WattTime

META CASE STUDY

How carbon accounting approaches do (or don't) reveal real-world impacts

An analysis of three methodologies to report emissions from **Meta's** 2023 data center electricity consumption and clean energy procurement

May 2025

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About WattTime

WattTime is an environmental tech nonprofit that empowers all people, companies, policymakers, and countries to slash emissions and choose cleaner energy. Founded by UC Berkeley researchers, we develop data-driven tools and policies that increase environmental and social good. During the energy transition from a fossil-fueled past to a zero-carbon future, WattTime 'bends the curve' of emissions reductions to realize deeper, faster benefits for people and planet.

Learn more at WattTime.org.

Executive Summary

Since 2020 Meta has matched 100% of its electricity use with more than 15 gigawatts of long-term clean energy purchase commitments, making it one of the world's largest corporate buyers of clean energy. As a result, Meta has reduced its electricity-associated emissions reported under the current industry standard, the Greenhouse Gas Protocol's (GHGP) market-based method, to nearly zero. But how well do these standard reported methodologies capture Meta's physical emissions in the real world?

The GHGP has played a key role in driving over 200 gigawatts of corporate clean energy purchases. But today it is undergoing a major revision — its first in over a decade. Since it was last updated, many power grid operators and third-party providers started releasing far more granular and complete emissions data than were available at the time the current system was devised.

These new data show that the carbon intensity of electricity varies substantially by time and exact location. The emissions impact of using or generating electricity depends not just on how much is consumed, but also on when and where — and what technologies (coal, natural gas, hydropower, etc.) are on the grid at that moment. These variations in emissions impact have become even more pronounced in recent years due to the widespread deployment of clean energy. In certain times and places electricity has become very clean — for example, in West Texas when the wind is blowing — while others have changed little.

If we're serious about reducing pollution from electricity grids and power sector decarbonization, then we need to measure the emissions impact of electricity consumption and clean energy generation more accurately, enabling companies to make informed decisions about where and when clean energy investments can have the greatest impact. The GHGP revision process currently underway provides a critical opportunity to ensure this foundational global standard better reflects real-world variations in electricity's carbon intensity across time and place.

A key element of past GHGP updates has been examining case studies. At this pivotal moment in the GHGP's evolution, Meta engaged WattTime to analyze its 2023 data center operations and clean energy procurement using three different methodologies currently under consideration by the GHGP. The goal was to use Meta's real-world data as a test case for the potential implications of different approaches for all companies.

Drivers of Variations in Electricity's Emissions Intensity

- **Timing:** The carbon intensity of the electricity grid changes throughout the day. In particular, it tends to be lower at times whenever clean electricity generation is abundant. For example, in California, the most common source of clean electricity is solar. As a result, today the grid is cleaner at 2:00 pm when solar is abundant than at 8:00 pm when the sun sets and fossil-fueled plants must ramp up. Yet current carbon accounting counts the emissions impact of a megawatt-hour of clean electricity generated at any time during a year as equally impactful.

- **Location:** Grid carbon intensity also varies by location. As with timing, the primary pattern is that wherever clean electricity is most abundant, carbon intensities are lowest. In particular, specific areas that are particularly favorable to building solar or wind power often experience transmission congestion or even curtailment. In these cases, the grid produces more clean electricity than can be used, and the excess must be discarded. Generating additional clean electricity at these times and places drives little or no reduction in carbon emissions. Yet current carbon accounting ignores such factors and counts a megawatt-hour of clean electricity generated anywhere in the US as equally impactful.

The three proposed methodologies

It's important to note that these different potential GHGP methodologies would only affect Meta's reported emissions. The actual physical emissions impact of Meta's electricity consumption and clean energy purchases in 2023 were the same regardless of reporting methodology. The question the GHGP needs to grapple with is how to improve reporting methodologies to better align with real-world emissions.

The three methodologies examined here are:

Annual Matching

(current GHGP methodology)

The market-based method portion of the GHGP's current Scope 2 methodology, Annual Matching estimates a company's electricity emissions primarily by using the volume of electricity consumed and procured each year as a proxy. It counts how many MWh of electricity the company used in a year, subtracts how many MWh of clean electricity the company purchased that year, and multiplies any remaining unmatched consumption by a grid residual emissions factor.

Finding: Using Annual Matching, Meta would continue to report that it has reduced electricity emissions to nearly zero (from ~5 million tonnes to 733 tonnes).

Hourly Matching

(24/7 CFE methodolog)

GHGP does not currently recognize this method. Hourly Matching focuses on time and place of electricity consumed and procured but as currently proposed, Hourly Matching does not attempt to measure the resulting emissions. Instead, it measures the percentage of clean electricity matched to the same hours and general grid region in which that company consumed electricity. The same "grid region" is mostly defined as the same country, or in the case of the US, the same balancing area such as an independent system operator (ISO) or regional transmission organization (RTO). This geographic requirement is intended to ensure that the clean energy could hypothetically be delivered to a company's load. "Matching" is defined as either a company itself procuring clean electricity in that hour and grid region, as well as counting the region's endemic clean energy in the "grid mix."

Finding: Using Hourly Matching, Meta would report a portfolio-wide average CFE score of 79%. Note: this is not a carbon measurement (i.e., it does not mean that Meta reduced its carbon footprint by 79% and therefore cannot be compared with the other two carbon calculations). It does mean that for 79% of hours in 2023, Meta matched at least as much clean electricity in the same grid region as its consumption, whether through direct purchases or through clean energy that was already on the grid (i.e., "grid mix"). Without additional information, two companies with the same CFE score can have very different levels of emissions in their operations.

Carbon Matching

(emissions matching methodology)

GHGP does not currently recognize this method. This approach uses time- and location-specific emissions factors (CO_2/MWh) to calculate the total emissions induced from consuming electricity at a particular time and place (i.e., the emissions that the electricity use caused) minus the total emissions avoided from clean energy procurement at a particular time and place (i.e., emissions that would have happened, if it had not been displaced by purchased clean energy), resulting in an estimate of the net carbon emissions caused by all of a company's actions. It does not count clean energy in the grid mix, because this is not related to a company's own actions.

Finding: Using Carbon Matching, Meta would report that its electricity consumption induced 8.12 million tonnes of emissions, while its clean energy purchases avoided 7.35 million tonnes of CO2e, leaving a remainder of 770,000 tonnes.

What can we learn from Meta's Annual Matching results?

This methodology shows that Meta addressed almost all of its electricity-associated emissions by procuring almost exactly as much carbon-free electricity in 2023 as it consumed. Were it to be content with this metric, Meta would conclude that almost no further work is needed other than continuing to match its annual consumption volumes with purchased clean energy. This methodology, also known as the current GHGP market-based method, is by far the most widely used approach today — in 2023, 97% of S&P 500 companies that disclosed their emissions did so using this method. It is commonly viewed as a helpful approximation of the emissions impact of a company's electricity use and clean energy procurement.

By (1) assuming all MWh in a grid have identical emissions impact, and (2) using annual grid emissions factors (which are averaged over large regions), this approximation fails to consider the significant variations in electricity's emissions intensity across time and location. Carbon accounting methodologies that are more granular in time and place can provide more insight.

What can we learn from Meta's Hourly Matching CFE score?

The proposed Hourly Matching approach is one such potential more granular accounting methodology. This approach shows that in 2023, 79% of the electricity consumed at Meta's facilities was matched with a clean MWh produced on the same grid and in the same hour, whether from Meta's own clean energy purchases or from existing clean energy on the grid. As currently proposed, this methodology does not produce a carbon measurement, so Meta's 79% CFE does not mean that it reduced its carbon footprint by 79%. It cannot, therefore, be directly compared to the values shown in Annual and Carbon Matching methodologies.

By using more granular time- and region-specific data, Hourly Matching recognizes an important issue: It's not just how much clean electricity a company buys over the course of a year that matters, but also when and where that electricity was generated. This approach aims to create a demand signal for clean technologies capable of generating electricity in all hours (such as nuclear power and long-duration energy storage) by encouraging companies to align their clean energy purchases with their patterns of consumption.

While this framework may help create a demand signal for clean, dispatchable power — something Meta is actively supporting — it is unclear what insights the 79% Carbon-Free Energy (CFE) score actually provides about Meta's environmental impact — or how that information should guide future investment decisions.

As a carbon accounting methodology, Hourly Matching has some key limitations:

- **It does not reflect Meta's actual impact:** The proposed Hourly Matching methodology directs companies to include "grid mix" clean energy — carbon-free electricity on the grid that the company did not directly procure. In Meta's case, while the company directly purchased clean energy sufficient to match 59% of its consumption on an hourly, regional basis, the methodology inflates the reported match to 79% by including grid mix clean energy procured by other consumers or utilities. This creates double counting and obscures what Meta's actual actions have achieved in terms of emissions reductions.

