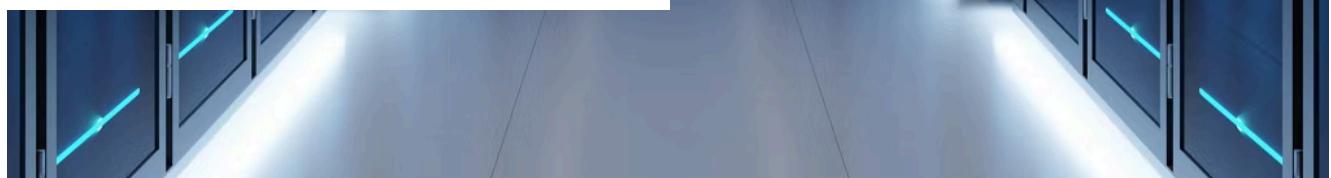
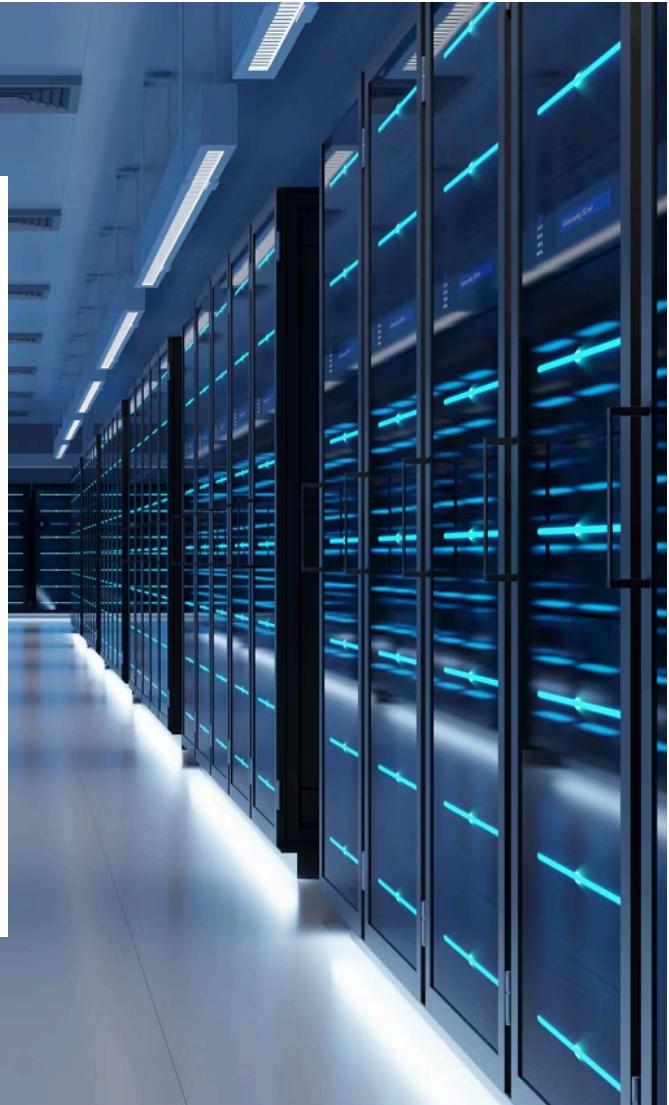




# Beneath the surface: Water stress in data centers

*This research does not constitute a Ratings action.*

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## HIGHLIGHTS

- Data centers (DCs) that use water-based cooling consume significant amounts of water. As companies build DCs to meet rising AI demand, water stress is an evolving consideration when choosing the location for these assets.
- The DC industry's average exposure to water stress is projected to be high in the 2020s, though this varies greatly by region. Middle Eastern countries, Belgium, Greece, Spain, Chile, Peru and Mexico are among the locations projected to face the most water stress. By the 2050s, about 45% of the 9,055 DCs in our analysis are projected to have high exposure to water stress, up from 43% in the 2020s.
- Although water scarcity risks are rising, we expect the financial materiality to be constrained in the near term. Water sourcing costs represent a small percentage of the industry's total operating costs. DCs can manage water stress exposure through adaptation and resilience investments, such as using treated wastewater for cooling instead of potable water.
- We consider water stress to be an emerging long-term business consideration, especially as attention to water use in water-stressed regions increases under evolving water management policies.

