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Research on Water Use Strategies for Hyperscale Data Centers

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Abstract: *This paper focuses on the current status of water usage and water use strategies of data centers of large Internet companies in the United States. Combined with the 2030 United Nations Sustainable Development Goals, the paper illustrates the cooling systems and factors affecting water consumption in data centers, as well as the difference between the Power Usage Effectiveness (PUE) and Water Usage Effectiveness (WUE). Then the paper analyses the water use strategies and water use targets of hyperscale data centers of Internet companies such as Amazon, Microsoft, Google and Facebook. Specifically, Amazon pays great attention to the Water Positive, and Google puts emphasis on water replenishment, meanwhile both Microsoft and Facebook choose to adopt efficient cooling systems to achieve their Water Positive goals. The water use strategies of data centers in China are recommended from the aspects of policy and technology by combining with the requirements of the green and low-carbon development of China's data centers.*

Keywords: *Data Center, WUE, Water Positive*

1. Introduction

With the rapid development of IoT, cloud computing, big data and AI technologies, data storage and network data communication have exploded, and the problem of excessive water consumption in data centers is becoming more and more prominent. One of the goals of the 2030 Agenda for Sustainable Development issued by the United Nations Environment Programme is to "achieve universal and equitable access to safe and affordable drinking water for all by 2030". In order to achieve this goal, the large US Internet companies have each established a corresponding water use strategies for their data centers. This paper proposes the development direction of water usage in the construction and operation of China's data centers through the study of water use indicators of hyperscale data centers and their water use strategies.

2. Water Consumption in Data Centers

Factors affecting water consumption in data centers include the size of the cooling facility, the type of cooling system and the temperature and humidity of the outdoor environment. In general, water consumption is directly proportional to the size of the refrigeration facility, with water-cooled systems using far more water than air-cooled systems, and using significantly more water in summer than in winter. Outdoor ambient temperature has the greatest impact on water consumption, i.e., the higher the outdoor ambient temperature, the greater the demand for cooling in the server rooms, and therefore the cooling system consumes a larger amount of water to meet the ambient cooling requirements of the server rooms. Comparison of water consumption in a large data center and an average sized data center.

Users of hyperscale data centers are usually cloud service providers and large Internet companies. These data centers have tens of megawatts of power capacity and millions of square feet in size, meaning their corresponding water consumption is huge. Google's hyperscale data centers, for example, use an average of 1.7 million litres of water per day in 2021, equivalent to 622 million litres per year. Wholesale and retail data centers are dominated by data cabinet rental users and typically range from 100,000 to 250,000 square feet, with corresponding water consumption much lower than that of hyperscale data centers. As an illustration, the Prince William County region of Northern Virginia, USA, counts the water consumption of 25 lease-operated data centers in the region in 2021. The largest

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water-using data center in the region uses an average of about 333,100 litres of water per day, which is about 20% of the annual water consumption of a hyperscale data center [1].

3. Water Usage Effectiveness

The Green Grid introduced the PUE (Power Usage Effectiveness) indicator in 2007 to evaluate data center energy efficiency, which is the ratio of all energy consumed by the data center to the energy used by the IT load. From the comprehensive point of view of energy use, it is difficult to comprehensively and accurately evaluate the energy consumption level of data center simply by PUE, in order to comprehensively and reasonably evaluate the energy consumption of data center, Green Grid proposes Water Usage Effectiveness (WUE). The WUE value is the ratio of the data center's annual water consumption (in litres) to the IT equipment's energy consumption (in kilowatt-hours) in litres per kilowatt hour (L/kWh).

4. Water Use Strategies for U.S. Hyperscale Data centers

4.1 Amazon

Amazon Web Services (AWS) has announced a water use target of 2030 for data centers to recharge more water to the region and external environment than they directly consume. The target applies to all three types of AWS-owned data centers - leased, owned and hosted - and the water metrics are assessed on the basis of the operating region in which the data center is located.

The primary cooling mode in AWS data centers is direct evaporative cooling (DEC). This cooling mode reduces the temperature of the outdoor air by evaporation of water, and the cooled outdoor air is filtered and fed into the machine room for cooling. To reduce the amount of water used in this cooling mode, AWS uses a natural air cooling strategy (free-air cooling system). In the natural air cooling mode, the cooling system tracks changes in outdoor ambient temperature and humidity and other parameters through sensors, and when the outdoor ambient temperature decreases to a certain level, the cooling system automatically shuts down the direct evaporative cooling system and turns on the free-air cooling system, and the cold outdoor air enters the server rooms through filtration to cool the servers, a process that no longer requires the consumption of water resources.

AWS uses the "Water Positive" metric to quantify its data center water use goals. Higher positive water efficiency values represent lower actual water consumption. When the positive water efficiency value is higher than 100%, it means that AWS is using water aggressively by supplying more water to the community and external environment than it directly consumes; when the positive water efficiency value is lower than 100%, it means that the AWS data center is not meeting its committed water conservation goals [2].

$$\text{Water Positive\%} = \frac{\text{Reused Water）+Water from Replenishment}}{\text{Total Water Withdraw-Water from Sustainable Source}} \tag{1}$$

AWS has proposed four water use strategies to achieve positive water efficiency metrics in line with expectations: 1.Improving water use efficiency across its operations; 2. Use sustainable water sources; 3. Returning water for community reuse; 4. Supporting water replenishment projects for communities and the environment.