- **It can create misaligned investment signals:** A focus on improving the CFE score may encourage shifting investments away from higher-emissions regions like the Midcontinent Independent System Operator (MISO) to cleaner regions like California. In 2023, Meta scored 92% CFE in MISO and just 56% in California. Yet MISO, powered 30% by coal and with more than twice the carbon intensity of California— which sometimes has too much clean energy — offers far greater emissions-reduction potential. Shifting more of it's investment into California would raise Meta's CFE score, but would reduce the emissions benefit of its clean energy purchases.

- **It overstates clean energy benefits by ignoring transmission congestion:** Hourly Matching assumes that clean energy purchased in the same grid region is physically deliverable to a company's load. In practice, frequent congestion on transmission lines prevents this. The proposed methodology includes no test of whether clean energy can actually reach the load its emissions are meant to address — so called "deliverability" — despite it being a core assumption of the framework's credibility. Studies show that without physical deliverability the method can fail to reduce emissions and even allow companies to overstate the emissions reductions of their clean energy purchases.

Because of these limitations, Meta's Hourly Matching-based CFE score — while laudable on its surface — offers limited insight into the company's true environmental impact. More accurate, impact-driven accounting would need to focus directly on emissions reductions, not just on aligning clean energy use with time and place.

What can we learn from Meta's Carbon Matching results?

Under the current industry standard of Annual Matching, Meta procured enough clean energy to report near-zero emissions in 2023 and also achieved an industry-leading score under Hourly Matching. However, a third, more stringent methodology known as Carbon Matching shows that in the real physical world, Meta still has residual emissions in its data center operations.

The reason lies in the emissions variations in electricity across time and location. As discussed earlier, the carbon intensity of electricity is significantly lower when clean energy is abundant — such as during sunny hours in California or windy periods in the Great Plains. In fact, when clean energy dominates the grid, emissions intensity can approach zero.

Annual Matching ignores this variation, while Hourly Matching accounts for changes over time but overlooks the importance of location (i.e., deliverability). By contrast, Carbon Matching directly evaluates the effect of these variations in time and space by employing location-specific emissions factors.

Applying Carbon Matching to Meta's data uncovers a key insight: The hours and locations in which Meta procures clean electricity on average have lower emissions intensity per MWh than hours and locations in which it consumes electricity. As a result, while Meta has procured as many MWh as it consumes and has remaining emissions of only 733 tonnes under current Annual Matching standards, under the more rigorous Carbon Matching methodology, its reported emissions would be higher at 770,000 tonnes.

This discrepancy arises because Meta, like many companies, often procures clean electricity in regions and hours where renewable resources are abundant. For example, when the wind is strong in West Texas, numerous wind farms generate simultaneously, cleaning the grid in that location at that time. While Meta's purchases are beneficial, their emissions reduction impact is muted because they occur during periods of already low grid emissions. Conversely, Meta's electricity consumption is spread across hours and regions that tend to have higher emissions intensity. In short, the clean electricity Meta procures is slightly less emissions-reducing per MWh than the electricity it consumes. By identifying this gap and leveraging the granular emissions metrics used in Carbon Matching, Meta can better target its future clean energy investments.

This pattern likely holds true for many — if not most — companies, but it becomes visible only when applying the Carbon Matching methodology to detailed operational data. What sets Meta apart is not the higher emissions revealed by this methodology, but its decision to voluntarily disclose these insights. In doing so, Meta is helping advance the industry's understanding of how to more accurately measure and reduce electricity-related emissions.

Where Meta and other corporate clean energy buyers could go from here

WattTime encourages other companies to follow Meta's example and voluntarily disclose their best estimates of the real-world emissions impact of their operations, using Carbon Matching or a similar granular methodology.

Meta has stated that it remains committed to using the most accurate emissions data available to better understand the impact of its clean energy purchases and to guide more strategic, high-impact investments in the future. This analysis strongly suggests a need for the GHGP (and other carbon accounting frameworks) to adopt more accurate carbon accounting methodologies such as Carbon Matching that more accurately reflect real-world emissions impact and empower companies to make more targeted, better informed, and higher-impact clean energy investments.

Introduction

Since 2020, Meta has matched 100% of the electricity consumption at its offices and data centers with clean energy. Under the current Greenhouse Gas Protocol (GHGP) — the world's most-used voluntary carbon accounting framework — this results in Meta reporting near-zero Scope 2 market-based emissions for its electricity use.

The GHGP has played a key role in driving over 200 gigawatts of corporate clean energy purchases. However, the GHGP's market-based Scope 2 standard, last updated in 2015 and referred to in this paper as Annual Matching, offers only an imprecise estimate of actual emissions.

The biggest advancements have come from a deeper understanding of the importance of time and location on the power grid. The Annual Matching approach assumes that all megawatt-hour (MWh) of electricity used on a given power grid over a year have the same emissions impact. But in reality, electricity-related emissions — both those caused by consumption and those avoided through clean energy generation — vary widely depending on the specific time and location of electricity use and generation, as well as which power plants (coal, gas, nuclear, etc.) are displaced. In short, when and where clean electricity is consumed or produced significantly affects emissions.

Drivers of Variations in Electricity's Emissions Intensity

- **Timing:** The carbon intensity of the electricity grid changes throughout the day. In particular, it tends to be lower at times whenever clean electricity generation is abundant. For example, in California, the most common source of clean electricity is solar. As a result, today the grid is cleaner at 2:00 pm when solar is abundant than at 8:00 pm when the sun sets and fossil-fueled plants must ramp up. Yet current carbon accounting counts the emissions impact of a megawatt-hour of clean electricity generated at any time during a year as equally impactful.

- **Location:** Grid carbon intensity also varies by location. As with timing, the primary pattern is that wherever clean electricity is most abundant, carbon intensities are lowest. In particular, specific areas that are particularly favorable to building solar or wind power often experience transmission congestion or even curtailment. In these cases, the grid produces more clean electricity than can be used, and the excess must be discarded. Generating additional clean electricity at these times and places drives little or no reduction in carbon emissions. Yet current carbon accounting ignores such factors and counts a megawatt-hour of clean electricity generated anywhere in the US as equally impactful.

In recognition of improvements in grid data availability, the GHGP is undergoing its first major revision in more than a decade. Several new carbon accounting methodologies have been proposed that incorporate more granular data on time and place.

One such proposed framework is Hourly Matching (aka 24/7 Carbon-Free Energy, or simply 24/7 CFE). Like Annual Matching, it pairs MWh of clean generation with MWh of consumption, with two refinements: a) matching the time of generation to the time of consumption, and b) sourcing that clean generation from the same grid region as the associated load.[1]

Separately, current Hourly Matching proposals also change the definition of "matching" to include clean energy that's on the grid purchased by other companies or utilities. The currently proposed methodology for Hourly Matching does not assess emissions directly. Instead, it calculates the percentage share of hours in a year during which the MWh consumed by a company's operations are matched with a clean MWh generated in the same hour and on the same grid. One argument for this approach is that it will encourage companies to send a demand signal for clean energy technologies that can deliver power when the sun isn't shining and wind isn't blowing.

Another proposed framework is Carbon Matching (aka Emissions Matching). Like Hourly Matching, it accounts for the timing of electricity consumption and generation, but it goes further by using granular, time- and location-specific emissions factors rather than regional averages. Unlike either Annual or Hourly Matching, it directly calculates the estimated emissions impact of electricity use and clean energy procurement — in tonnes of carbon. The method compares the emissions induced by a company's electricity consumption with the emissions avoided through its clean energy purchases, using time- and location-specific data. By focusing on actual emissions rather than MWh as a proxy, Carbon Matching offers a more precise picture of a company's climate impact and can better incentivize actions that reduce real-world emissions.

The GHGP process has historically benefited considerably from companies that volunteered to pioneer, document, and compare emerging new techniques to measure and reduce emissions. In this study, Meta allowed WattTime access to its detailed operational data in order to compare the effects of different proposed new carbon accounting methodologies.

WattTime analyzed the emissions impact from Meta's fleet of data centers and clean energy projects using the existing GHGP accounting frameworks, as well as the two new accounting frameworks, to gain a more precise understanding of the impact of its clean energy investments, and the insights afforded by each accounting methodology. It is to our knowledge the first such public analysis to use real-world data to examine the potential consequences of such methodologies. Results are provided here transparently for any institution interested in learning more on this important topic.

1
A "grid region" is defined as an area where electricity supply and demand are tightly controlled by a balancing authority. In the US, these regions often correspond to ISOs and RTOs. Internationally, these regions often correspond to country boundaries.

