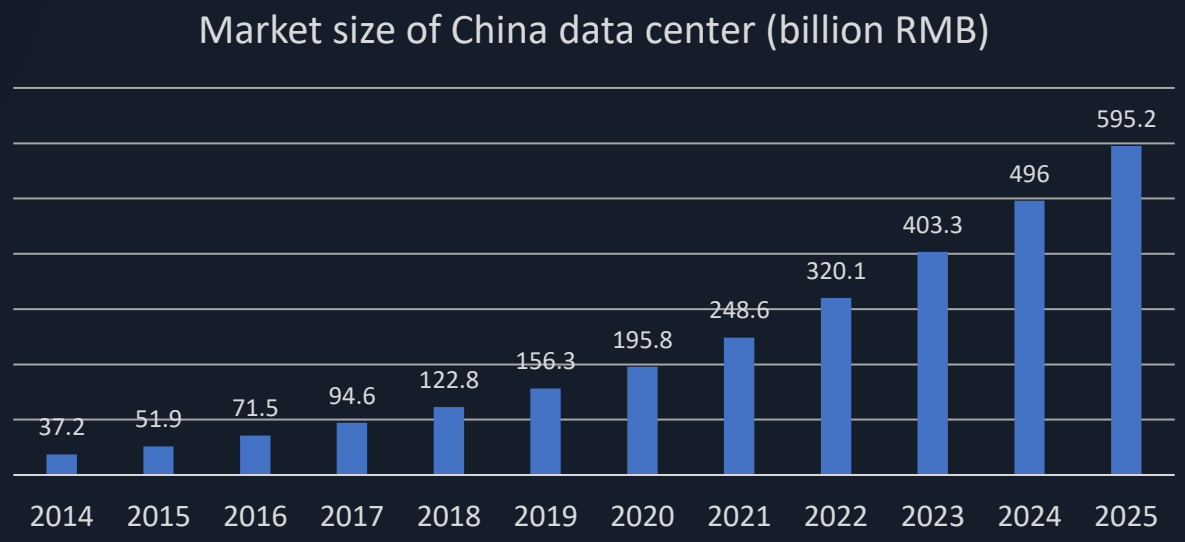
Overview

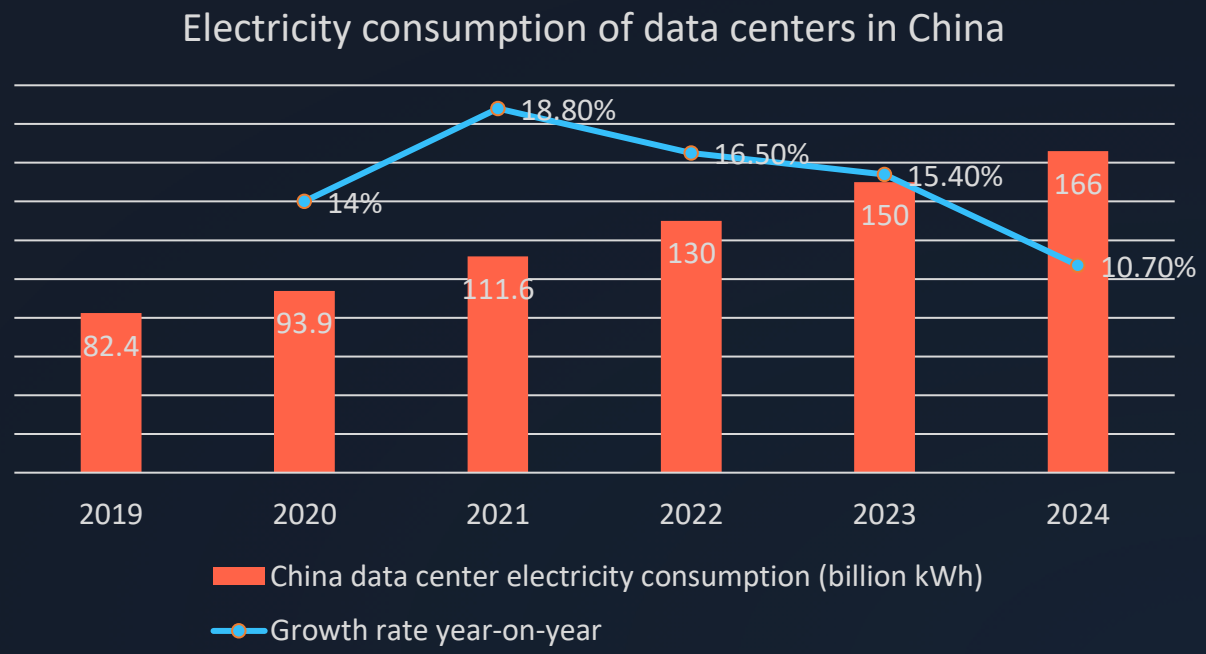
Development of Data Centers in China

Development of scale: By 2025, the intelligent computing power reached 788 EFLOPS (32% globally), and the market size is about 44 billion US dollars (with an annual growth rate of over 20%).

