GUIDE

Carbon-aware IT solutions: Choosing the right grid signals

A guide on leveraging granular grid signals to measure and reduce IT infrastructure emissions

ELECTRICITY MAPS

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The future of IT will be carbon-aware

Sustainability in IT is no longer a "nice-to-have" — with its rising electricity consumption and in the face of climate change, it is an operational necessity and a growing customer demand.

Data centers consumed 2% of global electricity in 2022 — about 460 TWh — resulting in 126 million tonnes of CO_2 emissions (**IEA report**). That's equivalent to nearly 10 times the electricity emissions of Ireland in the same year (**Electricity Maps**). And the impact is accelerating: According to the IEA, data centres' total electricity consumption is expected to more than double by next year, reaching more than 1 000 TWh in 2026 (**IEA report**).

1 year of global data center electricity emissions

9.77 times Ireland's yearly electricity emissions

Data centers and cloud computing are contributing more and more to global carbon emissions. The rapid adoption of AI is further amplifying this trend, with energy-intensive machine learning workloads driving higher electricity demand in IT operations. At the same time, machine-learning powered grid signals can be part of the solution — helping optimize workloads, predict energy-efficient scheduling, and dynamically adjust compute resources based on grid carbon intensity.

Organizations with energy-intensive IT infrastructure can leverage electricity grid signals to measure and reduce their carbon footprint effectively and meet the growing customer demand for carbon footprint reports to stay compliant and realize reduction opportunities. These signals are also the backbone of the growing number of frameworks and tools to manage IT emissions, such as the **Software Carbon Intensity (SCI)** specification or the **Kubernetes Emissions Insights Tool (KEIT)**.

This guide explores the types of electricity grid signals available, how to choose the right ones, and their applications in Green IT strategies.

Understanding electricity grid signals

Real-time grid signals or electricity signals are the cornerstone of building carbon-aware IT operations. Without accurate data on what is happening on the electricity grid, it is impossible to accurately measure and optimize the carbon footprint associated with IT operations, such as data center usage or cloud computing jobs.

Let's break down some of the key signals that can help IT organizations make informed decisions about optimizing their electricity usage:

Carbon intensity

Emissions associated with the consumption of electricity, measured in grams of CO_2 equivalents per kWh.

Electricity mix

Breakdown of electricity generation by energy source, providing insights into grid decarbonization.

Renewable energy (RE) percentage

Percentage of electricity generated from renewable sources like wind, solar, and hydro.

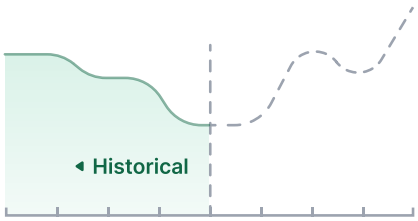
Carbon-free energy (CFE) percentage

Percentage of electricity generated from both renewable and low-carbon sources, incl. nuclear.

Grid signals can be provided for different temporalities. Historical, real-time, and predictive data can inform about the carbon footprint and power mix of the electricity:

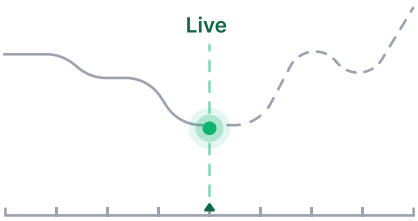
Historical data

Enables accurate carbon accounting, reporting, and historical analysis.



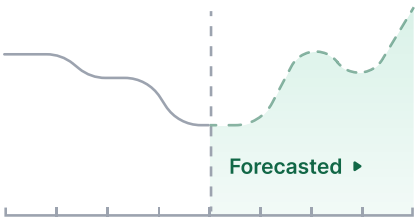
Real-time

Powers live analysis and decision-making, or dynamic product insights.