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To address growing AI demand, many companies are building or leasing data centers around the globe. DCs that use water-based cooling consume significant amounts of water, and in this research, we have analyzed DC exposure to water stress globally. We examined the current decade and the 2050s decade under both moderate and moderate-to-high emissions scenarios, using projections from the S&P Global Sustainable1 Physical Risk dataset. We found that exposure is already high in some regions, and we expect the industry's exposure to water stress will slightly increase by the 2050s. We also comment on the business implications of water risks for DC operators and owners (lessors), as well as approaches DCs are taking to mitigate water stress exposure.

## **Water stress, consumption, and risk defined**

**Water stress** measures the ratio of total water demand to available renewable surface and groundwater supplies. Water demand includes domestic, industrial, irrigation and livestock uses. Available renewable water supplies include the impact of upstream water consumption and large dams on downstream water availability. Higher values indicate greater competition among users.

The water stress metric is reported using a 1-100 range, and it describes the state of water availability (calculated based on a decadal average) for the local water basin. We define high water stress as a value of 40 or higher, consistent with our previous published research (see Related Research), and the Aqueduct Water Risk Atlas and World Resources Institute (WRI).

**Water consumption** refers to the amount of water withdrawn from either surface or groundwater sources that is not returned to those sources. Evaporative cooling is the primary form of water consumption for existing DCs.

**Water risk** refers to potential negative financial or stakeholder impacts from DC's water consumption. It encompasses the DCs' exposure to water stress as well as its water usage effectiveness (WUE). For the purposes of this report, regulations include laws, policies, agreements, and guidelines around water supply and consumption.

The S&P Global Sustainable1 Physical Risk dataset uses the locations of 9,055 DCs (asset location available via S&P 451 Data Center Knowledge Base [DCKB]) and their water stress exposure in the 2020s and 2050s. We use exposure data from two climate scenarios from the Intergovernmental Panel on Climate Change (IPCC) Shared Socioeconomic Pathways (SSPs) — SSP2-4.5 and SSP3-7.0.

