

Gridwater: The Embedded Water Cost of Electricity

Jason Newman, Aquadrio
www.aquadrio.com

Executive Summary

Electrification is on pace to be the great infrastructure project of the 21st century. The water consumed to generate a load of electricity is currently untracked and unattributed. This embedded water — gridwater — represents a large cost that is today invisible and unpriced, and is unattributed to the water basin in which it is consumed. This is driven today by large data center buildouts, and as more energy production and consumption moves onto electric grids, gridwater consumption will continue to increase. As such, more of the world's water will become gridwater, and is at greater risk of getting lost in our currently inadequate tracking systems. We propose a novel metering and accounting system to track, record, and attribute gridwater to the basin in which it was consumed, and to the hour of electricity that used it. Such a system should be verifiable through recomputation to ensure validity and fidelity for the hourly record it should create. Gridwater consumption must therefore be tracked per-hour and attributed per-basin in order to correctly derive the cost of the embedded water in an hour of electricity.

1. Introduction

The production of electricity is reliant on water and water access in order to meet the energy demands of the world. Grid expansions are underway almost everywhere because of the AI Industrial Revolution and efforts towards decarbonizing energy production. While these massive electrification efforts will be a net positive in reducing greenhouse gas emissions, they also carry a hidden risk: increased electrification means increased water consumption at power plants. We have a robust system to track carbon emissions, and a nearly \$1 trillion global market that trades on the back of carbon accounting and greenhouse gas protocols.¹ We do not have a comparable system for water, and so while the output of electricity is logged and traded, the input that makes it possible is only captured in aggregate annual reports that do not connect to an hour of electricity.

A system that accounts for water in the production of electricity is needed to manage energy infrastructure. An hour of electricity already reports several metrics; adding gridwater to its reporting would simultaneously close a gap in resource management and calculate the value of water lost in production. Organizations, utility groups, and governments seeking to maximize operational efficiency are currently blind to their water loss, affecting their decisions on growth and operations, and how the grid can or should be expanded. Proactive focus on gridwater tracking will lower business risks, increase operational efficiency, and support sustainable growth and grid expansion. And ultimately, it will pave the way to reduce gridwater in the production of electricity.

2. Gridwater

We define gridwater as the volume of water consumed during power generation for the electricity a building used. An hour of electricity's gridwater is then recorded in two ways by necessity: gridwater consumed at the power plant is attributed to the water basin in which it was consumed, and a building's gridwater is valued according to where that building is sited.

¹ LSEG. *Carbon Market Year in Review 2023: Growth Amid Controversy*. February 8, 2024. (€881 billion, about \$949 billion, in traded value in 2023.)
https://www.lseg.com/content/dam/data-analytics/en_us/documents/reports/lseg-yir-2023-full-report.pdf

$$G_b = \sum_h \left(U_h \times \frac{W_{b,h}}{E_h} \right) \quad G = \sum_b G_b$$

where G is the building's gridwater, G_b is its gridwater from basin b , U_h is the electricity the building used in hour h , $W_{b,h}$ is the water consumed in basin b by the plants generating the grid's electricity in hour h , and E_h is the electricity the grid generated in hour h .

The water-energy nexus spans across geopolitical, energy grid, and water basin boundaries for several reasons, one of which is hydrological. A water basin's border is determined by its drainage divide, the high ground that sends water toward one outlet or another. This does not line up neatly with political or grid boundaries. To further complicate the situation, many of the plants that provide power are shipping that power to a building sited in a different water basin. And so, while the electricity might be used in a different area, the gridwater behind it was consumed in the water basin where the power plant generated it.

3. All Water is Local

The Great Lakes hold about 21% of the world's surface freshwater, and the electricity that regional grids provide to their surrounding areas comes from basins that drain to Hudson Bay, the Atlantic, and the Gulf of Mexico.² The state of Michigan has the longest Great Lakes shoreline of any state. It also holds more Great Lakes surface water within its borders than any other state.³ Yet, on the regional grid that serves most of Michigan, about 70% of its gridwater is consumed in the Mississippi River basin.⁴ So while a building in Michigan is consuming electricity in Michigan, most of the gridwater

² U.S. Environmental Protection Agency. "Great Lakes Facts and Figures."

<https://www.epa.gov/greatlakes/great-lakes-facts-and-figures>

³ Michigan Department of Environment, Great Lakes, and Energy. "Shoreland Management." (3,288 miles of Great Lakes shoreline.)