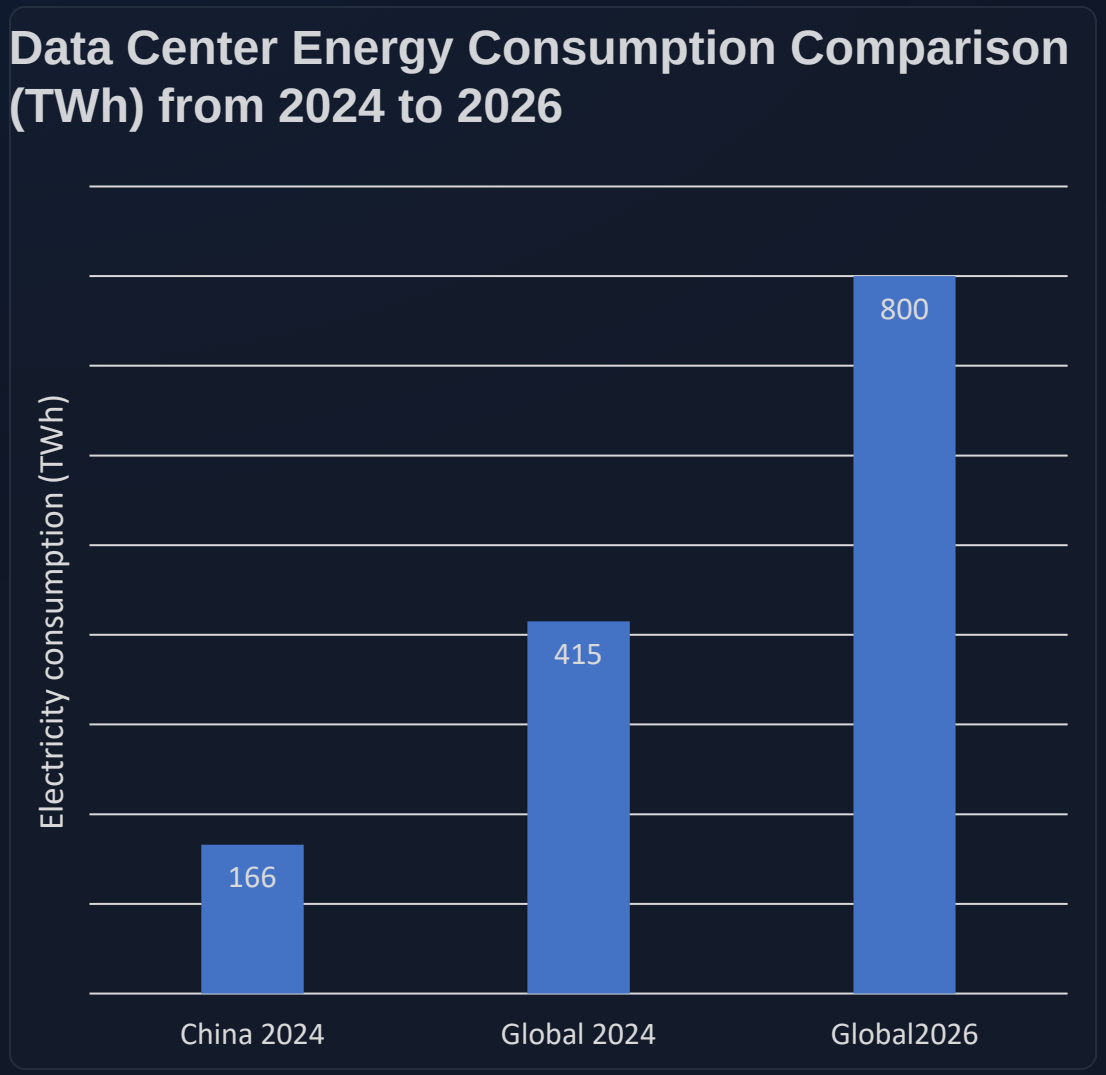
Computing power: The power of a single AI server cabinet exceeds 100kW, and the power density reaches over 30kW/rack.

Electricity consumption: The electricity consumption of data centers in China has grown at a double-digit rate for five consecutive years, reaching 166 billion kilowatt-hours in 2024, accounting for 1.68% of the total electricity consumption of the entire society. The power consumption per unit of computing power is approximately 5.9kVWh/EFLOPs.





Energy consumption of cooling systems



[Data source: International Energy Agency (IEA) report, data from China Institute of Information and Technology]

Energy consumption ratio: The cooling system accounts for approximately 20–50% of the total energy consumption in data centers, making it a key contributor to overall energy use.

Situation in China: The total electricity consumption of data centers is about 166 TWh in 2024, accounting for approximately 2% of the total electricity consumption.

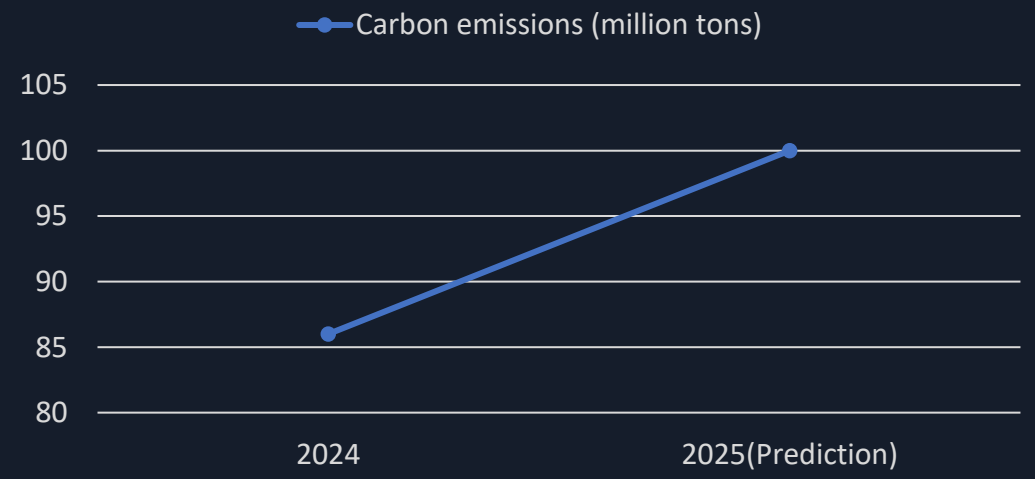
Global trend: The IEA predicts that global data center power consumption will exceed 800-1,050TWh by 2026, representing a 75% increase over the four years from 2022.