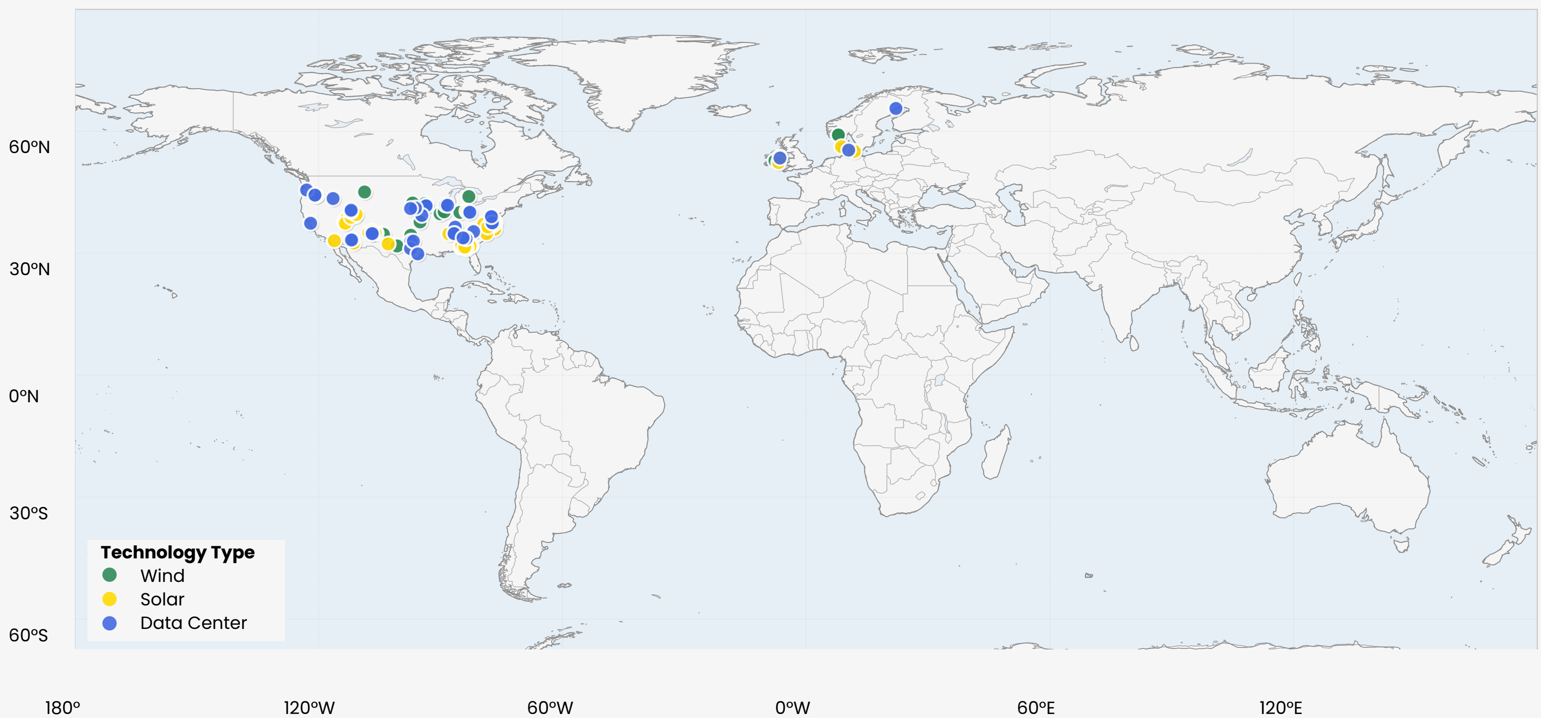
Methodologies

In this study, WattTime compared and contrasted the efficacy of three accounting methodologies (Annual Matching, Hourly Matching, and Carbon Matching) to report the impact of Meta's clean energy investments against its data center load. It's important to note that these different potential GHGP methodologies would only affect Meta's reported emissions. The actual physical emissions impact of Meta's electricity consumption and clean energy purchases in 2023 were the same regardless of reporting methodology.

Meta consumed [more than 14 terawatt-hours]() (TWh) of electricity in its data centers in 2023, comprising nearly 98% of the company's overall annual electricity consumption. Meta procured clean energy equal to 100% of its annual load in 2023.

For this assessment, WattTime used Meta's 2023 hourly data center electricity consumption and contracted clean energy generation specifically allocated to those data centers — plus grid generation and emissions data from the US EIA, Electricity Maps, PJM, REsurety, and WattTime.

Figure 1: Meta's data centers and major clean energy investments in 2023



Annual Matching
(current GHGP Scope 2 market-based methodology)

Current Scope 2 guidance including two methods for calculating an organization's electricity emissions footprint:

- **The location-based method** multiplies a facility's annual electricity consumption by an average grid emissions factor for that region to determine its emissions footprint. The location-based method excludes procured clean energy unless it is physically installed onsite, and overlooks the time- and location-based variations in electricity emissions intensity by using an annual emissions metric for the broader grid.
- **The market-based method** is similar, except it includes procured clean energy. Today, the vast majority of companies set emissions reductions targets using the market-based method. This method allows organizations to match electricity consumption with clean energy investment on a per-MWh basis and count that electricity consumption as having zero emissions impact, with the emissions of any remaining unmatched MWh multiplied by the grid's residual emissions factor.

WattTime used both the Scope 2 location-based method and market-based data center emissions footprint that Meta reported in its 2024 Sustainability Report as part of this assessment. For brevity, we treat GHGP's Scope 2 market-based method as synonymous with Annual Matching throughout.

Hourly Matching
(24/7 CFE methodology)

This proposed methodology aims to match every MWh of electricity consumed with a MWh of clean energy generated in the same hour and within the same grid region. The degree of alignment is expressed as a Carbon-Free Energy (CFE) score, which is a percentage representing how much of a company's electricity use is hourly- and regionally-matched with clean energy. A 100% CFE score means that every hour of electricity use is fully matched by clean energy generated in that same hour and region. As currently proposed, Hourly Matching allows companies to count both directly purchased clean energy as well as the existing clean energy from the endemic mix of electricity generation on that grid.

To calculate Meta's CFE scores, WattTime followed this methodology using the following steps:

1. **Hourly electricity consumption by grid region:** Meta provided WattTime with hourly electricity load data for all of its data centers. For each hour, total electricity consumption was summed across all data centers in each grid region. In the U.S., this was done by the Independent System Operator (ISO) or Balancing Authority (BA) region.

2. **Hourly CFE from procured clean energy generation:** Next, WattTime estimated the hourly generation from Meta's clean energy purchases. Meta shared location data for the majority of its clean energy procurement, which included Power Purchase Agreements (PPAs) with associated Renewable Energy Certificates (RECs), green tariffs (where utilities develop clean energy and RECs on Meta's behalf), and long-term REC contracts tied to specific generators. Short-term RECs, which do not always have precise location data, were excluded but represent less than 5% of Meta's reported 2023 clean energy purchases. Meta provided WattTime with historical hourly data for a comparatively high 65% of the clean energy it procured.

   WattTime then assumed that, for data centers with a retail sale agreement where a supplier is contracted to provide electricity from clean energy sources, the generation profile was the same as the data center consumption profile data.

   For projects where only monthly or annual generation data were available, WattTime estimated hourly profiles using Renewables.ninja.

   These data were aggregated to estimate Meta's total hourly clean energy output in each grid region, as defined by Hourly Matching.

3. **Hourly CFE from the same grid region:** For hours and regions where Meta's consumption wasn't fully matched by its own clean energy, WattTime then calculated what portion of the grid's clean energy mix could fill the gap. CFE from the grid was calculated by multiplying the MWh of grid energy Meta consumed by the percent of the grid region's electricity consumption supplied by CFE generation sources for each hour. The proportion of CFE on the grid was sourced from the US EIA and Electricity Maps.

4. **Final CFE score:** The final CFE score, which represents the percentage of data centers' electricity consumption matched by CFE in each hour, is calculated by dividing the total CFE by total electricity consumption for each grid region. Total CFE for each hour is the sum of CFE from procured clean energy projects and CFE from the grid. The currently proposed methodology does not result in a carbon measurement and therefore cannot be directly compared to the carbon values calculated under Annual or Carbon Matching.

Carbon Matching

(emissions matching methodology)

Carbon Matching assesses the actual emissions impact of a company's electricity consumption and clean energy procurement by applying granular, time- and location-specific marginal emissions rates.

To calculate the induced (from electricity use) and avoided (from clean energy procurement) emissions from Meta's global operations, WattTime used the following approach:

- **Electricity consumption and procurement data**: As with Hourly Matching, WattTime used Meta's 2023 hourly electricity consumption and clean energy procurement data. However, for Carbon Matching, the data were mapped to more granular grid locations, rather than broader grid regions. Importantly, clean energy already present on the grid (i.e., not directly procured by Meta) is not included in this methodology.

- **Grid marginal emissions rates:** To estimate emissions accurately, marginal emissions rates were collected for all locations where Meta has assets. A hierarchical data approach was used to ensure the most granular and accurate marginal emissions rates (MERs) were applied for each location. This included including hourly nodal level data from PJM as well as REsurety for ISO regions in the US, sub-hourly zonal and country-level data from WattTime for balancing authorities in the US and other countries in Europe and around the world, and annual country-level data from the UNFCCC for all countries.[2]

  When datasets varied in temporal resolution, the less granular timeframe was used to ensure consistency. In this analysis, the resolution across all asset locations was hourly or finer.

- **Induced / avoided emissions:** To determine the induced emissions for each data center load and the avoided emissions for each clean energy asset, each MWh was multiplied by the time- and location-specific MER data. WattTime reviewed and validated the approach Meta used to calculate avoided and induced emissions for global assets and found that it used the most granular and highest quality approach in each grid region.

