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White Paper

On the Top 10 Trends of Data Center Facilities

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HUAWEI

Foreword

Digital and low-carbon development is now a global trend. Digital technologies are reshaping society. Innovative services, such as AR/VR, autonomous driving, smart manufacturing, and smart healthcare, facilitate our life and production, making the digital economy a primary engine of social development. statistics show that the digital economy of 47 major countries accounted for 45%[①] of the world's gross domestic product (GDP) in 2021. The compound annual growth rate (CAGR) of computing requirements will reach 50%[②] in the next five years. As a foundation of the digital economy and intelligent world, data centers will usher in a golden development period.

Carbon neutrality has become a global mission. More than 130 countries have declared their commitments to carbon neutrality. Data centers have developed rapidly in recent years. They account for about 2% of the world's total energy consumption, and the proportion is surging. According to the Uptime Global Data Center Survey 2022, the power usage effectiveness (PUE) value of global large-scale data centers has remained at around 1.6 since 2014, and there is still much room to optimize the PUE. Many countries and international organizations have issued relevant policies to promote the green development of data centers. For instance, China requires that the PUE of newly built large and hyper-scale data centers be reduced to less than 1.3[③] by 2025. The "Eastern Data, Western Computing" project sets stricter requirements on the PUE of the eight data center hubs: The PUE must be less than 1.2 in West China and less than 1.25 in East China. European data center operators and industry associations announced that data centers would be carbon neutral by 2030[④]. The US has stepped up efforts to phase out old and inefficient data centers and requires that the PUE of new data centers be lower than 1.4 and that of reconstructed data centers be lower than 1.5[⑤].

Data center availability and reliability have been key metrics for the industry, and PUE is drawing more attention. As data centers develop rapidly and carbon neutrality is now a global mission, the industry is undergoing unprecedented changes. In addition to high reliability and efficient energy utilization, data center requirements will include higher renewable energy utilization, more intelligent management, more rapid deployment, more elastic capacity expansion, and more advanced overall sustainability.

After in-depth discussions with industry leaders, technical experts, and customers, Huawei Digital Power released the White Paper on the Top 10 Trends of Data Center Facilities based on its deep insights and long-term practices, providing a reference for advancing the healthy development of the data center industry.

See also:

①White Paper on Global Digital Economy, China Academy of Information and Communications Technology

②White Paper on China's Computing Power Development Index, China Academy of Information and Communications Technology

③Action Plan for Green and Low Carbon Development of the Information and Communications Industry (2022–2025), jointly issued by the Ministry of Industry and Information Technology and six other departments in August 2022

④Europe's Climate Neutral Data Centre Pact

⑤Update to Data Center Optimization Initiative (DCOI)

White Paper on the Top 10 Trends of Data Center Facilities

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Trend 1: Low Carbon

Carbon neutrality has become a shared mission of the world. Major economies have made commitments and put them into action. The European Union, Japan, and South Korea have proposed to achieve carbon neutrality by 2050. China has claimed to reach its peak carbon goals by 2030 and achieve carbon neutrality by 2060. India has declared to be carbon neutral by 2070. Driven by the pursuit of carbon neutrality, the data center industry is undergoing profound changes. Data centers will become low-carbon as clean energy will be widely used, efficient energy conservation technologies will be promoted, and more carbon reduction methods, such as waste heat recovery, will be adopted.

Green Energy Will Be More Widely Used

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Efficient Energy Consumption Will Reduce the PUE to 1.0x

PUE is a key metric of energy efficiency. According to the 2022 survey data of Uptime Institute, the average PUE of existing large-scale data centers worldwide is as high as 1.55, and that of most new data centers ranges from 1.25 to 1.3. Thanks to regulatory policies and technological development, more advanced energy conservation technologies will be widely used in data centers to reduce the PUE. It is estimated that the PUE will drop to 1.0x by 2027.

Energy Recovery Rate Will Increase; More Innovative Energy Conservation Technologies, Such as Waste Heat Recovery, Will Be Applied

In large-scale data center campuses, heat recovery is being successfully implemented as a new energy-saving solution. Driven by regulatory policies, many data centers emphasize the value of waste heat recovery. Excess heat from devices can be directed to other facilities through hot aisles to improve waste heat utilization and reduce energy costs.

According to Beijing National Development and Reform Commission, data centers should make full use of free cooling sources and enhance the utilization of waste heat resources through self-use and external heat supply. Data centers are also encouraged to make full use of technologies such as cabinet waste heat recovery.[7]

Waste heat recovery is a mature business in Europe. The Climate Neutral Data Centre Pact (CNDCP) lists the key steps for implementing the European Green Deal and specifies that heat recovery is critical. The governments of the four Nordic countries recommend that new data centers be connected to a heat pipe network, with a maximum subsidy for 75% for the heat recovery system purchase and installation costs.

As technical solutions mature and costs decrease, waste heat recovery will be more widely used to save energy and reduce carbon emissions in data centers.

Technologies and Applications

A large data center in the UAE has been built using Huawei's FusionDC prefabricated modular solution and is fully powered by a PV system. It uses green energy and construction and is the largest green and low-carbon data center in the Middle East and Africa.