Environmental Impact: Carbon Emissions and High GWP Refrigerants

Carbon emissions: In 2024, China's data centers generated approximately 85.9 million tons of CO2 emissions, accounting for about 1.5% of the nation's total carbon emissions. This figure is projected to rise to around 100 million tons by 2025

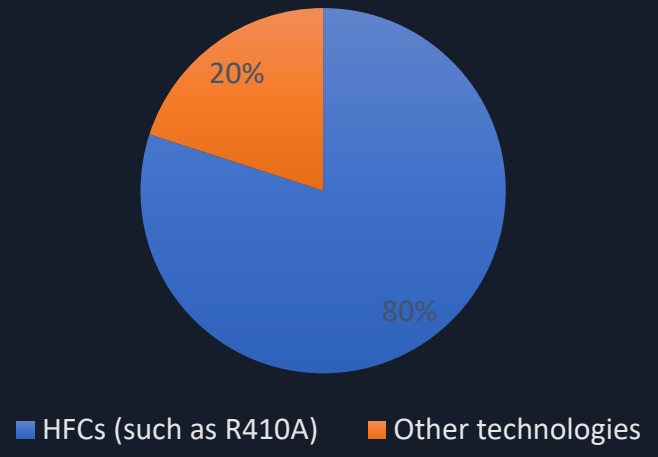
Refrigerants: More than 800 data centers in China use HFCs as refrigerants—mostly R410A, which has a global warming potential (GWP) of 2,088—with an estimated total stock of approximately 5,500 metric tons and an annual leakage rate of around 10%.

Carbon Emission Trends of China's Data Centers from 2024 to 2025 (in ten thousand tons)



[Data source: China Academy of Information and Communications Technology, "Report on Energy Consumption and Carbon Emissions of Data Centers"]

Technology and refrigerants in China's data centers



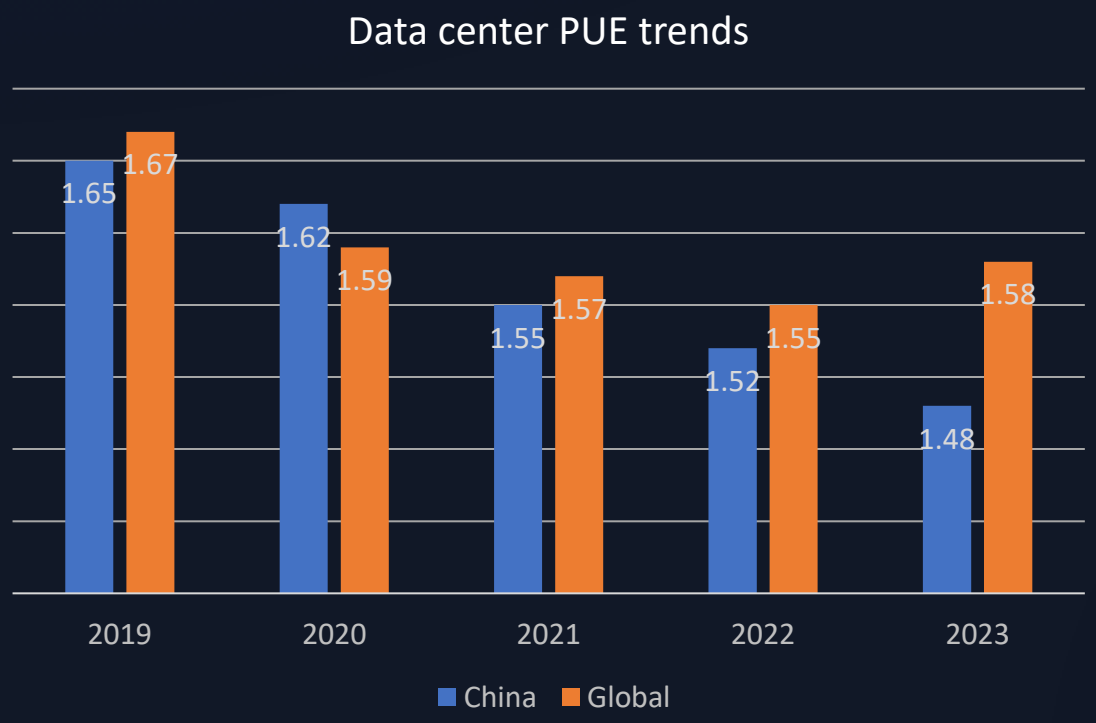
[Data Source: China Refrigeration Materials Technology and Market Analysis Report]

China’s Policies on Data Centers

East Data, West Computing

It was launched in 2022 to optimize the layout of China’s data centers and computing power.