- **Net emissions:** Meta's net emissions were calculated by subtracting the total avoided emissions from clean energy procurement from the total induced emissions due to electricity use. The result is a single carbon metric reflecting the net emissions impact of Meta's global operations in 2023.

Entities can use the Carbon Matching approach to gain a more accurate and transparent understanding of their emissions impact. By applying a hierarchical framework that prioritizes data with higher temporal and spatial granularity, Meta was able to evaluate its global portfolio of data centers and clean energy projects — uncovering insights not only in data-rich grid regions but across all areas where it operates.

Emissions data is increasingly available at various levels of detail worldwide, making it feasible to conduct Carbon Matching assessments in nearly any region. As data quality continues to improve, this approach becomes even more powerful. Importantly, the depth of analysis can be tailored to the granularity and sophistication of the available data, enabling organizations of all sizes — even those with limited resources — to apply Carbon Matching based on the information they have access to.

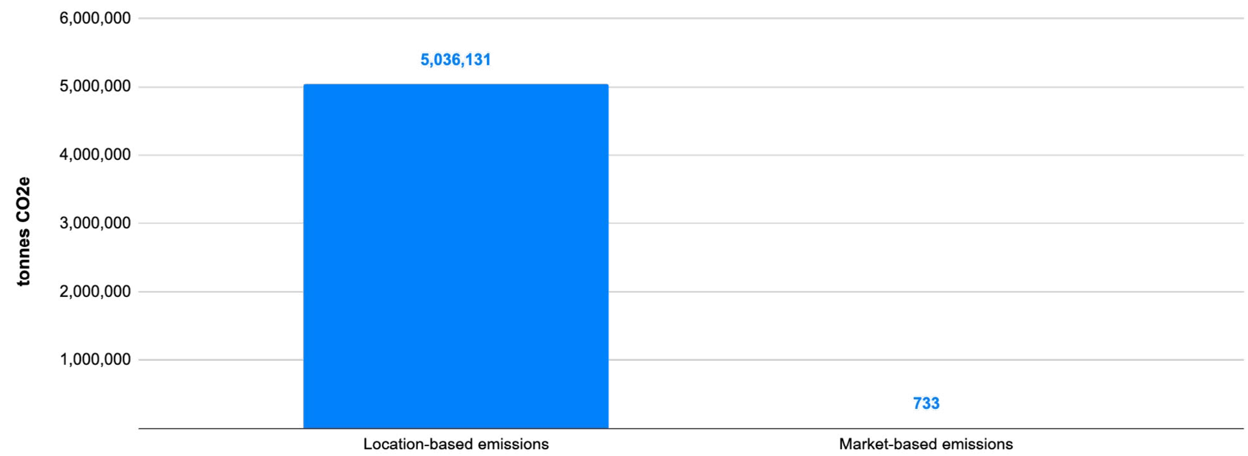
[2] All marginal emissions rates in this Carbon Matching assessment were short-run or operating marginal emission rates. Some newly proposed methods also suggest the inclusion of an hourly build margin or a long-run marginal emissions rate (see appendix). At the time of this analysis, such data were not available for most locations.

Results

Annual Matching results

Following the existing GHGP Scope 2 accounting guidelines, Meta reported approximately 5 million tonnes CO_2e from data center electricity consumption using the location-based methodology. Under the GHGP market-based method, which accounts for clean energy investment, Meta reported near-zero emissions (733 tonnes CO_2e). This difference can be attributed to Meta's extensive global portfolio of clean energy investments (as of April 2025, totaling 15 gigawatts and counting).

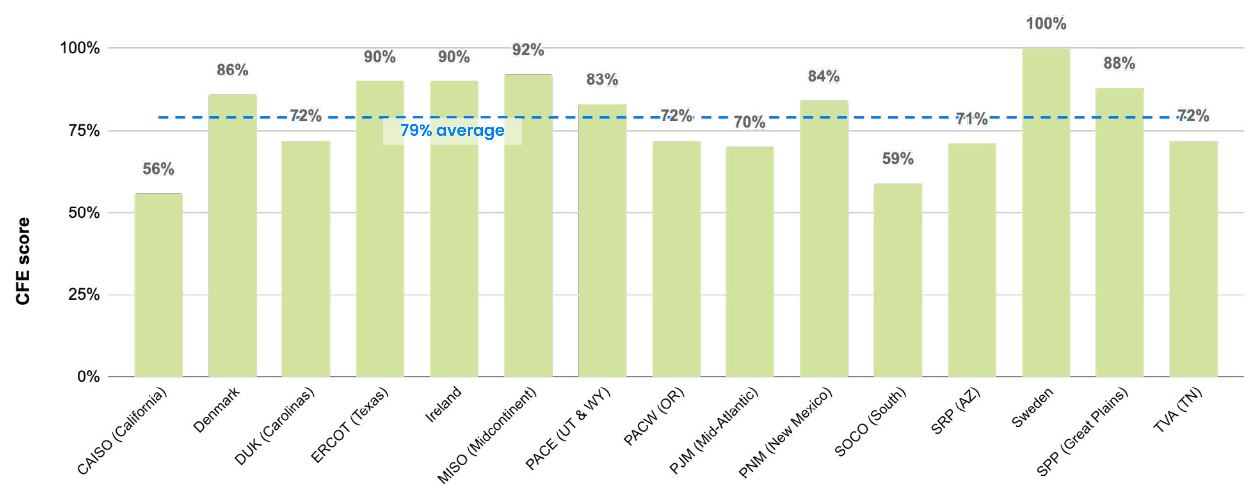
Figure 2: Meta's emissions under Annual Matching



Hourly Matching results

Although Meta did not focus on an Hourly Matching approach to drive its clean energy procurement decisions, it achieved an overall 79% CFE score across its global portfolio, with the score varying by grid region.

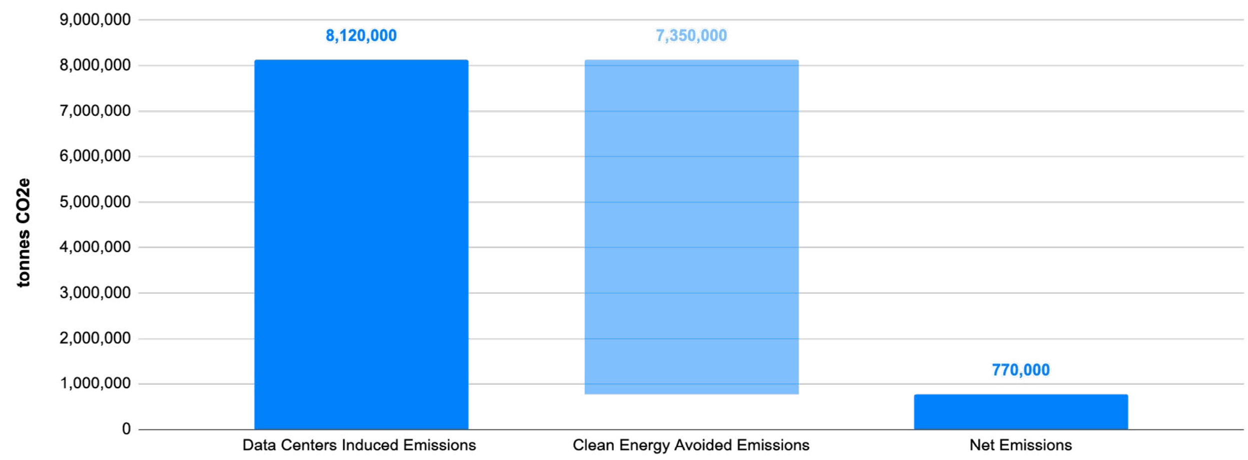
Figure 3: Meta's CFA score under Hourly Matching by grid region



Carbon Matching results

Using the Carbon Matching methodology, Meta's data center electricity consumption in 2023 induced 8.12 million tonnes CO_2e. The company's clean energy procurement avoided around 7.3 million tonnes CO_2e, leaving 770,000 tonnes remaining.

Figure 4: Meta's induced, avoided, and net emissions under Carbon Matching



Discussion & Key Takeaways

The carbon intensity of electricity generated, procured, or consumed varies by time and location. Annual Matching does not reflect this.

Since the GHGP was last updated nearly a decade ago, grid operators and third party data providers have released considerable amounts of data on the variation in carbon intensity by time and location.[3] This variation is not captured by the current GHGP Scope 2 market-based methodology, Annual Matching. One key takeaway of this study is that this discrepancy is often substantial —meaning Meta's real-world emissions may look quite different than the emissions reported under the GHGP's Annual Matching methodology.

3 He, Hua, et al. (2021) "Using marginal emission rates to optimize investment in carbon dioxide displacement technologies." The Electricity Journal 34.9: 107028.