<https://www.michigan.gov/egle/about/organization/water-resources/shoreland-management>; U.S. Census Bureau. "State Area Measurements and Internal Point Coordinates," 2010. (Great Lakes water area: Michigan 38,174 sq mi.) <https://www.census.gov/geographies/reference-files/2010/geo/state-area.html>

⁴ U.S. Energy Information Administration. *Form EIA-923, Power Plant Operations Report*, 2024 data. <https://www.eia.gov/electricity/data/eia923/>; *Form EIA-860, Annual Electric Generator Report*, 2024 data. <https://www.eia.gov/electricity/data/eia860/>; *Hourly Electric Grid Monitor* (Form EIA-930). <https://www.eia.gov/electricity/gridmonitor/>

that helped get it there was consumed in the Mississippi River basin. The same pattern holds on every grid. Power plants sited in Water Basin X consume water in that basin while many buildings that use their electricity are sited in Water Basin Y.

The water behind a building's electricity is estimated today with a national annual average, about 1.2 gallons per kWh.⁵ But, a gallon of water in the Great Lakes basin is fundamentally different from a gallon in the Lower Colorado basin, a region that has been in drought since the year 2000.⁶ We need a localized prescription number tied to a water basin — a limit translated from that basin's regime — so that water and gridwater usage is measured against what an area can sustain, not a number that treats the most water-rich area on the planet the same as a desert.

Why? Because all water is local.

4. Water & Carbon

The story of electrification is currently being written without one of its main characters: water. The world determined almost thirty years ago that it was in our best interest to reduce greenhouse gas emissions. A new genre of sustainability accounting emerged in order to track carbon, and eventually, a new market to make sense of it all. But the world forgot about water. While electrification will likely be the driving force in reducing manmade greenhouse gas emissions, it is also hiding a serious risk. As more infrastructure gets added to grids around the world, the water cost of everything will move upstream, into those grids, and out of sight. And if the embedded cost of water in electricity, gridwater, is not accounted for, we will wake up one day asking why we planned for a data center that uses as much water as an office building, when its electricity consumed about 2.8 billion gallons a year.⁷

What's more, the world learned to account for carbon in the aggregate, because a tonne here is the same as a tonne there. But water is not fungible like carbon. In other words, we are all breathing the same carbon, but no one is drinking the same water. A water

⁵ Shehabi, A., et al. *2024 United States Data Center Energy Usage Report*. LBNL-2001637, 2024; Environmental and Energy Study Institute. "Data Centers and Water Consumption." 2025. <https://www.eesi.org/articles/view/data-centers-and-water-consumption>

⁶ U.S. Bureau of Reclamation. First Lower Colorado River Basin shortage declaration, August 16, 2021, from the August 2021 24-Month Study; shortage conditions in effect each year since. Reported in "Bureau of Reclamation Announces First-Ever Water Shortage in Lake Mead, Colorado River." *Water & Wastes Digest*, August 2021. <https://www.wwdmag.com/utility-management/news/10940031/bureau-of-reclamation-announces-first-ever-water-shortage-in-lake-mead-colorado-river>

⁷ See note 4.

basin is a hyper-local, complex system, and we must treat it accordingly in order to keep it healthy and functional. Global targets could work for greenhouse gas emissions because the damage accrues slowly and the world had decades of warning before symptoms showed. Water's warnings are local, and by the time a basin's trouble is visible to the human eye, it is already too late. We simply cannot account for water in the same manner in which we account for carbon.

Carbon taught us the importance of tracking, that it is something we need to do. The GHG Protocol now has three scopes, with Scope 2 focusing on indirect emissions from purchased electricity, steam, or heating & cooling. Originally established in 2001, Scope 2 started out by only requiring annual reporting.⁸ In July 2025, the GHG Protocol Independent Standards Board approved proposed revisions requiring hourly matching for public consultation, with the final publication now expected by the end of 2028.⁹ This is on top of the location-based methodology amendment published in 2015.¹⁰

So, carbon has also taught us how to learn from its mistakes. It has now taken over twenty years in the emissions world to move from aggregated reporting to localized, hourly reporting. We do not need another twenty years to figure out that gridwater needs hourly reporting and its own version of Scope 2.

5. The National Average

The United States currently estimates a building's gridwater with a national average of 1.2 gallons per kWh. This might make sense to do with emissions tracking, but it is hydrologically wrong to do with water, which does not permeate equally across the planet like carbon. Water rights in the western United States have been a source of strife and intrigue, and this is precisely because bodies of water, water tables, and water basins are not all created equally. A national average erases all of this, while providing the illusion of accuracy.