- Balance regional development
- Reduce energy consumption and emissions
- Improve efficiency and resilience



Spatial layout	Site selection for a new data center	In principle, all should be concentrated within the national hub nodes, 8 hubs and 10 clusters
Energy efficiency	Power Utilization Efficiency (PUE)	• National data centers: The average has dropped below 1.5 • Newly built large and above: Reduced to within 1.25 • National hub nodes: No more than 1.2
Energy structure	Utilization rate of renewable energy	• New data centers at national hub nodes: The proportion of green electricity exceeds 80% • Renewable energy utilization rate: An average annual increase of 10%
Operational efficiency	Average Rack Utilization Rate	• National data centers: No less than 60% • National hub nodes/key clusters: Must be significantly higher than the national average (e.g. 65%)
Resource utilization	Water utilization efficiency (WUE)	Some regions (such as Qingyang) have set specific goals: • ≤1.60 L/kWh in the first year • ≤1.00 L/kWh in the second year
Advanced technology	Liquid cooling technology	Policy orientation: Comprehensive promotion in scenarios such as AI training and high-density computing power centers
Highly integrated	Single-cabinet power density	Encourage high-density deployment and require a single cabinet power of ≥20kW (supporting high-power loads such as AI computing power)

Standards and Regulations

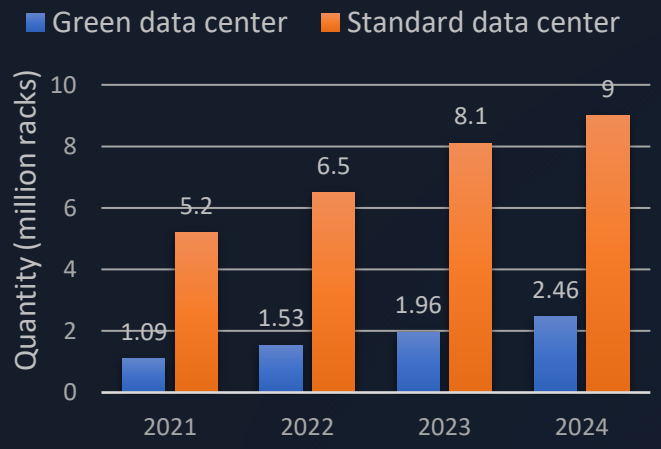
Energy Efficiency Standard

GB 40879-2021 enforces PUE classification and promotes the application of liquid cooling technology

Energy efficiency grade	PUE
Level 1	≤1.20
Level 2	≤1.30
Level 3	≤1.50

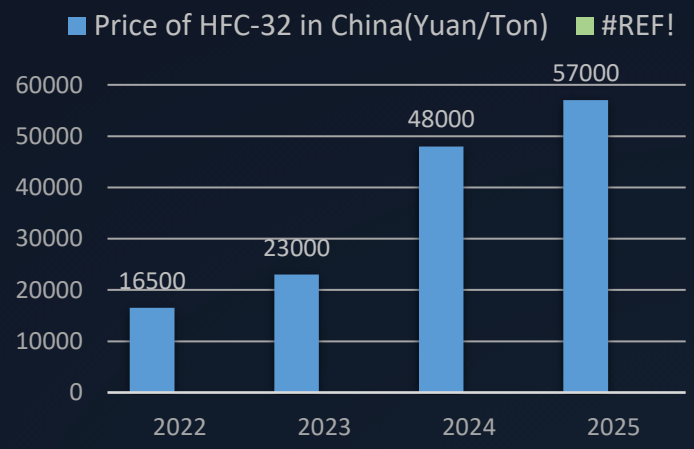
Green Data Center

GB/T 44989-2024: the utilization rate of green electricity in data centers shall not be less than 20%.



Kigali Amendment-HFC phase-down

HFCs supply in China has been limited by Quota system, low-GWP technologies is encouraged.



Cooling Technologies for Data Center

Air to Air Cooling

Traditional &

Optimized)CRAC/CRAH systems

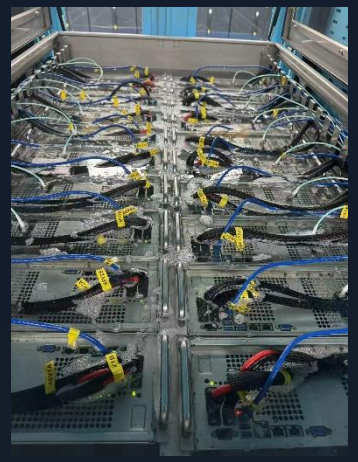
Liquid Cooling

- Single-Phase: Servers submerged in dielectric fluid
- Two-Phase: Fluid boils & condenses (e.g., 3M Novec/Fluorinert)
- Direct-to-Chip (D2C) Cooling, cold plates on CPU/GPU with water/glycol loop

Hybrid air-liquid systems

Combined Direct-to-Chip (D2C) Cooling, cold plates on CPU/GPU and CRAC/CRAH systems

Innovation of Next Generation Cooling Technologies



Breakthrough of liquid cooling technology

Single-phase immersion cooling (PUE≤1.1)
Power density and reliability of two-phase immersion cooling are improved.

Traditional technology upgrading

Evaporative cooling (using natural cold source) and cold plate cooling (saving energy by 15% and reducing water consumption by 31%)

