AI POWERED WATER TREATMENT

Engineering Sustainable and Circular Solutions for the Next Generation of Data Centers

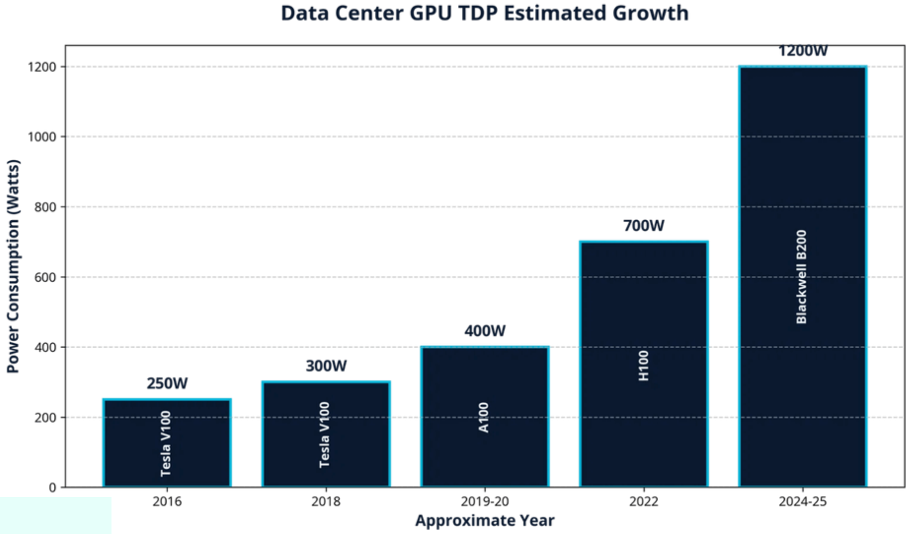
2026 TIEEP WATER FORUM
MARCH, 05

The AI Inflection point - Why Water Professionals Need to Pay Attention Now

AI has gone commercial scale, and the infrastructure behind it is rewriting the rules for water and energy consumption.

- AI large language models (LLMs) are growing exceptionally fast in size and power demand.
- GPU Thermal Design Power (TDP) scaled from **~250 KW (2016)** to **~1,200 KW (2024–2025)**
- AI servers run at up to **99% utilization** vs. legacy data centers at 10-50%.
- More power into the facility means more heat out and more cooling demand.

U.S. Data Center Water Consumption:
~17.4 billion gallons in 2023, growing rapidly.



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Rack Density Is Driving a Cooling Paradigm Shift

As rack power density scales from legacy 10 kW to frontier AI at 100+ kW, cooling approaches must fundamentally change.

WORKLOAD TIER	DENSITY	COOLING APPROACH	THROTTLING RISK
Legacy/Enterprise	≤ 10 kW/rack	Conventional air, hot/cold aisle	Low
Modern CPU/GPU	20–30 kW/rack	Enhanced air (RDHx) or partial liquid	Rising: DLC needed > 20 kW
AI Training Pods	40–80 kW/rack	Direct-to-chip (DLC) + air for auxiliaries	High with air-only
Frontier AI	**≥ 100 kW/rack**	**Liquid required (DLC/immersion)**	**Very high without liquid cooling**

KEY INSIGHT: At ≥100 kW/rack, air alone is considered "not suitable" (ASHRAE). Liquid cooling is no longer optional — it is the baseline.

Three Impacts of Unchecked Data Center Heat

Heat from high-density AI racks creates three compounding challenges that water and energy professionals must address together.

IMPACT TO ENVIRONMENT

- Increased fossil fuel consumption due to higher power demand.
- Increased cooling water demand due to higher heat generated.
- Higher CO_2e emissions from non-renewable grid mixes.

MITIGATION STRATEGIES

- Procure cleaner power (CFE PPAs).
- Improve PUE via Direct Liquid Cooling (DLC).
- Reduce WUE with dry/hybrid rejection.
- Capture waste heat.