See also:

[6] Implementation Plan on Promoting Green and High-Quality Development of New Infrastructures Such as Data Centers and 5G to Achieve the Goal of Carbon Peaking and Neutrality, jointly issued by the National Development and Reform Commission and other three departments of China on November 30, 2021

[7] Regulations on Strengthening Energy Conservation Review of Data Center Projects, National Development and Reform Commission, Beijing, China, 2021

Trend 2: Sustainability

Low or even zero carbon is not the only benchmark for sustainability. In a broad sense, sustainability needs to be considered from three aspects: environmental, social, and corporate governance (ESG). The sustainability of data centers is evaluated by the utilization efficiency of energy and resources and the impact on the environment. In addition to PUE, data centers will also be measured by more comprehensive indicators, such as renewable energy utilization, water usage effectiveness (WUE), carbon usage effectiveness (CUE), space usage effectiveness (SUE), grid usage effectiveness (GUE), material recovery rate, and lifetime contaminant emissions.

High Energy Efficiency Is a Prerequisite for Sustainable Development

Data centers are attracting much attention because they consume about 2% of the world's total electricity. In 2007, The Green Grid proposed PUE as an indicator to measure the energy efficiency of data centers. Since then, PUE has been gradually accepted across the industry. For the majority of data centers, the PUE value has remained high for an extended period. Reducing the PUE can slash the operating expenditure (OPEX) without affecting the computing performance of the data center. Because fossil energy is still a dominant source of electricity generation, reducing the PUE will significantly cut carbon emissions and lead to carbon neutrality. It is worth mentioning that as the PUE value approaches 1, more attention will be paid to the energy efficiency of IT equipment, and more refined indicators, such as the energy consumption per unit of computing power, will be proposed. As green energy utilization increases, the CUE indicator, combined with the PUE and renewable energy coefficient, becomes increasingly important.

WUE Will Become More Important

Resources such as water, land, and utility power should be efficiently used to build and operate a sustainable data center and maximize value utilization. Resource utilization indicators such as WUE, GUE, and SUE are drawing more attention. Water is essential to life, industry, and agriculture. Therefore, WUE will become a more important indicator.

Conventional data centers consume much water. In northern China, such as Ulanqab in Inner Mongolia, it is prohibited to use groundwater for cooling or supply tap water to new big data centers. It is required that the WUE be less than 1.4 L/kWh in water-rich areas and less than 0.8 L/kWh in water-deficient regions. In a data center, most water is consumed for cooling. Cooling technologies that use little or even no water will be favored.

Data Centers Will Have Lower Impact on the Surrounding Environment

In addition to power and water consumption, data centers produce contaminant emissions and noise during the entire process, from construction to recycling.

Data centers are special facilities with building materials and various internal equipment. Prefabricated green buildings are promoted in China for their advantages, such as green building materials, standardized design, 80% material recovery rate or higher, and little noise and dust pollution during construction. Internal equipment should be made of eco-friendly materials. For example, lead-acid batteries can be replaced by lithium batteries that deliver better performance and are more environment-friendly.

Technologies and Applications

The Hainan Prefecture Big Data Industry Campus in Qinghai is China's first demonstration base for a big data business fully powered by clean energy. The campus was deployed using Huawei's FusionModule2000 smart modular solution that integrates energy conservation technologies such as cold aisle containment, AI, and high-efficiency modular UPS. The campus delivers 30% higher energy efficiency than a conventional data center.

Qinghai Hainan Big Data Industrial Park

Trend 3: Fast Deployment

Thanks to the development of AI and HPC, global computing requirements are snowballing with an expected CAGR of over 50% in the next five years. Data centers need to be rapidly deployed to meet the exploding demands of computing services. The time to market (TTM) will drop from 12 to 6 months or even be shorter.

Data centers are heavy assets. In the colocation industry, large-scale data centers will be built only after tenants are finalized. Internet services will need to meet exploding computing requirements within a short period. For instance, ChatGPT attracted 100 million monthly active users in late January 2023, just two months after launch, making it the fastest-growing consumer application in history. TikTok took nine months to reach 100 million users, while Instagram took 2.5 years. To cope with the sudden and explosive growth of services, many tenants require that the TTM of a data center with about 1000 racks be shortened to one year or less.

We believe that in the next five years, driven by the rapid growth of global computing power, the TTM of a data center with 1000 racks will be shortened from 9–12 months to 6 months or even shorter.

Technologies and Applications

The Wuhan AI Computing Center uses Huawei's prefabricated modular data center solution FusionDC to implement parallel construction. The containers are deployed with power supply and cooling subsystems at the same time. The facility was built in just 120 days, and it took only five months to complete the deployment process from foundation construction to service rollout. The TTM was halved.

Wuhan Artificial Intelligence Computing Center

Trend 4: High Density

As chips and servers deliver higher computing performance and consume more power, the power density per IT rack will increase from 6–8 kW to 12–15 kW in the next five years.

Chips are upgraded every 2–3 years to meet higher computing performance, leading to multiplying power consumption. IT technologies will also be upgraded to efficiently meet the requirements of hyper-scale data centers. In the post-Moore's Law era, various innovative technologies, such as core stacking and motherboard stacking, have been introduced. Some CPUs have reached 48 cores or even 64 cores. The corresponding power consumption is increasing rapidly (with an average annual growth rate of 30%). Power consumption varies with computing types. GPU/NPU power consumption is growing rapidly. Currently, the thermal design power (TDP) of a standard x86 chip (Eagle Stream platform) is 350 W, whereas the TDP of the latest generation of NVIDIA H100 is 700 W.