Forecasts

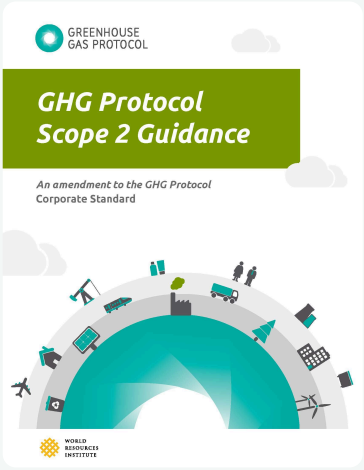
Up to 72h forecasts empower emissions reduction with load shifting.



Key considerations for selecting grid signals

To effectively measure and reduce IT emissions, organizations need reliable and actionable grid signals. The most important considerations include:

- **Flow-traced data:** The electricity mix available in each grid should be traced back through all power flows to reflect the actual origin of electricity consumed and associated emissions, avoiding misleading assumptions from production-based signals.
- **Spatial granularity:** As the electricity mix varies around the globe, emissions accounting and decision-making require using highly spatially granular grid signals that accurately reflect grid conditions in each region.
- **Temporal granularity:** As emissions can significantly fluctuate between days and between hours, accurate measurement requires a high temporal granularity of grid signals. Using hourly electricity data provides the most precise estimate of IT emissions, however, even daily or monthly data offer closer approximations than relying on yearly data.
- **Compliance**: Ensure you comply with current major regulations (GHG Protocol,SBTi, CSRD) by using signals based on an average accounting logic and avoiding marginal signals that are prohibited for Scope 2 accounting purposes. Anticipate upcoming regulations by leveraging flow-traced signals with high spatial and temporal granularity.
- **Verifiability**: Use consistent and verifiable data to ensure your sustainability initiatives lead to accurate and tangible emissions reduction while mitigating operational and reputation risk. Avoid signals that **cannot be measured or validated** against a ground truth, such as marginal signals.



GREENHOUSE GAS PROTOCOL

"Companies shall not use marginal emission factors [...] for a location-based scope 2 calculation"

GHG Protocol Scope 2 Guidance

Learn more about the limitations of using **marginal signals in practice**.

APPLICATIONS

Companies can integrate grid signals into their IT operations to drive sustainability and efficiency. Which signal is the most suitable depends on the specific use case. Let's go through the most common applications of electricity grid signals within IT operations:

1. IT emissions accounting and reporting

Effective decarbonization of IT infrastructure begins with accurate measurement of Scope 2 emissions. Calculating reliable emissions baselines is crucial for both internal and external reporting, ensuring compliance with current and upcoming sustainability standards.

- **Reporting scope 2 emissions**: To calculate their IT emissions in compliance with frameworks such as the GHG Protocol and Science-Based Targets Initiative (SBTi), companies should rely on grid signals calculated with an average accounting logic (as opposed to marginal signals, which are prohibited). Using hourly and flow-traced data anticipates current and upcoming developments in the regulatory landscape while ensuring the most accurate emissions accounting, considering emissions fluctuations in time and all electricity flows across the grid.
- **Internal carbon reports**: Precise IT emissions reports are the baseline for an impactful analysis that enables companies to understand, improve and demonstrate progress toward their decarbonization goals by leveraging both historical electricity data, as well as real-time insights.

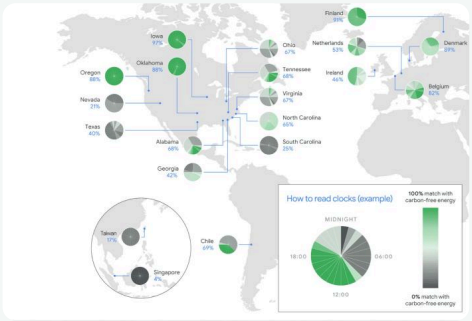
SIGNALS	TEMPORALITY	REGULATIONS
Carbon intensity	Historical	GHG Scope 2 Guidance
Electricity mix	Real-time	SBTi
		CSRD

Google

Google tracks its progress toward 24/7 carbon-free energy with hourly grid data

Electricity Maps' historical and real-time carbon intensity and electricity mix signals supports Google in tracking and progressing their global sustainability goals.

