WHITEPAPER

Methodology for the electricity mix and derived signals

A validation of Electricity Maps methodology for electricity mix, carbon intensity, renewable energy percentage, and carbon-free energy percentage data

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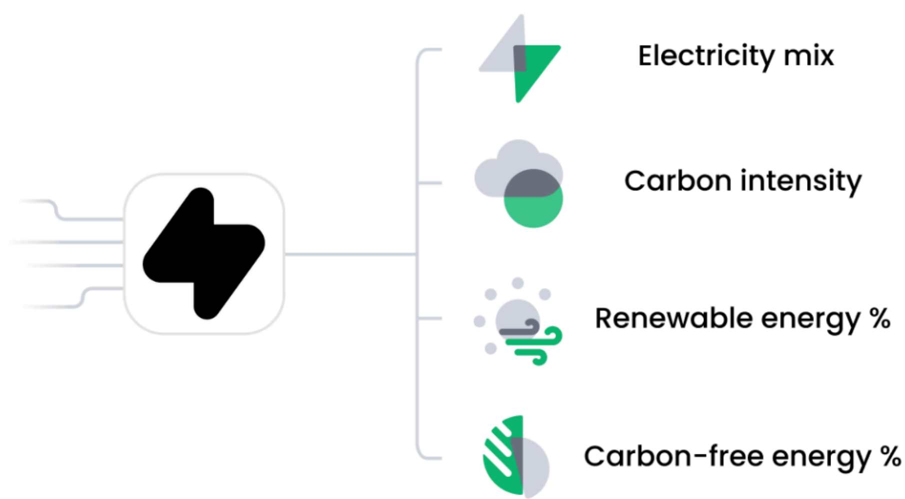

Electricity Maps

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Executive summary

Electricity Maps provides a range of data for electricity grids worldwide with high spatial and temporal granularity. Besides high granularity, Electricity Maps leverages the flow-tracing method to account for electricity flows across power grids and provide data with the highest accuracy. In particular, Electricity Maps carbon intensity, renewable energy percentage, and carbon-free energy percentage data can be used to calculate location-based emissions for scope 2 reporting.

This whitepaper provides a detailed overview of the Electricity Maps methodology for electricity mix data, carbon intensity, renewable energy percentage, and carbon-free energy percentage signals. It also describes the flow-tracing method used by Electricity Maps, which is one of the primary differences between Electricity Maps and other data sources, along with data granularity. The flow-tracing method traces back all electricity flows across interconnected grids to calculate the electricity mix available in each grid, considering local electricity generation as well as electricity flows. Flow-traced data with high spatial and temporal granularity provided by Electricity Maps is more accurate for emissions accounting and reporting than data sources such as the International Energy Agency.

Electricity Maps data is validated against alternative sources, including worldwide sources (Ember, IEA), and authoritative regional sources (Eurostat). The validation is run on production-based yearly-aggregated data. On average, the difference between Electricity Maps data and these datasets remains below 2.1 percentage points for the renewable energy and carbon-free energy percentage data worldwide. This demonstrates the validity of Electricity Maps data.

Finally, this whitepaper clarifies the process used by Electricity Maps for data updates as well as data publication through the publicly available datasets and the API. Electricity Maps data is regularly updated to leverage consolidated data available from primary data sources. On average, 90% of data points in each zone reach their final value within 37 days for the renewable energy percentage, and 51 days for carbon intensity. These updates enable Electricity Maps to provide the most up-to-date and accurate historical and real-time data while remaining compatible with accounting and reporting use cases.

Customers & scientific references

Electricity Maps data is used today by leading companies worldwide, including Google, Cisco, and Schneider Electric for purposes such as accounting and reporting their emissions both internally, and externally for their customers and end-users. The Electricity Maps API also served an average of 20 million requests per day with 99.98% uptime in 2025.

Finally, Electricity Maps is a trusted partner in the academic world, collaborating with leading research institutions and providing its data for free to researchers worldwide. At the end of 2024, Electricity Maps had provided data or been cited by more than 100 scientific publications. The publication [1] co-authored by Electricity Maps in 2017 that introduces the flow tracing method used by Electricity Maps and applies it to the European grid has received more than 100 citations.

Used by more than 300M users worldwide. Trusted by leading companies, including:

Concepts, scope, and definitions

When measuring the environmental impact of human activity, some fundamental methodological choices have to be made. This is also the case when measuring the climate impact of electricity consumption, which is at the core of the data provided by Electricity Maps. This section introduces the most important concepts and definitions that are relevant for understanding the Electricity Maps data offering, as well as its scope.

Attributional vs consequential approach

The first and most important choice that has to be made is to define and select what kind of method should be used for assessing climate impacts. **Inventory accounting** (also called **attributional accounting**) is used by companies and organizations to report greenhouse gas (GHG) emissions and removals over time. **Project-based accounting** (also called **consequential accounting**) is used to quantify changes in GHG emissions and removals of a specific project compared to a counterfactual baseline scenario. Read more about the key differences between these two methodologies in the comparative review[1] from the GHG Protocol.

Leading standards for carbon accounting and reporting worldwide, such as the Greenhouse Gas Protocol Scope 2 Guidance[2] and the SBTi Corporate Near-term Criteria[3], require the use of an attributional approach. Additionally, a number of climate-related disclosure rules worldwide reference the GHG Protocol Scope 2 Guidance and, by extension, also require an attributional approach[4]. Electricity Maps data is suited for calculations following an attributional approach.

Location-based vs market-based

Two different approaches exist for calculating GHG emissions from electricity consumption within the attributional method, and numbers for both of them must be reported. As described by the GHG Protocol Scope 2 Guidance in section 4.1 on “Approaches to accounting scope 2”[2], *“the market-based method reflects emissions from electricity that companies have purposefully chosen (or their lack of choice), while the location-based method reflects the average emissions intensity of grids on which energy consumption occurs”*.

Electricity Maps data represents emissions following a **location-based approach** where electricity from different sources, such as wind, solar, coal, and others, gets mixed in the electricity grid and cannot be unmixed anymore. This is the closest representation of the actual electricity mix consumed from the grid, and the associated emissions. Location-based data does not reflect electricity purchases or investments made by companies. Location-based data can also be used in market-based calculations, in place of residual mix data, according to Table 6.3 of the Scope 2 Guidance[2].

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[1] Inventory and Project Accounting: A Comparative Review | GHG Protocol
[2] Scope 2 Guidance.pdf
[3] Corporate Near-term criteria V5.2
[4] GHG-Protocol-Integration.pdf

Spatial granularity

At Electricity Maps, spatial units are called **zones**. A zone represents a physical network where power lines connect power plants generating electricity to consumers. Most zones represent an **electricity grid,** where an operator is responsible for the network's reliability which might involve transmitting electricity to neighboring grids. Accounting for these electricity flows between grids is crucial to accurately represent the physical reality. Electricity Maps aims to display the smallest subdivision of electricity grids within the limits of data availability. A zone might not always exactly overlap with political entities such as countries or federal states, but often does.

Temporal granularity

Electricity Maps gathers data with different levels of **temporal granularity**. Electricity Maps provides data at the highest level of temporal granularity available, and at least hourly (when data is only available at lower granularity). Electricity Maps also provides **aggregation** of its data both on the temporal level (days, months, and years) and the spatial level (countries).

Electricity mix

Electricity Maps operates with a harmonized subdivision of **electricity production technologies**, all gathered in Table 1. The **electricity mix** can be expressed as a relative share of each technology or as their absolute power or energy output. The power output is expressed in **megawatts (MW)** and represents the instantaneous output of a power plant or technology. The energy output is expressed in **megawatt hours (MWh)** and represents the output of a power plant or technology over time. A power plant generating 500MW of power over 1 hour will generate 500MWh of energy. For larger amounts of power and energy, Electricity Maps also uses gigawatts (GW), gigawatt hours (GWh), terawatts (TW), and terawatt hours (TWh); for smaller amounts, kilowatt (kW) and kilowatt hours (kWh) are used.

Flow-tracing

As described in the above section on spatial definition and granularity, electricity grids can transmit electricity with neighboring grids via so-called **interconnectors**. The **electricity production mix,** which ignores the electricity flows through these interconnectors, in most cases does not accurately represent the mix of electricity available to consumers on the grid, also called the **flow-traced electricity mix** (or electricity consumption mix). To calculate the flow-traced electricity mix in a given zone, Electricity Maps uses a flow-tracing method. This peer-reviewed scientific approach [1, 2, 3] is used to trace back the flows of electricity across all interconnected grids, even in the presence of loop flows, to accurately represent the mix of electricity available in a given zone.

Emission factors

Emission factors (also called fuel emission factors) quantify the emissions induced when generating a unit of electricity using a specific technology (e.g. wind, solar, or coal). The technology used, the facilities' age, and the geographical location are some parameters that influence these factors. They are a ratio usually expressed in grams of CO_2 equivalent per kilowatt hour of electricity generated (gCO_2/kWh).

There are two main types of emission factors, each of them relying on a different methodology and capturing a different scope: direct emission factors (also called operational or combustion emission factors) and life cycle emission factors.

- **Direct emission factors** include only the emissions that occur from combusting the fuel.
- **Life cycle emission factors** include not only the emissions that occur from combusting the fuel, but all other emissions that occur in the life cycle of the fuel such as emissions from extraction, processing, and transportation of fuels.

Direct emission factors are required in the GHG Protocol Scope 2 guidance[5]. Both types of emission factors are supported by Electricity Maps.

For a full review of Electricity Maps emission factors, download the report here.

[5] Corporate Standard Frequently Asked Questions | GHG Protocol

Signals

Based on the flow-traced electricity mix, Electricity Maps calculates different indicators, also referred to as **signals**. A signal is an easy-to-interpret indicator that gives insights into the impacts of electricity consumption and allows comparison across space and time.

The first signal is called **carbon intensity (CI),** which represents the amount of greenhouse gas emitted per kWh of electricity consumed. It can be calculated for each hour in each zone by combining power mix data with technology-specific emission factors.

Besides carbon intensity, other indicators can represent the impact of electricity consumption, such as the share of low-carbon technologies, referred to as the **carbon-free energy percentage (CFE%)**, and the share of renewable technologies, referred to as the **renewable energy percentage (RE%)**. The classification of each electricity production technology as either low-carbon and/or renewable is summarized in Table 1.

Table 1: Categorization of different electricity production technologies regarding Carbon-Free Energy and Renewable energy.

Technology	Carbon-Free Energy (CFE%)	Renewable Energy (RE%)
Coal		
Gas		
Oil		
Unknown	Zone-specific	
Nuclear	X	
Wind	X	X
Solar	X	X
Hydro	X	X
Geothermal	X	X
Biomass[6]	X	X
Hydro storage	Zone-specific	
Battery storage		

[6] A distinction between sustainable and non-sustainable biomass is not made as supply-chain certification data is not tracked in real-time or hourly generation feeds provided by primary grid operators (e.g., ENTSO-E, EIA). Consequently, direct combustion CO_2 emissions are treated according to applicable regulatory frameworks (e.g., EU-ETS rules), while life cycle factors reflect average regional or global biomass feedstocks.

Methodology

This section explains the Electricity Maps methodology, building on the concepts and definitions introduced above and using the data processing pipeline as a point of reference.

Simplified overview of the data processing pipeline

Figure 1 represents a simplified version of the Electricity Maps data processing pipeline for the electricity mix, carbon intensity (CI), renewable energy percentage (RE%), and carbon-free energy percentage (CFE%) calculations. The paragraph below describes this pipeline high-level and the next sections dive into the methodology used at each step of the pipeline.

