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Water, Energy and AI

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Introduction

Water is essential to life. Energy is essential to modern life. Both are essential to artificial intelligence ("AI"). Since 2006, global freshwater reserves have significantly declined by an estimated 324 billion cubic meters per year—enough to meet the annual water needs of 280 million people [1].

In the U.S. state of Texas, there are currently 136 operating data centers [2]. Their combined capacity is 7,678 MW [3]. As of August 2026, an additional 302 data center projects are planned in Texas equating to 94,656 MW [4]. With 94 data center developers, Texas is the epicenter of the fastest-growing data center market in the U.S [5]. If growth rates continue as projected, Texas will be the world's largest data center hub by 2028 [6]. In comparison, the U.S. state of Alaska has zero operating data centers and only one planned project which will require an additional 1,000 MW of capacity [7].

Potable water is a valuable commodity in hot, arid regions. Among the many things Texas is known for is its heat and large areas of arid land. Historically, Texas relied on 15 rivers and 31 aquifers to support its population and agriculture [8]. Texas' population is soaring, consequently, water demand for household use is increasing. By 2070, its population may climb 70%, which corresponds to approximately 3.2 million acre-feet of water [9]. By 2080, water demand in Texas is expected to reach 18,384,630 acre-feet with a potential shortfall of 5,812,309 acre-feet based on existing supplies of 13,978,122 acre-feet [10]. The water impact of global warming includes increased droughts and higher temperatures. By 2040, Texas aquifers may lose 1.6 million acre-feet of water due to lower soil moisture and less surface water [11]. By 2030, if Texas experiences periods of prolonged drought, the lack of 6.9 million acre-feet of needed additional water resources may result in a loss of $160 billion annual GDP [12].

In the U.S., many AI data centers rely on water for cooling. To initially fill the cooling system for each AI data center building, it takes an estimated 1.5 to 2 million gallons of water — enough to supply 6,000 homes [13]. To cool a large-sized AI data center, up to 5 million gallons of water is needed daily [14]. In comparison, conventional data centers are typically smaller and older than new AI data centers. Conventional data centers rely on energy for air conditioning and chilled air cooling instead of water [15]. Unlike the states in the Great Lakes region, Texas does not have abundant water resources. If data center growth continues as projected, this means data center water use could account for up to 9% of Texas' water supply by 2040 [16,17].

In addition to the need for access to a stable supply of water for cooling, AI data centers are also dependent on electrical power. On average, AI data centers require 20 MW to 1 GW of power [18]. Lack of excess grid capacity limits AI data center construction; however, Texas' abundant natural gas energy resources meet that need [19]. Most U.S. states do not have Texas' natural energy resources. Similarly, most countries do not have access to abundant natural energy resources. The solution is a combination of efficient water management, use of alternative energy sources, smart energy-efficient construction and optimized site selection.

Water Resources

If water is the key to life, then efficient water management and resource allocation is crucial to AI data centers. The amount of water needed directly for water cooling using evaporative techniques

and of indirect water usage by steam turbines used in power plants to power data centers, microchip manufacturing plant, hardware manufacture is enormous. For example, microchip plants use ultra-pure water in the manufacturing process. To make 1000 gallons of ultra-pure water, it takes an average of 1400-1600 gallons of water [20]. An average microchip plant uses 10 million gallons daily of ultra-pure water [21]. In human terms, the average U.S. household uses 300 gallons of water daily [22]. If 40% to 60% more water is required to make ultra-pure water, a microchip plant would use 14 million to 16 million gallons of water daily – enough to supply the daily needs of over 53,000 households [23].

Although Texas and Virginia are the main hubs of U.S. AI data center infrastructure, their water resources differ greatly. Historically, Texas has experienced cycles of drought and floods. For example, "[i]n 2014, the U.S. Department of Agriculture designated 240 Texas counties as primary natural disaster areas due to drought" [24]. In contrast, although Virginia has over one million acres of freshwater and coastal wetlands, the regional drought status of nearly half the counties in Virginia was "warning" or "emergency" in September 2026 [25].