By 2027, more than 70% of the operating data centers will become cloud data centers. With the exponential growth of data and computing volumes generated by cloud computing services, data center resources, especially those in tier-1 cities, are becoming increasingly insufficient. The value of data centers can be maximized by improving the computing, storage, and transmission capabilities per unit area of space. Therefore, it is estimated that the power density per IT rack will increase from 6–8 kW to 12–15 kW in the next five years.

Against this background, data center facilities are bound to adopt high-density design.

Data Centers Will Use Integrated and High-Density Power Supply Systems

As IT racks' power density increases, the power room's area in a data center will increase significantly. Data from recent surveys indicate that when the power density/rack reaches 16 kW, the ratio of the power room to available space will reach 1:1. To prevent SUE reduction, the power supply system in a data center needs to increase its power density or reduce its size. In the future, the power supply system will be highly dense and integrated. Increasing the density of power modules or reducing the size and number of devices will shorten the entire power supply link. This way, the footprint of the power supply system will be reduced, and space and other resources of data centers can be efficiently utilized.

High Density Will Drive Liquid Cooling Technology Evolution

Another challenge for high IT rack density is cooling. Liquid cooling has a higher cooling capacity per unit volume than air cooling and is increasingly used in scenarios with ultra-high power density, such as AI and supercomputing data centers. There are two types of mainstream liquid cooling modes: cold plate and immersion. Compared with air cooling, liquid cooling better meets the cooling requirements of racks with a high power density and features a lower PUE and higher GUE. Cold plate liquid cooling has a typical PUE of 1.1x and a GUE of more than 75%, while immersion liquid cooling has a PUE as low as 1.0x and a GUE of more than 80%. However, liquid cooling technology has its limitations. Compared with the conventional air-cooled architecture, liquid-cooled servers need to be customized, resulting in high initial investment and complex maintenance. In actual applications, liquid cooling is not the first choice in most service scenarios. Even in high-density scenarios, liquid cooling is not preferred. Air cooling has been used in 30 kW/rack scenarios for many years. High IT rack density will continue to drive the development of liquid cooling technology in the next five years. However, liquid cooling solutions will only be applied on a small scale, and air cooling will remain the mainstream cooling solution.

Technologies and Applications

In the first phase of the Chengdu Intelligent Computing Center project, the highest AI computing performance planned was 1000P. The power density per AI rack (Atlas) reaches 46 kW. The liquid cooling technology cools about 5% of the total racks. Standard computing racks each have a power density of 8 kW and are air-cooled. The FusionPower6000 and SmartLi high-density power solution is used for power supply, reducing the footprint of the power supply system in the data center by 40%.

Chengdu Intelligent Computing Center

Trend 5: Elasticity

As cloud services develop rapidly, data centers will feature large-scale deployment and fast IT service rollouts and need help in predicting service demands. A conventional data center requires one-off planning, construction, and investment for civil and electromechanical engineering, resulting in a high capital expenditure (CAPEX), low load rate, high energy consumption, and a long payback period. After a service rollout, it is difficult to increase the power density of racks without interrupting services.

One Generation of Facilities Will Accommodate Two or Three Generations of IT Equipment

The lifetime of IT equipment is generally 4 to 5 years, while that of data center facilities (such as power supply and cooling equipment) is 10 to 15 years. The data center facilities must meet the power evolution requirements of two or three generations of IT equipment. As the power density of IT equipment doubles every five years, data centers need to upgrade the power supply and cooling capabilities accordingly. Conventional data centers cannot be upgraded without interrupting services. Data center facilities must be resilient enough to support smooth and flexible capacity expansion.

Deployment Will Be Flexible to Match Different Power Densities

Data centers evolve towards convergence. IT equipment with different power densities may need to be deployed in the same data center to implement heterogeneous computing, general-purpose computing, and storage. Data centers will use a more flexible architecture to facilitate phased deployment, on-demand capacity expansion, flexible configuration based on service conditions, and precise matching of power density requirements of different phases and services. In this way, flexible deployment and upgrade will be implemented, ensuring an appropriate CAPEX and an optimal total cost of ownership (TCO) and internal rate of return (IRR).

Technologies and Applications

In 2019, a colocation customer in Finland purchased Huawei's SmartLi UPS solution that included 2.4 MW UPSs, 400 kW UPS modules, and four sets of intelligent lithium batteries. In 2020, the customer purchased 2 MW UPS modules and eight sets of intelligent lithium batteries to expand the capacity without interrupting services. This ensures return on investment (ROI) and business development.

Finland - Data Center

Trend 6: Prefabrication

System and data center prefabrication will address challenges that conventional data centers face, such as slow construction, high CAPEX, and complex O&M. Prefabricated power supply modules and cooling modules will be used in the power supply and cooling systems of data centers that adopt an integrated and link-level prefabricated architecture. Data centers will feature fast delivery, easy maintenance, phased deployment, and low TCO.