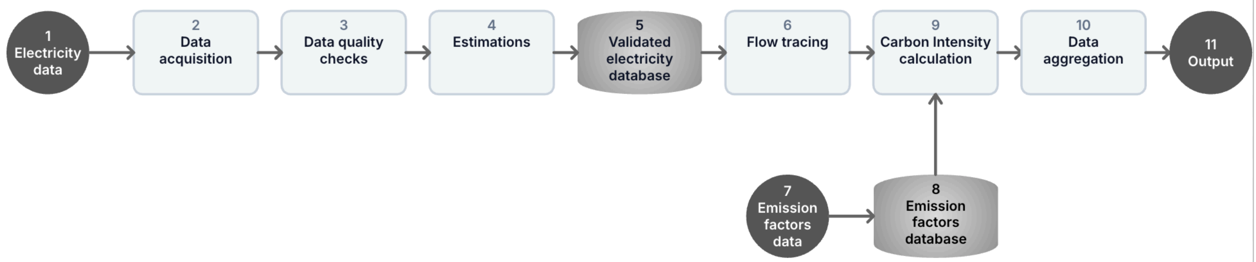

Figure 1: Simplified representation of Electricity Maps pipeline for carbon intensity, carbon-free energy percentage, and renewable energy percentage calculation.

All Electricity Maps data is calculated based on the highest-quality data available (**step 1**). The pipeline starts by ingesting this electricity data using data integrations (**step 2**) that collect and transform it into a standardized format. This includes data on production mix and electricity flows. Quality tests are performed before the data is ingested in Electricity Maps systems (**step 3**). All invalid data points detected are removed, and estimation models are used to replace missing data (removed invalid data points, data gaps, data delays...) (**step 4**). The now complete and quality-guaranteed data is stored (**step 5**). The next step consists of applying the flow-tracing algorithm, which computes the electricity consumption mix based on the electricity production mix and electricity flows (**step 6**). Once the flow-traced mix is obtained, it can be used to calculate the following signals: renewable energy percentage (RE%), and carbon-free energy percentage (CFE%). The calculation of the carbon intensity (CI) signal (step 9) requires emission factors to be previously sourced (**step 7**) and stored in a separate database (**step 8**). All data is aggregated at different time granularities (sub-hourly, hourly, daily, monthly, yearly, etc.) (**step 10**) and delivered through Electricity Maps platforms (**step 11**): App, API, and data sets for carbon accounting available on request.

Input data & data parsers (steps 1 & 2)

Data sources

Electricity Maps collects electricity data from a range of data sources. This data includes:

- Electricity production mix
- Electricity flows between zones
- Electricity load (also called electricity demand)

Electricity Maps uses a list of criteria (authoritative data sources, primary data sources, regulations, data accuracy, data confirmability, and rigorous and transparent methodology) to only ingest accurate and high-quality data from credible and trustworthy data sources.

Data sources with a high degree of credibility include authoritative data sources (internationally or regionally), data sources publishing data validated against supranational trusted data sources, and data sources under legal requirements regarding the quality and provision of this data. This entails government sources like energy ministries, government-affiliated sources such as official statistical bureaus, transmission system operators, and utility companies directly generating electricity. Examples of data sources integrated by Electricity Maps are the EIA in the US, the ENTSO-E in Europe, the Grid Controller of India[7], the Tokyo Electric Power Company Holdings in Japan, and the IEA or Ember for monthly and yearly-aggregated data worldwide. All data sources used by Electricity Maps are made publicly available.

Data acquisition

The fact that contributing to the Electricity Maps product is open to the public comes with many benefits, such as contributions from experts and increased scrutiny. Contributions, feedback, and reviews from experts have enabled the development of regional emissions factors, and the identification of high-quality electricity data sources in several regions.

The data is acquired from many sources through data integrations called **parsers** that convert it to a standardized format. Contributing to building new parsers and updating current ones is open to the public. To ensure these parsers fulfill certain quality criteria, several guidelines[8,9,10] are used and enforced to control quality.

In addition to these guidelines, all contributions to the Electricity Maps open-source project follow a thorough contribution lifecycle described here that includes automated tests and multi-stage approval from Electricity Maps employees before acceptance.

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[7] https://grid-india.in/en/, only accessible from India
[8] https://github.com/electricitymaps/electricitymaps-contrib/blob/master/CONTRIBUTING.md
[9] https://github.com/electricitymaps/electricitymaps-contrib/blob/master/parsers/README.md
[10] https://github.com/electricitymaps/electricitymaps-contrib/wiki/Building-a-new-parser

Data quality checks & estimation (steps 3 & 4)

Data quality checks

All data collected by parsers is continuously and automatically validated according to a list of quality checks. These checks are regularly enriched and improved over time, and, for all data worldwide, consist of rules such as:

- The *exceeded-capacity rule*: detects if, within a certain time interval, the maximum capacity of a zone is exceeded for a production mode or an exchange. For example, if a data source reports 15GW of wind generation in a zone with 10GW of installed wind capacity, the data will be flagged as invalid.
- The *expected mode rule*: detects if, within a certain time interval, an expected production mode is not reported. For example, if a data source reports no gas generation in a zone with only gas generators, the data will be flagged as invalid.

All events flagged as invalid by one of the quality checks are removed and replaced by estimated data (also known as imputation). If the data source later returns an updated data point that is no longer flagged as invalid, Electricity Maps data is updated with the newest data available. Electricity Maps keeps track of all data points removed and replaced in all zones, as well as all data updates.

Estimation models

Electricity Maps uses a range of estimation models to generate synthetic data in the presence of invalid data, delays, or temporary or permanent data gaps. Electricity Maps uses different estimation methods for different grids depending on their level of data availability. In this regard, zones are divided into three tiers:

A. *Tier A* comprises all zones where hourly data is available for the full power mix. The Time Slicer Average estimation method is used in the presence of data gaps and outliers, and for so-called now-casting when data is delayed. The model fills in gaps by using neighboring observations to guarantee data completeness.
B. *Tier B* comprises all zones where hourly data is partially available. Zone-specific estimation models are developed to leverage available hourly data and estimate the remaining data. These models are validated against available hourly data.
C. *Tier C* comprises all zones where only monthly or yearly data is available. The General Purpose Zone Development model is used to estimate hourly data from the available data. It guarantees that aggregated hourly data sums up to available monthly and yearly data. The model is trained and validated on zones with the full power mix available.

An overview of all Electricity Maps zones and the tier they belonged to in January 2025 is available in Table A1 of Appendix A. Documentation about the estimation methods is available in Appendix B. Validation of these models with performance metrics is available in the Data Validation section. Additional documentation and validation can be provided on demand.

Validated electricity database (step 5)

Electricity Maps stores all collected and validated data for all zones worldwide. It includes data that passed all quality checks and data from proprietary estimation methods. In addition, Electricity Maps keeps a record of all updates made to each data point over time, including the values and where each data point originates from (data source, estimation model) for each update. Thus, Electricity Maps has a complete data lineage that ensures the traceability of all data updates.

Flow-tracing (step 6)

Flow-tracing is the methodology used to trace back the origin of consumed electricity. The concept was introduced in 1996 by J. Bialek [2]. It has been applied to the European [1] and US [3] electricity grids in scientific publications. It is a peer-reviewed and validated methodology to account for electricity exchanges in the grid mix.

The flow-tracing methodology calculates the electricity consumption mix to reflect what is available on a grid (as a mix of local generation and imports). It relies on two rules: (1) *Proportional mixing* assumes that all electricity produced from different local sources (i.e. the different production technologies) and imported from neighboring grids is mixed proportionally to their respective amount of energy; and (2) *Irreversibility* assumes that all electricity consumed in the grid has a mix of the same proportions of the grid mix, i.e., once mixed in the grid, electricity cannot be unmixed anymore. This implies that electricity exported by a zone is made of the same mix as the electricity available in that zone. This further implies that flow-traced data on a specific zone already considers the potential case that a zone imports electricity from a zone that also imports electricity, accounting for this ad infinitum. This is achieved by calculating the consumption mix for all zones simultaneously using matrix algebra. The flow-tracing algorithm traces back all flows on the grid, beyond the closest neighbors, and even in the presence of loop flows (A loop flow happens when three grids A, B, and C have the following exchange structure: A → B → C → A such as between Bulgaria, Serbia, and Romania in the example below).

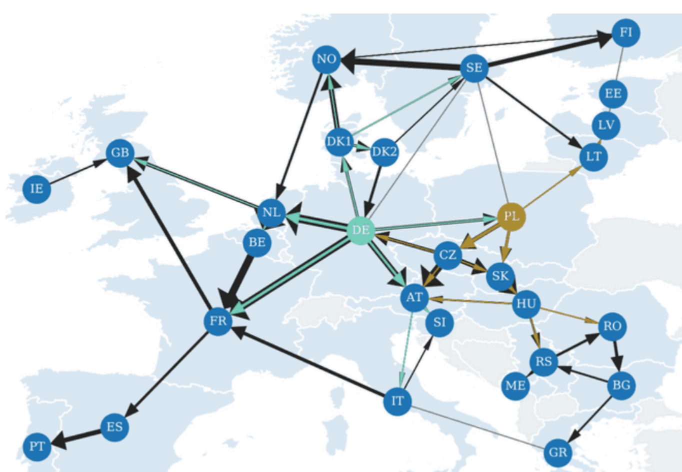

Figure 2: Graphical representation of electricity flows in Europe.

Figure 2 shows electricity flows in the European electricity grid for a specific hour. For simplicity, all zones are aggregated on the country level. The width of the arrows is proportional to the electricity traded and transmitted between zones. The share of German wind production (turquoise) and Polish coal production (brown) have been highlighted in this example. The electricity mix from these two countries cascades to all interconnected countries through interconnectors. For the sake of representation, the arrow is not drawn anymore when the share becomes too small (even though the flow is still taken into account by the algorithm).

Overall, it is crucial to include exchanges in the electricity mix. More than 10% of electricity emissions come from imported electricity. Ignoring exchanges can cause a difference of up to twice the carbon emissions accounted for, with errors typically in the 10-15% range.

Emission factors (steps 7 & 8)

In parallel with the validated electricity database for electricity mix data, Electricity Maps also collects and stores technology-specific emission factors, with one direct and one life cycle emission factor per technology and grid. Electricity Maps uses global values for all grids worldwide and, when possible, computes grid-specific factors.

Global emission factors used by Electricity Maps come, for most technologies, from Annex III of the IPCC (2014) Fifth Assessment Report [4] which contains greenhouse gas emission factors for electricity and heat. Global emission factors used by Electricity Maps are available in Table C1 of Appendix C.

In Europe, Electricity Maps computes grid-specific direct emission factors from the power-plant emissions data of the European Union's emissions trading scheme (EU-ETS) and the power-plant production data of ENTSO-E. Life cycle emission factors are calculated by adding upstream emission factors from widely acknowledged data sources, such as Annex III of the IPCC (2014) Fifth Assessment Report [4] and the UNECE 2022 report [5].

In the United States, Electricity Maps computes grid-specific direct emission factors from the power-plant emission and production data of the US Environmental Protection Agency's Emission & Generation Resource Integrated Database (eGRID). Life-cycle emission factors are calculated by adding upstream emission factors from widely acknowledged data sources.

The Electricity Maps methodology for regional emission factors with a higher granularity has been developed with the collaboration and review of leading experts in electricity emissions data and life cycle analysis. A white paper describing the Electricity Maps methodology for emissions and validating it against the methodology from the IEA was first published in 2024.

Electricity Maps updates regional emission factors on an annual cycle, subject to the publication schedules of primary data providers. When primary dataset updates are delayed or unavailable, the most recent verified data release is maintained to ensure methodological stability and reporting continuity.

Carbon Intensity calculation (step 9)

The carbon intensity calculation represents the final synthesis of the data pipeline, where the physical electricity consumption mix determined via flow-tracing (Step 6) is multiplied by the corresponding technology-specific emission factors (Steps 7 & 8).

The calculation yields an hourly indicator of GHG emissions per unit of electricity consumed, expressed in grams of carbon dioxide equivalent per kilowatt-hour (gCO2e/kWh). This calculation explicitly accounts for a comprehensive scope of greenhouse gases relevant to climate inventories, including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), converted using standard global warming potential (GWP) coefficients.

To accommodate different accounting boundaries and reporting use cases, the pipeline independently executes two distinct calculation streams:

1. **Direct Carbon Intensity:** This stream uses direct operational emission factors representing combustion-only emissions at the power plant stack. This physical attribution metric aligns with the foundational data criteria required for standard corporate GHG Protocol Scope 2 Location-Based carbon accounting.