INCREASED ENERGY CONSUMPTION

- Electricity costs rising globally.
- UK: ~ $ 0.4 /kWh
- USA: ~ $ 0.11/kWh

MITIGATION STRATEGIES

- Transition to DLC/immersion.
- Raise coolant temps for economizer hours.
- Implement AI-driven controls.

THROTTLED PERFORMANCE

- Inadequate cooling prevents full-service delivery.
- Risk of thermal throttling in high-density racks.

MITIGATION STRATEGIES

- Adhere to ASHRAE H1/W-class limits.
- Ensure CDU redundancy.
- Deploy workload migration playbooks.

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The AI-Water-Energy Nexus: Metrics That Matter

PUE (Power Usage Effectiveness)

Total facility energy / IT energy. The industry's primary energy efficiency metric.

WUE (Water Usage Effectiveness)

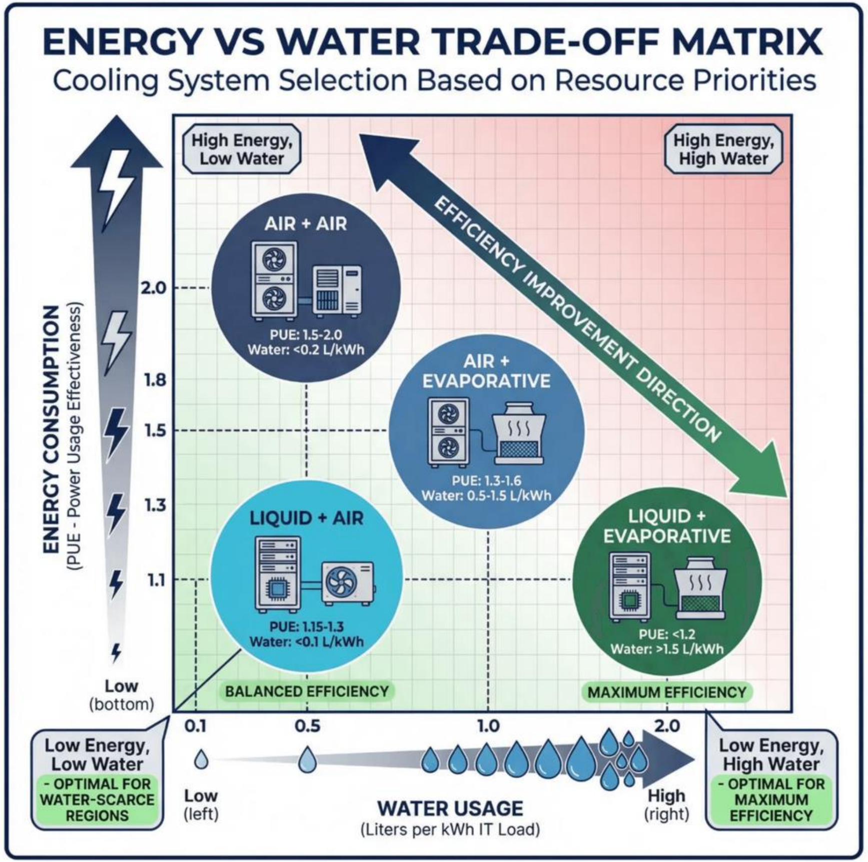
On-site water consumption per kWh of IT energy (L/kWh). Drops to around 0 without evaporative cooling.

WUE-Source

Accounts for "hidden" water embedded in electricity generation. Varies with grid mix.

NREL HPC CASE STUDY

- Warm-water liquid cooling: **WUE ~0.7 L/kWh**
- Tower-only configuration: **WUE ~1.4 L/kWh**
- Including electricity's water: **WUE-Source ~5 L/kWh**