Variations across grid regions

An example of this, in Figure 5, is the fact that each MWh of clean energy procured in the PACE region (the grid around Utah and Wyoming) is nearly twice as effective at avoiding emissions on a per-MWh basis than clean energy in the CAISO region (the California grid). This is primarily because the grid in CAISO has significantly more clean energy capacity, whereas the grid in PACE is still heavily reliant on coal. A new solar project in PACE would displace nearly 70% more carbon than one in CAISO. Yet under Annual Matching, which only looks at the MWh unit of electricity generated, these projects are treated as identical.

This sort of variation appears to be quite common. Figure 6 compares the avoided emissions rates for all of Meta's clean energy projects globally, by grid region. The emissions impact of clean energy projects varies dramatically by region, from under 300 kg CO_2/MWh to almost 800 kg CO_2/MWh. Despite this variation, Annual Matching instructs Meta to treat all US clean energy projects noted in Figure 6 as the same on a per-MWh basis.

This imprecision lowers the accuracy of the current market-based methodology. It also provides little incentive for companies to prioritize procuring clean energy in locations (either within or across grid regions) where it would drive more emissions reductions. This leaves potential real-world emissions reductions on the table because more impactful projects are not captured, incentivized, or valued by the current market-based methodology.

Figure 5: Avoided emissions rate of two solar projects in different grid regions

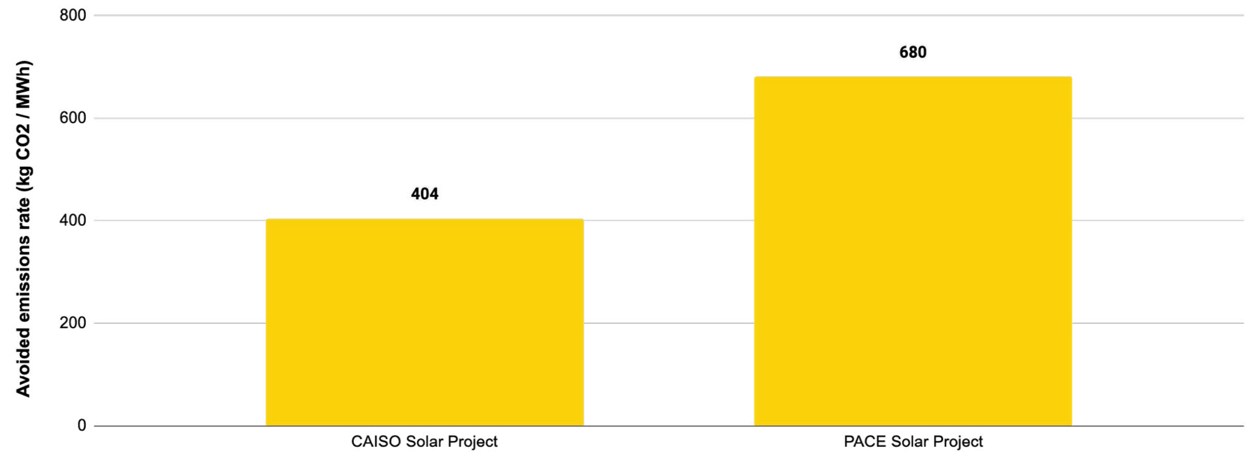
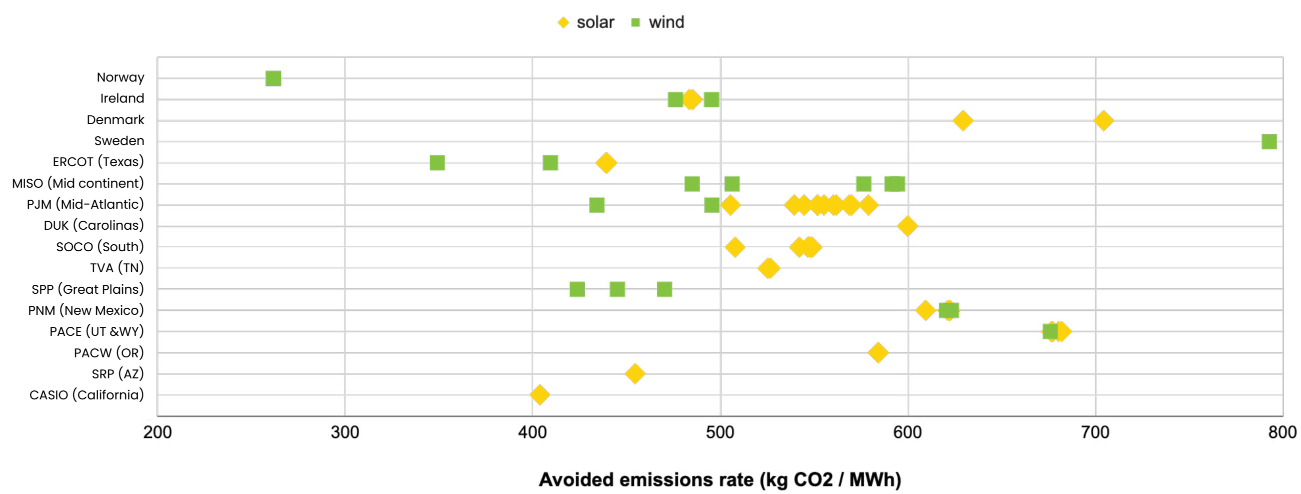


Figure 6: Avoided emissions rate of all Meta clean energy projects by grid region



Variations within grid regions

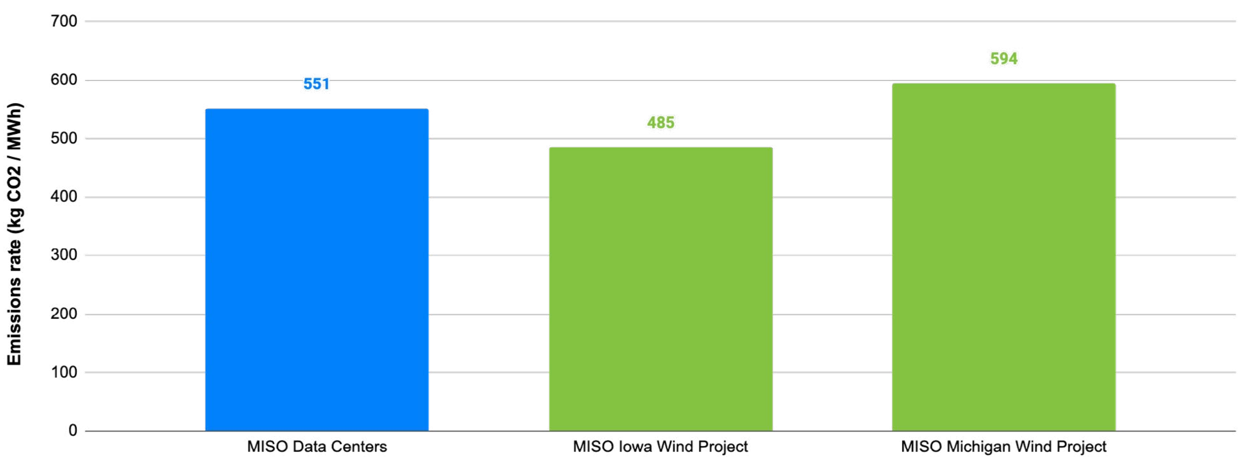
Carbon intensity also varies systematically within grid regions, and by time. WattTime examined this by comparing the actual location and times that Meta's data centers and clean energy projects consumed or generated electricity. For an example, consider Meta's data centers and wind projects in the MISO grid region (which covers much of the US Midwest), as shown in Figure 7 below.

Despite being located in the same grid region, Meta's data centers and wind projects all have different carbon intensities per MWh. Its wind project in Michigan avoids 594 kg CO_2e/MWh, more than the carbon intensity of Meta's MISO data centers. While its wind project In Iowa avoids 485 kg CO_2e/MWh, less than the carbon intensity of electricity consumed by Meta's MISO data centers. That's a 20% difference, despite both projects being in the same grid and using the same generation technology. The difference arises because these wind farms operate in different parts of the MISO grid, are affected by varying grid congestion patterns, and generate electricity at different times relative to the data center load profile.

KEY TAKEAWAYS

- Carbon intensity varies by location — both across and within grid regions — and time.
- Annual Matching ignores this variation, leading to less accurate results and offering no incentive for clean energy developers to prioritize more impactful projects.

Figure 7: Data center induced emissions vs. wind projects' avoided emissions rate in MISO



Meta's physical emissions are likely higher than reported under Annual Matching. The same is likely true for most companies.