2. **Life Cycle Carbon Intensity:** This stream incorporates electricity life cycle data, accounting for both combustion and upstream/downstream life cycle phases (such as fuel extraction, transport, and infrastructure development).

GHG Protocol Scope 2 and 3 compliance

The Life Cycle Carbon Intensity metric encompasses the complete emissions footprint of electricity consumption for GHG Protocol carbon accounting by incorporating both Scope 2 direct emissions (power plant combustion) and Scope 3 Category 3 indirect emissions (upstream fuel extraction, processing, transportation, and infrastructure development).

As necessary, reporting entities using Electricity Maps data can isolate the exact delta between the life cycle and direct values to populate Scope 3 Category 3 (Fuel- and Energy-Related Activities) inventories natively, without introducing interpretive ambiguity or risking double-counting under Scope 2 boundaries.

The final carbon intensity results undergo automated internal validation checks against historic thresholds and regional statistical bounds to ensure the algorithmic integrity of the system before passing to the final aggregation layer.

ISO-14064 compliance

To ensure compliance with ISO 14064-1:2018 requirements, reporting entities can properly map Electricity Maps carbon intensity to their corresponding indirect greenhouse gas emission categories:

- **Category 2:** Indirect greenhouse gas emissions from imported energy: Organizations reporting grid electricity under Category 2 should utilize Electricity Maps Direct Carbon Intensity. This accounts solely for physical emissions occurring at the generation stack during power production, fully satisfying the location-based direct energy imports criteria.

- **Category 4:** Indirect greenhouse gas emissions from products used by an organization: Upstream emissions associated with fuel extraction, refining, transport, and power generation infrastructure fall under Category 4 (specifically upstream energy-related activities). Reporting entities can natively quantify these emissions by calculating the delta between the Electricity Maps Life Cycle Carbon Intensity and Direct Carbon Intensity. Alternatively, if an organization chooses to report its total energy-related footprint comprehensively within Category 4 under a complete life-cycle boundary, the full Life Cycle Carbon Intensity metric may be applied directly.

By applying this structured allocation, organizations maintain clear reporting boundaries, prevent the double-counting of operational versus upstream supply-chain emissions, and preserve full traceability during third-party ISO 14064-3 verification.

Data aggregation and output (steps 10 & 11)

Finally, all data is aggregated to the same temporal resolution. The data pipeline output consists of all signals (generation and flow-traced mix, RE%, CFE%, CI) per zone and aggregation period (e.g., hourly, daily, monthly).

Data validation

Validation of yearly data

This section aims to validate the renewable energy percentage and carbon-free energy percentage numbers of Electricity Maps by running a comparison against the International Energy Agency (IEA) and Ember, both of which have a global focus.

The following two subsections present the comparison results. The methodology used to source and compare data is available in Appendix D, with results for all geographies available in the respective datasets.

The data from the IEA and Ember are compared to production-based Electricity Maps data, as the two sources do not include electricity flows in their calculations. The comparison focuses on yearly-aggregated data from 2025, the most recent year available for all three data sources. Detailed results for all available geographies can be found in Table D2.1 and Table D2.2 of Appendix D.

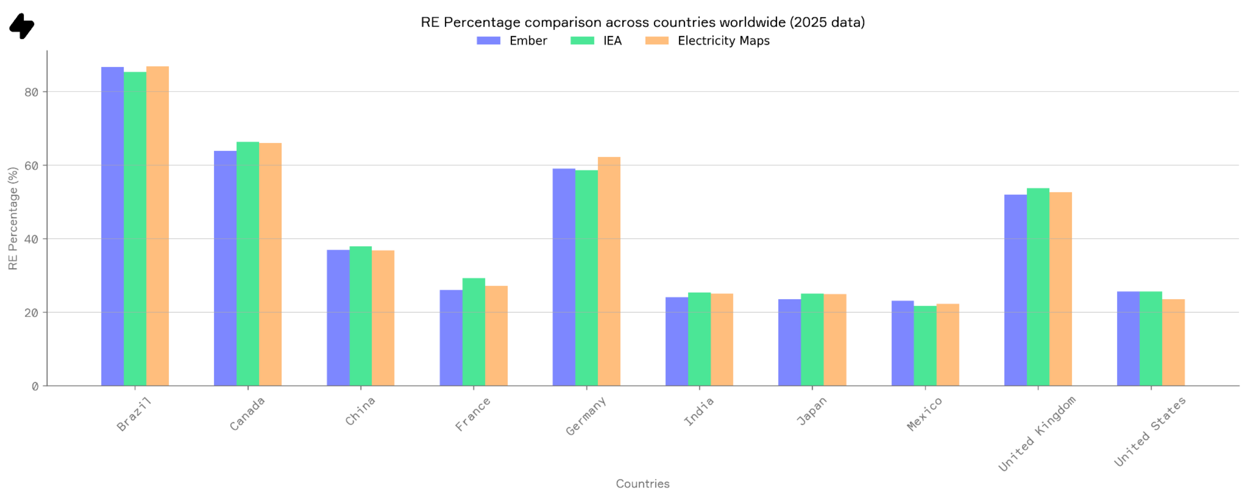

Figure 3: Comparison of the renewable energy percentage for different data sources across selected countries in 2025.

The comparison for the RE% in Figure 3 shows that the three datasets overall have consistent values for all geographies. In some countries, the Electricity Maps value can deviate slightly from one dataset but remain consistent with the other one, highlighting that these deviations are not only applicable to Electricity Maps data.

The median absolute differences between the data sources for the 90 countries considered are 1.4 percentage points (pp) between Ember and the IEA, 2.1 pp between Ember and Electricity Maps, and 2.1 pp between Electricity Maps and the IEA. All three datasets are highly correlated (between 0.97 and 0.99correlation). Based on these values, Electricity Maps data for the RE% over 2025 is consistent with values provided by Ember and the IEA worldwide.

In addition to absolute differences between datasets, the median difference is also computed to analyze if the Electricity Maps dataset shows any bias compared to the other datasets, such as a consistently higher RE%. This reveals that, on average, Electricity Maps RE% is 0.2 percentage points lower than Ember data and 1.1 percentage points lower than the IEA data.

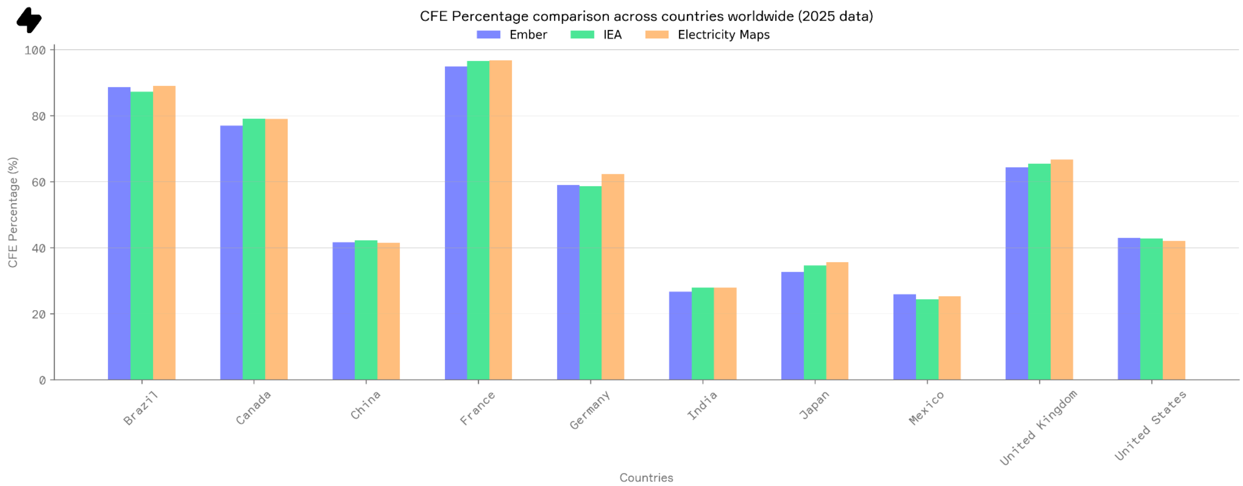

Figure 4: Comparison of the carbon-free energy percentage for different data sources across selected countries in 2023.

The comparison of CFE% shown in Figure 4 does not yield notably different results compared to the RE% presented above. The median absolute differences are of similar order, with 1.9 pp between Ember and Electricity Maps and 1.9 pp between Electricity Maps and the IEA. The bias analysis also does not show any major differences, with the Electricity Maps value being, on average, 0.2 percentage points lower than the Ember value and 0.1 percentage points lower than the IEA. Electricity Maps RE% and CFE% data is thus consistent with these two widely acknowledged data sources.

Validation of hourly estimations

Electricity Maps uses two main estimation methods introduced earlier: the TSA model and the GPZD model. The TSA model estimates mainly temporary data gaps and delays that are later replaced by data provided by data sources. It therefore has a non-material impact on reported data at the end of the year as less than 1% of data points remain estimated with this method.

The validation section focuses on the GPZD model that estimates hourly data for zones where only monthly or yearly data is available, as for these zones, data remains estimated even after months. Validation is performed by running the GPZD model for zones where hourly data is available, with the same input as for the zones it is applied to, and comparing the estimated data to data reported by available data sources. This gives a representative overview of the model's accuracy.

The validation was run on a set of 10 representative zones worldwide: Australia New South Wales (AU-NSW), Central Brazil (BR-CS), Germany (DE), Spain (ES), France (FR), India West (IN-WE), Japan Tokyo (JP-TK), US California (US-CAL-CISO), US Texas (US-TEX-ERCO), and South Africa (ZA).

For each, GPZD is applied over the full year 2025. Based on its results, the RE% and CI are computed (for production-based data, with life cycle emission factors) and compared to actuals. GPZD can estimate hourly data from both monthly and yearly totals. Both methods are evaluated.

On average, across the 10 representative zones considered, the estimated hourly CI from yearly totals has an average error of 37 gCO2e/kWh, which represents 16.5% of the yearly value. For renewable energy percentage, this error represents 6 percentage points. By construction, the model has no bias over a year as it ensures yearly aggregated of hourly estimates correspond to yearly totals used in input.

The GPZD model produces hourly estimates from yearly totals with low error on final RE% and CI and that are aggregate to published yearly totals. Therefore, in zones where granular data is not available, it constitutes a robust method.

Mean Absolute Error	RE% monthly to hourly	RE% yearly to hourly	CI monthly to hourly		CI yearly to hourly	
	percentage points	percentage points	gCOe/kWh	%	gCOe/kWh	%
Average	*4*	*6*	*26*	*10.7%*	*37*	*16.5%*
AU-NSW	6	6	44	9%	50	10%
BR-CS	2	6	11	10%	36	32%
DE	6	9	49	13%	77	21%
ES	5	6	22	16%	28	20%
FR	2	3	6	22%	10	33%
IN-WE	3	4	23	4%	32	5%
JP-TK	4	5	20	4%	24	5%
US-CAL-CISO	5	8	27	16%	41	23%
US-TEX-ERCO	6	8	38	10%	48	13%
ZA	2	3	18	3%	22	3%

Data publication and versioning

This section covers how data publication and data versioning work in Electricity Maps data sets and the Electricity Maps API.

The data points are marked according to the beginning of the time frame they are valid for, and all dates are in the UTC timezone. For example, with an hourly granularity, the data point marked with the date and time '2024-01-10T10:00:00Z' represents the timeframe spanning from 10 am to 11 am on the 10th of January 2024 in the UTC timezone.

Data sets

Electricity Maps provides historical flow-traced signals (carbon intensity, renewable energy percentage, carbon-free energy percentage) via selected data sets available on request for carbon accounting. Data is available for 2021 and onwards, per zone and country, and can be retrieved on an hourly, daily, monthly, and yearly aggregation level.

In case of major data source or emission factor updates and changes, data for a given year can be updated more than once a year. To ensure that changes in data can be traced, snapshots of current and previous versions are stored in the Electricity Maps database and provided on request.

