



Expanding Adiabatic Cooling in the Face of Water Scarcity: Solve Water to Solve Energy

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Executive Summary

As the global demand for digital infrastructure accelerates, cooling has emerged as one of the most pressing challenges for data centers. Cooling systems consume vast amounts of energy, accounting for 30–40% of non-IT electricity use in many facilities. Historically, operators have relied on energy-intensive chillers to manage thermal loads, often avoiding adiabatic systems due to concerns about water consumption.

However, **Adiabatic cooling is the most efficient form of heat rejection available to data centers.** While it requires water, the trade-off versus energy-intensive chillers is overwhelmingly favorable. When viewed holistically, including the upstream water use required to generate additional electricity, the overall water footprint of a data center can even be reduced by adiabatic cooling.

The central message is clear: **data centers should innovate around water sourcing and reuse to unlock the unparalleled efficiency of adiabatic cooling.** Energy lost to inefficient cooling can never be recovered. Water challenges, by contrast, can be solved through technology, planning, and partnerships.

Introduction: The Cooling Imperative

Data centers are critical infrastructure for a digital economy. They power cloud computing, AI, financial services, e-commerce, and nearly every other sector of modern life. With this centrality comes enormous energy demand: global data centers already account for ~1–1.5% of global electricity use, a figure projected to grow sharply with the rise of AI workloads.

Cooling represents a substantial fraction of that energy draw. In hyperscale and colocation facilities, cooling can account for **30–40% of total facility power consumption.** In hotter climates or high-density compute environments, this percentage can be even higher.

Historically, operators have had two main paths for thermal management:

- **Chiller-based systems**, which reject heat through mechanical refrigeration, consuming significant amounts of electricity.
- **Airside economization/free cooling**, which uses outside air but is often limited by climate and humidity conditions.

Between these lies adiabatic cooling — an approach that uses the **evaporation of water to pre-cool air or reduce heat rejection temperatures**, thereby reducing or even eliminating the need for chiller operation under many conditions.

Why Efficiency Matters More Than Ever

Efficiency is not just an engineering goal. It is now a business and sustainability imperative.

1. **Cost and Operational Savings**

Electricity is often the single largest operating expense for data centers. In large facilities, reducing cooling loads can be translated into millions of dollars of annual savings.

2. **Carbon Emissions and ESG Reporting**

Energy efficiency is directly tied to carbon intensity. Every kilowatt-hour saved reduces emissions, helping operators meet public sustainability commitments.

3. **Grid Impact and Reliability**

Local grids can be strained by large data centers, particularly during summer peaks. Peak demand can be lowered through more efficient cooling, easing regulatory pressures and improving resilience.

Given these drivers, any system that minimizes cooling energy use should be prioritized.

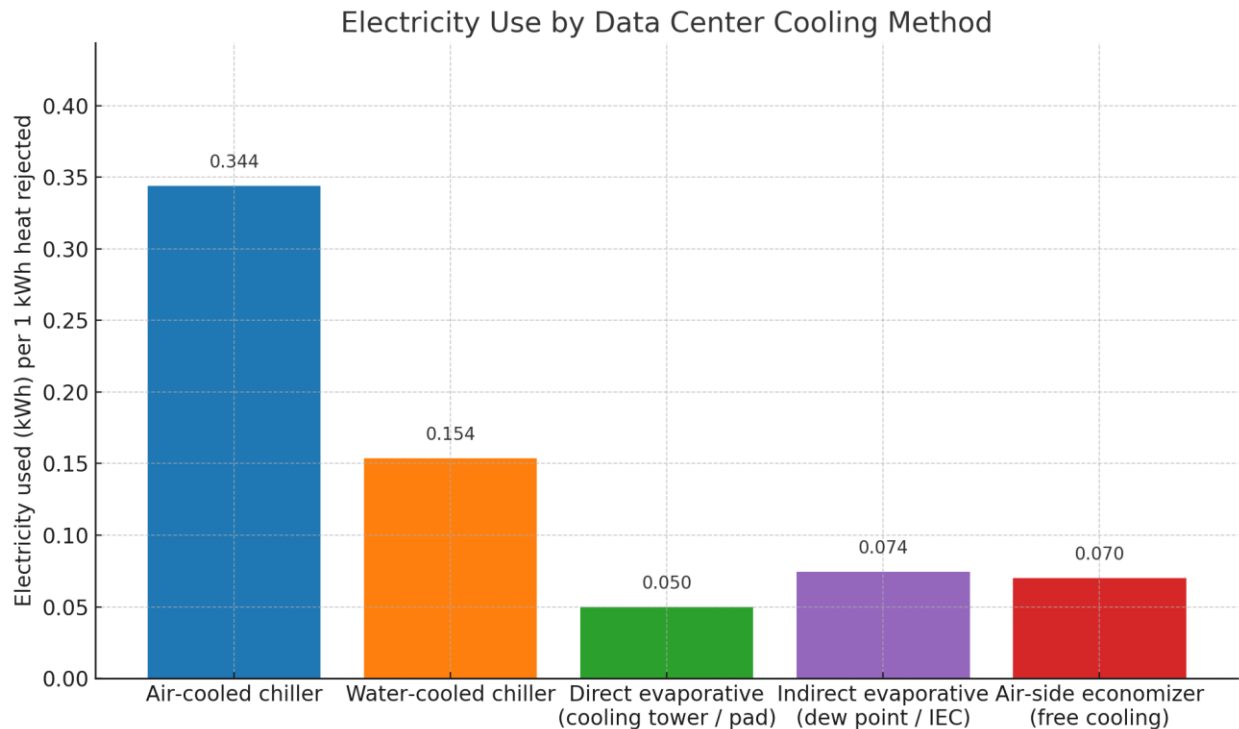
Adiabatic Cooling: The Most Efficient Heat Expulsion Method