Modular Design of Components Will Simplify Capacity Expansion and Maintenance

Data centers involve complex systems and various internal equipment. To ensure stable service operations, critical subsystems such as power supply and cooling systems must be highly reliable, easy to maintain, and support expansion without interrupting services. The modular design of components simplifies the systems. A defective module can be located if a system fault occurs. Redundancy design ensures that a faulty module will not affect system operation and module maintenance will not impact system functions. Modular power supply systems (such as UPS power, management, centralized bypass, feed, and lithium battery modules) and cooling systems (such as hot-swappable fans, control units, and power supply modules) are becoming standard in the industry.

Product Prefabrication Will Accelerate Equipment Installation and Delivery

Product prefabrication is becoming a trend as data centers develop rapidly, and customers require flexible construction and quick delivery. Thanks to mature component modularization technologies, power supply and cooling systems and the overall architecture can be prefabricated.

Power supply systems used in conventional medium- and large-scale data centers are assembled onsite and have problems such as low efficiency and complex management. In contrast, a prefabricated power supply system integrates components such as power modules, lithium battery modules, and power distribution modules to deliver a route of power in just a row. It attracts customers' attention due to its high efficiency and easy O&M.

A prefabricated cooling system is pre-integrated, pre-installed, and pre-commissioned in the factory, facilitates quick and flexible capacity expansion, and simplifies maintenance. With the rapid growth of data centers, power supply, cooling, and IT rack systems that are pre-integrated, design-free, and easy to deliver and replicate are becoming the preferred choice for data center construction.

Data Center Prefabrication Will Enable Fast Service Rollout

Increasing numbers of Internet and enterprise services are being moved to the cloud. Cloud computing has become the mainstream IT architecture. In the future, cloud data centers will become larger and more intensive. A data center building will house over 1000 racks, and a campus will accommodate over 10,000 racks. Prefabricated solutions and continuous innovation are inevitable for ensuring on-demand deployment, high reliability, and optimal TCO for cloud infrastructure. A large, prefabricated data center that adopts a modular design will consist of multiple points of delivery (PODs) and will be deployed on demand to reduce the CAPEX and shorten the TTM. Moreover, if L0–L4 joint design is adopted, data center facilities will be built and upgraded on demand to keep pace with IT evolution.

Technologies and Applications

China Transport Telecommunications & Information Center (CTTIC) used Huawei's FusionPower6000 solution in its Shanghai-based data center to deploy a modular and simple power supply system. The system occupies a 40% smaller area than a conventional system, helping the customer deploy 350 more IT racks and save more than 16,000 meters of power cables. Products are prefabricated in the factory and delivered onsite in just two weeks. AI technologies are used to implement predictive maintenance, improving the safety and reliability of the power supply system.

Trend 7: Storage and Backup Integration

As the proportion of renewable energy in the power supply increases, the difference in electricity prices between peak and off-peak hours widens, and virtual power plant (VPP) technology is becoming mature enough for commercial use, energy storage systems will be more widely used in data centers and integrated with short-term backup power systems in data centers.

Trend 7: Storage and Backup Integration

More renewable energy will be fed to power grids. However, its inherent variability will compromise the stability of the power grids and affect electricity consumers. Currently, energy storage systems are deployed to address this challenge. Governments of various countries have released policies that encourage deploying energy storage systems on the user side. For example, according to the Notice on Further Optimizing the Time-of-Use Electricity Price Mechanism issued by the Chinese government, the electricity price difference between peak and off-peak hours should not be lower than 4:1 in areas where the maximum load difference is 40%. Increasing the electricity price difference will make the time-of-use business profitable and promote the healthy development of the energy storage industry.

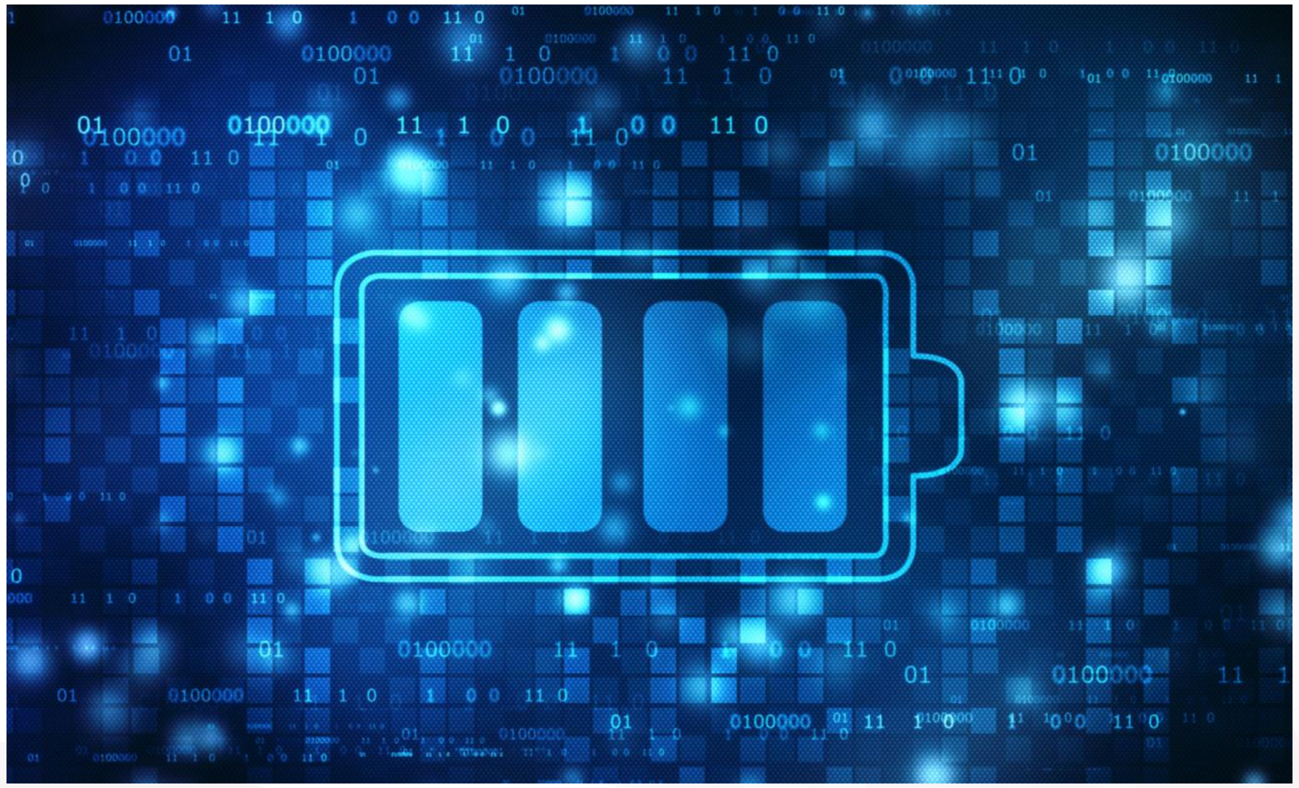
The following points will encourage data centers to deploy energy storage systems:

- Energy storage systems will solve the variability inherent in green energy, increasing its proportion in the power supply to data centers.
- Energy storage systems will reduce the data center OPEX by leveraging the time-of-use pricing.
- Energy storage systems will mitigate the dependence of data centers on diesel generators by reducing the use of diesel fuel.
- Energy storage systems can be used for peak shaving to reduce the peak PUE and improve GUE so that more IT racks can be deployed to increase rental revenue.

Energy storage systems deployed in data centers will integrate with the original short-term backup power systems.

Technologies and Applications

The medium-voltage UPS + energy storage technology enables coordinated scheduling of data centers, clean electricity, and energy storage systems. Such data centers will become complexes that carry variable and adjustable loads and adjust charging and discharging policies based on the requirements for the power grid and renewable energy generation. Intelligent peak shaving will be implemented to increase GUE and benefit from time-of-use pricing to reduce OPEX.



Trend 8: Distributed Cooling

The reliability of the cooling system in a data center is often overlooked. According to the survey data in 2022 from Uptime Institute, the cooling system accounts for 13% of data center accidents or interruptions, the third largest fault source after power supply and network faults.

Currently, most large data centers use centralized chiller plants for cooling. A chiller plant consists of seven subsystems: chiller, cooling tower, chilled water tank, indoor unit, cooling water pump, plate heat exchanger, and management system. Dozens of devices are connected by hundreds to thousands of meters of water pipes. There are innumerable adapters, valves, and other components. As a result, there are many failure points. In addition, when a centralized architecture is adopted, any single point of failure may cause breakdowns in multiple equipment rooms or buildings in a data center. The fault domain is large, posing significant challenges to the stability of data centers. For example, in December 2022, a water leakage occurred in the cooling pipe of a large equipment room in Hong Kong, causing all chillers to stop functioning. The high temperature in the equipment room triggered a secondary fire accident. As a result, servers were down for more than 15 hours. This failure caused the unavailability of multiple websites and apps and affected the services of well-known brands, resulting in significant economic losses. Another example is a data center in South China. The cooling water system of the data center was blocked due to the lack of water in the main pipe. As a result, the entire cooling system failed, and the cooling of the whole building was interrupted. In 2020, a data center of a leading cloud service provider in the United States went out of service. The reason was that the cooling system became faulty due to the hot weather. Therefore, it is important to find a way to improve the reliability of the data center cooling system.

Given such incidents, the distributed cooling system will become the mainstream choice for secure and reliable data centers.