API

Electricity Maps data is also available through an API. The data is available historically, in real-time, and forecasted. Data provided can be updated over time for different reasons. An example is when data coming from external data sources is delayed and has been estimated in the meantime. Other reasons can also trigger an update of the data after weeks or even months, such as an outage of a data source or a data source publishing consolidated data after some time.

To cover all updates coming from external data sources, Electricity Maps applies an automatic data refetch policy that is available here. A refetch means retrieving (again) data for a data point already stored in memory. Electricity Maps also keeps track of all changes made to any data point over time. Based on these updates, Electricity Maps provides premium customers with a data quality report indicating how many updates are made to data points in each zone over time and how long it takes for data points to reach within 1% of their final value (making later updates non-material).

Table 2 gathers metrics about the updates made by data sources used by Electricity Maps to published data points. The results for all Tier A zones are available in Table E1 of Appendix E.

For half of the Electricity Maps zones, less than 50% of data points are updated after 48 hours. After 3 months, this number falls to 3%, with an average of 9% of data points updated after this time. The large differences between the median and average metrics show that there are large differences from one zone to another.

Table 2: Share of data points that are updated by data sources after selected periods (aggregate statistics). These metrics are computed over all 2025 data for the 212 Tier A zones available commercially at that time.

Share of data points updated after…	6 hours	24 hours	48 hours	72 hours	7 days	30 days	3 months
Average	68%	57%	50%	48%	47%	45%	9%
Median	99%	68%	47%	41%	38%	32%	3%
75th percentile	100%	98%	97%	97%	97%	94%	15%
90th percentile	100%	100%	100%	100%	100%	100%	22%

The previous statistics indicated how many data points are expected to be updated after a certain period. However, this is not an indication of these updates' magnitude and their impact on the renewable energy percentage (RE%), carbon-free energy percentage (CFE%), and carbon intensity (CI) values provided by Electricity Maps. Table 3 shows, through aggregated statistics, how much time it takes for RE% and CI values provided by Electricity Maps to reach within 1% of their final value. The results for all zones are available in Table E2 in Appendix E.

Table 3: Average number of days for Electricity Maps RE% and CI data to reach within 1% of their final value. These metrics are computed over the first quarter of 2026 for all 337 zones available in Electricity Maps at that time. The metrics presented in this table are averaged over all zones.

Average number of days to reach within 1% of final value	Flow-traced Renewable Energy Percentage	Flow-traced Carbon Intensity
For half of the data points	16	24
For 90% of the data points	37	51

Results show that most data points reach their final value in less than a month on average. After 50 days, more than 90% of data points have reached their final value, and data can be considered final, as future updates may happen but will most likely not be material.

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Appendix A - Zones and tiers

Table A1: Electricity Maps zones and zones' metadata

Zone identifier	Zone name	Country name	Tier
AE	United Arab Emirates	United Arab Emirates	Tier C
AF	Afghanistan	Afghanistan	Tier C
AG	Antigua and Barbuda	Antigua and Barbuda	Tier C
AL	Albania	Albania	Tier C
AM	Armenia	Armenia	Tier C
AO	Angola	Angola	Tier C
AT	Austria	Austria	Tier A
AU-NSW	New South Wales	Australia	Tier A
AU-NT	Northern Territory	Australia	Tier A
AU-QLD	Queensland	Australia	Tier A
AU-SA	South Australia	Australia	Tier A
AU-TAS	Tasmania	Australia	Tier A
AU-VIC	Victoria	Australia	Tier A
AU-WA	Western Australia	Australia	Tier A
AZ	Azerbaijan	Azerbaijan	Tier C
BA	Bosnia and Herzegovina	Bosnia and Herzegovina	Tier A
BB	Barbados	Barbados	Tier C
BD	Bangladesh	Bangladesh	Tier A
BE	Belgium	Belgium	Tier A
BF	Burkina Faso	Burkina Faso	Tier C
BG	Bulgaria	Bulgaria	Tier A
BH	Bahrain	Bahrain	Tier C
BI	Burundi	Burundi	Tier C
BJ	Benin	Benin	Tier C
BN	Brunei Darussalam	Brunei Darussalam	Tier C
BO	Bolivia	Bolivia	Tier A
BR-CS	Central Brazil	Brazil	Tier A
BR-N	North Brazil	Brazil	Tier A
BR-NE	North-East Brazil	Brazil	Tier A
BR-S	South Brazil	Brazil	Tier A
BS	Bahamas	Bahamas	Tier C
BT	Bhutan	Bhutan	Tier C
BW	Botswana	Botswana	Tier C
BY	Belarus	Belarus	Tier C
BZ	Belize	Belize	Tier C

CA-AB	Alberta	Canada	Tier A
CA-BC	British Columbia	Canada	Tier C
CA-MB	Manitoba	Canada	Tier C
CA-NB	New Brunswick	Canada	Tier C
CA-NL	Newfoundland & Labrador	Canada	Tier C
CA-NS	Nova Scotia	Canada	Tier C
CA-NT	Northwest Territories	Canada	Tier C
CA-NU	Nunavut	Canada	Tier C
CA-ON	Ontario	Canada	Tier A
CA-PE	Prince Edward Island	Canada	Tier C
CA-QC	Québec	Canada	Tier A
CA-SK	Saskatchewan	Canada	Tier C
CA-YT	Yukon	Canada	Tier C
CD	Democratic Republic of Congo	Democratic Republic of Congo	Tier C
CF	Central African Republic	Central African Republic	Tier C
CG	Congo	Congo	Tier C
CH	Switzerland	Switzerland	Tier C
CI	Côte d'Ivoire	Côte d'Ivoire	Tier C
CL-SEN	Sistema Eléctrico Nacional	Sistema Eléctrico Nacional	Tier A
CM	Cameroon	Cameroon	Tier C
CN	China	China	Tier C
CO	Colombia	Colombia	Tier A
CR	Costa Rica	Costa Rica	Tier A
CU	Cuba	Cuba	Tier C
CV	Cabo Verde	Cabo Verde	Tier C
CW	Curaçao	Curaçao	Tier C
CY	Cyprus	Cyprus	Tier A
CZ	Czechia	Czechia	Tier A
DE	Germany	Germany	Tier A
DJ	Djibouti	Djibouti	Tier C
DK-DK1	West Denmark	Denmark	Tier A
DK-DK2	East Denmark	Denmark	Tier A
DM	Dominica	Dominica	Tier C
DO	Dominican Republic	Dominican Republic	Tier C
DZ	Algeria	Algeria	Tier C
EC	Ecuador	Ecuador	Tier C
EE	Estonia	Estonia	Tier A
EG	Egypt	Egypt	Tier C

ER	Eritrea	Eritrea	Tier C
ES	Spain	Spain	Tier A
ET	Ethiopia	Ethiopia	Tier C
FI	Finland	Finland	Tier A
FJ	Fiji	Fiji	Tier C
FK	Falkland Islands	Falkland Islands	Tier C
FR	France	France	Tier A
GA	Gabon	Gabon	Tier C
GB	Great Britain	Great Britain	Tier A
GB-NIR	Northern Ireland	Northern Ireland	Tier B
GE	Georgia	Georgia	Tier A
GF	French Guiana	French Guiana	Tier A
GH	Ghana	Ghana	Tier C
GI	Gibraltar	Gibraltar	Tier C
GL	Greenland	Greenland	Tier C
GM	Gambia	Gambia	Tier C
GN	Guinea	Guinea	Tier C
GQ	Equatorial Guinea	Equatorial Guinea	Tier C
GR	Greece	Greece	Tier A
GU	Guam	Guam	Tier C
GW	Guinea-Bissau	Guinea-Bissau	Tier C
GY	Guyana	Guyana	Tier C
HK	Hong Kong	Hong Kong	Tier C
HR	Croatia	Croatia	Tier A
HT	Haiti	Haiti	Tier C
HU	Hungary	Hungary	Tier A
ID	Indonesia	Indonesia	Tier C
IE	Ireland	Ireland	Tier B
IL	Israel	Israel	Tier C
IN-EA	Eastern India	India	Tier A
IN-NE	North Eastern India	India	Tier A
IN-NO	Northern India	India	Tier A
IN-SO	Southern India	India	Tier A
IN-WE	Western India	India	Tier A
IQ	Iraq	Iraq	Tier C
IR	Iran	Iran	Tier C
IS	Iceland	Iceland	Tier A
IT-CNO	Central North Italy	Italy	Tier A
IT-CSO	Central South Italy	Italy	Tier A

IT-NO	North Italy	Italy	Tier A
IT-SAR	Sardinia	Italy	Tier A
IT-SIC	Sicily	Italy	Tier A
IT-SO	South Italy	Italy	Tier A
JM	Jamaica	Jamaica	Tier C
JO	Jordan	Jordan	Tier C
JP-CB	Chūbu	Japan	Tier A
JP-CG	Chūgoku	Japan	Tier A
JP-HKD	Hokkaidō	Japan	Tier A
JP-HR	Hokuriku	Japan	Tier A
JP-KN	Kansai	Japan	Tier A
JP-KY	Kyūshū	Japan	Tier A
JP-ON	Okinawa	Japan	Tier A
JP-TH	Tōhoku	Japan	Tier A
JP-TK	Tōkyō	Japan	Tier A
KE	Kenya	Kenya	Tier C
KG	Kyrgyzstan	Kyrgyzstan	Tier C
KH	Cambodia	Cambodia	Tier C
KM	Comoros	Comoros	Tier C
KP	North Korea	North Korea	Tier C
KR	South Korea	South Korea	Tier A
KW	Kuwait	Kuwait	Tier C
KY	Cayman Islands	Cayman Islands	Tier C
KZ	Kazakhstan	Kazakhstan	Tier C
LA	Laos	Laos	Tier C
LB	Lebanon	Lebanon	Tier C
LC	Saint Lucia	Saint Lucia	Tier C
LK	Sri Lanka	Sri Lanka	Tier A
LR	Liberia	Liberia	Tier C
LS	Lesotho	Lesotho	Tier C
LT	Lithuania	Lithuania	Tier A
LU	Luxembourg	Luxembourg	Tier A
LV	Latvia	Latvia	Tier A
LY	Libya	Libya	Tier C
MA	Morocco	Morocco	Tier C
MD	Moldova	Moldova	Tier A
MG	Madagascar	Madagascar	Tier C
MK	North Macedonia	North Macedonia	Tier A
ML	Mali	Mali	Tier C

MM	Myanmar	Myanmar	Tier C
MN	Mongolia	Mongolia	Tier C
MR	Mauritania	Mauritania	Tier C
MT	Malta	Malta	Tier C
MU	Mauritius	Mauritius	Tier C
MV	Maldives	Maldives	Tier C
MW	Malawi	Malawi	Tier C
MX	Mexico	Mexico	Tier A
MY-EM	Borneo	Malaysia	Tier C
MY-WM	Peninsula	Malaysia	Tier A
MZ	Mozambique	Mozambique	Tier C
NA	Namibia	Namibia	Tier C
NC	New Caledonia	New Caledonia	Tier C
NE	Niger	Niger	Tier C
NG	Nigeria	Nigeria	Tier A
NI	Nicaragua	Nicaragua	Tier A
NL	Netherlands	Netherlands	Tier A
NO-NO1	Southeast Norway	Norway	Tier A
NO-NO2	Southwest Norway	Norway	Tier A
NO-NO3	Middle Norway	Norway	Tier A
NO-NO4	North Norway	Norway	Tier A
NO-NO5	West Norway	Norway	Tier A
NP	Nepal	Nepal	Tier C
NZ	New Zealand	New Zealand	Tier A
OM	Oman	Oman	Tier C
PA	Panama	Panama	Tier A
PE	Peru	Peru	Tier A
PG	Papua New Guinea	Papua New Guinea	Tier C
PH-LU	Luzon	Philippines	Tier A
PH-MI	Mindanao	Philippines	Tier A
PH-VI	Visayas	Philippines	Tier A
PK	Pakistan	Pakistan	Tier C
PL	Poland	Poland	Tier A
PM	Saint Pierre and Miquelon	Saint Pierre and Miquelon	Tier C
PR	Puerto Rico	Puerto Rico	Tier C
PS	State of Palestine	State of Palestine	Tier C
PT	Portugal	Portugal	Tier A
PY	Paraguay	Paraguay	Tier C
QA	Qatar	Qatar	Tier C