At its core, **adiabatic cooling leverages the simple physics of evaporation**: as water is evaporated, heat is absorbed from the surrounding air and lowers its temperature. When applied in data centers, this process can be integrated in several ways:

- **Direct adiabatic cooling**, where outside air is cooled through evaporation before entering the facility.
- **Indirect adiabatic cooling**, evaporatively cooled air passes through a heat exchanger, transferring its cooling effect to the supply air stream without adding humidity to the white space.
- **Adiabatic assist to dry coolers and condensers**, lowering return water or refrigerant temperatures to reduce or eliminate chiller load.

The efficiency benefits are profound. Evaporating **just one liter of water absorbs ~0.7 kWh of heat energy**. In comparison, running a chiller to remove that same amount of heat requires significantly more electricity. This is why adiabatic systems consistently extend the hours of free cooling and reduce reliance on mechanical chilling.

In hot, dry regions, chillers can be replaced by adiabatic cooling for most of the year. Even in more temperate climates, adiabatic cooling dramatically reduces peak loads and allows chillers to operate more efficiently.



The Water/Energy Trade-Off Reframed

The most common critique of adiabatic cooling is its water use, but this critique often ignores the full picture.

Electricity requires water too. In thermal power plants (coal, natural gas, nuclear), vast amounts of water are consumed or withdrawn for cooling towers and condensers. On average, generating 1 kWh of electricity requires **1–2 liters of water** upstream, depending on the fuel mix.

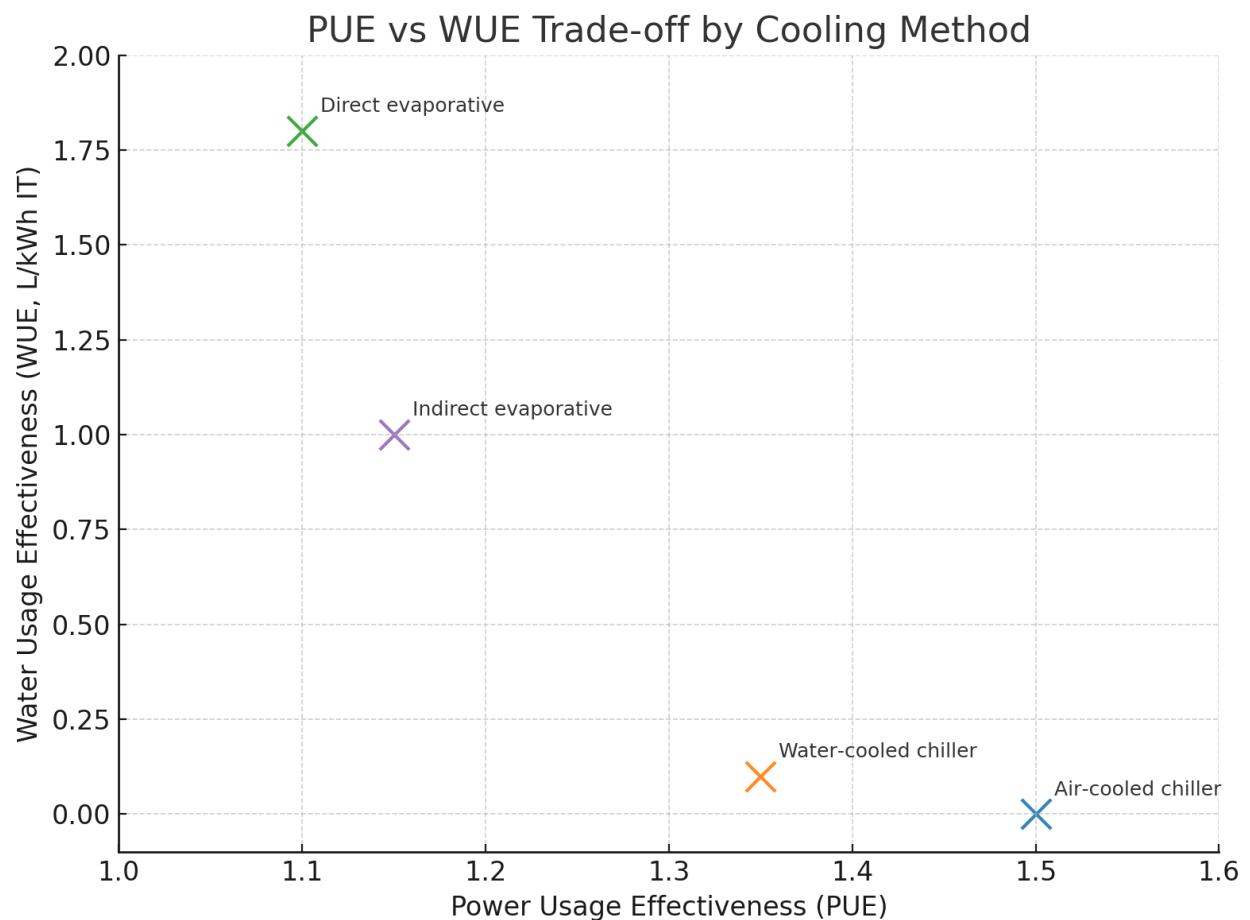
When a data center uses chillers instead of adiabatic systems, the higher electricity demand results in **greater hidden water consumption** at the power plant. Thus, while adiabatic systems consume water on-site, they may actually reduce the **total water footprint** when both direct and indirect consumption are accounted for.