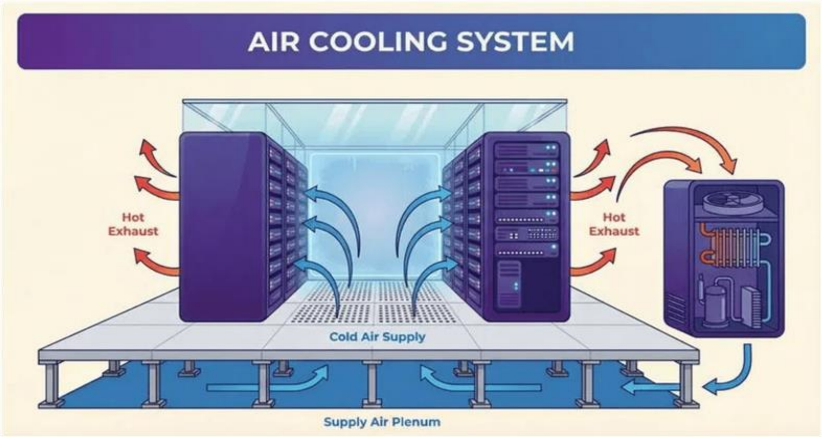
Key Insight: Low site WUE does not automatically equate to a low total water footprint.

Cooling Technology Stack

Choosing for Climate, Grid, and Water.
Operations stage modes:
(1) dry economization,
(2) adiabatic assist,
(3) mechanical compression.

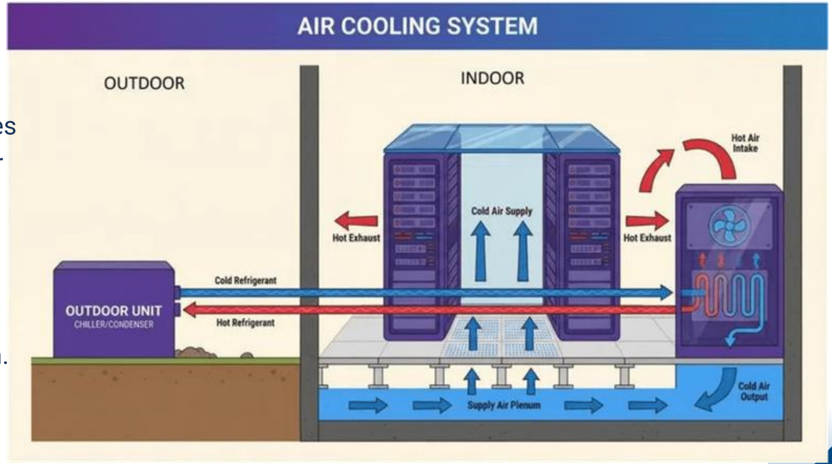
1. AIR ECONOMIZATION & HYBRID ADIABATIC

Dry economizer for most hours; adiabatic pre-cool only in hot/dry conditions. **Annual water savings >80% vs. towers** (e.g., BAC Trillium, EVAPCO eco-Air).



2. CLOSED-LOOP LIQUID (DLC) & IMMERSION

Captures heat at the device and rejects via closed loops to dry coolers. Enables **zero evaporative water**. Microsoft next-gen sites avoid >125 million liters/yr per facility.



3. SEAWATER OR BRACKISH HEAT REJECTION

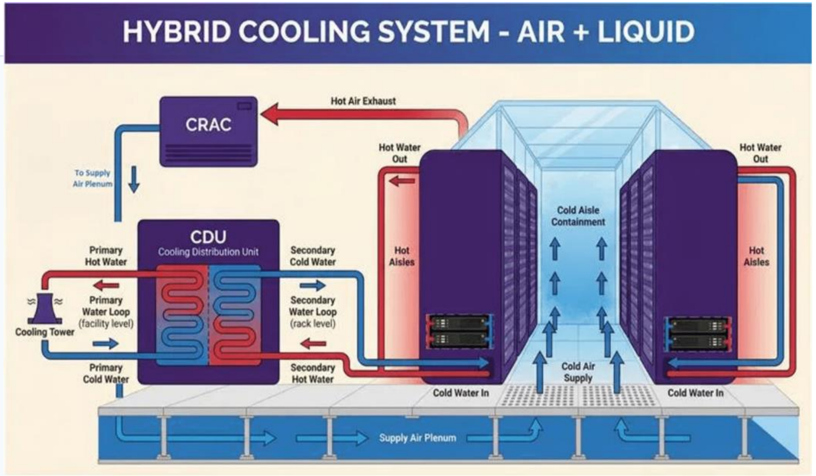
Uses ambient seawater via heat exchangers. **Zero freshwater** for heat rejection. (e.g., Google Hamina (Finland) uses Gulf of Finland seawater).