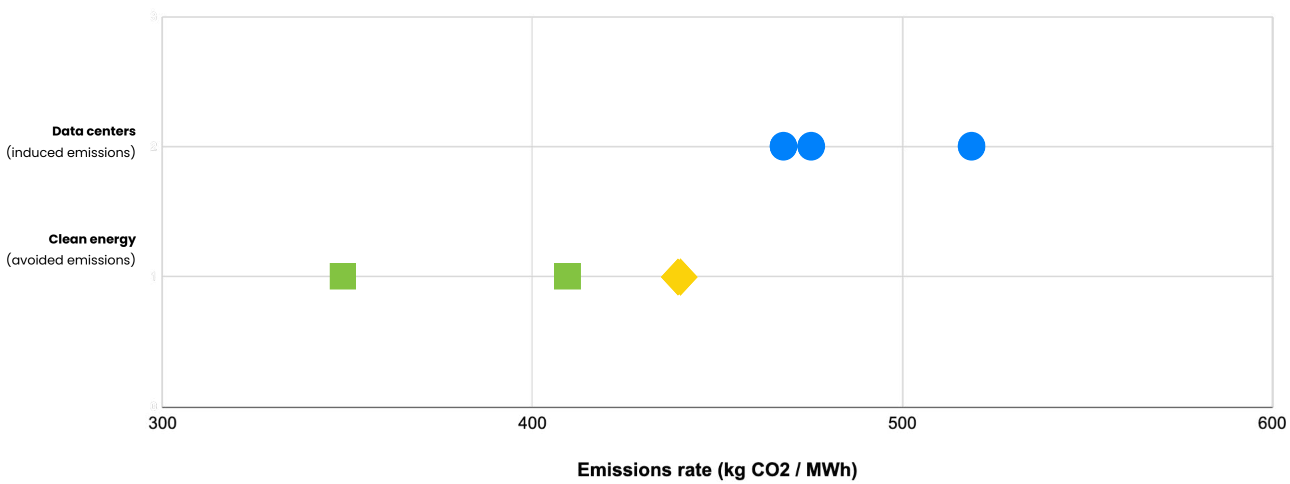
To date, Meta has been using the methodology mandated by the GHGP Scope 2 market-based method, Annual Matching. Like most companies, Meta has set targets that prioritize what this methodology instructs it to: procuring the same number of MWh of carbon-free electricity as it consumes. Under this methodology, its reported emissions have fallen to under 800 tonnes, or virtually zero.

But the Carbon Matching analysis reveals that, although Meta procured as many clean MWh as it consumed, the emissions avoided by those clean energy investments were, on average, lower than the emissions induced by data center load. As a result, induced emissions exceeded avoided emissions by over 770,000 tonnes.

The reason for this discrepancy is that Meta's data centers are on average located in higher-carbon intensity locations, and consume electricity at higher-carbon intensity times, than the clean energy facilities it procures from.

For example, Figure 8 shows the annual mean emissions impact per MWh of all Meta operations in ERCOT. The marginal emissions rate is on average systematically higher at Meta's data centers (blue) than for its clean energy generators such as wind (green) or solar (yellow).

Figure 8: Emissions impact of all assets in ERCOT



While Meta is the first company to offer its data for a systematic public analysis like this, it is very unlikely that the pattern of Annual Matching systematically understating emissions is unique to Meta. Rather, it is primarily driven by the fact that wherever many companies procure clean energy, it changes the carbon intensity of the local grid. This tends to reduce the impact of further clean energy procurement in the same grid. In the extreme, such as the dense concentration of wind projects in certain locations like West Texas, this can lead in many hours to a local grid carbon intensity of zero as the grid must discard excess wind or solar — meaning a company generating or procuring additional MWh of clean energy would not reduce physical emissions at ***all***.

In short, the result that Annual Matching likely underestimates Meta's actual carbon impact occurs primarily because the locations and times that Meta is procuring clean energy are avoiding less emissions on average than the emissions induced by data center load. These insights only become apparent when examining Meta's reported emissions under the Carbon Matching methodology. Meta's approach to clean energy procurement is not significantly different from what other companies are doing. As a result, it's very likely that the same pattern applies to most, if not virtually all, companies. The only reason this information is not known is that no company besides Meta has yet disclosed these numbers.

KEY TAKEAWAYS

- While Meta procures sufficient MWh of clean energy to report virtually zero emissions under Annual Matching, this understates Meta's physical emissions.
- This is driven by the fact that the carbon intensity of Meta's electricity consumption is systematically higher per MWh than the carbon avoided by its clean energy procurements.
- It is very likely that most companies experience the same pattern but have simply not publicly reported it yet.

Hourly Matching fails to resolve key limitations in emissions accounting, even with tighter spatial matching.

While it introduces tighter spatial boundaries known as grid regions, Hourly Matching assumes — without verifying — that all locations within a grid region are equally impactful.

To account for the importance of location, Hourly Matching proposes that companies match electricity consumption with clean energy procurement within the same grid region and hour. The underlying theory is that such alignment ensures the clean energy purchased directly offsets the grid energy used. However, Hourly Matching does not test its core assumption: that energy generated anywhere in a grid region can be physically delivered to the point of consumption.

The assumption of physical deliverability is critical to the effectiveness of Hourly Matching. Yet studies show that without physical deliverability the Hourly Matching method can fail to reduce emissions.

Previous studies have also examined whether this assumption of physical deliverability is true for a typical grid location (e.g., ERCOT, the Texas grid region), and concluded this assumption is likely not correct and can allow companies to overstate the emissions reductions of their clean energy purchases.

The reason lies in transmission congestion. When transmission lines are congested, clean energy can be curtailed — unable to reach demand — while fossil fuel generators in uncongested areas continue to operate.

This is because of transmission grid congestion patterns. At times, clean energy generation can get “stuck” behind transmission grid congestion, forcing clean generators to curtail their output while fossil fuel generators in other locations with uncongested transmission pathways continue to operate. This means clean energy generated in certain locations, even within the same grid region, may not displace fossil generation and therefore may reduce fewer emissions per MWh than the emissions induced by electricity consumption.

KEY TAKEAWAYS

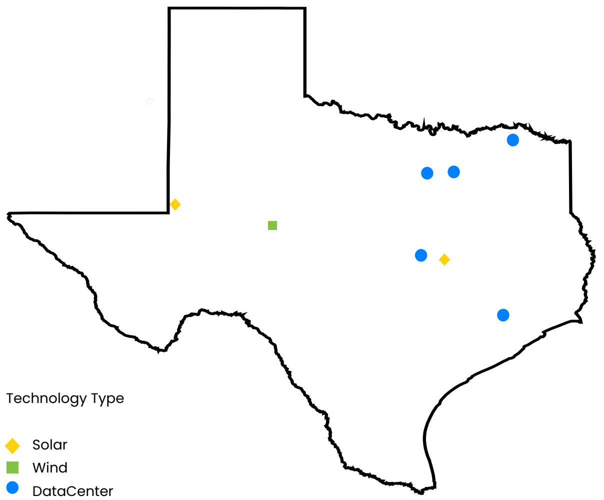
- Hourly Matching seeks to ensure that MWh of clean energy procurement are equally impactful as MWh of electricity consumption by ensuring they are deliverable.
- Hourly Matching prescribes that clean energy procurement should occur in the same grid region to ensure deliverability. Studies show this is not an effective test for deliverability due to transmission congestion.
- Hourly Matching does not ensure that MWh of clean energy procured are equally impactful as the MWh of electricity consumed.

Even if Meta were to achieve a perfect Hourly Matching score of 100%, it would not eliminate its physical emissions.

Partly as a result of such effects, even if Meta were to achieve a 100% Hourly Matching CFE, it still would not eliminate its physical real-world emissions.

To explore this further, consider Meta's data centers and clean energy procurement in the ERCOT (Texas) grid region. Meta's data centers and clean energy procurement in the state are located in different parts of ERCOT. Like most companies, its electricity consumption is on average more in the eastern part of the state where infrastructure is more available, and its clean electricity projects tend to be in the western part of the state, where clean resources are more abundant (Figure 9).

Figure 9: Location of Meta's fleet in ERCOT

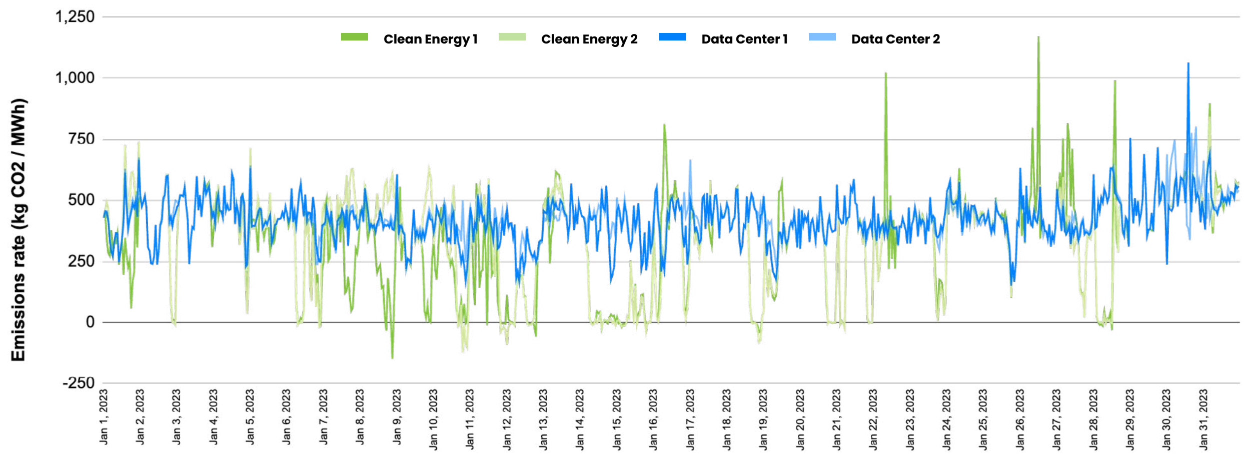


Under Hourly Matching, Meta would be directed to count this procured clean energy as deliverable to load and treat it as having the same carbon intensity. Figure 10 explores this assumption by graphing the actual hourly carbon intensity of different Meta clean electricity locations (in green) and data center locations (in blue).