## **DC exposure to water stress is already high in many regions**

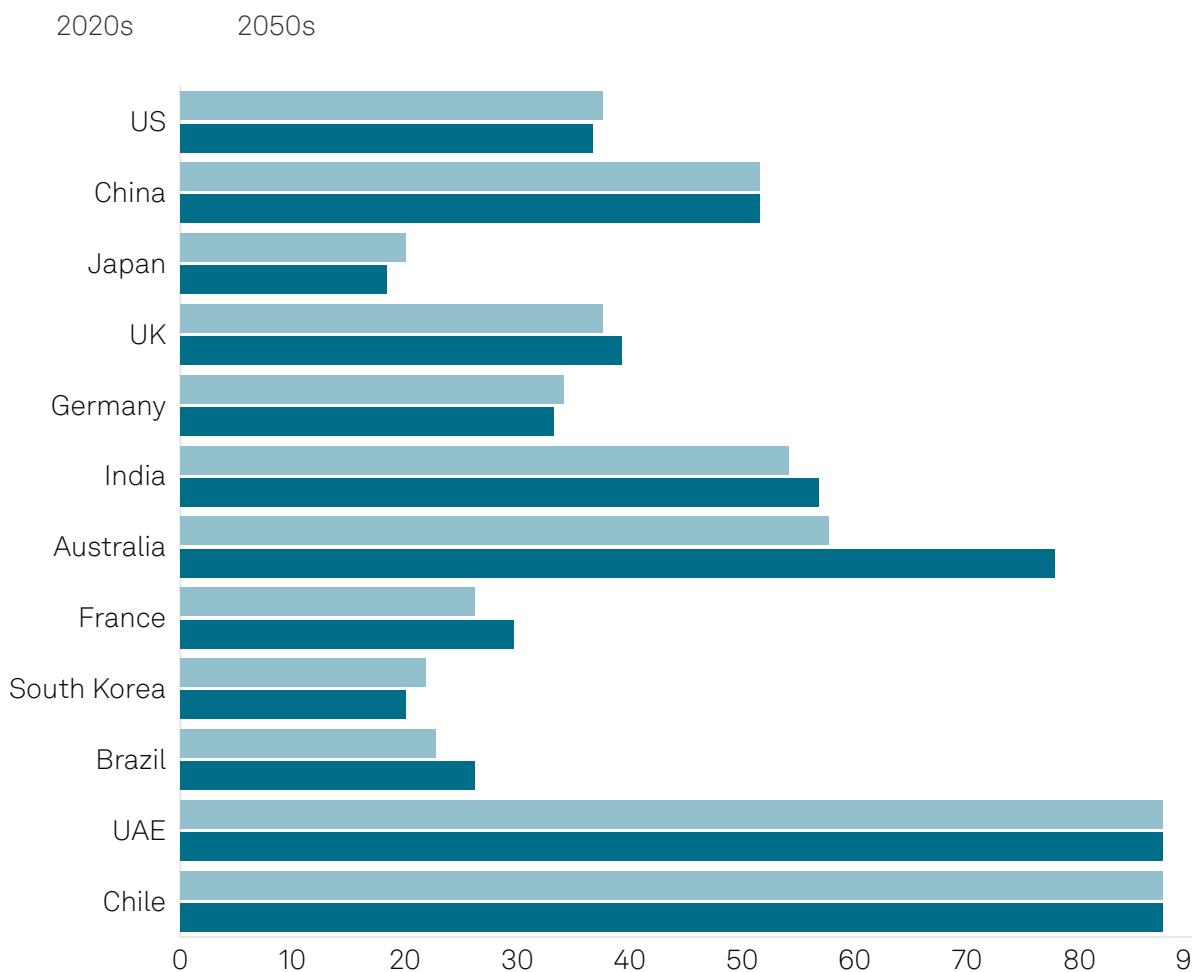
**Our analysis, based on S&P Global Sustainable1 Physical Risk and S&P 451 DCKB datasets, shows that 43% of DCs globally are operating in areas of high water stress in the current decade.** The exposure varies greatly by country. As shown in the interactive map (chart 1), we project all DCs in Middle Eastern countries, along with some countries in Europe (Belgium, Greece and Spain) and certain Latin American countries (Chile, Peru and Mexico) are in areas with high water stress in the 2020s. Areas of high water stress are characterized by high competition for water resources but low availability. In our database, we quantify the state of water stress using a scale of 1 to 100 . We define high water stress areas as those with a value of 40 or higher, consistent with our previously published research.

The DCs in the aforementioned countries have an average water stress **index** between 80 and 100 in the 2020s, significantly exceeding the threshold for high water stress used in this research. Meanwhile, the US and China, global leaders in DC operational capacity, exhibit divergent levels of water stress exposure. Specifically, approximately 60% of China's assets are exposed to high water stress in the 2020s, with an average water stress index of 59, while the US has 38% of its assets exposed, with an average water stress index of 43 in the 2020s.

Chart 2

## Water stress exposure in the top 12 countries by data center installed capacity

Average water stress index under SSP3-7.0 scenario



Data as of August 2025.