Hybrid and Liquid Cooling Systems
The New Baseline for AI Density

At 40+ kW per rack, liquid cooling is not optional.
These systems capture heat at the device and reject it via closed loops.

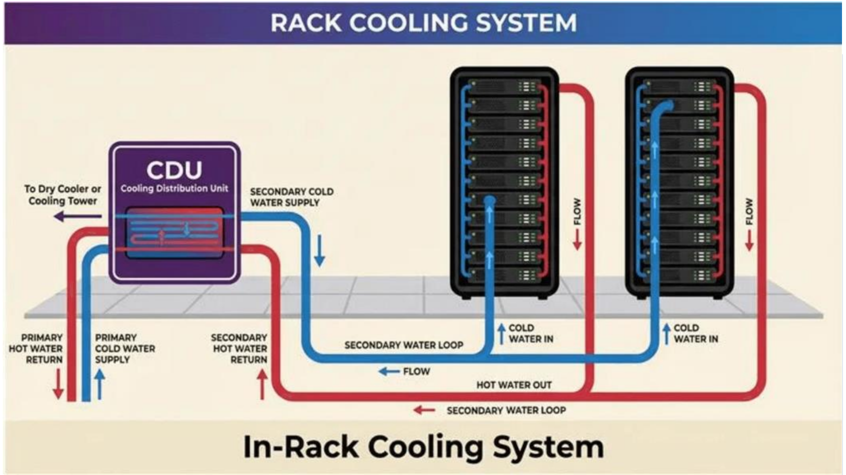
HYBRID AIR + LIQUID

CRAC handles ambient air while the CDU manages primary/secondary water loops to racks.



IN-RACK COOLING

CDU distributes secondary cold water through rack-level loops; primary loop rejects to dry cooler.



Key Insight: Fleet WUE is trending toward near-zero in these closed-loop deployments.

Source Hierarchy, Treatment Trains, and Brine Management

1. SOURCE HIERARCHY

Prefer non-potable sources whenever practical:

- **Tertiary Municipal Reclaimed**
- **Industrial Reuse**
- Stormwater
- Seawater / Brackish
- *Potable (Last Resort)*

2. TREATMENT TRAINS

Typical Reclaimed-Water Train:

- Coagulation / Filtration or MBR
- UV / Cl_2 Disinfection
- Softening / Alkalinity Control (Lime/Soda Ash)
- High-Recovery RO / EDR (if Silica/TDS dictates)
- Side-Stream Filtration & Biofilm Control

3. BRINE MINIMIZATION

- High-recovery RO (incl. CCRO), EDR, and crystallizers.
- Blending with lower-salinity streams to reduce discharge.
- Smart concentrate management (lined ponds, salt recovery) where ZLD is impractical.

Reference Implementation:

Quincy Water Reuse Utility (QWRU) - A closed-loop system treating and recirculating Microsoft's cooling water.

Example: *AWS is expanding reclaimed wastewater use to 120+ U.S. sites by 2030, preserving ~530 million gal/yr of drinking water.*

Circular Heat: From Waste to District Energy

Data centers should be treated as stable, low-grade heat sources with reliable export to district-heating networks.

1 **Design for low temperatures first**

Target 4th-gen DH (~55 - 70 °C supply).

2 **Confirm stable source**

Size for high utilization and hours.

3 **Lift, don't burn**

Use high-temp, low-GWP heat pumps.

4 **Hydraulically decouple**

Control ΔT via plate-and-frame HX.

5 **Protect water quality**

Demineralized fill, controlled pH.