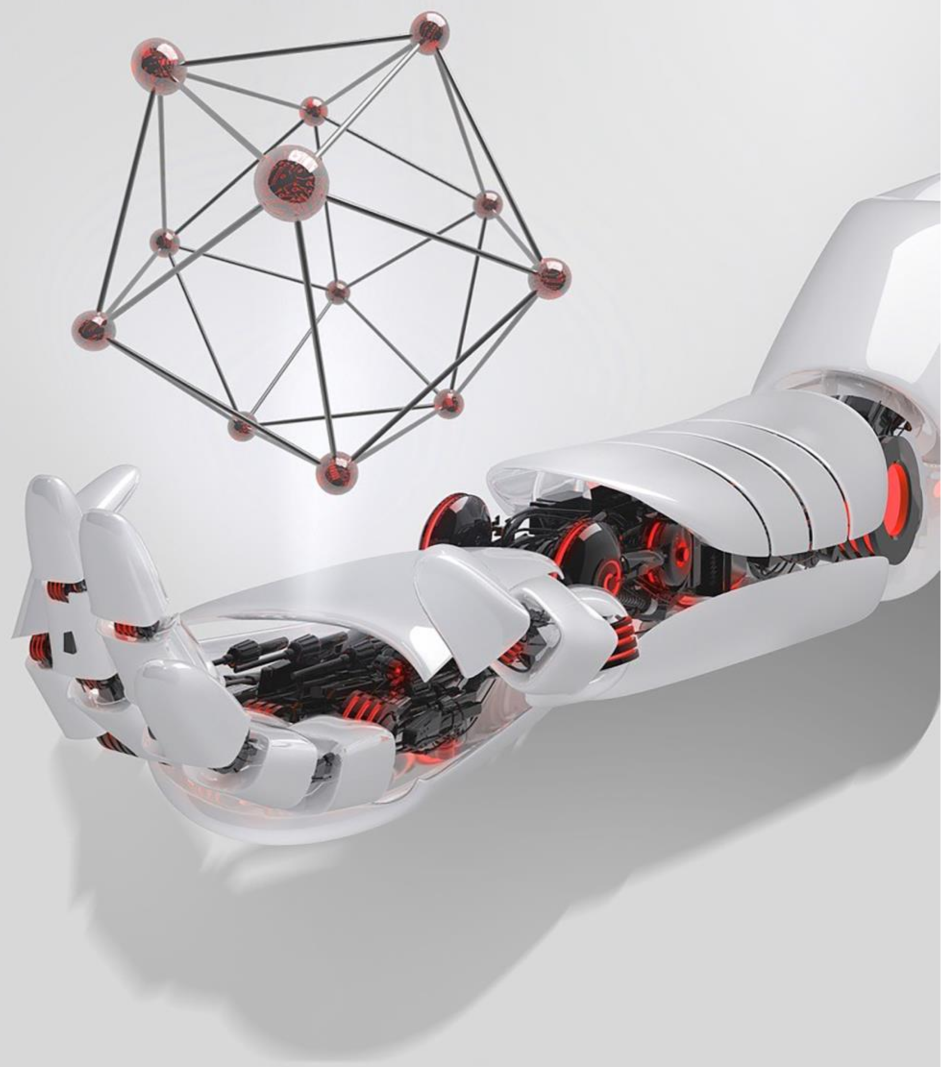
The distributed cooling system uses cooling sources for each data hall and adopts a redundancy configuration. The failure of a single device does not affect the regular running of the equipment room or other equipment rooms. This significantly improves the reliability of the data center. In addition, it is easy to prefabricate the distributed cooling system, which reduces the onsite engineering workload and minimizes the potential risks due to problems in construction quality. Also, the distributed cooling system features clear pipelines, simple O&M, and a low probability of errors during emergency handling. As data centers grow in scale, there is a corresponding increase in the disadvantages of centralized cooling. With its flexible architecture and high reliability, the distributed cooling system will be more widely used in new data centers and gradually replace centralized cooling as the mainstream solution.

Technologies and Applications

In a large data center with 4000 racks in Ireland, Huawei FusionCol's indirect evaporative cooling solution implements free cooling throughout the year. The optimal PUE reaches 1.15, saving more than 14 million kWh of electricity annually and reducing the TTM by more than 50%.

Trend 9: Smart O&M

As data centers grow in scale and quantity, there is a significant increase in management complexity. Moreover, it is increasingly difficult to employ professional O&M personnel. Therefore, it is imperative to quickly improve the digitalization of data center facilities. On the technical side, with the improvement in computing power and the development of HD video and image recognition technologies, AI is being widely used in data centers. In the context of carbon neutrality, digitalization and AI technologies change the focus of data center O&M management from energy consumption to reducing carbon emissions, driving full-lifecycle carbon management and facilitating carbon neutrality.



Data Center Facilities Will Be Further Digitalized, and All Links Will Be Visualized, Manageable, and Controllable

As the bearer of AI, big data, and communications technologies (5G, PLC, and IoT), data center facilities are a solid foundation for their development. At the same time, the development of these technologies is driving the further digitalization of data center facilities. The use of digital devices, sensors, and smart terminals facilitates self-detection and self-diagnosis of power supply and cooling systems in data centers, ensuring safety, shortening the time for fault rectification, and improving O&M efficiency. Digital twin technology will be more widely used and integrated into the process of building data centers (planning, construction, O&M, and optimization), visualizing data centers, making them more manageable and controllable, and delivering an excellent experience throughout the data center lifecycle.

AI Is Rapidly Becoming a Key Tool for Data Center Operations and Management

As data center facilities become more critical to businesses, technologies will become increasingly complex, and networking will be strengthened. Decision-making will depend more on experience and data than intuition, and management complexity will increase. Using conventional methods and manual analysis and decision-making limits the ability to improve energy and O&M efficiency. The complexity of data collection, analysis, and decision-making related to cooling, power distribution, and management systems indicates the need for big data analysis, independent learning, and rapid decision-making, making them the main goals of AI innovation. With AI technologies, data centers will see a gradual increase in the level of intelligence in O&M, operations, and energy saving and eventually evolve to full autonomy.

(1) AI O&M: During data center operations, massive O&M data, including configuration data, status, alarms, and logs, is continuously generated. The data increases exponentially over time. Tens of thousands or even tens of millions of O&M indicators are beyond the monitoring and management scope of O&M personnel. Currently, the analysis of data center O&M data based on AI technologies aids in understanding the complexity of the O&M environment. It has been widely used in fault detection, root cause locating, and resource prediction, significantly improving O&M efficiency.