SSP3-7.0 refers to the Intergovernmental Panel on Climate Change's shared socioeconomic pathways (SSPs). SSP3-7.0 is a medium-to-high emissions scenario. The water stress metric is reported using a 0-100 range, and it describes the state of water availability (calculated on a decadal average) for the local water basin. We define high water stress as a value of 40 or higher, consistent with our previous published research (see Related Research), and the Aqueduct Water Risk Atlas and World Resources Institute (WRI). Low to medium water stress are values below 40.

Source: S&P Global Ratings.

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**Some regions with substantial DC growth prospects are already experiencing high water stress.** In India and Australia, for example, 60% to 80% of their operating DCs are projected to face high water stress this decade. The average DC water stress index for such countries is 62 and 66, respectively. Despite having installed capacity similar to Italy (up to 500 MW, according to S&P Global's 451 Research), Brazilian assets have lower exposure to water stress, with only 8% of DCs in the country in areas of high water stress or an average DC water stress index of 26 in the 2020s. That is because most of Brazil's DCs are in areas with low water competition and reasonable availability. We note that country-level data often obscures significant in-country variations in matching DC location and water availability, which could be important as water supplies are largely local.

**DCs' water stress exposure is currently not a material credit risk.** However, it could be compounded by stakeholder pushback and an eventual loss of license to build or operate, thus impairing the industry's long-term growth. We consider water stress to be an emerging long-term business consideration, especially as attention to water use in water-stressed regions increases under evolving water management policies. For example, in the US, DCs that use more than 200,000 gallons (757 cubic meters) of water per day may be subject to large water user policies. These policies require facilities to have water conservation plans, among other requirements, and impose extra charges if they fail to comply. Adopting water management best practices that consider other stakeholders' dependence on the same water basin may yield both operational and financial efficiencies in the interim. This approach can also help avoid permitting process disruptions, as seen with Google in Santiago, Chile (and according to a 451 Research [report on Chile's leased DC market](#)).

**DC industry exposure to high water stress to remain similar from the 2020s to the 2050s**

**By the 2050s, about 45% of DCs in our sample are projected to have high exposure to water stress,** up from 43% in the 2020s. To conduct this analysis, we layered the location of 9,055 DCs over projections for water stress in these locations, based on S&P Global Sustainable1 Physical Risk dataset. We used a slow transition scenario (SSP3-7.0).

As shown in chart 3, out of the 9,055 DCs analyzed, we estimate that 285, or 2%, will experience a decrease in ecosystem capacity to restore water availability at the same rate as increasing consumption trends, moving from areas classified as low water stress in the 2020s to high water stress in the 2050s. Water stress may

decrease in some regions due to changing precipitation patterns, which is the case for a minimal share (less than 1%) of DCs in the sample.

## **Water stress exposure is location dependent**

**Adaptation and resilience measures can be incorporated into DC designs** for areas in which operators cannot avoid water stress. Adaptation and resilience measures include sourcing water from lower-impact supplies such as recycled water or treated wastewater, which can shift demand away from potable water. For example, Google built a DC adjacent to a wastewater treatment plant in Douglas County, Georgia, in the US, which uses treated wastewater for cooling. Meta did the same in Gallatin, Tennessee, in the US, using 100% reclaimed wastewater through investment in the city's wastewater treatment capacity. That said, in the US, alternative water sources contribute less than 5% of water used by the industry according to the 2024 United States Data Center Energy Usage Report, Lawrence Berkeley National Laboratory (US Department of Energy). Seawater can also be used instead of freshwater, as in Google's DC in Hamina, Finland — although special materials need to be introduced given seawater's corrosive properties. Additionally, DC design increasingly focuses on controlling water consumption and treating cooling water. These controls include monitoring systems, back-up water supplies and recycling processes, all to ensure operations can withstand fluctuations in water availability.

**Existing DCs have various options to adapt and build resilience to high water stress.** Retrofitting a DC with entirely new cooling systems can be cost prohibitive and operationally disruptive. Operators can introduce alternative water supplies such as municipal greywater, adopt recycled water loops, run DCs at higher ambient temperatures to reduce cooling demand or leverage optimization software to decrease water use.