RE	Réunion	Réunion	Tier A
RO	Romania	Romania	Tier A
RS	Serbia	Serbia	Tier A
RW	Rwanda	Rwanda	Tier C
SA	Saudi Arabia	Saudi Arabia	Tier C
SB	Solomon Islands	Solomon Islands	Tier C
SC	Seychelles	Seychelles	Tier C
SD	Sudan	Sudan	Tier C
SE-SE1	North Sweden	Sweden	Tier A
SE-SE2	North Central Sweden	Sweden	Tier A
SE-SE3	South Central Sweden	Sweden	Tier A
SE-SE4	South Sweden	Sweden	Tier A
SG	Singapore	Singapore	Tier A
SI	Slovenia	Slovenia	Tier A
SK	Slovakia	Slovakia	Tier A
SL	Sierra Leone	Sierra Leone	Tier C
SN	Senegal	Senegal	Tier C
SO	Somalia	Somalia	Tier C
SR	Suriname	Suriname	Tier C
SS	South Sudan	South Sudan	Tier C
SY	Syria	Syria	Tier C
SZ	Eswatini	Eswatini	Tier C
TD	Chad	Chad	Tier C
TG	Togo	Togo	Tier C
TH	Thailand	Thailand	Tier C
TJ	Tajikistan	Tajikistan	Tier C
TM	Turkmenistan	Turkmenistan	Tier C
TN	Tunisia	Tunisia	Tier C
TO	Tonga	Tonga	Tier C
TR	Turkey	Turkey	Tier A
TT	Trinidad and Tobago	Trinidad and Tobago	Tier C
TW	Taiwan	Taiwan	Tier A
TZ	Tanzania	Tanzania	Tier C
UG	Uganda	Uganda	Tier C
US-CAL-BANC	Balancing Authority of Northern California	USA	Tier A
US-CAL-CISO	CAISO	USA	Tier A
US-CAL-IID	Imperial Irrigation District	USA	Tier A
US-CAL-LDWP	Los Angeles Department of Water and Power	USA	Tier A
US-CAL-TIDC	Turlock Irrigation District	USA	Tier A

US-CAR-CPLE	Duke Energy Progress East	USA	Tier A
US-CAR-CPLW	Duke Energy Progress West	USA	Tier A
US-CAR-DUK	Duke Energy Carolinas	USA	Tier A
US-CAR-SC	South Carolina Public Service Authority	USA	Tier A
US-CAR-SCEG	South Carolina Electric & Gas Company	USA	Tier A
US-CAR-YAD	Alcoa Power Generating, Inc. Yadkin Division	USA	Tier A
US-CENT-SPA	Southwestern Power Administration	USA	Tier A
US-CENT-SWPP	Southwest Power Pool	USA	Tier A
US-FLA-FMPP	Florida Municipal Power Pool	USA	Tier A
US-FLA-FPC	Duke Energy Florida	USA	Tier A
US-FLA-FPL	Florida Power and Light Company	USA	Tier A
US-FLA-GVL	Gainesville Regional Utilities	USA	Tier A
US-FLA-JEA	Jacksonville Electric Authority	USA	Tier A
US-FLA-SEC	Seminole Electric Cooperative	USA	Tier A
US-FLA-TAL	City of Tallahassee	USA	Tier A
US-FLA-TEC	Tampa Electric Company	USA	Tier A
US-MIDA-PJM	PJM Interconnection	USA	Tier A
US-MIDW-AECI	Associated Electric Cooperative	USA	Tier A
US-MIDW-LGEE	Louisville Gas and Electric Company and Kentucky Utilities	USA	Tier A
US-MIDW-MISO	Midcontinent ISO	USA	Tier A
US-NE-ISNE	ISO New England	USA	Tier A
US-NW-AVA	Avista Corporation	USA	Tier A
US-NW-BPAT	Bonneville Power Administration	USA	Tier A
US-NW-CHPD	Chelan County	USA	Tier A
US-NW-DOPD	Douglas County	USA	Tier A
US-NW-GCPD	Grant County	USA	Tier A
US-NW-GRID	Gridforce Energy Management	USA	Tier A
US-NW-IPCO	Idaho Power Company	USA	Tier A
US-NW-NEVP	Nevada Power Company	USA	Tier A
US-NW-NWMT	Northwestern Energy	USA	Tier A
US-NW-PACE	Pacificorp East	USA	Tier A
US-NW-PACW	Pacificorp West	USA	Tier A
US-NW-PGE	Portland General Electric Company	USA	Tier A
US-NW-PSCO	Public Service Company of Colorado	USA	Tier A
US-NW-PSEI	Puget Sound Energy	USA	Tier A
US-NW-SCL	Seattle City Light	USA	Tier A
US-NW-TPWR	City of Tacoma	USA	Tier A

US-NW-WACM	Western Area Power Administration - Rocky Mountain Region	USA	Tier A
US-NW-WAUW	Western Area Power Administration - Upper Great Plains West	USA	Tier A
US-NY-NYIS	New York ISO	USA	Tier A
US-SE-SOCO	Southern Company Services	USA	Tier A
US-SW-AZPS	Arizona Public Service Company	USA	Tier A
US-SW-EPE	El Paso Electric Company	USA	Tier A
US-SW-PNM	Public Service Company of New Mexico	USA	Tier A
US-SW-SRP	Salt River Project	USA	Tier A
US-SW-TEPC	Tucson Electric Power Company	USA	Tier A
US-SW-WALC	Western Area Power Administration - Desert Southwest Region	USA	Tier A
US-TEN-TVA	Tennessee Valley Authority	USA	Tier A
US-TEX-ERCO	Electric Reliability Council of Texas	USA	Tier A
UY	Uruguay	Uruguay	Tier A
UZ	Uzbekistan	Uzbekistan	Tier C
VC	Saint Vincent and the Grenadines	Saint Vincent and the Grenadines	Tier C
VE	Venezuela	Venezuela	Tier C
VI	Virgin Islands	Virgin Islands	Tier C
VN	Viet Nam	Viet Nam	Tier C
VU	Vanuatu	Vanuatu	Tier C
WS	Samoa	Samoa	Tier C
YE	Yemen	Yemen	Tier C
YT	Mayotte	Mayotte	Tier C
ZA	South Africa	South Africa	Tier A
ZM	Zambia	Zambia	Tier C
ZW	Zimbabwe	Zimbabwe	Tier C

Appendix B - Documentation of estimation models

Time-Slicer Average estimation model

The Time-Slicer Average (TSA) method estimates short-time data gaps occurring in Tier A, usually ranging from hours to a couple of days. It can be either permanent delays or unexpected gaps.

This estimation method uses available data to fill in the gap. Each missing point in the gap is filled by the average of the available data points that belong to the same time but on different days in the given month. The estimation is then aligned to ensure the continuity of the estimation points with the neighboring of the gap observed. This is illustrated in Figure 7 below. This estimation method is also, in some cases, complemented by other estimates sourced from external or internal forecasts, in particular for highly weather-dependent production modes like solar and wind. These different models are associated with achieving more accurate estimates.

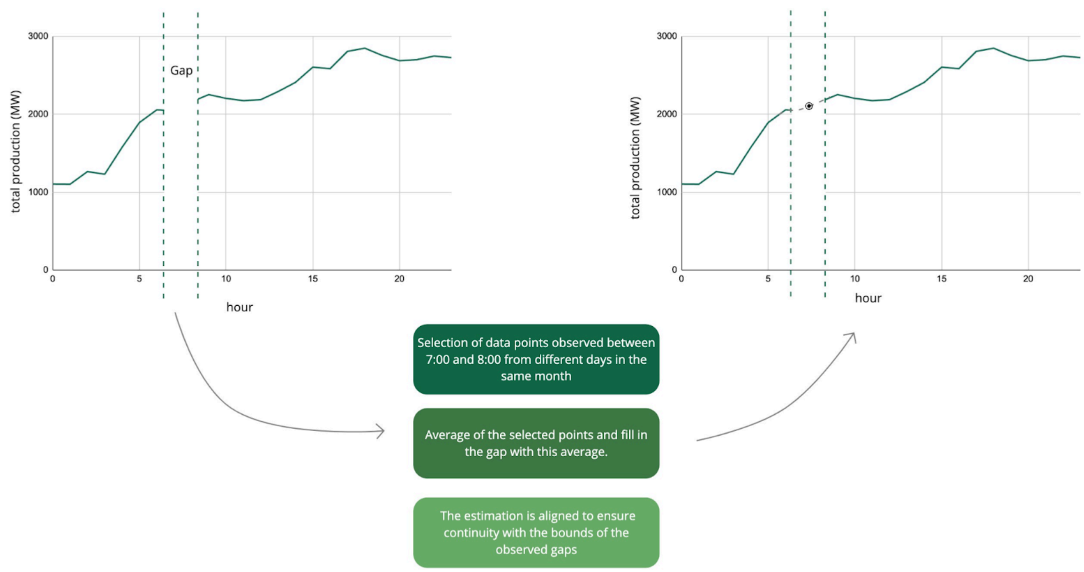

Figure 7: Illustration of the Time-Slicer Average (TSA) method used to estimate data gaps for Tier A zones.

Zone-specific estimation models

Zone-specific estimation models estimate hourly data in Tier B zones when only partly available. In some cases, only the total hourly production data is available in real time. In other cases, only some production modes can be available or reliable.

These estimation methods aim at leveraging all hourly (or daily) data available. When not available, variable renewable energy production (wind and solar) is estimated with models using weather parameters such as wind speed, wind direction, and solar irradiation. These models are trained based on the historical data available. The rest of the production is estimated using dedicated estimation methods that are improved over time. The most basic estimation method used applies a static breakdown over the remaining gap between total production and variable renewables production based on the zone's yearly power mix. This is illustrated in Figure 8 below.

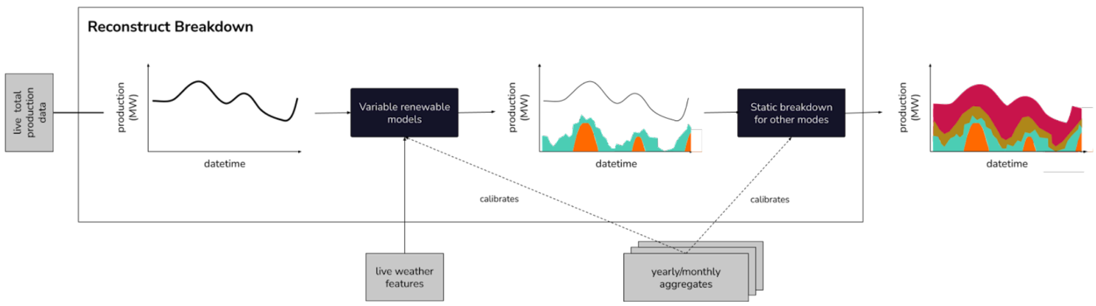

Figure 8: Illustration of the Reconstruct breakdown method used in zone-specific models for Tier A zones.

General Purpose Zone Development estimation model

The General Purpose Zone Development (GPZD) model estimates hourly data in Tier C zones when only monthly or yearly data is available. It estimates hourly production for all modes by leveraging the available data (yearly or monthly) and weather data. This estimation method also guarantees that yearly aggregates of hourly values match up with the publicly available yearly data.

As illustrated in Figure 9 below, it is broken down into two steps. The first step estimates monthly data from yearly data by capturing seasonal variations in electricity production. The second step estimates hourly data from monthly data by capturing daily and hourly variations in electricity production. The first step is skipped when monthly data is publicly available. Both steps use machine learning methods trained on zones with fully available hourly power mix data in combination with weather data.