Currently, over 300 data centers are located in Northern Virginia that handle 67% to 70% of the world's internet traffic [26]. By 2024, their corresponding water usage increased to over 1.85

billion gallons, roughly 64% from 1.13 billion gallons in 2019 [27]. Currently, Northern Virginia hosts 12% of global hyperscale data center capacity with nearly 250 data centers located in Loudoun County alone [28]. Fifteen of the top twenty hyperscale data center locations in the world are located in the U.S [29]. Although 12 such centers are located in Northern Virginia, hyperscale capacity in Texas

grew 71% in 2025 [30]. Of the 15 largest data center projects in the U.S., six are located in Texas and one in Virginia [31]. The two largest data centers under construction in North America are located in Texas (11-gigawatt Hypergrid in Amarillo) and in Wyoming (10-gigawatt Project Jade near Cheyenne) [32]. At present, estimates indicate the Project Jade facility will use 2.7 gigawatts power, nearly triple the power used by the entire state of Wyoming [33].

Across the U.S., local concerns about data center water and energy usage are growing. Since 2022, nearly 67% of new data centers were located in areas where water resources are stressed [34]. As nearly 13% of the world's data centers holding 20.3 GW of capacity are located in Northern Virginia, the daily water needed to support their cooling is enormous [35]. This means that approximately 75% of the water to cool them comes from one source, the Potomac River [36]. The Potomac River is also "the sole source of drinking water for Washington, D.C., and Arlington County, supporting over 1 million residents and critical federal services in the National Capital" [37]. Across the region, water usage varies seasonally with the hot summer months seeing the largest demand increase. "From 2019 through 2023, summer production averaged 501 MGD, about 13 percent higher than the annual average of 445 MGD. During the same period, the peak-day production reached 630 MGD in 2020, approximately 42 percent higher than the annual average [38]."

Loudoun County, Virginia alone has 53.3 million square feet of data centers in operation or under development, making it the data center capital of the U.S. and the world [39]. Excluding Loudoun County where the bulk of the region's data centers are located, water use in the DMV is projected to increase from 471 million gallons per day ("MGD") in 2025 to 553 MGD in 2050 [40]. In the event drought occurs, water deficits are predicted in 2030 for the Medium Flows, High Demands and all Lower Flows scenarios modeled by the Interstate Commission on the Potomac River Basin ("ICPRB") Section for Cooperative Water Supply Operations on the Potomac [41]. Although Washington, DC metropolitan area ("DMV") has a temperate mid-Atlantic climate, during peak summer months "can be close to three times the average annual demand while peak daily use can be as much as 10 times" [42]. As of March 2026, the ICPRB estimated water use by data centers to " increase to approximately 22 MGD on average and over 80 MGD at peak by 2050. Upstream consumptive use is projected to reach about 5 MGD annually and about 17 MGD at peak" [43].

Within the DMV, housing, businesses, schools, hospitals, government facilities and other facilities depend on public utilities to supply water. AI data centers do not generate or provide water themselves, they rely on those same public utilities to supply water [44]. While direct water usage by data centers is substantial, the indirect water use from power generation is greater and has wider implications for existing water resources. From 2017 to 2019, thermoelectric power plants were responsible for 18% of total water consumption upstream from DMV supplier intakes [45]. In 2022, Virginia data centers received approximately 60% of their energy from water-intensive fossil fuel power plants. In 2023 alone, an estimated 211 billion gallons of water was used in the U.S. in generating power supplied to data centers [46].

The projected growth of data centers' share of total water consumption in the DMV is expected to increase to 25% in 2035 from 8% in 2025 [47]. This exponential growth in water usage means that millions of gallons of water used daily to cool data centers simply disappears in the form of evaporation or are discharged as waste water to water treatment facilities and/or waterways instead of being recycled or reclaimed. Across the U.S., data centers use water to keep racks containing thousands of servers cool so they do not overheat or experience equipment failure [48]. This means

daily consumption required to power and to cool data centers diverts tens of millions of gallons of water from other uses, including aquifer and ground water replenishment.