Innovation of next generation cooling technology

Green energy

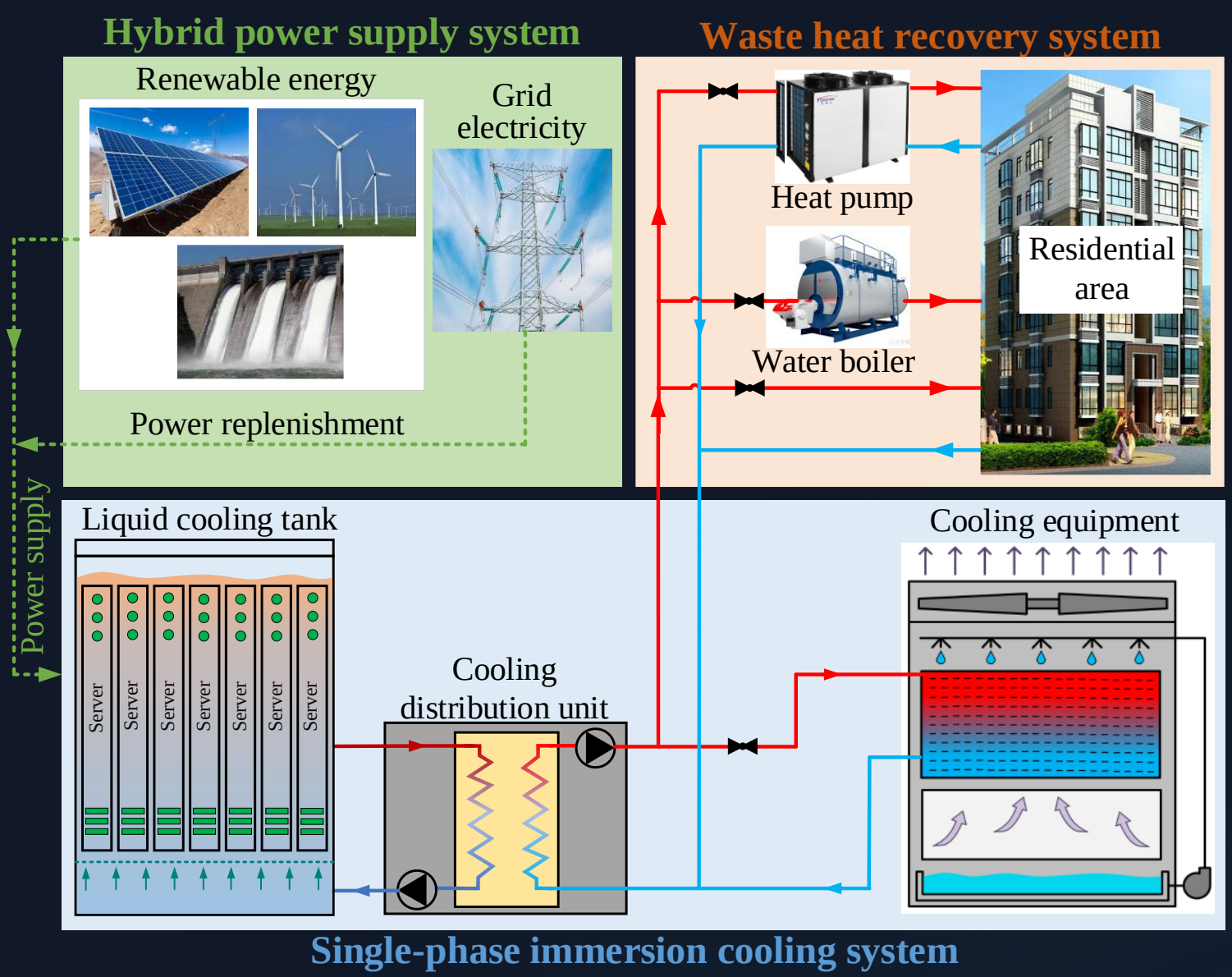
Combine renewable energy (solar energy, wind energy, water energy, etc.)

Efficient cooling

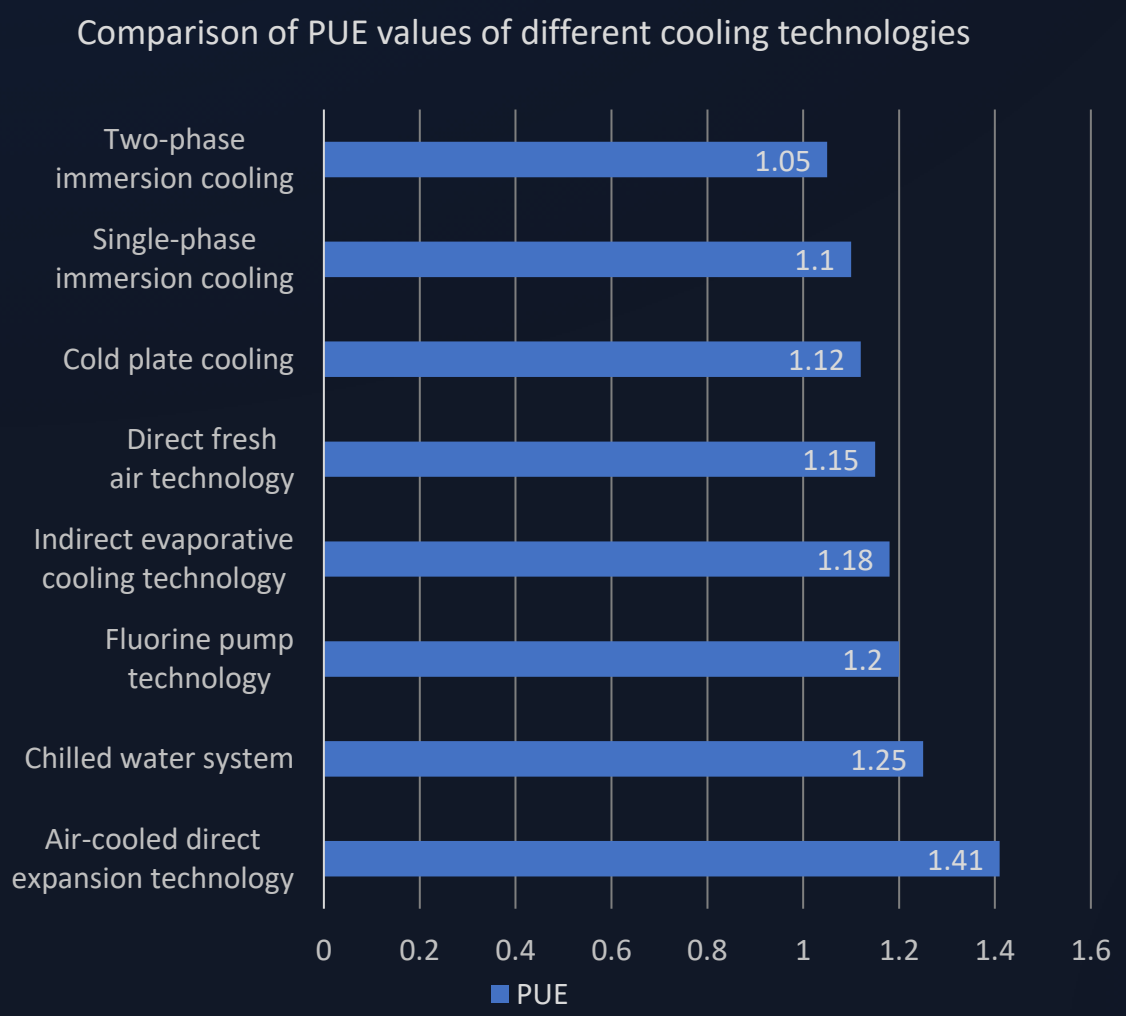
Optimized design of all kinds of refrigerantion transmission and heat exchange in data center process

