Google

Improving Energy Data Access and Transparency for the Clean Energy Transition

Introduction

To mitigate the worst impacts of climate change and accelerate the decarbonization of our energy systems, companies need effective carbon accounting tools to measure, analyze, and understand their carbon footprints. By accurately quantifying their carbon footprints, companies gain vital insights that empower them to set goals, track progress, and make decisions that drive real, measurable carbon reductions. Furthermore, carbon accounting increases transparency around the carbon footprint of companies' products and services, empowering their customers with the information they need to make informed choices and enabling greater corporate accountability.

A key component of carbon accounting is electricity-based emissions ("scope 2"), which result from fossil fuel–powered electricity generation. Fully decarbonizing the global electricity sector, which represents about a third of global CO_2 emissions,[1] is critical to accelerating progress towards a carbon-free future. Scalable access to high-quality, granular electric grid data can support this carbon-free energy transition by enabling solutions that improve grid reliability, advance carbon-free grid planning, and spur technological innovation.[2]

At Google, our mission is to organize the world's information and make it universally accessible and useful. This mission extends to our work in sustainability. Since we set our goal of operating our data center and office campuses on 24/7 carbon-free energy by 2030, we have been working to build a more granular understanding of the availability of carbon-free energy on the electricity grids that serve us, so we can maximize the effectiveness of our clean energy purchasing in both reducing our carbon emissions and accelerating grid decarbonization.

Today, the availability of high-quality, granular electricity data access across the globe is variable.[3] Even in some of the most data-rich regions, like Europe and the United States, where the data exists within utility and grid operator systems, challenges remain in customers ability to directly access, or authorize third parties to access, high-quality, granular data. Both the data acquisition process and the data itself often lack standardization and digital automation.

As we wrote in our Policy Roadmap for 24/7 Carbon-free Energy,[4] improving data transparency and access is critical for the energy transition. Not only will it enable more accurate carbon footprint measurement and management, but it will also fuel the development of data-driven technologies and evidence-based policies that can accelerate global decarbonization of our energy systems. This paper focuses on the challenges and solutions associated with improving scalable data access and standardization across the United States based on the state of the grid, digital transformation, and local policy environments. It is intended to inform decision-makers in the energy industry about these issues and identify a roadmap that can be used to invest in data infrastructure, standardize data access, and advance data transparency. It is organized into three sections:

Section One discusses the ways that granular carbon accounting informs high-impact decarbonization strategies. It outlines why carbon accounting is complex and the key use cases for carbon accounting, which are trending towards methods that require more accurate calculations and rely on more granular, high-quality data, across a variety of end users.

Section Two discusses what regulators, policymakers, registries, and utilities can do to advance the development of robust data ecosystems to enable granular carbon accounting for the use cases identified.

Section Three presents established standards that policymakers and regulators can incorporate in applicable directives and that grid operators, utilities, and registries can implement to support interoperability and harmonization of data systems.

1. How granular carbon accounting informs high-impact decarbonization strategies

While there are clear ways to measure how much electricity is entering the grid from any given generator and its associated emissions, tracking emissions at points of consumption is difficult due to the physical dynamics of grid electricity flows. There could be congestion between a specific generator and consumer on the same grid, preventing electricity from flowing freely to any destination within the grid; electricity may be traded across different, interconnected grids; or consumers could purchase clean energy from sources on a different grid than the one they are physically connected to.[5,6]