Energy Resources

Regardless of fuel type (i.e., coal, natural gas, nuclear), most electrical power generation in the U.S. uses steam generators to generate power in the form of electricity [49]. In 2020, the U.S. electricity production used an average 11,857 gallons of water per megawatt-hou [50]r. Power plants are the largest consumers of water in the U.S., accounting for a total of approximately 47.5 trillion gallons of water consumption in 2020 [51]. "In 2022, approximately 40% of all total U.S. annual and freshwater withdrawals, or about 48.5 trillion gallons, were made by coal and gas power plants" [52]. According to the U.S. Geological Survey, "[t]hermoelectric (TE) power plants withdraw more water than any other sector of water use in the United States and consume water at rates that can be significant especially in water-stressed regions" [53].

In 2018, nearly "70% of U.S. water withdrawals [were] associated with the once-through cooling systems of approximately 300 steam cycle power plants that produce about 25% of US electricity" [54].54 Data center power demand is expected to grow 160% by 2030 and their worldwide consumption to increase 3% to 4% by 2039 [55]. Assuming an annual consumption increase of 200 terrawatt-hours, AI will account for nearly 19% of data center power demand and consume approximately 8% of all power generated in the U.S [56]. To meet anticipated AI data center demand, the U.S. will need to invest about $50 billion in new power generation capacity by 2030 [57].

In line with the basic economic principles of supply and demand, the increasing energy demands of AI data centers means higher energy costs for consumers as power generation and transmission capacity are finite. According to David Rosner, Chairman of the U.S. Federal Energy Regulatory Commission, "America's energy landscape is experiencing a transformation as regions across the

country see significant electricity demand growth to power industries of the future—from the artificial intelligence revolution to the re-shoring of advanced manufacturing" [58]. By 2030, an estimated 120 gigawatts of additional electricity demand is anticipated – half of that demand (60 gigawatts) is from data centers [59].

Apart from data centers, microchip manufacturing plants also consume huge amounts of energy. In 2025, Nvidia announced an approximately $100 billion investment in OpenAI to build and

deploy 4 million and 5 million graphics processing units -- the associated power demand is a whopping 10 gigawatts of power [60]. Currently, the annual energy demand to run AI tasks is growing at a rate of 26% to 35% [61]. Given the ever-increasing energy demands of AI data centers and microchip manufacturing plants, the existing U.S. power grid cannot supply the amount of energy required. The strain is showing in power grids across the U.S. For example, in 2025, grid operators in Northern Virginia delayed new project approvals in order to support mounting AI infrastructure electricity demands [62].

To put things in perspective, a one million square foot data center requires approximately the same amount of electrical power as two million households [63]. To meet data center power demand, the cost of power grid transmission projects is being passed along to customers. In 2024, customers in seven states paid an additional $4.3 billion to fund transmission projects to data centers [64]. At present pace, US server farm demand is expected to exceed 600 terawatt-hours of electrical power by 2030 [65]. A 2024 study by McKinsey & Co. noted that "providing the more than 50 gigawatts (GW) of additional data center capacity needed in the United States by the end of the decade would

require an investment of more than $500 billion in data center infrastructure alone" [66]. To meet data center power demand, investment in transmission and distribution is crucial.

Increasingly, major technology companies such as Google, Microsoft and Amazon are investing in small SMR to ensure a reliable power supply for data centers [67]. In March 2024, Amazon acquired a data center near a nuclear power plant – part of the package was access to 300MW of behind-the-meter ("BTM") electricity; however, it sought an additional 180 MW of power [68]. As BTM power isn't metered, it essentially means 300 MW of Amazon's data center power needs are supplied from customer-generated means (e.g., wind, solar, battery, SMR). To meet its data center power needs, Amazon also led a $500 million capital raise to fund completion of X-energy's reactor design and licensing as well as the first phase of its TRISO-X fuel fabrication facility in Oak Ridge, Tennessee [69]. In September 2024, Microsoft entered into a 20-year agreement with Constellation Energy to access power for its data centers -- 835 MW will come from re-opening Unit 1 at Three Mile Island [70]. As of September 2026, four nuclear start-up companies achieved "steady, self-sustaining fission reaction and produce a controlled release of energy" to power data centers [71]. Today, a typical AI data center requires 80 MW of power and U.S. data center energy demand is anticipated to soar to 35 GW by 2030 [72].