Recovery of waste heat

The waste heat of cooling system is collected by heat pump, which is used for building heating and hot water supply, to improve overall energy utilization.



Energy efficiency comparison of cooling technologies
Horizontal analysis of PUE



Conclusion

The single-phase immersion cooling technology demonstrates a significant advantage in energy efficiency, achieving a PUE of just 1.1—approximately 22% lower than that of conventional air-cooled direct expansion systems (PUE 1.41). This marks a key direction in the evolution of next-generation cooling technologies.

Technical comparison

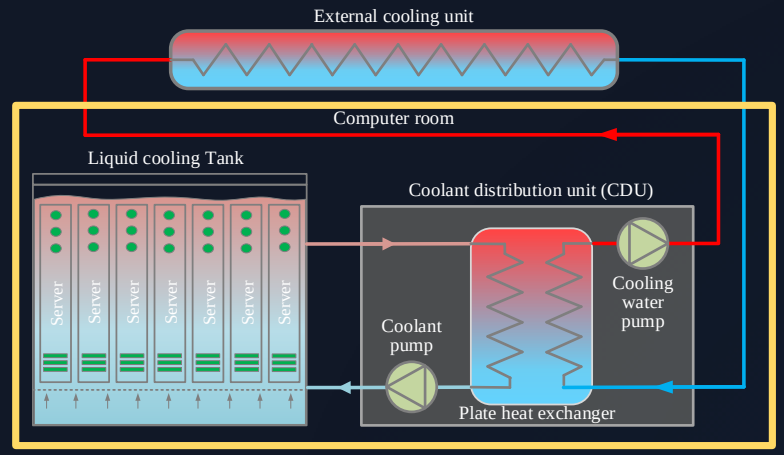
- Single-phase immersion cooling: PUE=1.1 (Low energy consumption, high-density compatibility)
- Air-cooled technology: PUE=1.41 (Traditional solution, significant energy efficiency gap)

Single-phase immersion liquid cooling technology

High cooling capacity: The coolant is in direct contact with the server, with a heat dissipation of up to 100W/cm².

No auxiliary cooling system required: Solve the heating problem of all components at one time.

High power per cabinet: With a high density of electronic equipment layout, the power of a single cabinet can reach 120kW.



Low failure rate: Full immersion protection reduces the server failure rate by about 50% compared with air cooling technology.

Low noise: The internal fans of the servers have been eliminated, and the noise in the data center is reduced to below 45dB.

Extremely low energy consumption: No external air conditioning system is required, and the PUE can be reduced to below 1.1.

Multi-dimensional performance evaluation

Comprehensive comparison of air-cooled/cold plate/immersion cooling technologies

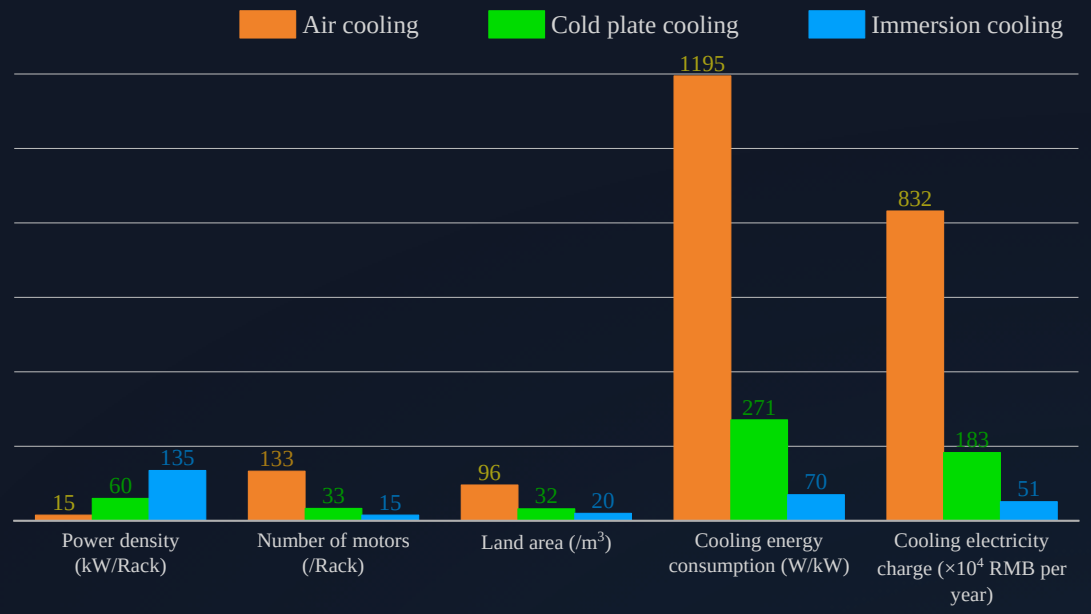
Core comparison of cooling energy consumption

- Air-cooling technology: 1195kW (high energy consumption, traditional architecture)
- Cold plate technology: 771kW (Medium energy consumption, partially optimized)
- Immersion cooling: 70kW (ultra-low energy consumption, comprehensive optimal)

Conclusion

Immersion cooling delivers up to 94% cooling-energy savings versus air-based systems and supports ultra-high densities (>250 kW/rack), positioning it as a leading solution for next-generation AI and HPC data centers.