## **AI-driven optimization can improve the effectiveness of water usage**

**For new and existing facilities, AI-driven optimization and real-time analytics offer means to reduce water usage.** Methods include systems that dynamically adjust cooling system parameters based on temperature, humidity and server load, thus minimizing unnecessary water and energy usage. Systems simulate operating conditions at various loads, enabling predictive maintenance and more efficient use of cooling resources. These technologies enhance responsiveness and reduce the risk of overheating or overcooling.

**Independent of AI optimization, strategic site selection is crucial for avoiding exposure to water stress.** Siting allows operators to leverage existing infrastructure, such as water and wastewater treatment plants or solar power

plants, and natural resources, such as lakes or cooler climates, to meet their cooling and energy needs. That said, water is typically not the primary consideration for operators when building new DCs. Instead, land and power availability, connectivity and latency are the main priorities. Location decisions may also benefit from considering the type of renewable energy sources available locally, which can help reduce overall water demand.

**There is limited information on the costs of installing or converting cooling technologies.** However, some water municipalities in water-stressed regions such as southern Nevada in the US are offering rebates on the replacement or upgrade of existing evaporative cooling systems. These rebates are credits or discounts on the water bill based on the expenditure for conversion or upgrade and can reach up to \$1,500 per ton of conversion of a water-cooled system to an air-cooled system.

## **How do DCs use water to cool their servers and buildings?**

DCs house and provide accompanying infrastructure for servers. All components of the server generate heat and must be cooled to maintain it in the optimum performance window and maximize longevity. Cooling systems can be air- or water-based.

Primary cooling refers to the cooling of the building while secondary cooling is the cooling of DC equipment. Heat generated in IT equipment is transferred from the secondary to the primary system. Secondary cooling systems either involve air or liquid cooling (where a coolant, typically water, is used to remove server heat). Primary cooling involves using either traditional air conditioning or evaporative (water-based) cooling towers to expel the heat.

The primary system does the bulk of cooling. Therefore, DCs with an evaporative primary system use more water than a DC that has a secondary liquid cooling method but a primary air-cooled system.

## **Water consumption in the DC industry is expected to rise**

The International Energy Agency (IEA) projects the DC industry's water consumption will rise to 1.2 billion cubic meters by 2030 from approximately 560 million cubic meters in 2023. This amount of water is equivalent to the annual consumption of a city of about 7.5 million people. IEA's estimate considers that about two-thirds of the DC industry consumption in 2023 was associated with energy, one-quarter for DC cooling and the remainder for semiconductor and microchip manufacturing. The global semiconductor industry, which also serves sectors including automotive, telecommunications and aerospace defense, consumed approximately 1 billion cubic meters in 2021 (see [Sustainability Insights: TSMC And Water: A Case Study Of How Climate Is Becoming A Credit-Risk Factor](#)). Assuming the ratios of water usage remain constant, direct cooling water needs could therefore rise to 300 million cubic meters in 2030 from 140 million cubic meters in 2023, per the IEA.