6 **Measure circularity**

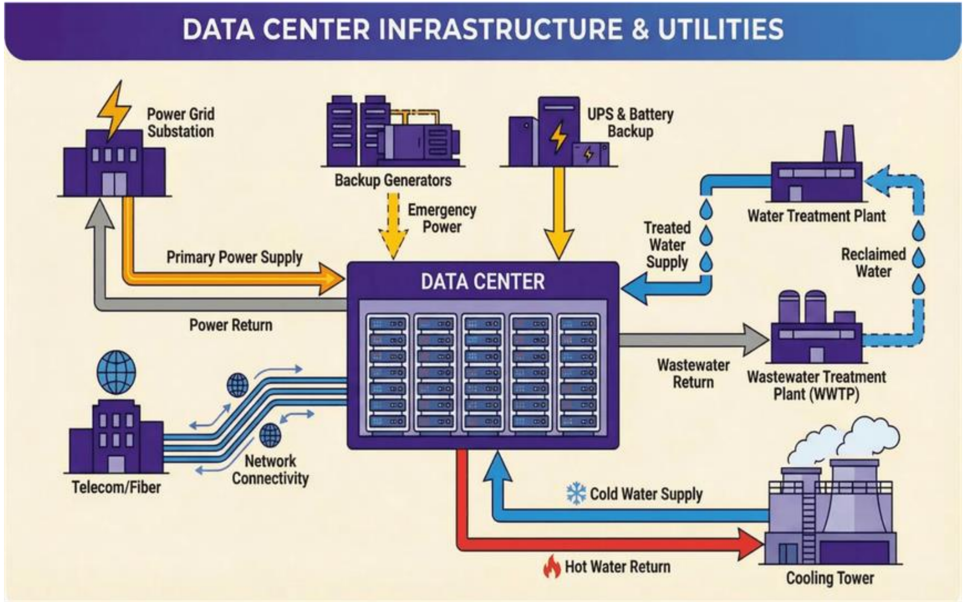
Track ERF, recovered GWh, avoided CO_2.

7 **Align with off-taker**

Secure long-term utility contracts early.

8 **Engineer for resilience**

Modular blocks, N+1 redundancy.



Key Example: Google Hamina heat-recovery plant will supply ~80% of local district-heating demand.

AI-Enabled Treatment, Operations, and Control

FACILITY-SIDE COOLING OPTIMIZATION

- **Google DeepMind RL Control**

  Achieved up to **40%** cooling energy reduction via reinforcement learning.

- **Siemens WSCO**

  55% energy cut in production case via dynamic CRAC adjustment using rack sensors.

- **Digital Twins**

  Simulate loops and airflows to test zero-water or liquid-cooling retrofits virtually before procurement.

WATER-TREATMENT SIDE (UTILITY)

- **Leading Platforms**

  Veolia Hubgrade, SUEZ AQUADVANCED, Xylem Vue (GoAigua).

- **Predictive Analytics & Control**

  Cut aeration energy, chemical usage, and overflows while maintaining permit compliance.

- **Reliability Focus**

  Provides the exact toolset needed for reclaimed-water reliability feeding data center cooling.

PREDICTIVE MAINTENANCE (AI + IOT)

- Forecast scaling and biofouling events before they impact thermal performance.
- Optimize blowdown and make-up cycles to reduce water waste.
- Detect degraded treatment performance early to protect assets.

Where the Strategy Is Already Working:
- Five Representative Cases

MICROSOFT

Quincy, WA

QWRU closed-loop reuse system treats and recirculates cooling water, offsetting potable wells in an arid basin.

~138 million gal/yr demand offset

AWS

120+ U.S. Sites

Transition to tertiary reclaimed wastewater for evaporative cooling in major hubs (VA, CA, GA).

~530 million gal/yr preserved

GOOGLE

Hamina, Finland

Seawater cooling scheme complemented by a heat-recovery plant for the local network.

~80% of local district-heating demand

META (FACEBOOK)

Los Lunas, NM

Water-positive program funding river/wetland restoration projects in the Rio Grande watershed.

Enterprise water-positive goal by 2030

MICROSOFT NEXT-GEN

Global Design

"Zero-Water" design: no evaporative water for cooling (closed-loop liquid and chip-level cooling).