(2) AI operation: AI will gradually replace repetitive work, the experience of experts, and business decision-making. Based on AI simulation device status and AI service prediction, the system automatically obtains data center asset statuses, designs data center services, and selects the optimal configuration solution based on site requirements, improving resource utilization and operational benefits.

(3) AI energy efficiency optimization: AI technologies are used to dynamically build a machine learning model for adjustable parameters, such as energy consumption and IT load, climate conditions, and device operations. While ensuring the reliability of devices and systems, the model can diagnose the energy consumption of each subsystem in real time, automatically and accurately infer and configure the optimal control logic of the data center, and adjust parameters in real time to reduce data center PUE.

Technologies and Applications

Huawei iCooling energy-efficiency optimization solution is being used in the Zhongyuan Data Base of China Unicom in Henan, and has transformed cooling into smart cooling. The project's first phase saved 3.85 million kWh of electricity annually, equivalent to reducing carbon emissions by 1829 tons and planting 79,500 trees.

Trend 10: Security & Trustworthiness

As the heart of organizations' IT infrastructure, data centers carry massive volumes of data and serve as the core resource base for centralized information processing, computing, storage, transmission, exchange, and management. Typically, data centers are essential to society and the economy. Therefore, safety is critical to data centers. From the perspective of data center solutions, predictive maintenance at the system-, component-, and device-level is required to continuously improve hardware reliability and system resilience.

In addition, for implementing refined management and control of devices, digital technologies and industrial Internet technologies play an increasingly important role in critical data center systems, including the data center management system, battery management system (BMS), and device health monitoring system. This way, people, data, and machines are connected. Industry, technologies, and the Internet are deeply integrated. Network security and trustworthiness are extended to the industrial Internet field and underlying devices. As data center facilities become more intelligent, network security threats increase by several times. Statistics show that each attack on a data center causes an average loss of approximately CNY30 million. Therefore, greater emphasis is placed on software security, privacy, and availability of data center facilities, and hierarchical defense is implemented to enhance data center security and trustworthiness.

There are six features: hardware reliability, software security, system resilience, safety, privacy, and availability. Hierarchical defense is performed to enhance data center security and trustworthiness.

1.**Hardware reliability:** the ability to ensure no failure in a given period under given conditions.

2.**Software security:** the ability to defend against malicious network threats.

3.**System resilience:** the ability to keep the minimum core system running when the system is attacked.

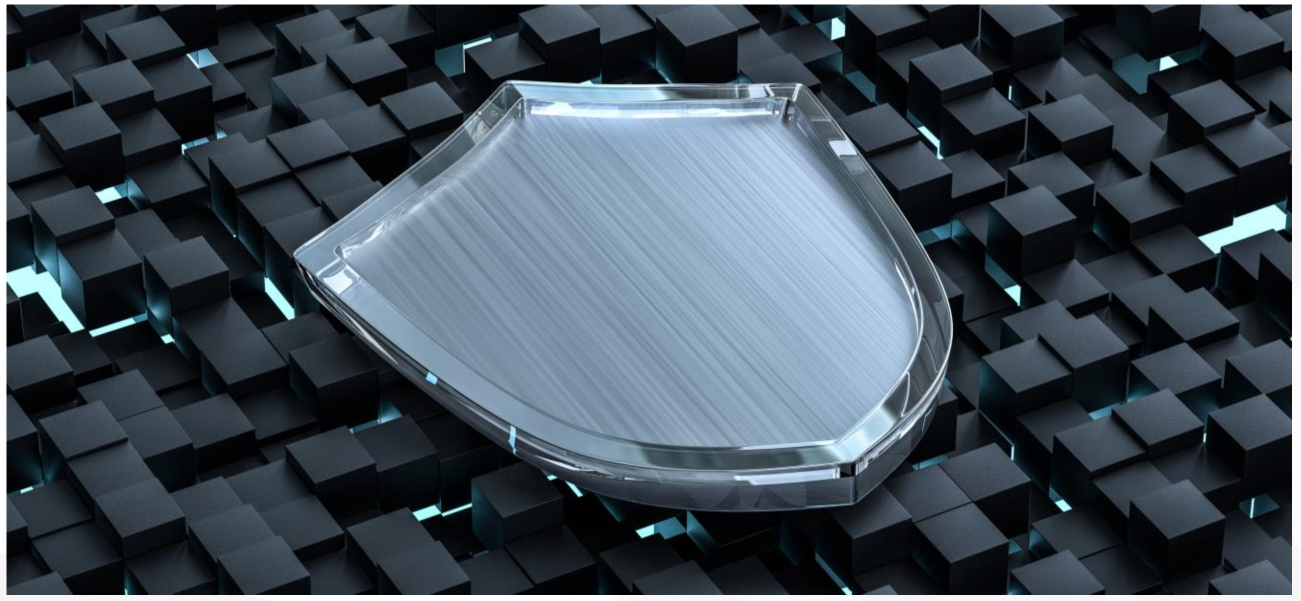
4.**Safety:** the ability to ensure no damage to the environment or loss of personnel and property when the system fails.