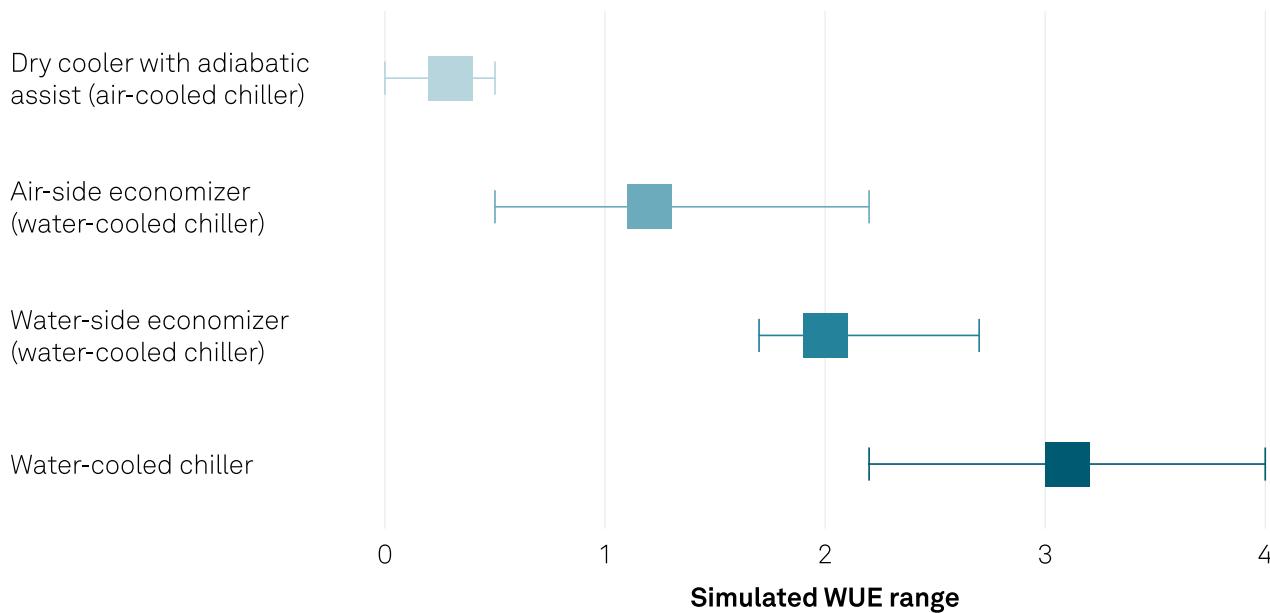
**The US will double its water footprint for cooling.** The US has the highest DC power capacity at approximately 28% of global operational capacity (according to [S&P Global's 451 Datacenter Knowledge Base](#)). Using data from the 2024 US Data Center Energy Usage Report, University of California researchers estimated water consumption should rise to 150 million cubic meters by 2028 from an estimated level of 70 million cubic meters in 2023. Despite such increase, when comparing the DC industry's historical and projected water cooling footprint to other industries, the footprint should remain limited. According to the US Energy Information Administration, in 2021 (latest available year), the nation's power generation sector consumed approximately 180 billion cubic meters of water for power plant cooling.

**We expect planned DCs that prioritize AI computing, which favors cost-effective air cooling, to use less water than many existing facilities**

**Planned DCs solely serving generative AI are opting for dry cooling with adiabatic assist** (secondary liquid cooling and primary air cooling; best WUE range as shown in (chart 5) due to lower costs. Lower-cost air cooling has become the most preferred cooling option. However, while primary air-cooled chillers use no water, they tend to consume more energy.

Chart 5

## Water usage effectiveness by data center primary cooling system



As of August 2025.

WUE = water usage effectiveness.

WUE measures the efficiency of a data center's use of water needed for cooling. It is calculated as the ratio of the data center's annual water usage to the power consumed by its IT equipment (measured in liters per kilowatt hour).

Water-cooled chillers utilize water-cooled condensers to extract heat from the building, releasing via cooling towers. These chillers are often integrated with computer room air handling units between the racks of the server. Water-side economizers use cool water sourced from lakes, rivers, or the sea or water produced by cooling towers when outdoor air is cool and dry.

Air-side economizers use outdoor air to cool the interior of a data center during favorable weather conditions.

Source: 2024 United States Data Center Energy Usage Report, Berkeley Lab.

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**Most existing DCs, which mainly serve cloud computing and storage, use water-cooled chillers (worst WUE shown in chart 5).** Evaporative cooling is more energy efficient than air cooling, but it requires large amounts of water and is the main source of water consumption for existing DCs. Despite the rapid build-out of new DCs, such older facilities form the backbone of the industry.