Results like this show the practical challenges with assuming that all electricity within the same grid region is equally carbon-intensive. The carbon intensities do not match, revealing transmission congestion and indicating that the Hourly Matching methodology's assumption of physical deliverability is almost certainly not correct in practice.

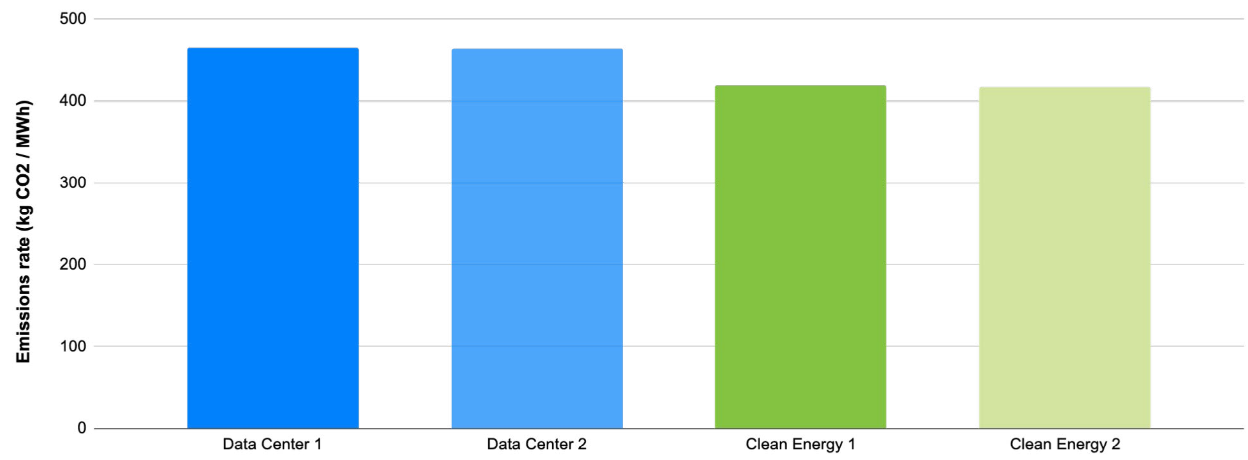
Notably, the carbon intensity at Meta's clean energy project locations (where renewable energy is abundant) is consistently lower than at its data center sites (where it is not). In many hours, the emissions impact of the clean energy is effectively zero — likely due to the high concentration of wind and solar projects in the same area, leading to transmission congestion and curtailment.

Figure 10: Marginal emissions rate of two data centers and two clean energy projects



As a result, even if Meta were to achieve a 100% Hourly Matching score by aligning procurement with its consumption times, it would not eliminate its physical emissions. As shown in Figure 11, if Meta were to procure hourly matched clean energy at its existing locations, the induced emissions caused by the data centers would still be more than 10% higher than the avoided emissions of that clean energy procurement. This challenge would not be resolved even by achieving a 100% CFE score under Hourly Matching. Such patterns are common and reinforce that Hourly Matching — even in the same grid and at the same time — is an imperfect approximation of physical emissions.

Figure 11: Comparing induced vs. avoided emissions across four locations



KEY TAKEAWAYS

- Even if Meta were to achieve a 100% Hourly Matching CFE score at its current locations, it would still have induced emissions higher than its avoided emissions.
- This is because carbon intensity per MWh tends to be lower in areas where clean energy procurement is abundant, and Hourly Matching does not reflect this.
- Results would likely be similar for any company with operations in ERCOT, or any other grid with transmission congestion near areas where clean energy procurement is common.

The current Hourly Matching method partly reflects actions taken by others, potentially inflating the perception of companies' progress.

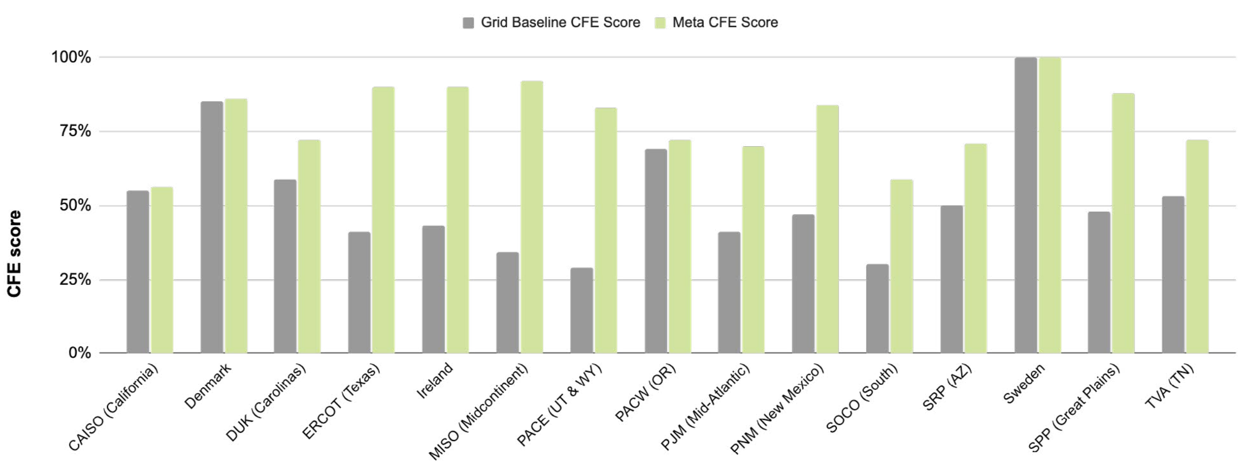
WattTime has examined the data of very many companies, and Meta achieved the highest hourly CFE score of any company whose data WattTime has seen. Yet, as shown above, even if Meta were to achieve 100% CFE under Hourly Matching, its induced emissions would still exceed the avoided emissions from its clean energy procurement. This issue is further compounded by the fact that Hourly Matching allows companies to count clean electricity already endemic to the grid — potentially built and claimed by others — toward their own CFE scores. In some cases, this could result in companies procuring less clean electricity than they do under Annual Matching.

Despite not optimizing procurements against the Hourly Matching methodology, Meta achieves a comparatively high hourly CFE score in all of its data center regions. This is due to a combination of its clean energy procurements and the existing clean energy on the grids.

Figure 12 below illustrates this by comparing Meta's actual Hourly Matching CFE score (in green) with the score it would have received if it had undertaken no clean energy procurement (in gray).

In some cases — such as in Sweden — Meta would have achieved a 100% Hourly Matching CFE score even without any clean energy procurement. While Meta is the first company to publicly share this level of detail, similar patterns would likely apply to other companies operating in the same grids, as the endemic CFE (gray bars) is shared across all entities in those regions.

Figure 12: Grid mix CFE score vs. Meta's CFE score with direct procurement, by grid region



KEY TAKEAWAYS

- As currently proposed, Hourly Matching would direct Meta to include endemic grid clean electricity — potentially built and claimed by other companies — in its own CFE score.
- While Meta has a high CFE score, a significant portion of this (up to 100% in one region) is driven by the existing clean energy on the grid in certain regions.
- This leads to an overestimation of a company's individual climate actions.

Meta's Hourly Matching CFE score provides little insight into actual impact.

A closer look at the data reveals that Meta's Hourly Matching CFE score provides little insight into the action impacts of Meta's action. For example, in both PACW (Oregon) and MISO (Midwest), Meta's data centers induced approximately 700,000–800,000 tonnes of emissions in 2023. Meta achieved relatively high Hourly Matching CFE scores in both regions — 72% in PACW and 92% in MISO. While both scores appear strong on paper, the underlying drivers are starkly different.