Water and Energy Options

While tax incentives, transportation infrastructure, and work force are factors in data center and microchip manufacturing facility site selection, access to ample water and power are critical globally as the projected freshwater shortfall in 2025 was approximately 2000 billion m3/yr [73]. Intelligent site selection, energy efficient construction, renewable energy sources, and water conservation, recapture and desalination can be used in combination or individually to reduce strain on water and energy resources.

One possible solution to water and energy demands is nuclear powered desalination and energy generation. Nuclear power can be used to generate low carbon electricity and desalinate sea water. The International Atomic Energy Agency ("IAEA") supports using nuclear power plants to remove salt and minerals from seawater through distillation or membrane separation, mostly reverse osmosis as it is less carbon intensive and is cost competitive with fossil fuel-based techniques [74]. Nearly 67% of thermal energy from nuclear power plants is waste heat discharged into the atmosphere or bodies of water [75]. Instead of discharging waste heat, it can be recycled to desalinate or demineralize water.

Water desalination is a global issue. Using nuclear power to desalinate seawater, mineralized groundwater or urban waste water can alleviate strain on water resources by providing a new source of potable water for use by local populations as well as data centers and microchip manufacturing plants. Small modular nuclear reactors (300 Mwe to 600 MWe) ("SMR") may be erected in remote communities, industrial clusters, or regions with small electricity grids where large plants may be impractical due to cost, construction period, site limitations and community opposition [76]. As SMR components and reactor modules are factory-made, they offer significant benefits: up front capital costs are less; factory manufacturing offers economies of scale; on-site assembly reduces the construction time; and operation can commence years sooner than larger nuclear reactors (1000 Mwe) [77]. When used for desalination, SMRs can provide "freshwater at costs between $0.50 to $2.50 [per cubic meter] and with life cycle [carbon dioxide ("CO2")] emissions of about 0.009 [kg] to 0.045 kg CO2 [per cubic meter] of freshwater produced, depending on technology and scale of deployment and these figures remain stable and immune to external factors such as fuel prices or carbon taxes" [78]. Water desalination's corresponding market value in 2025 was $24 billion to $28 billion – and nearly $65 billion in 2030 (based on a projected 9% to 12% growth rate) [79]. As desalinated water can be stored in reservoirs, flexible SMR operation can enhance water security for local populations and support the sustainable growth of data centers and microchip manufacturing facilities. SMR desalination and power generation are a winning combination.

While one should not boil the ocean, 59% of desalination is from seawater and 22% is from brackish groundwater [80]. Desalinated seawater yields around 50% of its volume as freshwater; however, brackish water yields 70% to 90% freshwater as it is less saline, uses less energy and has a higher recovery rate [81]. In the U.S., there is 800 times more brackish groundwater than fresh water. SMR desalination provides water in countries ranging from Kazakhstan to India to Japan and the UAE [83,84]. In Texas, SMR construction of a molten-salt reactor to desalinate water is underway at Abilene Christian University [85]. To facilitate SMR desalination and power generation, the AIEA offers no-cost performance and cost evaluation software as well as a toolkit on nuclear desalination [86]. IAEA's no-cost Water Management Program also enables member countries to project cooling water and other SMR essential system needs [87].

In addition to SMR power and desalination, intelligent site selection and efficient construction technologies can optimize water and power usage. Sites in geologically stable coastal regions have access to seawater for intake and discharge. In arid and semi-arid regions, co-located SMR power and desalination can and should tie into existing transmission grids and water distribution networks for cost and operating efficiencies (e.g., increased output, decreased conversion losses, reduced carbon footprint) [88].