**DC scale influences water consumption.** According to the IEA 2025 Energy and AI Report, the share of cooling system energy usage as a share of total energy consumption ranges from approximately 7% for efficient hyperscale DCs to over 30% for less efficient enterprise DCs. Currently, about half of hyperscale DCs utilize airside economizers with water-cooled chillers, which have the second-best WUE according to the US Data Center Energy Usage Report.

**DCs and water stress: Not currently a material credit risk, but may present as a long-term business consideration**

**Low costs of water, relative to other operating expenditures, and greater reliance on air-cooling severely limit the financial materiality of water management.** The US Environmental Protection Agency in its WaterSense reports estimates that the average cost per 1,000 gallons (3.785 cubic meters) of water withdrawn was \$5.56 for commercial users in 2023. In many countries, costs are even lower. A DC with an installed capacity of about 5 MW (usually up to 3,000 square meters), that uses over 1 billion gallons (3.8 million cubic meters) annually — comparable to a beverage company with \$500 million in revenue — might pay single-digit millions annually, or less than 1% of its revenue.

Generally, the cost of alternative water supplies, such as recycled, desalinated or seawater supply, is significantly higher than that of traditional sources given the greater treatment requirements and infrastructure investment. However, the limited number of cases of business interruption due to restricted water access and low costs of water, even from alternative supplies, relative to other operating expenditures, limit the credit risk associated with DC water stress exposure.

**Increasing water scarcity and stakeholder awareness may impair long-term growth**

**DCs in areas with higher water stress face increased risk of community pushback,** which can lead to loss of social license to build or operate. This was the case with Google's planned \$200 million DC in Chile, a country that has had a severe drought

for the past decade. The plaintiff, in a court decision that halted construction in Cerillos, Santiago, was the local community surrounding the planned DC. Such incidents could become more commonplace in the next decade. However, the financial impact of climate-related litigation on companies remains difficult to measure (see [Climate Litigation: Assessing Potential Impacts Remains Complex](#)).

**DC operators that are not proactively managing water-related risks could face reputational damage, operational interruption and profitability decline**, if regulations tighten in the coming decade. DC operators can mitigate such risks by adopting measures outlined in the prior section, including using alternative water sources, strategic siting of assets and advanced cooling methods that increase both water and energy efficiency. In doing so, they could reap both operational efficiency and financial performance gains.

Examples of recent regulatory developments related to DC water use:

- In 2026, the European Commission expects to roll out regulation that requires DC operators to set minimum performance standards to curb water usage. In terms of reporting, the Delegated Regulation 2024/1364 set reporting requirements for DCs, specifically WUE metrics.
- Singapore will require DC operators to gradually increase the overall operating temperatures of their facilities to 26 degrees C or higher to reduce the demand for cooling and lower power consumption.
- In the US, southern Nevada's local building codes and ordinances have banned the use of evaporative cooling in all new developments due to the state's high water stress. Meanwhile, California Assembly Bill (AB) 93 would, if passed, mandate energy and water use reporting when applying for or renewing business licenses. It would allow local jurisdictions to impose water efficiency standards as conditions for licenses.
- According to the IEA's 2025 Energy and AI report, China is the only country that has incorporated WUE performance standards into its DC building code.

## Looking forward

As the DC industry continues to grow, water stress exposure will remain a concern alongside land and energy availability. By the 2050s, about 45% of DCs globally are projected to have high exposure to water stress, up from 43% in the 2020s. Water consumption is expected to rise, but at limited absolute levels compared with other industries. To avoid water stress exposure, planned DCs can consider strategic

siting of assets while existing DCs can adopt measures such as using alternative water sources or conversion of DC cooling type. This research does not suggest that DCs in non-water-stressed areas and that have low site water use efficiency are inherently state of the art. However, the low costs of water relative to other operating expenditures, along with a greater reliance on air cooling, significantly limit the credit materiality of water risks. For this reason, and due to focus on other site development factors — such as land and energy availability — water stress can sometimes be overlooked. Therefore, the research underscores the importance of considering water in the site selection of planned DCs and in the adaptation efforts of existing ones.