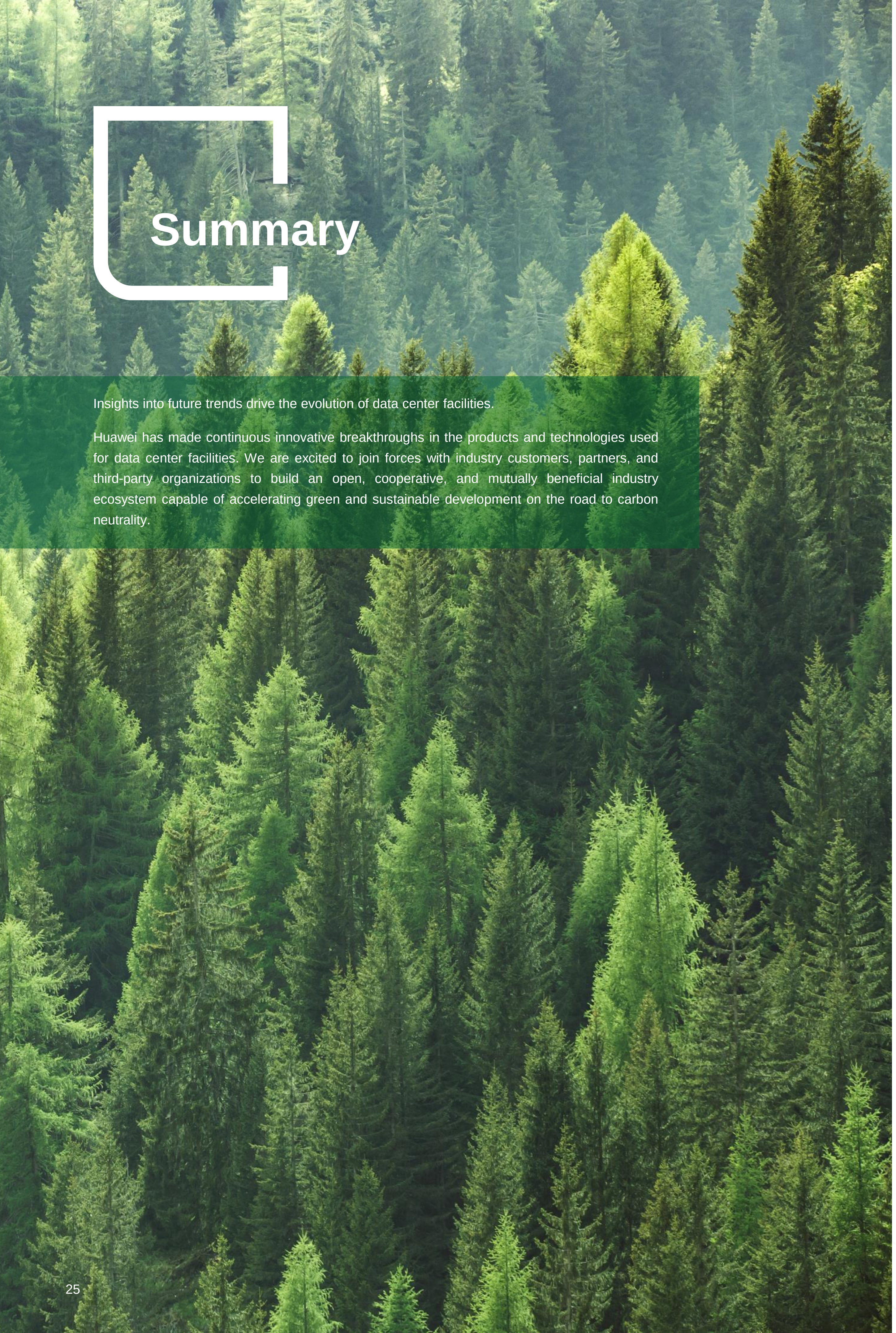
5.**Privacy:** the ability to protect customer data and information.

6.**Availability:** the ability to ensure that the system is in a serviceable state.

Technologies and Applications

With iPower, Huawei DCIM provides functions such as component life prediction and temperature prediction for the data center power supply and distribution system. From passive maintenance to proactive warning, Huawei DCIM ensures system safety and reliability. In addition, Huawei DCIM utilizes multiple techniques, such as transmission encryption and storage hardening, and carrier-class security design standards to provide all-around data security assurance.





Summary

Insights into future trends drive the evolution of data center facilities.

Huawei has made continuous innovative breakthroughs in the products and technologies used for data center facilities. We are excited to join forces with industry customers, partners, and third-party organizations to build an open, cooperative, and mutually beneficial industry ecosystem capable of accelerating green and sustainable development on the road to carbon neutrality.

Acronyms and Abbreviations

No.	Acronyms and Abbreviations	Term
1	PUE	Power Usage Effectiveness
2	WUE	Water Usage Effectiveness
3	CUE	Carbon Usage Effectiveness
4	SUE	Space Usage Effectiveness
5	GUE	Grid Usage Effectiveness
6	ESG	Environmental, Social, and Corporate Governance
7	IDC	Internet Data Center
8	UPS	Uninterruptible Power Supply
9	CAPEX	Capital Expenditure
10	TTM	Time to Market
11	DOD	Depth of Discharge
12	TCO	Total Cost of Ownership
13	VPP	Virtual Power Plant