4.2 Microsoft

Microsoft has committed to achieving water positive by 2030, where the company's total water replenishment exceeds its total water consumption globally, and to reducing water use for evaporative cooling in data centers by 95 per cent (about 5.7 billion litres of water) by 2024. Microsoft's data centers use the adiabatic cooling system, which allows the use of outside air to cool the server rooms when the outdoor temperature is below 29.4 degrees Celsius. This mode of cooling system varies depending on the climate of the region in which the data center is located, with Microsoft's Swedish data center being able to use this mode of cooling all year round, whereas the data center in Arizona, USA, is only able to use this mode of cooling for two-thirds of the year [3]. Microsoft has proposed two water use strategies to meet the 2030 Water Positive Efficiency target: 1. improving the Water Use Efficiency (WUE), i.e., reducing the water consumption per kWh. Microsoft's WUE is calculated by dividing the annual water consumption used for humidification and cooling by the total annual electricity required for the operation of the IT equipment in the data center in kilowatt-hours [3]; and 2. Developing water replenishment projects in water-stressed areas.

4.3 Google

Google's published water use target is that total replenishment exceeds total water consumption in 2030, i.e. Google's total replenishment reaches 120% of the total office and data center consumption in 2030 and meets the water security requirements for the region in which the data centers are located. Google's water consumption is primarily for data center cooling, with a small portion occurring during the manufacturing of data center hardware equipment. Google's water consumption is calculated as the amount of water used minus the amount of water it drains, and in 2021 Google's combined global data center water consumption was 16.4 billion litres, of which 20.9 billion litres was water used and 4.5 billion litres was drained [4]. Google's data center water consumption was dominated by the U.S. domestic region, with 15 data centers in the U.S. locally consuming a combined total of 12.7 billion litres of water in 2021, and data centers in other country regions consuming a combined total of 3.68 billion litres of water, with the former accounting for 78% of the total water consumption in Google's data centers globally [4].

Google has proposed three water use strategies to meet the 2030 water use goals: 1. Enhancing responsibility for water use and strengthen water resource management at the Google Office Parks and Data centers. 2. Protecting regional water resources, balancing the relationship between water consumption and water replenishment, improving the ecological health of regional water basins, and supporting ecosystem restoration projects in water-stressed areas. 3. Developing technological applications related to water resources and make available to the public relevant products and technologies for the prediction, prevention and rehabilitation of water resources.

4.4 Facebook

Facebook is committed to achieving water positive by 2030, where the company's total water recharge exceeds its total water consumption globally, and is committed to recharge twice as much as it consumes in areas of high water pressure and the same amount as it consumes in areas of medium water pressure.

Facebook's water consumption is primarily for cooling system, with over 99% of data center water coming from third-party water supplies represented by municipal water supplies. The total water consumption of Facebook data centers in 2021 was 2.41 billion litres, of which 3.42 billion litres were used for water consumption and 1.01 billion litres were drained. The total water recharge of Facebook data centers to the external environment was 2.34 billion litres in 2021 and will reach 3.79 billion litres for the whole year by 2030 [5]. Facebook Data center's water use efficiency (WUE) targets for the period 2018 to 2021 were 0.27 L/kWh (2018), 0.27 L/kWh (2019), 0.30 L/kWh (2020) and 0.26 L/kWh (2021) respectively. The reason for the increase in WUE in 2021 is the adoption of a new cooling system, State Point Liquid Cooling System (SPLC), in Facebook's data centers, which provides an 80% increase in WUE compared to the average cooling system [5].

Facebook has proposed three water use strategies to meet its 2030 water positive target: 1) strengthening water accountability; 2) improving water use efficiency (WUE) in data centers; and 3) developing water recharge projects in areas where data centers are located.

5. Summary

In summary, with the launch of the "East Counts, West Counts" large-scale project and the release of national policies such as the "Three-Year Action Plan for the Development of New Data center (2021-2023)", the green and low-carbon development of data center is receiving increasing encouragement and attention. Taking into account the current development of the domestic industry and from the perspective of encouraging Chinese Internet enterprises to go overseas, this paper argues that water use strategies for hyperscale data centers should be proposed in terms of both policy and technology.

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5.1 Policy Guidance

From the central to local levels, China's water policies for data centers are gradually being introduced and put into practice. From 2022 to 2023, the NDRC, together with relevant ministries and commissions, issued the "14th Five-Year Plan for the Construction of a Water-Saving Society" and the "14th Five-Year Plan for Water Safety and Security", which require adherence to the concepts of "water-saving priority, spatial balance, systematic management, and two-handed approach" to water management. In October 2022, Ulanqab City, Inner Mongolia, issued the notice on prohibiting the use of groundwater for cooling and dehumidification by big data enterprises in Jining District, which requires that "all big data enterprises within the jurisdiction are prohibited from using groundwater for cooling and dehumidification".

In addition to the above policies, policy guidance can be provided in the following three areas: 1. Setting stricter WUE standards and targets, and rewarding or penalising data centers for meeting or exceeding them. 2. Establishing a water quota and pricing system so that the water consumption by data centers is proportional to the amount of water they use. 3. Encouraging data centers to synergize and share water with other industries and sectors, for example, by using water or wastewater from agriculture, industry and domestic life to meet the water needs of data centers; and also by using the cooling water or waste heat from data centers for greenhouse cultivation, fishery farming, heating and heating, and other purposes.

5.2 Technology-driven

There are three ways in which technological innovations and improvements can be made to reduce water demand and losses in data centers: 1.Water reuse, that is, recycled water and sewage water to remove metal ions, acidic ions, colloids, suspended solids, bacteria, microorganisms and other pollutants and the PH value of weakly alkaline, the water quality of the circulating water system with the operation of the water quality is basically the same, and can be recycled again for cooling. 2. Adoption of more advanced cooling systems and equipment, such as the use of submerged liquid cooling technology for data centers in desert areas and the development of underwater data centers in coastal areas. 3. Intelligent and digital management systems could be used to monitor and optimise the operational status of the data center and to improve the efficiency of water use in the operation data centers.

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