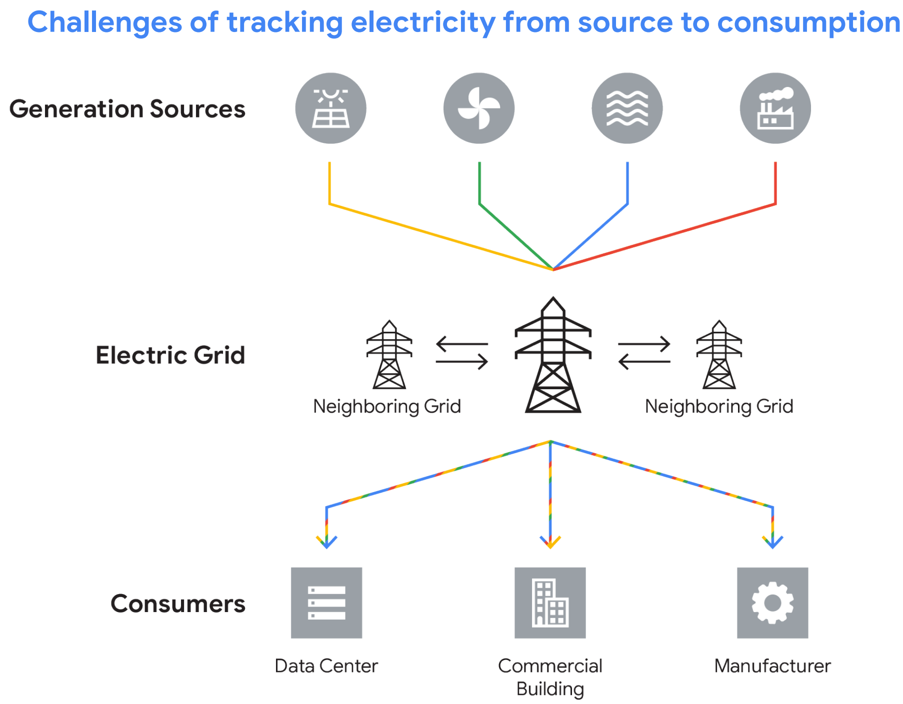

Figure 1: It is easy to measure how much clean power generation enters the grid from any given generator. But due to the complexity of power flows through a shared and constrained grid network, it is harder to know how much clean power is being consumed by a given consumer at another point in the grid. It is reasonable to assume proportional mixing in uncongested regions,[7] but it is also important to consider electricity that is traded between grids and whether any entities have laid claim to generation from specific purchases on the same grid.

As a result, it is hard to know exactly how much clean electricity an energy consumer is using to power their operations compared to relying on fossil fuel–based sources. Clear and consistent data standards are needed to calculate and allocate emissions and build a more granular, accurate understanding and disclosure of energy consumption. Driving and implementing these standards, in a way that expands access to high-quality electricity data for states, industry, corporates, and utilities, will ultimately serve four key use cases:

1. **State emissions accounting:** Measuring and assigning greenhouse gas emissions from the electricity sector to each individual state. This is crucial as more states adopt Renewable Portfolio Standards or Clean Energy Standards.[8] These policies require a specific portion of electricity to come from carbon-free sources, thus reducing emissions, and often necessitate a demonstration of compliance. If every state uses its own unique method, the sum of the parts may not equal the whole, meaning some emissions may be double counted, while some may be missed entirely. Strengthening the integrity of this emissions accounting requires a coordinated effort across states to agree on common principles for the assignment and verification of emissions data.

2. **Emissions accounting for purchased electricity:** Tracking the carbon footprint of the electricity delivered by energy providers to their customers. This is important because there is tremendous power in customer demand. Empowering customers to make informed choices about their energy supply through data transparency and tracking improves market efficiency. Additionally, in a world where customers care about their energy supply, energy suppliers must employ carbon accounting to demonstrate the cleanliness of their footprint to remain competitive, thereby creating more opportunities for cost-effective decarbonization. The challenge is that energy suppliers get their power from different sources. Some suppliers may own the power plants, while others buy wholesale electricity. Each customer's electricity usage varies based on their size, how and when they use electricity, and perhaps other preferences reflected in the rate they choose. In the end, electricity from all electricity suppliers is mixed into the same power grid. However, tracking and assigning the exact source of electricity to each customer, especially with increased precision, will require clear and consistent allocation methods.

3. **Product emissions accounting:** Calculating the emissions of a product that uses electricity, such as electrolytic hydrogen. This is increasingly critical as governments look to reward and subsidize clean products. For example, the EU is set to adopt granular carbon accounting rules for hydrogen to ensure accurate accounting. Additionally, this will be relevant in areas where granular and standardized emissions measurement will enhance stakeholder information and ensure a level playing field, such as the EU's Carbon Border Adjustment Mechanism.

4. **Corporate emissions accounting:** Calculating the carbon footprint of organizations like Google, which have global operations. This is important because the voluntary market is huge and growing. Since 2008, corporations have signed clean energy contracts for 148GW,[9] surpassing the total power-generating capacity of France, and voluntary procurement volumes continue to grow year over year.[10] Additionally, what is currently voluntary is trending towards higher scrutiny and regulation.[11] In many cases, a company may use a set of contractual instruments to more easily identify the source of the power, such as Power Purchase Agreements (PPAs), Energy Attribute Certificates (EACs), or green tariffs.[12] Otherwise, it must rely on either what the energy supplier procured and allocated to them, or whatever is left unclaimed on the grid. The energy supplier mix, explained in the "emissions accounting for purchased electricity" use case, is preferred and should be accounted for first, since

energy suppliers are usually best positioned to know what is being delivered. The leftover electricity, known as the "residual mix," can be more difficult to measure. The calculation of residual mix today relies on data that is fragmented across different entities called registries. Registries also lack standardization, interoperability, and the responsibility to report the data at an aggregated level, often leaving corporate accounting reporters in the dark.