## Appendix

### Data and approach: Assessing DC water stress exposure

#### Shared Socioeconomic Pathways defined

Shared Socioeconomic Pathways (SSPs) are a set of scenarios for projected greenhouse gas emissions and temperature changes. They incorporate broad changes in socioeconomic systems, including population growth, economic growth, resource availability, and technological developments. This research uses the two following SSPs:

- **SSP2-4.5**, a moderate emissions scenario, is consistent with a future with relatively ambitious emissions reductions but where social, economic, and technological trends don't deviate significantly from historical patterns. This scenario is close to countries' current pledges but falls short of the Paris Agreement's aim of limiting the global temperature rise to well below 2 degrees C, with a projected increase of 2.0 degrees C (1.6 degrees C-2.5 degrees C) by 2050 or 2.7 degrees C (2.1 degrees C-3.5 degrees C) by the end of the century.
- **SSP3-7.0**, a moderate-to-high emissions scenario, is akin to a slow transition, in which countries increasingly focus on domestic or regional issues, with slower economic development and lower population growth. A low international priority for addressing environmental concerns leads to rapid environmental degradation in some regions. This SSP projects a global temperature increase of 2.1 degrees C (1.7 degrees C-2.6 degrees C) by 2050 or 3.6 degrees C (2.8 degrees C-4.6 degrees C) by the end of the century.

#### Scenarios allow comparison of multiple potential exposures

**Many physical risks of climate change will materialize regardless of current government policies**, given the lock-in effect of historical greenhouse gas emissions. This is particularly the case for timepoints before the midcentury (see the Intergovernmental Panel on Climate Change's Sixth Assessment Report: Summary For Policymakers). Countries' current commitments, if met, align with a global temperature increase of 2.4 degrees C to 2.6 degrees C by 2100, according to the United Nations Environment Programme. This is similar to SSP2-4.5. Using a range of scenarios helps us understand the likely transmission channels of credit risk and the potential impact on credit quality (see “Scenarios Show Potential Ways Climate Change Affects Creditworthiness,” July 25, 2024).

**In this research, we consider companies' exposures to climate hazards primarily using SSP3-7.0 through to the 2050s** given this lock-in effect and inherent challenges and uncertainties associated with long-term projections. Because of these uncertainties, we applied the other SSPs to describe a broader range of possible outcomes, where appropriate.

## Related Research

- [Sector-Specific Provisions: Corporate And Infrastructure Section 13 | Digital Infrastructure](#), Jul. 7, 2025
- [Sustainability Insights: TSMC And Water: A Case Study Of How Climate Is Becoming A Credit-Risk Factor](#), Feb. 25, 2023
- [Why Climate Risks Are Changing So Few Corporate Ratings](#), Apr. 12, 2023
- [Risky Business: Companies' Progress On Adapting To Climate Change](#), Apr. 3, 2024
- [S&P 451 Research Chile Leased Datacenter Market](#), March, 2025
- [S&P 451 Research Georgia: Datacenters and Energy Report](#), Aug. 22, 2025

## External Research

- University of California, Making AI Less Thirsty: Uncovering and Addressing the Secret Water Footprint of AI Models, 2025
- Google, Hamina Finland Data Center, 2025
- Southern Nevada, Building Officials, 2025
- California Legislative Information, AB 93, 2025
- International Energy Agency, Energy and AI, 2025
- Infocomm Media Development Authority Singapore, Green Data Center Roadmap, 2025
- European Union Comission, Commission Delegated Regulation (EU) 2024/1364 for Data Centers, 2024U.S. Data Center Energy Usage Report, 2024
- US Environmental Protection Agency, WaterSense, 2024