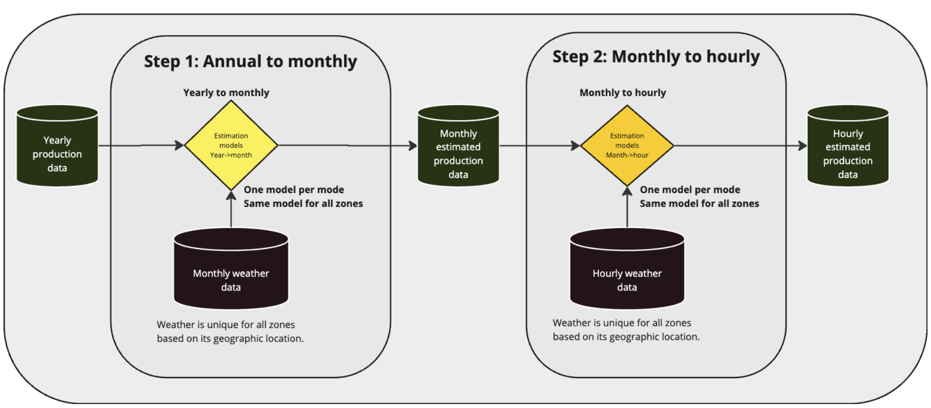

Figure 9: Illustration of the General Purpose Zone Development method used to estimate hourly data for Tier C zones.

Appendix C - Global emission factors

Table C1: Global emission factors used by Electricity Maps worldwide

Technology	Life cycle emission factor (gCO2eq/kWh)	Direct emission factor (gCO2eq/kWh)	Sources
Biomass	230	0	IPCC 2014
Coal	820	760	IPCC 2014
Gas	490	370	IPCC 2014
Geothermal	38	0	IPCC 2014
Hydro	24	0	IPCC 2014
Nuclear	12	0	IPCC 2014
Oil	650	406	UK Parliamentary Office of Science and Technology, EIA 2020/BEIS 2021
Solar	45	0	IPCC 2014
Unknown	700	575	Assumes a mix of thermal sources
Wind	11	0	IPCC 2014

Appendix D - Data comparison with Ember and IEA datasets

Methodology for sourcing and comparing data

Data sourcing

Data used for the comparison of RE% and CFE% from the IEA is issued from the Monthly Electricity Statistics dataset, using the version of 20th July 2026. This dataset is updated monthly by the IEA and provides electricity production data for OECD member countries and “a selection of other economies”. The renewable energy percentage for the IEA was calculated as 'Total Renewables (Hydro, Geo, Solar, Wind, Other)' divided by ‘Electricity’. For the carbon-free energy percentage, the numerator used was the addition of 'Total Renewables (Hydro, Geo, Solar, Wind, Other)' and ‘Nuclear’.

Data used for comparison from Ember is issued from the Yearly Electricity Data dataset, using the version from July 2027. This dataset is also updated monthly and provides the “electricity demand, generation, capacity, and CO2 data by country”. Ember directly provides the renewable energy percentage (called ‘Renewables’) and the carbon-free energy percentage (called ‘Clean’).

Data used for comparison from Electricity Maps is the renewable energy percentage and the carbon-free energy percentage calculated according to the methodology described in this report. The numbers are calculated on the electricity production mix as the IEA and Ember do not provide any flow-traced numbers.

Values for all three datasets are for the year 2025.

Data comparison

The datasets are compared with two main metrics: the absolute difference and the difference. With $RE_{x,i}$ and $RE_{x,j}$, the renewable energy percentage for a zone x given by data sources i, j respectively, the two metrics are computed as follows:

$$Diff_{RE,x,i-j} = RE_{x,i} - RE_{x,j}, \quad AbsDiff_{RE,x,i-j} = abs(Diff_{RE,x,i-j}) = abs(RE_{x,i} - RE_{x,j})$$

The absolute difference (*AbsDiff*) quantifies the overall difference between two datasets, while the difference (*Diff*) more specifically quantifies if values from one dataset are consistently lower or greater than the others.

The two metrics are computed for all zones, and the median values are provided in the report.

Comparison results

Table D2.1: Comparison of the renewable energy percentage between Ember, the IEA, and Electricity Maps.

Country	Ember (2025)	IEA (2025)	Electricity Maps (2025)
Albania	100%	100%	100%
Armenia	31%		31%
Argentina	35%	38%	38%
Austria	84%	83%	86%
Australia	39%	41%	44%
Azerbaijan	10%		15%
Bosnia and Herzegovina	43%	43%	38%
Bangladesh	2%		3%
Belgium	44%	41%	39%
Bulgaria	33%	34%	28%
Bolivia, Plurinational State of	36%		37%
Brazil	87%	85%	87%
Belarus	4%		4%
Canada	64%	66%	66%
Switzerland	68%	71%	72%
China	37%	38%	37%
Colombia	77%	80%	87%
Costa Rica	110%	98%	99%
Cyprus	28%	28%	25%
Czechia	17%	18%	11%
Germany	59%	59%	62%
Denmark	94%	92%	91%
Dominican Republic	24%		22%
Ecuador	79%		73%
Estonia	60%	65%	60%
Egypt	13%		14%
Spain	56%	57%	59%
Ethiopia	100%		91%
Finland	56%	57%	55%
France	26%	29%	27%
United Kingdom	52%	54%	53%
Georgia	80%	80%	78%

Greece	48%	45%	49%
Croatia	76%	78%	72%
Hungary	35%	37%	27%
Ireland	48%	50%	46%
Israel	17%		14%
India	24%	25%	25%
Iran, Islamic Republic of	4%		4%
Iceland		100%	100%
Italy	49%	50%	44%
Japan	24%	25%	25%
Kenya	90%		92%
Cambodia	41%		43%
Korea Republic of	10%	10%	4%
Kuwait	2%		0%
Kazakhstan	15%		15%
Sri Lanka	56%		54%
Lithuania	78%	86%	79%
Luxembourg	92%	94%	95%
Latvia	74%	74%	73%
Morocco	23%		28%
Moldova, Republic of	28%		23%
Montenegro	76%	78%	75%
North Macedonia	53%	66%	23%
Mongolia	8%		9%
Malta	16%	17%	17%
Mexico	23%	22%	22%
Malaysia	21%		19%
Nigeria	31%		27%
Netherlands	51%	49%	52%
Norway	99%	99%	99%
New Zealand	89%	88%	89%
Oman	5%		2%
Peru	64%		69%
Philippines	23%		19%
Pakistan	47%		48%
Poland	31%	35%	29%

Puerto Rico	6%		39%
Portugal	81%	81%	82%
Paraguay	100%		100%
Qatar	4%		0%
Romania	47%	48%	45%
Serbia	28%	32%	29%
Russian Federation	17%		0%
Sweden	71%	72%	72%
Singapore	5%		5%
Slovenia	40%	42%	37%
Slovakia	19%	19%	16%
El Salvador	91%		65%
Thailand	17%		17%
Tajikistan	94%		93%
Tunisia	4%		2%
Republic of Turkiye	43%	45%	38%
Taiwan, Province of China	12%		14%
United States	26%	26%	24%
Uruguay	98%		98%
Uzbekistan	19%		10%
Viet Nam	45%		47%
South Africa	14%		10%

Table D2.2: Comparison of the carbon-free energy percentage between Ember, the IEA, and Electricity Maps.

Country	Ember (2025)	IEA (2025)	Electricity Maps (2025)
Albania	100%	100%	100%
Armenia	62%		63%
Argentina	42%	46%	46%
Austria	84%	83%	86%
Australia	39%	41%	44%
Azerbaijan	10%		15%
Bosnia and Herzegovina	43%	43%	38%
Bangladesh	2%		3%
Belgium	80%	73%	73%
Bulgaria	72%	73%	68%

Bolivia, Plurinational State of	36%		37%
Brazil	89%	87%	89%
Belarus	41%		46%
Canada	77%	79%	79%
Switzerland	98%	98%	99%
China	42%	42%	41%
Colombia	77%	80%	87%
Costa Rica	110%	98%	99%
Cyprus	28%	28%	25%
Czechia	59%	61%	56%
Germany	59%	59%	62%
Denmark	94%	92%	91%
Dominican Republic	24%		22%
Ecuador	79%		73%
Estonia	60%	65%	60%
Egypt	13%		14%
Spain	75%	75%	79%
Ethiopia	100%		91%
Finland	96%	96%	94%
France	95%	97%	97%
United Kingdom	64%	65%	67%
Georgia	80%	80%	78%
Greece	48%	45%	49%
Croatia	76%	78%	72%
Hungary	75%	77%	72%
Ireland	48%	50%	46%
Israel	17%		14%
India	27%	28%	28%
Iran, Islamic Republic of	6%		4%
Iceland		100%	100%
Italy	49%	50%	44%
Japan	33%	35%	36%
Kenya	90%		92%
Cambodia	41%		43%
Korea Republic of	40%	38%	37%
Kuwait	2%		0%
Kazakhstan	15%		15%

Sri Lanka	56%		54%
Lithuania	78%	86%	79%
Luxembourg	92%	94%	95%
Latvia	74%	74%	73%
Morocco	23%		28%
Moldova, Republic of	28%		23%
Montenegro	76%	78%	75%
North Macedonia	53%	66%	23%
Mongolia	8%		9%
Malta	16%	17%	17%
Mexico	26%	24%	25%
Malaysia	21%		19%
Nigeria	31%		27%
Netherlands	54%	52%	55%
Norway	99%	99%	99%
New Zealand	89%	88%	89%
Oman	5%		2%
Peru	64%		69%
Philippines	23%		19%
Pakistan	61%		62%
Poland	31%	35%	29%
Puerto Rico	6%		39%
Portugal	81%	81%	82%
Paraguay	100%		100%
Qatar	4%		0%
Romania	68%	69%	66%
Serbia	28%	32%	29%
Russian Federation	36%		0%
Sweden	99%	99%	100%
Singapore	5%		5%
Slovenia	79%	81%	79%
Slovakia	85%	85%	84%
El Salvador	91%		65%
Thailand	17%		17%
Tajikistan	94%		93%
Tunisia	4%		2%

Republic of Turkiye	43%	45%	38%
Taiwan, Province of China	14%		15%
United States	43%	43%	42%
Uruguay	98%		98%
Uzbekistan	19%		10%
Viet Nam	45%		47%
South Africa	18%		15%

Appendix E - Data updates

Table E1: Share of data points that are updated by data sources after selected periods per zone. These metrics are computed over all 2025 data for the 216 Electricity Maps zones using real-time data sources.