Consider this simplified comparison:

- **Adiabatic cooling:** 1 liter of water evaporated = ~0.7 kWh cooling effect.
- **Chiller cooling:** Removing 0.7 kWh of heat may require ~0.25 kWh of electricity. At 1–2 liters/kWh upstream, that translates to 0.25–0.5 liters of hidden water use — in addition to higher carbon emissions.

The point: **energy inefficiency is a permanent loss, while water challenges are solvable.**

This tradeoff between Power Usage Effectiveness (PUE) and Water Usage Effectiveness (WUE) is clearly illustrated in the graph below:



Addressing Water Challenges Head-On

Instead of avoiding adiabatic systems, securing sustainable water sources should be the focus of data centers. Solutions include:

- **Non-potable sources:** Use of greywater, industrial wastewater, or municipal effluent.
- **Rainwater capture and reuse:** Cost-effective in many climates.
- **On-site atmospheric water generation (AWG):** Extracting water from air to feed adiabatic systems, ensuring resilience even in arid regions.
- **Circular partnerships:** Working with municipalities to recycle and reuse water streams.

Water management requires planning, but unlike wasted energy, it can be offset, recycled, and innovated upon. This approach aligns with broader sustainability goals and positions operators as leaders in environmental stewardship.

Case Studies and Industry Evidence

Hyperscale operators have already recognized these dynamics:

- **Google** has deployed indirect evaporative cooling in multiple regions, significantly lowering PUE and extending free cooling hours.
- **Microsoft** has used adiabatic systems in its Arizona data centers, proving viability even in arid climates.
- **Meta (Facebook)** has pioneered direct evaporative designs in data centers across the U.S. and Europe.

Across these deployments, the results are consistent: lower PUE, lower operating costs, and reduced total water-energy footprint when analyzed holistically.

The Future Outlook: Toward Water-Positive Data Centers

The next frontier for adiabatic cooling lies in pairing it with **innovative water strategies**.

Technologies such as advanced evaporative media, hybrid closed-loop systems, and AWG will enable operators to enjoy efficiency gains without compromising resilience.

Some forward-looking operators are even pursuing “water-positive” goals, aiming to return more water to the environment than they consume. In this context, adiabatic cooling can be a central enabler of both energy efficiency and water stewardship.

Conclusion

Adiabatic cooling is not just another tool in the data center engineer’s kit. It is **the most efficient form of heat expulsion available**. By prioritizing energy efficiency first and addressing water through innovation, operators can achieve both lower operating costs and stronger sustainability outcomes.

The choice is not between energy and water. The real choice is between short-sighted avoidance of adiabatic systems and the forward-looking innovation required to make them work.

Data centers that embrace this mindset will lead the industry — in performance, in sustainability, and in long-term resilience.

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