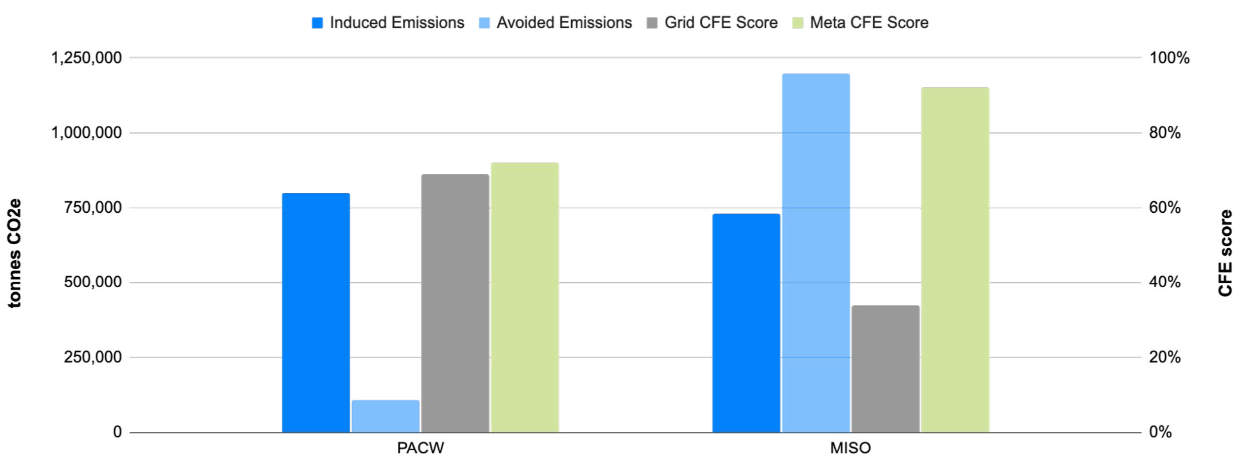
In PACW, the grid was already 69% clean before Meta took any action. Meta's own procurement only marginally increased its score to 72%. In MISO, by contrast, the grid started at just 34% clean. Meta's 92% score reflects significant procurement efforts.

This contrast is illustrated in Figure 13 shows, which shows that Meta's actions in MISO avoided approximately 1.2 million tonnes of emissions — more than 10 times the 108,000 tonnes avoided in PACW. Yet this substantial difference in real-world emissions impact is not visible through either Annual or Hourly Matching methodologies.

KEY TAKEAWAYS

- As currently proposed, Hourly Matching provides limited visibility into a company's actual procurement impact.
- High CFE scores can result either from the company's own clean energy actions or from clean electricity already present on the grid.
- Without distinguishing between these sources, Hourly Matching risks overestimating the climate impact of corporate procurement.

Figure 13: PACW vs. MISO example: CFE misaligned incentives



As a result, Hourly Matching's CFE score does not provide a good signal for where a company should make future clean energy purchases.

These scores can often send misleading market signals that are misaligned with maximizing real-world emissions reductions. Meta's Hourly Matching CFE scores by grid region, with the blue line indicating Meta's average score (see Figure 3, earlier).

If Meta were to focus on raising its CFE score under the Hourly Matching methodology, the data would suggest shifting clean energy procurement to CAISO, where it has a lower CFE score, 56%. However, this would likely be ineffective from a climate perspective. California already has one of the cleanest grids in the U.S. and frequently overproduces clean energy, leading to curtailment. Procuring more clean energy in California — especially during low-demand hours — risks having that energy go unused, resulting in little to no actual emissions reduction. A carbon-aware procurement approach, like Carbon Matching, would instead focus on the regions and times when clean energy can have the largest impact.

Conversely, Meta has one of its highest CFE scores (92%) in MISO, a region that remains 30% coal-powered and has more than double the carbon intensity of California. Yet under the Hourly Matching framework, Meta would have little incentive from investing further in MISO.

From a climate standpoint, this creates a troubling dynamic: Companies are incentivized to shift procurement away from high-impact regions toward cleaner grids where additional clean energy has minimal emissions benefit.

This pattern recurs across grid regions, and because grid carbon intensity is the same regardless of which company is operating there, similar outcomes are likely for other companies as well.

KEY TAKEAWAY

- Hourly Matching encourages companies to pursue higher CFE scores without regard to grid carbon intensity — potentially steering clean energy investment away from regions where it would do the most good.

Conclusion

As electricity grids evolve and clean energy deployment accelerates, the need for more accurate carbon accounting has never been more urgent. This analysis compares three leading carbon accounting approaches — Annual Matching, Hourly Matching, and Carbon Matching — using real-world operational data to assess their ability to reflect the true emissions impact of electricity consumption and clean energy procurement.

The findings reveal a significant divergence between reported emissions and actual climate impact under the current Greenhouse Gas Protocol framework. Annual Matching, the prevailing Scope 2 market-based method, assumes uniform emissions intensity across time and geography and treats all megawatt-hours of clean energy as equally impactful. While straightforward, this approach fails to capture substantial variation in grid emissions. Results indicate that Annual Matching leads to an underestimation of Meta's real-world carbon footprint, and that the same would likely be true for most if not all companies.

Hourly Matching introduces welcome refinements by bringing focus to the time and location of electricity consumption and generation. However, as currently proposed, it still does not quantify emissions directly. Instead, it reports a Carbon-Free Energy (CFE) score that can obscure key differences in climate impact. This score includes clean energy from the broader grid mix—potentially resulting in double counting—and assumes that electricity generated anywhere in a grid region can be delivered to any point of consumption, despite growing evidence of transmission constraints. Thus Hourly Matching leads to double counting that, while not technically measuring emissions, still de facto undercounts physical emissions.

Another insight is that Meta's 79% CFE score doesn't accurately reflect its true carbon footprint, and may send a misleading signal about where future clean energy investments should be directed. This is partly because the CFE score includes clean energy from the grid mix, which may double count emissions reductions from projects Meta did not directly support. As observed in examples like comparing MISO vs. CAISO, Hourly Matching can unintentionally steer investment toward regions that are already relatively clean, missing opportunities to make a greater emissions impact elsewhere.

Carbon Matching appears to address these limitations by directly measuring both induced and avoided emissions using time- and location-specific marginal emissions rates. Results indicate that even when clean energy procurement matches 100% of electricity use in volume, real-world emissions may remain due to differences in the emissions intensity of consumption versus procurement. In multiple grid regions, the analysis showed that clean energy purchased during periods of low grid emissions — such as high-wind hours in West Texas — displaces little or no fossil generation, while consumption occurs at higher emission times and locations.

The implications of these findings are profound. Megawatt-hour based accounting frameworks, whether annual or hourly, fail to consistently align with real-world emissions outcomes. Without reforms, they may inadvertently incentivize clean energy procurement in already clean or congested regions, missing opportunities for greater emissions impact elsewhere. Conversely, Carbon Matching provides a robust framework for identifying where and when clean energy investments can drive the largest reductions in fossil-fueled generation. If every company adopted a net-zero target using Carbon Matching, it would align activities as closely as current data allow with true net-zero physical emissions.

Meta remains a leader in clean energy procurement, having maintained its 100% renewable energy goal since 2020 and achieving near-zero emissions under the current GHGP's carbon accounting methodology of Annual Matching. By being the first to publicly disclose its operational data for this first-of-its-kind case study, Meta is helping to anchor ongoing discussions around updates to the Greenhouse Gas Protocol (GHGP) in real-world evidence. As the GHGP undergoes its first major update in over a decade, this analysis highlights the importance of incorporating more granular emissions data and shifting toward emissions-based accounting. Widespread adoption of methodologies like Carbon Matching would allow organizations to:

- Accurately measure the climate impact of their electricity consumption and clean energy purchases
- Avoid double counting and better distinguish between company-driven action and ambient grid conditions
- Target investments to regions and hours where clean energy can displace the most carbon-intensive generation
- Improve transparency and comparability across corporate climate disclosures

Ultimately, the goal of carbon accounting should be not only to track progress, but to guide action. Frameworks that fail to reflect the true environmental impact of electricity-related emissions risk misallocating capital and slowing decarbonization. Carbon Matching offers a pathway to overcome these shortcomings — and align corporate action with the real-world goal of reducing emissions from the power sector.

Appendix 1: Carbon accounting for grid operation and structural changes

This case study examines three methodologies for reporting on the impact of corporate actions. Each methodology relies on metrics that reflect carbon emissions and activity from power plants that exist today. For Annual Matching it is average and residual emission rates; for Hourly Matching it is CFE score; and for Carbon Matching is the marginal emission rates.

Annual Matching and Carbon Matching both have the useful accounting property that the sum of all power plant emissions that should be reported under these methods by the companies who generate the power (Scope 1 emissions) equals the sum of all power plant emissions that should be reported by companies who consume and procure the power (Scope 2 emissions). Hourly Matching, because it does not measure emissions and as currently proposed includes double counting, does not have this property.

An intriguing emerging new school of thought argues that carbon accounting should also consider the effect of corporate actions on power plants that do not yet exist. For example, a wind farm investment could not only reduce carbon emissions by displacing coal generation in a grid's operation but also by preventing a gas peaker plant from being built. This is known variously as a structural or "build" effect.

Research suggests that build effects may be significant. Thus, new build effect datasets are being developed that have been proposed to potentially add a build effect to Carbon Matching. Annual Matching and Hourly Matching, which also do not include a build effect, could potentially benefit from these improvements as well.

But, build effects are understudied and the same research also finds they are highly uncertain. At the time of this study build effect data did not even exist yet for most locations and time periods in the study. Therefore, build effect data were not included in this case study. WattTime recommends further research to explore the potential of build margin inclusion as an improvement in carbon accounting.

WattTime