Share of datapoints updated after...	6 hours	24 hours	48 hours	72 hours	7 days	30 days	3 months
Average	68%	57%	50%	48%	47%	45%	9%
Median	99%	68%	47%	41%	38%	32%	3%
75th percentile	100%	98%	97%	97%	97%	94%	15%
90th percentile	100%	100%	100%	100%	100%	100%	22%
AR	0%	0%	0%	0%	0%	0%	0%
AT	100%	100%	100%	100%	100%	100%	20%
AU-NSW	100%	100%	100%	100%	100%	100%	23%
AU-NT	100%	94%	23%	8%	8%	5%	0%
AU-QLD	100%	100%	100%	100%	100%	100%	21%
AU-SA	100%	100%	100%	100%	100%	100%	21%
AU-TAS	80%	79%	79%	78%	76%	72%	12%
AU-TAS-FI	3%	3%	3%	2%	1%	0%	0%
AU-TAS-KI	3%	3%	3%	3%	1%	0%	0%
AU-VIC	100%	100%	100%	100%	100%	100%	22%
AU-WA	100%	100%	100%	100%	100%	100%	22%
AU-WA-RI	3%	3%	3%	2%	1%	0%	0%
AW	0%	0%	0%	0%	0%	0%	0%
AX	25%	0%	0%	0%	0%	0%	0%
BA	99%	99%	99%	99%	99%	99%	17%
BB	100%	40%	0%	0%	0%	0%	0%
BD	18%	6%	6%	6%	5%	0%	0%
BE	100%	100%	100%	100%	100%	100%	46%
BG	100%	100%	100%	100%	100%	100%	51%
BO	84%	84%	84%	84%	82%	77%	0%
BR-CS	0%	0%	0%	0%	0%	0%	0%
BR-N	0%	0%	0%	0%	0%	0%	0%
BR-NE	0%	0%	0%	0%	0%	0%	0%
BR-S	0%	0%	0%	0%	0%	0%	0%
CA-AB	0%	0%	0%	0%	0%	0%	0%
CA-NB	91%	86%	79%	72%	45%	0%	0%
CA-ON	2%	2%	2%	2%	2%	1%	0%
CA-QC	44%	1%	0%	0%	0%	0%	0%

CA-SK	100%	100%	88%	80%	50%	0%	0%
CA-YT	18%	15%	14%	13%	8%	0%	0%
CH	100%	100%	100%	100%	100%	100%	19%
CL-SEN	100%	100%	100%	100%	100%	100%	10%
CO	100%	100%	100%	100%	98%	84%	10%
CR	99%	99%	99%	99%	99%	98%	0%
CY	100%	100%	100%	100%	100%	98%	6%
CZ	15%	14%	6%	1%	1%	1%	0%
DE	100%	100%	100%	100%	100%	100%	16%
DK	96%	96%	96%	96%	96%	96%	21%
DK-BHM	0%	0%	0%	0%	0%	0%	0%
DK-DK1	99%	99%	99%	99%	99%	99%	22%
DK-DK2	96%	96%	96%	96%	96%	96%	21%
DO	8%	0%	0%	0%	0%	0%	0%
EE	99%	99%	99%	99%	99%	99%	15%
ES	63%	63%	63%	63%	63%	63%	17%
ES-CE	10%	9%	9%	9%	9%	2%	0%
ES-CN-FV	13%	11%	11%	11%	10%	3%	0%
ES-CN-FVLZ	2%	0%	0%	0%	0%	0%	0%
ES-CN-GC	11%	9%	9%	9%	9%	3%	0%
ES-CN-HI	4%	3%	3%	3%	3%	1%	0%
ES-CN-IG	11%	9%	9%	9%	9%	3%	0%
ES-CN-LP	10%	9%	9%	9%	9%	3%	0%
ES-CN-LZ	13%	11%	11%	11%	10%	3%	0%
ES-CN-TE	11%	9%	9%	9%	9%	3%	0%
ES-IB-FO	0%	0%	0%	0%	0%	0%	0%
ES-IB-IZ	3%	2%	2%	2%	2%	2%	0%
ES-IB-MA	10%	9%	9%	9%	9%	3%	0%
ES-IB-ME	1%	0%	0%	0%	0%	0%	0%
ES-ML	10%	9%	9%	9%	9%	2%	0%
FI	97%	97%	97%	97%	97%	97%	16%
FO	1%	0%	0%	0%	0%	0%	0%
FO-MI	1%	0%	0%	0%	0%	0%	0%
FO-SI	0%	0%	0%	0%	0%	0%	0%
FR	85%	84%	84%	84%	83%	78%	11%
FR-COR	55%	53%	52%	51%	50%	0%	0%
GB	100%	100%	100%	100%	100%	100%	32%
GB-NIR	1%	0%	0%	0%	0%	0%	0%
GB-ORK	4%	4%	3%	3%	2%	0%	0%

GE	90%	90%	90%	90%	90%	90%	18%
GF	1%	0%	0%	0%	0%	0%	0%
GP	0%	0%	0%	0%	0%	0%	0%
GR	99%	99%	99%	99%	99%	98%	18%
GT	47%	45%	45%	45%	45%	38%	4%
HN	1%	0%	0%	0%	0%	0%	0%
HR	94%	94%	94%	94%	94%	94%	17%
HU	100%	99%	98%	98%	98%	98%	18%
IE	1%	0%	0%	0%	0%	0%	0%
IN	100%	93%	87%	87%	87%	87%	6%
IN-DL	0%	0%	0%	0%	0%	0%	0%
IN-EA	100%	93%	88%	87%	86%	80%	0%
IN-KA	6%	6%	5%	5%	3%	0%	0%
IN-MH	0%	0%	0%	0%	0%	0%	0%
IN-NE	100%	93%	88%	87%	86%	80%	0%
IN-NO	100%	93%	88%	87%	86%	80%	0%
IN-PB	0%	0%	0%	0%	0%	0%	0%
IN-SO	100%	93%	88%	87%	86%	80%	0%
IN-WE	100%	93%	88%	87%	86%	80%	0%
IS	0%	0%	0%	0%	0%	0%	0%
IT-CNO	97%	93%	93%	93%	93%	92%	14%
IT-CSO	98%	91%	90%	90%	90%	90%	16%
IT-NO	98%	91%	90%	90%	90%	90%	16%
IT-SAR	97%	90%	90%	90%	90%	90%	15%
IT-SIC	97%	90%	90%	90%	90%	90%	16%
IT-SO	98%	93%	93%	93%	93%	93%	15%
JP-CB	100%	100%	100%	100%	100%	100%	54%
JP-CG	100%	100%	100%	100%	100%	100%	54%
JP-HKD	100%	100%	100%	100%	100%	100%	54%
JP-HR	100%	100%	100%	100%	100%	100%	54%
JP-KN	100%	100%	100%	100%	100%	100%	54%
JP-KY	100%	100%	100%	100%	100%	100%	54%
JP-ON	99%	99%	99%	99%	99%	99%	53%
JP-SK	100%	100%	100%	100%	100%	100%	54%
JP-TH	100%	100%	100%	100%	100%	100%	54%
JP-TK	100%	100%	100%	100%	100%	100%	54%
KR	4%	3%	3%	3%	3%	1%	0%
LK	100%	29%	0%	0%	0%	0%	0%
LT	99%	99%	99%	99%	99%	99%	18%

LU	100%	99%	98%	98%	98%	98%	17%
LV	100%	100%	100%	100%	100%	100%	17%
MD	100%	100%	100%	99%	98%	91%	6%
ME	96%	96%	96%	95%	95%	95%	18%
MK	100%	100%	99%	99%	99%	99%	15%
MN	1%	0%	0%	0%	0%	0%	0%
MQ	0%	0%	0%	0%	0%	0%	0%
MX	100%	100%	100%	100%	100%	45%	0%
MY-WM	96%	96%	96%	96%	96%	82%	5%
NG	15%	2%	2%	2%	2%	2%	0%
NI	0%	0%	0%	0%	0%	0%	0%
NL	100%	100%	100%	100%	100%	99%	19%
NO	98%	98%	97%	96%	95%	92%	23%
NO-NO1	98%	98%	98%	98%	98%	98%	22%
NO-NO2	98%	98%	98%	98%	98%	98%	22%
NO-NO3	99%	99%	99%	99%	99%	99%	22%
NO-NO4	99%	99%	99%	99%	99%	99%	20%
NO-NO5	99%	99%	99%	99%	99%	99%	22%
NZ	3%	3%	3%	2%	1%	0%	0%
PA	0%	0%	0%	0%	0%	0%	0%
PE	100%	86%	79%	79%	79%	79%	6%
PF	0%	0%	0%	0%	0%	0%	0%
PH-LU	86%	11%	0%	0%	0%	0%	0%
PH-MI	86%	11%	0%	0%	0%	0%	0%
PH-VI	86%	11%	0%	0%	0%	0%	0%
PL	100%	100%	100%	100%	100%	100%	22%
PT	100%	100%	100%	100%	100%	100%	22%
RE	1%	0%	0%	0%	0%	0%	0%
RO	67%	67%	67%	67%	67%	65%	17%
RS	99%	94%	93%	93%	93%	93%	17%
RU	0%	0%	0%	0%	0%	0%	0%
RU-1	58%	58%	57%	57%	56%	50%	0%
RU-2	58%	58%	57%	57%	56%	50%	0%
RU-AS	0%	0%	0%	0%	0%	0%	0%
SE	97%	97%	97%	97%	97%	97%	13%
SE-SE1	98%	98%	98%	98%	98%	98%	15%
SE-SE2	97%	97%	97%	97%	97%	97%	14%
SE-SE3	99%	99%	99%	99%	99%	99%	15%
SE-SE4	99%	99%	99%	99%	99%	99%	14%

SG	0%	0%	0%	0%	0%	0%	0%
SI	97%	97%	97%	97%	97%	97%	20%
SK	99%	99%	99%	99%	99%	99%	21%
SV	31%	30%	30%	30%	30%	25%	0%
TH	12%	12%	12%	12%	12%	12%	0%
TR	100%	100%	100%	100%	99%	70%	1%
TW	0%	0%	0%	0%	0%	0%	0%
US-AK-SEAPA	0%	0%	0%	0%	0%	0%	0%
US-CAL-BANC	100%	55%	31%	28%	27%	26%	3%
US-CAL-CISO	25%	17%	17%	17%	17%	13%	0%
US-CAL-IID	100%	70%	51%	45%	44%	36%	1%
US-CAL-LDWP	100%	75%	47%	41%	40%	37%	3%
US-CAL-TIDC	100%	48%	19%	15%	14%	13%	1%
US-CAR-CPLE	100%	98%	62%	36%	34%	32%	5%
US-CAR-CPLW	100%	89%	49%	37%	36%	35%	4%
US-CAR-DUK	100%	65%	34%	29%	28%	27%	3%
US-CAR-SC	100%	72%	47%	44%	42%	39%	4%
US-CAR-SCEG	100%	68%	40%	36%	33%	31%	3%
US-CAR-YAD	100%	49%	23%	22%	21%	19%	1%
US-CENT-SPA	100%	80%	61%	58%	57%	51%	1%
US-CENT-SWPP	1%	1%	1%	1%	1%	1%	0%
US-FLA-FMPP	100%	65%	38%	34%	33%	32%	4%
US-FLA-FPC	100%	72%	40%	32%	31%	30%	4%
US-FLA-FPL	100%	69%	44%	40%	39%	39%	9%
US-FLA-GVL	100%	56%	24%	20%	19%	19%	4%
US-FLA-HST	98%	38%	4%	3%	3%	3%	0%
US-FLA-JEA	100%	69%	40%	33%	31%	31%	4%
US-FLA-SEC	100%	54%	24%	21%	20%	20%	3%
US-FLA-TAL	100%	56%	22%	18%	17%	16%	2%
US-FLA-TEC	100%	67%	33%	29%	28%	27%	3%
US-MIDA-PJM	15%	15%	15%	15%	15%	10%	1%
US-MIDW-AECI	100%	74%	52%	46%	44%	43%	5%
US-MIDW-LGEE	100%	68%	31%	26%	24%	24%	3%
US-MIDW-MISO	100%	86%	74%	72%	71%	67%	10%
US-NE-ISNE	20%	20%	20%	20%	20%	20%	4%

US-NW-AVA	100%	60%	37%	32%	30%	30%	7%
US-NW-BPAT	100%	63%	37%	32%	31%	30%	4%
US-NW-CHPD	100%	50%	19%	15%	14%	14%	3%
US-NW-DOPD	100%	33%	0%	0%	0%	0%	0%
US-NW-GCPD	100%	31%	1%	1%	0%	0%	0%
US-NW-GRID	100%	55%	28%	24%	23%	23%	3%
US-NW-IPCO	100%	99%	98%	98%	98%	91%	8%
US-NW-NEVP	100%	63%	41%	37%	35%	34%	6%
US-NW-NWMT	100%	74%	53%	51%	50%	49%	8%
US-NW-PACE	100%	100%	92%	63%	61%	51%	5%
US-NW-PACW	100%	95%	88%	82%	81%	77%	13%
US-NW-PGE	100%	76%	62%	58%	55%	53%	7%
US-NW-PSCO	100%	62%	36%	32%	31%	30%	5%
US-NW-PSEI	100%	83%	66%	52%	51%	50%	8%
US-NW-SCL	100%	34%	0%	0%	0%	0%	0%
US-NW-TPWR	100%	31%	1%	0%	0%	0%	0%
US-NW-WACM	100%	63%	38%	33%	31%	30%	6%
US-NW-WAUW	100%	40%	7%	4%	4%	2%	0%
US-NY-NYIS	62%	62%	62%	62%	62%	62%	6%
US-SE-SEPA	99%	35%	3%	2%	2%	1%	0%
US-SE-SOCO	100%	94%	90%	88%	88%	78%	11%
US-SW-AZPS	100%	63%	38%	33%	31%	30%	4%
US-SW-EPE	100%	51%	24%	21%	21%	20%	4%
US-SW-PNM	100%	76%	58%	54%	53%	45%	4%
US-SW-SRP	100%	78%	60%	56%	55%	53%	11%
US-SW-TEPC	100%	68%	48%	43%	42%	42%	7%
US-SW-WALC	100%	88%	79%	77%	77%	76%	11%
US-TEN-TVA	100%	78%	60%	57%	57%	53%	5%
US-TEX-ERCO	2%	0%	0%	0%	0%	0%	0%
UY	28%	27%	27%	27%	27%	25%	5%
XK	99%	99%	99%	99%	99%	99%	18%
ZA	100%	100%	99%	98%	35%	0%	0%

Table E2: Number of days to reach within 1% of their final value for RE% and CI data for all 337 available zones in Electricity Maps. These metrics are computed over data from the first quarter of 2026.