Averages have ranged from 2.0 to 1.2 depending on the year and the study.¹¹ This is in part because of changing machinery and energy type, and in part because we do not

⁸ World Resources Institute and WBCSD. *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard*. 2001; revised 2004. <https://ghgprotocol.org/corporate-standard>

⁹ GHG Protocol. "Upcoming Scope 2 Public Consultation: Overview of Revisions." September 29, 2025. <https://ghgprotocol.org/blog/upcoming-scope-2-public-consultation-overview-revisions>; EnergyTag.

"'Under the Hood' of the GHGP Scope 2 Consultation." 2026. <https://energytag.org/under-the-hood-ghgp/>

¹⁰ World Resources Institute. *GHG Protocol Scope 2 Guidance*. 2015. <https://ghgprotocol.org/scope-2-guidance>

¹¹ Torcellini, P., N. Long, and R. Judkoff. *Consumptive Water Use for U.S. Power Production*. NREL/TP-550-33905, 2003. <https://www.nrel.gov/docs/fy04osti/33905.pdf>

have an agreed upon standard. The number matters to industry, infrastructure, and communities making decisions that span decades, not years. And the number is wrong for the vast majority of grids, with their own figures hiding that the water basins within their boundaries are all affected differently. Others have counted this water before, at the scale of a nation, a technology, or a year.¹² But gridwater differs in resolution: the hour, the basin, and the building that used the electricity.

In the Pacific Northwest, the Bonneville Power Administration (BPA) runs on a majority of hydro energy. This grid's consumption basis is higher than the 1.2 gallons per kWh because of reservoir evaporation, coming in at 1.28 gallons per kWh. The grid system below it, the California Independent System Operator (CAISO), comes in well below the 1.2 average at 0.31 gallons per kWh.¹³ The average is wrong in both directions and by different amounts, because all water is local.

Securitization is likely at the greatest risk from water going unmeasured, on two fronts: siting and longevity. S&P's data center criteria measure a facility's long-term competitive position, and issue scores based on location, age of build, cost of power, and power efficiency.¹⁴ Water is not one of them. Data center securities are often issued in 30 or 35 year terms, and financing makes things even more complex.¹⁵ Agencies are considering a facility's operational lifetime without considering the water basin it sits in, and without realizing that gridwater itself affects whether any facility in any region stays operational and competitive, let alone whether the region could support the facility in the first place. These facilities sit within the federal government's critical infrastructure sectors, and a 2025 executive order names data center development a matter of national security.¹⁶

With siting, securities, and financing guidelines blind to gridwater loss, facilities and their operators are making a gamble as to whether or not any given facility will survive in the long-term. A national average only furthers the jeopardy by painting an inaccurate

¹² The Green Grid. *Water Usage Effectiveness (WUE)*. White Paper #35, 2011; Macknick, J., et al. *A Review of Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies*. NREL/TP-6A20-50900, 2011. <https://www.nrel.gov/docs/fy11osti/50900.pdf>

¹³ See note 4.

¹⁴ S&P Global Ratings. *Data Center Securitizations: Global Methodology and Assumptions*. June 13, 2024; republished August 21, 2025. <https://www.spglobal.com/ratings/en/regulatory/article/240613-criteria-structured-finance-general-data-center-securitizations-global-methodology-and-assumptions-s13095954>

¹⁵ Asset Securitization Report, "Data center ABS Iskandar and Kaveh bring to market, raising \$1.4 billion," 2026 (five-year anticipated repayment date, 30-year legal final maturity, rated by Fitch and S&P). <https://asreport.americanbanker.com/news/data-center-abs-iskandar-and-kaveh-bring-to-market-raising-1-4-billion>

¹⁶ Cybersecurity and Infrastructure Security Agency, *Information Technology Sector*; Executive Order 14141, 90 Fed. Reg. 5469, January 17, 2025. <https://www.cisa.gov/topics/critical-infrastructure-security-and-resilience/critical-infrastructure-sectors/information-technology-sector>; <https://www.govinfo.gov/content/pkg/FR-2025-01-17/pdf/2025-01395.pdf>

picture that forgoes local consideration. This inaccuracy comes with economic and environmental costs. We cannot maintain and manage this critical infrastructure if we pretend that water — and more specifically, water basins — is not integral to sustaining it.

6. Measurement & Attribution

Gridwater, while being a strict property of power infrastructure, still touches everything in other, more subtle ways, namely a water basin. And the way we distribute power over interconnections and regional grid systems has created more of a spiderwebbed system than a neat chart to read. This means that in any given hour, the gridwater of a building sited in the Great Lakes basin can be consumed under the Great Lakes Compact, in the Mississippi River basin, and from an aquifer governed by a state, all at once. The regional grid itself may be unified, but the different water basins it spans follow the boundaries of hydrology, not the ones we drew for power grids.