~125 million liters/yr avoided per facility

Where Alignment Is Missing - Four Lessons Learned

Where the strategy lagged, the remedy has been more transparency, smarter siting, or a redesign toward closed-loop/liquid cooling.

THE DALLES, OREGON (GOOGLE)

After a legal fight over public records, site-level water use was disclosed showing data centers used >¼ of city water.

LESSON LEARNED

Site-level transparency and watershed context are non-negotiable.

URUGUAY (CANELONES)

Initial plans for 7.6M L/day potable water prompted protests amid historic drought. Redesigned to smaller air-cooled project.

LESSON LEARNED

Design choices must track basin hydrology and local water stress realities.

NETHERLANDS (MICROSOFT)

Campus consumed ~84 million liters drinking water in 2021 vs. 12 - 20 million estimates, fueling public scrutiny.

LESSON LEARNED

Underestimating potable use fuels public scrutiny and calls for stricter governance.

GREATER PHOENIX, AZ

Ceres analysis warns water use could jump several-fold, exposing operators to cost and reputational risk.

LESSON LEARNED

Cumulative cluster growth in stressed basins demands aggressive non-potable sourcing.

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A Design Playbook for AI-Era Water Stewardship

01 SITING & SOURCE SCREENING

Run watershed risk screen. Commit to non-potable sources or zero-water cooling in stressed basins. Pre-negotiate purple-pipe access.

02 COOLING CONCEPT SELECTION

Arid/Hot: Prioritize closed-loop liquid with dry coolers.
Temperate/Coastal: Consider air economization + seawater/brackish with biofouling controls.

03 FIT-FOR-PURPOSE TREATMENT

Engineer multibarrier reclaimed-water trains. Use AI-assisted dosing. Ensure N+1 reuse capacity and continuous monitoring (turbidity, silica).

04 DIGITAL-FIRST O&M

Deploy digital twins spanning cooling and treatment. Train MPC/RL agents for real-time optimization. Wrap with predictive maintenance on towers and pumps.

05 CIRCULARITY BEYOND WATER

Route low-grade heat to district networks, greenhouses, or low-temperature industrial loads (e.g., anaerobic digesters).

KPIs, Economics, and Community Engagement

FIVE KPIS TO TRACK

- **WUE (L/kWh)**

  Target ≤0.1 with zero-evap designs. Include WUE-Source for grid mix.

- **% Non-Potable Make-up**

  Target ≥80% in stressed basins (Benchmark: AWS 120+ sites).

- **Freshwater Withdrawal Intensity (FWI)**

  Track gal/MW-yr (direct) + Source-FWI (embedded in power).

- **Restoration Balance**

  Volumetric replenishment vs. consumption (water-positive trajectories).

- **Thermal Circularity**

  % IT heat recovered and utilized.

STRATEGIC DRIVERS

Economics (TCO)

Total Cost of Ownership now favors zero-water or reclaimed strategies where you **price risk**: permitting certainty, avoided rate shocks, ESG capital access, and social license to operate.

Community Engagement

Transparency (site-level reporting) and community co-investment (reuse plants, aquifer-storage) defuse opposition and can **unlock public funding**.

Key Design Factors in 2026+
The Integrated Thermal-Water System

Next-generation data centers must be treated as integrated thermal - water systems, not isolated consumers.

KEY DESIGN PRINCIPLES

- Default to **non-potable** or **zero-evaporative** cooling.
- Instrument for rigorous **water chemistry control** and corrosion prevention.
- Apply **AI/MPC** to minimize combined kWh and liters while protecting assets.
- Specify **liquid cooling** and design heat-recovery interfaces with high-temperature heat pumps.
- Monitor performance with **PUE and WUE.**
- Prioritize siting and source choices that **protect local watersheds**
- Publish **transparent KPIs** and build strong utility partnerships.

THE VISION

Reframe data centers from "thirsty, energy-hungry" loads into resilient community assets that deliver reliable compute, lower emissions, and shared thermal value.

THANK YOU

Save Water, Save Life!