Number of days to reach within 1% of final value	Flow-traced RE% (median)	Flow-traced RE% (p90)	Flow-traced CI (median)	Flow-traced CI (p90)
Average	16	37	24	51
AE	4	11	4	16
AF	7	20	26	43
AG	19	33	19	33
AL	2	23	22	53
AM	65	85	72	96
AO	0	4	2	30
AR	0	0	0	0
AT	5	37	68	108
AU-NSW	9	44	13	47
AU-NT	31	125	71	125
AU-QLD	11	48	13	55
AU-SA	11	36	31	74
AU-TAS	0	9	11	30
AU-TAS-FI	16	29	8	29
AU-TAS-KI	0	5	4	6
AU-VIC	8	44	14	52
AU-WA	3	21	24	44
AU-WA-RI	2	5	2	5
AW	19	29	19	29
AX	0	4	6	104
AZ	68	102	69	102
BA	0	17	2	23
BB	11	20	11	20
BD	84	126	138	170
BE	42	79	90	147
BF	2	15	3	16
BG	124	155	131	162
BH	0	0	0	0
BI	30	61	30	61
BJ	8	16	9	19
BN	0	0	0	0
BO	0	6	0	6
BR-CS	0	0	0	4

BR-N	0	0	0	4
BR-NE	0	0	0	5
BR-S	0	0	1	5
BS	0	0	0	0
BT	0	0	0	0
BW	0	0	0	0
BY	41	83	72	102
BZ	33	61	36	61
CA-AB	0	0	0	21
CA-BC	1	33	28	103
CA-MB	2	12	8	26
CA-NB	6	35	20	34
CA-NL	0	0	3	17
CA-NS	5	30	9	28
CA-NT	4	26	17	31
CA-NU	0	1	0	1
CA-ON	47	85	44	83
CA-PE	0	5	18	30
CA-QC	47	85	46	82
CA-SK	1	29	1	18
CA-YT	16	29	18	31
CD	0	0	0	0
CF	0	0	0	0
CG	0	29	1	29
CH	69	87	120	149
CI	1	8	5	15
CL-SEN	1	1	6	46
CM	0	5	11	23
CN	52	65	59	73
CO	3	22	7	27
CR	0	0	3	104
CU	0	7	0	10
CV	27	50	28	55
CW	10	29	11	29
CY	0	0	0	12
CZ	0	7	0	25
DE	1	16	33	82
DJ	29	53	30	57
DK-DK1	128	160	128	160

DK-DK2	126	156	128	156
DM	14	25	14	25
DO	0	0	0	0
DZ	0	0	0	0
EC	77	91	81	99
EE	6	34	26	51
EG	9	32	13	43
ER	5	19	5	19
ES	0	8	0	12
ES-CE	0	0	0	0
ES-CN-FV	0	2	0	4
ES-CN-GC	0	2	0	5
ES-CN-HI	0	5	2	5
ES-CN-IG	0	4	0	4
ES-CN-LP	0	1	0	2
ES-CN-LZ	0	4	0	4
ES-CN-TE	0	2	0	4
ES-IB-FO	23	38	38	45
ES-IB-IZ	36	42	39	45
ES-IB-MA	0	2	0	0
ES-IB-ME	0	0	0	0
ES-ML	0	0	0	0
ET	0	0	0	0
FI	0	0	0	27
FJ	18	32	20	32
FK	0	1	0	1
FM	0	18	1	19
FO-MI	0	0	0	12
FO-SI	0	0	0	11
FR	72	108	127	147
FR-COR	2	62	25	95
GA	10	31	12	31
GB	9	23	29	78
GB-NIR	0	12	2	24
GE	0	33	0	96
GF	1	35	1	38
GH	0	2	0	11
GI	0	0	0	2
GL	28	61	30	61

GM	0	0	0	0
GN	8	25	26	54
GP	0	97	0	109
GQ	14	31	16	31
GR	43	60	58	129
GS	1	10	19	31
GT	21	30	24	33
GU	14	22	15	23
GW	0	0	0	0
GY	29	61	29	61
HK	0	0	0	10
HN	0	2	3	14
HR	2	18	14	31
HT	0	1	0	1
HU	0	5	8	29
ID	0	0	0	0
IE	0	10	0	24
IL	4	14	6	14
IN-EA	1	1	0	1
IN-NE	1	6	1	6
IN-NO	1	8	1	8
IN-SO	1	6	1	8
IN-WE	1	6	1	6
IQ	0	0	0	28
IR	2	21	2	18
IS	0	0	0	0
IT-CNO	13	26	39	71
IT-CSO	9	30	34	81
IT-NO	16	51	22	49
IT-SAR	49	99	56	114
IT-SIC	5	28	40	58
IT-SO	6	28	31	97
JM	4	23	5	22
JO	6	30	5	26
JP-CB	99	139	106	135
JP-CG	102	128	112	133
JP-HKD	106	143	108	148
JP-HR	103	129	119	151
JP-KN	96	115	113	141

JP-KY	87	131	122	155
JP-ON	105	153	115	156
JP-SK	119	155	121	156
JP-TH	91	132	100	156
JP-TK	72	112	115	152
KE	2	37	23	38
KG	62	102	65	102
KH	0	11	1	23
KM	0	8	0	8
KP	16	31	19	32
KR	0	4	0	0
KW	0	0	0	0
KY	19	37	19	37
KZ	6	51	13	80
LA	0	14	15	31
LB	4	14	6	19
LC	0	3	0	2
LK	1	4	1	5
LR	30	60	30	60
LS	0	0	0	0
LT	6	39	65	112
LU	8	30	62	116
LV	125	157	127	159
LY	0	0	0	0
MA	26	36	44	84
MD	0	6	26	67
ME	8	68	20	88
MG	2	24	8	31
MK	32	51	50	80
ML	29	61	29	61
MM	3	19	6	21
MN	32	63	33	63
MO	29	61	29	61
MQ	23	41	24	50
MR	23	60	25	60
MT	60	88	60	82
MU	0	1	0	2
MV	3	19	3	19
MW	7	31	22	33

MX	27	39	28	40
MY-EM	18	45	23	45
MY-WM	0	0	0	0
MZ	0	0	3	30
NA	0	1	14	32
NC	28	61	28	61
NE	0	8	2	16
NG	0	0	0	0
NI	0	0	0	0
NL	42	120	84	140
NO-NO1	0	0	10	86
NO-NO2	0	2	46	110
NO-NO3	0	0	0	0
NO-NO4	0	0	0	0
NO-NO5	0	0	0	24
NP	0	0	0	0
NZ	0	0	0	0
OM	0	0	0	0
PA	0	0	0	4
PE	0	77	0	77
PF	2	6	2	8
PG	2	30	2	28
PH-LU	1	9	1	1
PH-MI	1	1	1	1
PH-VI	1	1	1	1
PK	51	87	69	88
PL	0	4	0	23
PM	0	0	0	0
PR	81	95	84	96
PS	16	33	17	33
PT	0	11	23	96
PT-MA	14	25	16	27
PW	6	19	7	19
PY	0	0	0	0
QA	0	0	0	0
RE	0	0	0	4
RO	5	21	53	92
RS	65	147	91	153
RU-1	0	0	0	0

RU-2	0	0	0	0
RU-AS	0	0	0	0
RW	16	29	18	31
SA	0	0	0	15
SB	19	38	19	38
SC	19	38	19	38
SD	0	0	5	31
SE-SE1	0	0	0	1
SE-SE2	0	0	0	0
SE-SE3	0	0	14	112
SE-SE4	0	37	33	111
SG	64	70	64	70
SI	22	46	39	56
SK	0	8	2	25
SL	6	16	30	61
SN	4	26	6	27
SO	17	35	17	39
SR	10	24	17	29
SS	4	19	4	19
ST	29	61	29	59
SV	6	31	6	39
SY	0	0	0	27
SZ	0	12	7	24
TD	1	18	1	18
TG	12	25	14	26
TH	63	91	82	103
TJ	38	65	68	95
TL	0	0	0	0
TM	0	0	0	0
TN	0	0	0	0
TO	11	22	13	23
TR	0	0	0	0
TT	0	0	0	0
TW	0	8	0	4
TZ	6	31	9	31
UG	0	0	11	31
US-AK	27	51	27	51
US-AK-SEAPA	0	0	0	0
US-CAL-BANC	36	129	96	169

US-CAL-CISO	19	103	86	162
US-CAL-IID	3	104	23	118
US-CAL-LDWP	69	152	110	168
US-CAL-TIDC	17	85	46	119
US-CAR-CPLE	1	4	1	16
US-CAR-CPLW	1	43	2	141
US-CAR-DUK	1	8	1	29
US-CAR-SC	34	60	20	129
US-CAR-SCEG	42	109	38	118
US-CAR-YAD	11	77	18	91
US-CENT-SPA	73	126	79	130
US-CENT-SWPP	0	2	2	27
US-FLA-FMPP	2	60	12	109
US-FLA-FPC	1	52	3	64
US-FLA-FPL	0	1	1	21
US-FLA-GVL	1	56	7	95
US-FLA-HST	0	1	1	21
US-FLA-JEA	1	10	2	30
US-FLA-SEC	0	1	1	30
US-FLA-TAL	20	56	21	56
US-FLA-TEC	1	15	1	48
US-HI	19	45	16	44
US-MIDA-PJM	0	4	0	7
US-MIDW-AECI	18	146	20	146
US-MIDW-LGEE	1	44	2	85
US-MIDW-MISO	1	2	1	2
US-NE-ISNE	0	7	0	13
US-NW-AVA	84	164	111	169
US-NW-BPAT	79	161	112	171
US-NW-CHPD	0	0	0	0
US-NW-DOPD	0	0	0	6
US-NW-GCPD	1	6	38	122
US-NW-GRID	1	110	1	110
US-NW-IPCO	34	146	104	171
US-NW-NEVP	62	147	91	161

US-NW-NWMT	108	168	108	169
US-NW-PACE	20	87	51	117
US-NW-PACW	88	168	114	173
US-NW-PGE	33	150	108	172
US-NW-PSCO	1	44	8	62
US-NW-PSEI	62	156	121	173
US-NW-SCL	4	103	98	168
US-NW-TPWR	16	130	91	162
US-NW-WACM	22	149	27	148
US-NW-WAUW	91	154	102	154
US-NY-NYIS	0	9	0	26
US-SE-SEPA	4	35	10	102
US-SE-SOCO	45	61	45	73
US-SW-AZPS	7	66	10	134
US-SW-EPE	6	26	9	30
US-SW-PNM	3	51	6	68
US-SW-SRP	2	98	4	134
US-SW-TEPC	4	32	11	73
US-SW-WALC	18	135	52	139
US-TEN-TVA	1	19	1	37
US-TEX-ERCO	0	6	0	10
UY	4	9	11	15
UZ	0	23	0	16
VC	14	25	14	26
VE	1	24	19	31
VI	0	14	0	14
VN	9	23	13	26
VU	15	31	15	31
WS	29	51	29	55
XK	1	35	5	50
YE	0	4	0	9
YT	1	20	3	20
ZA	5	13	4	7
ZM	0	0	18	31
ZW	0	2	0	8