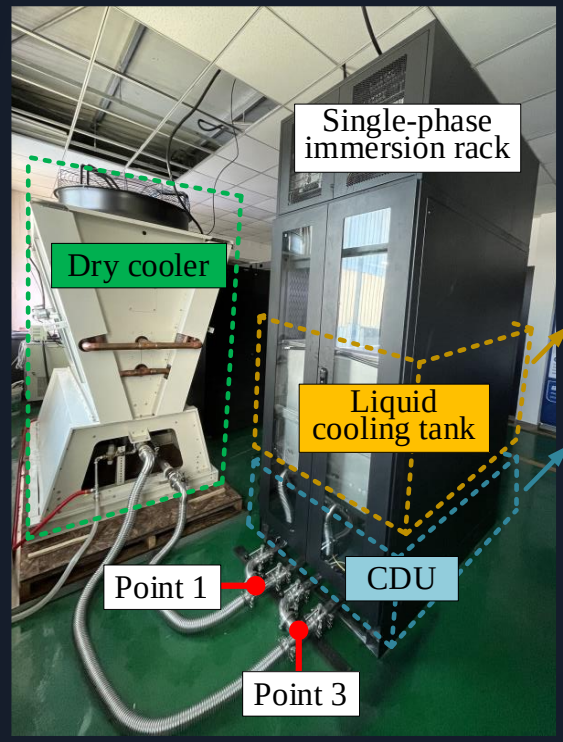
Multi-dimensional evaluation of three cooling technologies

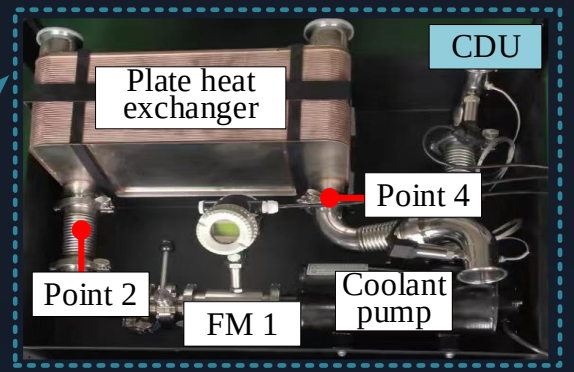


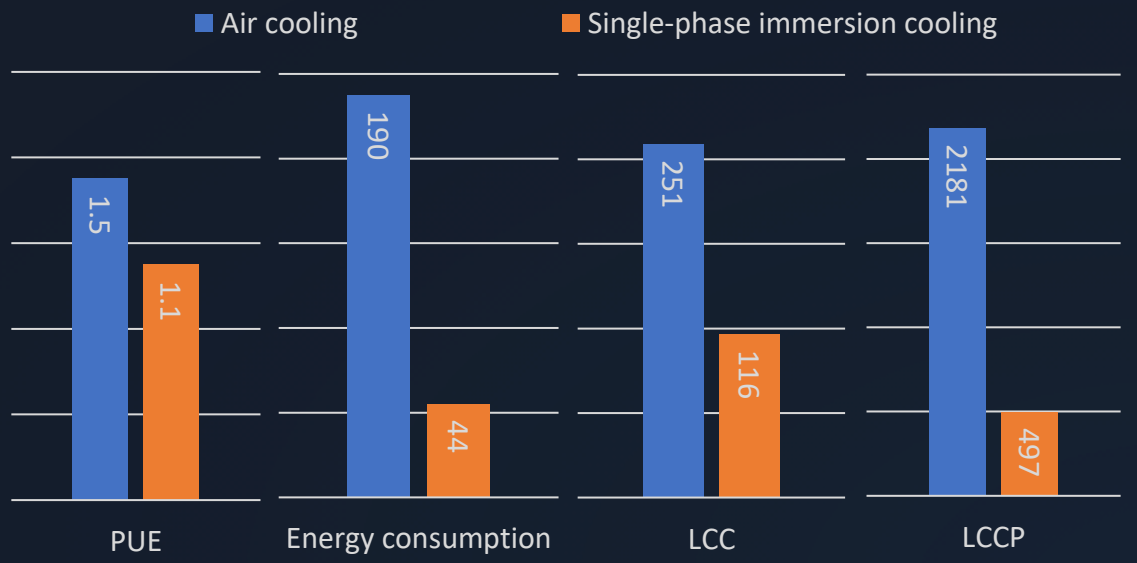
[Based on a 2MW-scale data center]