Learn more



2. Optimizing cloud and data center energy procurement

Data center operators and cloud providers can use historical and real-time grid signals to inform electricity procurement strategies.

- **Hourly carbon-free energy matching:** Many tech companies, such as Google and Microsoft, aim for operating on 24/7 or 100/100/0 carbon-free energy (CFE), meaning that their power consumption is matched with renewables every hour, not just on an annual basis. Granular CFE signals allow optimizing power purchasing to ensure real-time alignment with clean electricity.
- **Strategic renewable electricity contracts:** While traditional PPAs (Power Purchase Agreements) secure renewable electricity on an annual basis, having access to hourly data allows better structuring of contracts that match the actual consumption patterns of data centers. This way, companies can prevent over-reliance on offsets and enhance their procurement of renewables during peak usage hours.
- **Energy storage optimization:** Hourly grid emissions signals enable data centers to optimize energy storage by charging batteries when clean electricity is abundant and discharging when grid carbon intensity is high. This can reduce carbon emissions and reliance on more costly fossil fuel-based electricity, minimizing electricity expenses.

SIGNALS

- Carbon intensity
- Electricity mix
- Carbon-free energy %

TEMPORALITY

- Real-time
- Historical

REGULATIONS

- GHG Scope 2 Guidance
- SBTi
- CSRD

Microsoft

Microsoft uses granular grid data to achieve their 100/100/0 target

The company uses historical and real-time carbon intensity signals to match its energy consumption with carbon-free electricity on an hourly basis.

Learn more

3. Carbon-aware IT load shifting

Shifting IT workloads to periods and locations with lower emissions can significantly reduce a company's carbon footprint.

- **Temporal load shifting**: Many IT processes, such as batch processing, backups, and non-urgent computations, can be scheduled during periods of lower carbon intensity. In regions such as California, Texas, Germany, and the UK, with high renewable energy fluctuations, shifting workloads within a 72-hour window can reduce emissions by over 50%.

Aligning compute load with renewable energy availability, Source: Google client story.

- **Spatial load shifting**: Compute-heavy workloads can be relocated to data centers in regions with a higher low-carbon share or greater renewable energy availability, minimizing the use of fossil-based electricity and reducing emissions.
- **Automated carbon-aware scheduling**: By integrating predictive grid signals, IT workloads can automatically and dynamically be scheduled based on forecasted changes in grid carbon intensity, ensuring optimal emissions reductions without impacting operations effectiveness.

SIGNALS	TEMPORALITY	TOOLS & FRAMEWORKS
Carbon intensity	Forecast	SCI (Software Carbon Intensity)
Renewable %	Real-time	KEIT (Kubernetes Emissions Insights Tool)
		Grid-aware websites project

Google

Google aligns data centers workloads with low-carbon electricity to reduce their carbon footprint

Google's carbon-aware computing platform uses carbon intensity and renewable % forecasts to smartly shift computing tasks.

Learn more

4. Empowering customers with emissions insights

Organizations that provide digital services can integrate electricity grid signals into their platforms to meet customers' needs for sustainability data that enables compliant carbon reporting in line with regulation, as well as carbon reductions to reach their net-zero targets.

- **Product carbon footprint:** Cloud platforms and tech product providers can integrate real-time carbon intensity tracking into their product offering, giving customers visibility into the carbon footprint of their product usage and enabling them to accurately report its emissions.
- **Carbon-aware cloud operations**: Predictive emissions signals allow businesses and customers to make informed choices about where and when to deploy computing resources, optimizing for reduced electricity emissions and prices.
- **Green IT as a service**: Companies can differentiate themselves by offering carbon-aware IT solutions that enable customers to reduce emissions through carbon-aware scheduling and energy procurement, supporting them in their net-zero progress.