In 2024, the U.S. Department of Energy's ("DOE") Federal Energy Management Program (FEMP) and the National Renewable Energy Laboratory (NREL) published a best practices guide containing the following Key Steps to Sustainable Data Centers: "1. Reduce energy use by making systems as efficient as possible – the associated data center metric is Power Usage Effectiveness (PUE).

- o **Maximize Compute Entering Temperature to Maximize Energy Efficiency While Ensuring Information Technology (IT) Equipment Thermal Guidelines are Met to Avoid Overheating or Compromising Reliability**.
- o Use "free" cooling to reduce or eliminate compressor-based cooling (chiller, direct expansion [DX]).
- o Optimize fan/pump speeds and uninterruptible power supplies.

2. Reuse heat to achieve the lowest Energy Reuse Effectiveness (ERE) metric possible. o **Maximize compute leaving temperature to maximize energy reuse**.
3. Reject as much remaining heat to dry coolers as possible – water savings reflected in data center metric Water Usage Effectiveness (WUE).

- o **Maximize compute leaving temperature to maximize heat rejected dry to air**.

4. Maximize energy from renewable systems on-site or within grid region – tracked through data center metric Carbon Usage Effectiveness (CUE).

- o **Work toward the goal of 100% renewable energy 100% of the time**."

In addition to DOE's recommendations, there are additional ways to reduce cooling demands [89]. Energy efficient data center design that takes advantage of passive and active approaches to energy consumption is crucial. Passive Design ("PD") optimizes "the building envelope, shape, and layout during the design process" and "encompasses floors, ceilings, and layout and zoning of racks and active design" [90].90 Passive cooling and heat storage methods may include constructing a building below ground or using earth removed during grading to shelter or partially shelter buildings takes advantage of thermal properties of subsurface earth temperature for cooling in summer and heating in winter [91]. White roofs shield buildings from solar radiation due to high solar reflectance; therefore, coating roofing with insulating and reflective paints, membranes or roof tiles can reduce building temperature and reduce air conditioning costs by up to 30% as a cool roof reduces the heat island effect by lowering exterior temperature [92]. Active Design ("AD") optimizes "energy-efficient heating, ventilation, and air conditioning (HVAC), hot water production, lighting, and other building service applications" and "includes air, liquid, free, and two-phase cooling" [93].

Reducing microchip heat may also reduce water and energy consumption. As microchips continue to stack ever-growing numbers of transistors into ever-decreasing spaces, reducing chip heat is critical. Microchips are like elevators – the more people inside an elevator, the hotter it becomes.

When people and equipment get too hot, they shut down. The same thing happens with microchips. By 2030, chip density will result in a projected temperature rise of 9°C [94].

While a single hot microchip doesn't sound like a show-stopper, millions of hot microchips housed in a data center translates to increased water and energy consumption to avoid shutdown [95]. To reduce power and water demand for data center cooling, some potentially feasible current options include applying diamond coatings to (and using glass substrates for) chip packaging; using copper blocks for ground/power connections using 3-D printed pure copper cooling plates; and embedding ultra-short pulse laser cooling in microchips [96,97,98,99]. In addition, lab-grown diamond material may be "suitable for spreading heat, directly atop semiconductor devices" as Stanford University research demonstrated it reduced the temperature of gallium-nitride radio-frequency transistors over 50°C and boosted RF signal amplification [100]. Diamond's high thermal conductivity and electrical insulation make it ideal for spreading heat within chips, reducing hot spots and improving performance [101].

Conclusion

SMR desalination and power generation are a winning combination. SMR can provide reliable, stable and long-term power generation for data centers, microchip manufacturing facilities and local populations. SMR desalination can reduce strain on local aquifers, provide additional water resources to thirsty populations, and support smart water usage in water-intensive industries. Intelligent, efficient data center construction and heat-reducing microchip technologies will also ease the strain on water and energy infrastructure.

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