Comparison of cooling technologies: 48kW heat load case

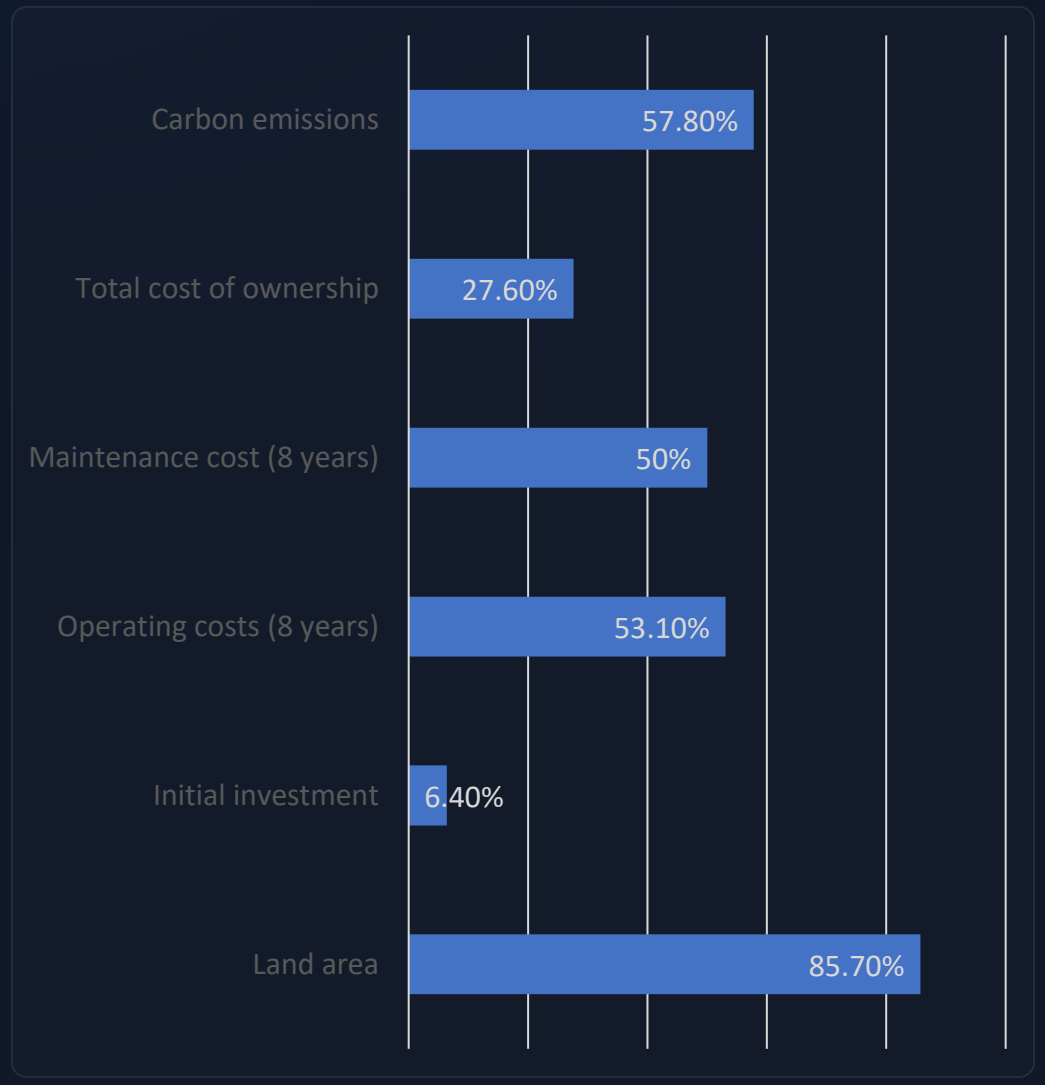
- **Energy-saving effect:** compared with traditional air cooling, immersion liquid cooling saves 146 MWh in total.
- Carbon emission reduction: the total carbon emission reduction is 1684 tons (90,200 tons directly+1.418 million tons indirectly).
- **PUE comparison:** immersion liquid cooling 1.1 vs traditional air cooling 1.4-1.5







Benefits of the pilot project



Pilot Installation

The Qingyang Hub node of the National "East Data, West Computing" hub
immersed liquid-cooled intelligent computing cluster

Pilot Installaiton

Anhui Tier Wuhu liquid cooling intelligent calculation industrial park

- **Single-phase immersion liquid cooling technology:** It adopts a 120KW/RACK fully immersed cabinet, with a fanless server design, and the heat exchange efficiency is increased by more than 40%
- **Photovoltaic integrated power supply:** Deploy a 523kWp monocrystalline silicon photovoltaic system, with an annual power generation of approximately 500,000 kilowatt-hours, which can replace part of the city's power consumption
- **Water resource recycling:** 100% of the production wastewater is recycled for production after separation and purification. Domestic sewage is treated and pumped through three stages, and the consumption of municipal water supply is reduced by 30%

Indicator type	Specific value	Industry advantages
PUE	Running average ≤1.1, target 1.05	Lower than 30%+ in industry air-cooled data centers
Power density	Single cabinet up to 120KW	6-8 times that of traditional air-cooled cabinets
Proportion of renewable energy	Photovoltaic annual power supply accounts for about 8%	Reserved wind power/energy storage interface for capacity expansion.
Noise control	Operating noise at full load <45dB	Far below the noise limit of industrial plants.

Technology Outlook and Perspectives

- **Energy Efficiency and Sustainability:** Achieves PUE as low as 1.2—utilization rate of green electricity will exceed 50% by 2030.

- **AI-Ready Performance and Density:** Delivers superior thermal capacity for high-density AI and HPC workloads, enabling reliable operation of next-generation servers.

- **Future-Driven Infrastructure Evolution: E**nhances reliability, focusing on intelligent, modular, and environmentally responsible infrastructure.

Thanks for your attention!

Together, we’re shaping a digital world that’s smarter, greener, and more sustainable for generations to come.

Contact: li.xiaoyan@fecomee.org.cn