SIGNALS

- Carbon intensity
- Electricity mix
- Carbon-free energy %
- Renewable %

TEMPORALITY

- Forecast
- Real-time
- Historical

REGULATIONS

- GHG Scope 2 Guidance
- SBTi
- CSRD

TOOLS & FRAMEWORKS

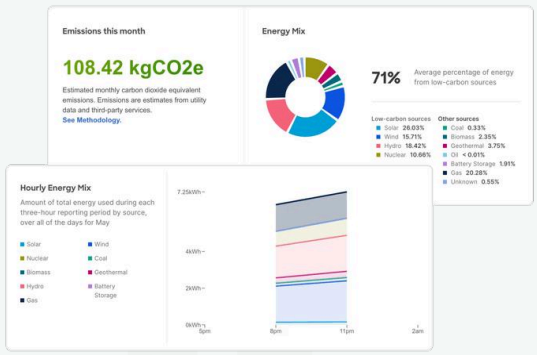
- SCI (Software Carbon Intensity)
- KEIT (Kubernetes Emissions Insights Tool)
- Grid-aware websites project

CISCO

Cisco helps customers track their data center network emissions

The Cisco Nexus Dashboard offers Cisco customers visibility into their tech carbon footprint, leveraging carbon intensity and electricity mix signals.

Learn more



CONCLUSIONS

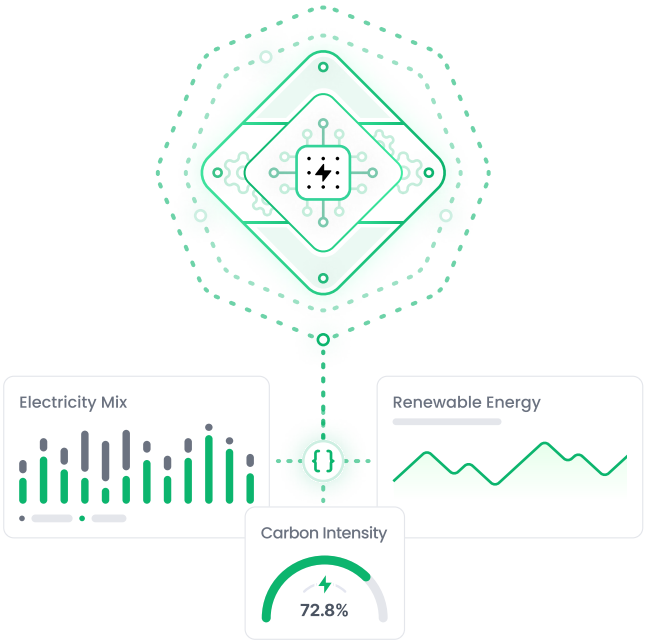
Adopting electricity grid signals in IT operations enables organizations to move beyond compliance-driven sustainability efforts and take proactive steps to reduce emissions and reach their net-zero targets.

Global companies can play a crucial role in decarbonizing the IT landscape: By leveraging flow-traced electricity grid signals organizations can truly understand their emissions impact, make their IT operations carbon-aware, and empower their customers on their journey to report and reduce emissions by integrating better emissions insights into customer solutions.

Ready to make your IT carbon-aware?

Electricity Maps provides the best-in-class API for electricity grid signals. A single endpoint delivers real-time, historical, and forecasted electricity signals, empowering organizations around the globe. Customers benefit from:

- Market-leading **accuracy** backed by quality SLAs and compliance with leading standards, including the GHG protocol and SBTI.
- A **single API** resolving data integration complexity by covering all necessary grid signals, standardized for over 150+ countries.
- Leading **industry standard**, already used by leading technology companies, incl. Google, Microsoft, and Cisco.
- Expert **advisory** on the best signals to use for accurate calculations and real-world emissions reductions.



Contact us to discuss how Electricity Maps' API can support your specific use case to help you reach your sustainability goals.

Get started today

Explore our API with a free trial or talk to our team to get answers to your questions.

Contact us | Start using our API

Learn more about our product offering on **our website.**

ELECTRICITY MAPS