Water regimes all differ in kind. Compact rules, federal shortage declarations, state basin closures, and seasonal closures all have different limits and different schedules... because all water is local. So while gridwater is a component of the power grid, it has a far greater impact on the water basin in which power is produced, even if that power gets shipped to a building that sits in a completely different water basin. There is no mechanism that tells a water governing body which buildings its water was consumed for, and with only a national average, the snippets that do get through are not traveling accurately.

A water basin threshold translated from a basin's regime, enacted as a prescription for a single basin, would give each basin's gridwater a limit it can be measured against, and hydrologically correct attribution would show which buildings are drawing it down. We do not currently think about gridwater consumption in such granular terms like that of a building, and at first glance, it is not very obvious why we need to. But again, we are in the beginning stages of a new era of electrification that will see demand continue to rise, perhaps in perpetuity. If a single gigawatt of load is added to a grid like the one serving Michigan, we will lose about 2.8 billion gallons of gridwater per year, and grids are actively adding gigawatts at a time. Basins already under stress will be flirting with failure.

7. Communication

Because power and water answer to separate regulators, a good deal of data gets siloed between them, and nothing signals which buildings used whose water in an hour. Neither has authority over the other's purview for good reason, but even though they are divorced, some elements of custody remain shared by physics or necessity, like gridwater. Electricity production cannot occur without water, be it to process raw materials used in a facility or to generate the electricity itself. Power agencies are well aware that water stress poses risks to energy production, even down to the transport of fuels and materials. Water agencies are well aware that water consumption from electricity generation poses risks to the water supply. They are both aware of the water-energy nexus they sit within, but answer to different reporting requirements, maintenance needs, demand management, and so on. And while both sides are aware that gridwater consumption is occurring, neither can attribute it to the buildings that used the electricity, hour by hour, nor can they put a price on it. Thus, we have a decided lack of interoperability between two sides of the same coin.

We can take another lesson from carbon here. Carbon accounting and the almost \$1 trillion global market it supports solved interoperability amongst vastly different industries through protocols and pricing. Industries can speak the same language as long as that language is money. The difference we see between carbon's reporting structure and gridwater's reporting structure can be boiled down to valuation. Emissions tracking and measurement was a "nice to have" until we put a price on carbon at the power plant. So, while carbon and gridwater are both costs of electricity generation that demand tracking and measurement, only one gets the attention it needs, while the other does not because it is not priced.

8. Value & Security

Electricity carries its water value at zero. Plants draw most of this water themselves and pay no utility for it, which creates a situation that sees the largest power customers receiving the largest free input. The same conditions allow for the current configuration where water delivered by a pipe to a tap gets metered and billed at a published rate, while water consumed at a plant for a building's electricity is billed to no one. The price already exists: a building's gridwater can be valued at the published rate of the water utility that serves it. Additionally, water and gridwater consumption means a basin loses water for good through evaporation — a permanent loss that today goes unpriced. This sits in uncomfortable tension with water rights and diversion rules that have seen their share of lawsuits and contention over water loss.

We are adding gigawatts to our grids at a rapid pace. Data centers coming online present a risk to those grids' ability to provide continuous power, which has been the main focus surrounding their implementation. But no facility of any size or capacity can escape operational failure without a healthy water supply, and the grid's own reliability body agrees. NERC's summer assessments have warned that drought cuts output at plants that cool with river water and at hydro dams.¹⁷ Regions that do not adapt on a localized level risk their infrastructure and their ability to provide water to the people, businesses, and organizations within them.

Data centers are moving forward despite the current political and social backlash, in no small part because they produce compute, a resource that humanity now depends on just like electricity. In other words, they have been brought into the national security conversation because we need them to operate continually and over the span of decades. These facilities cannot do so without paying attention to their region's water basin health. Sustainability often comes up in reference to environmental concerns, and rightly so, but we also mean it here in the sense of critical infrastructure sustainability. If gridwater is not taken into account, this critical infrastructure will be at even more risk.

Of all the things we cannot predict regarding national security and infrastructure stability, gridwater should not be added to that list. It can and should be tracked, measured, accounted for, and valued in order to improve the system as a whole.

9. Conclusion

We have described a system that tracks gridwater by the hour, attributes it to the basin it left, puts a price on it, and keeps a record for anyone to recompute. And we are already running it today. This system would provide communities, businesses, and policymakers faced with tough decisions a means to help them maintain and manage critical infrastructure to meet the specific needs of a region. It eliminates inefficiencies in the current system while paving the way for water and gridwater to take their place next to carbon in how we govern electricity and the water-power nexus.

¹⁷ North American Electric Reliability Corporation. *2022 Summer Reliability Assessment*. May 18, 2022. https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_SRA_2022.pdf