Improving energy data access and standardization: Key steps and actors

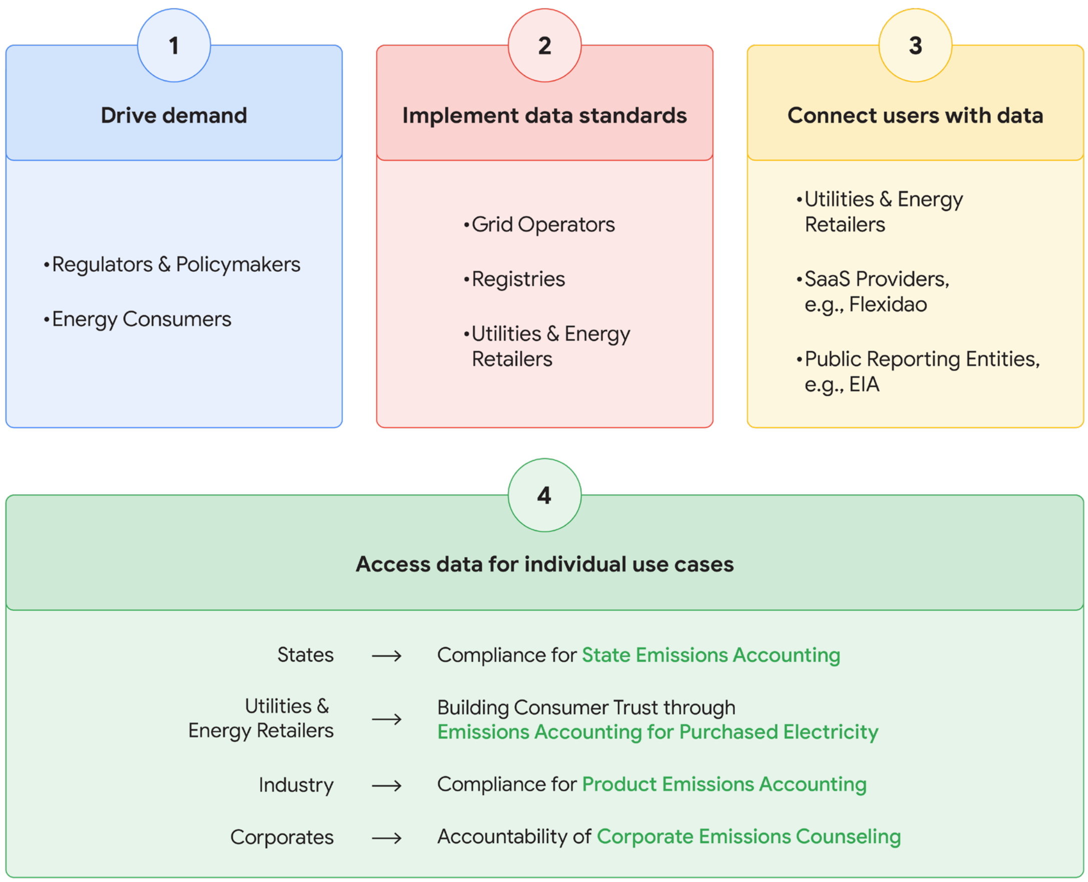

Figure 2: This paper outlines the actions that stakeholders can take to enable the four granular accounting use cases.

In each of these use cases, we observe a growing need for more accurate carbon accounting.[13] Accuracy depends on matching the location and time of electricity generation to electricity consumption, which, in turn, relies on access to more granular data. Specifically, we need more transparency into when and where electricity is generated, how the power flows on the grid, and how electricity is consumed. This enables full disclosure, or the ability to specify and prove the origin of an end user's electricity consumption. As shown by a growing body of research, these location- and hour-matching strategies are important not only for fair allocation of emissions accounting, but also for driving emissions reductions.[14]

Components of granular energy disclosure

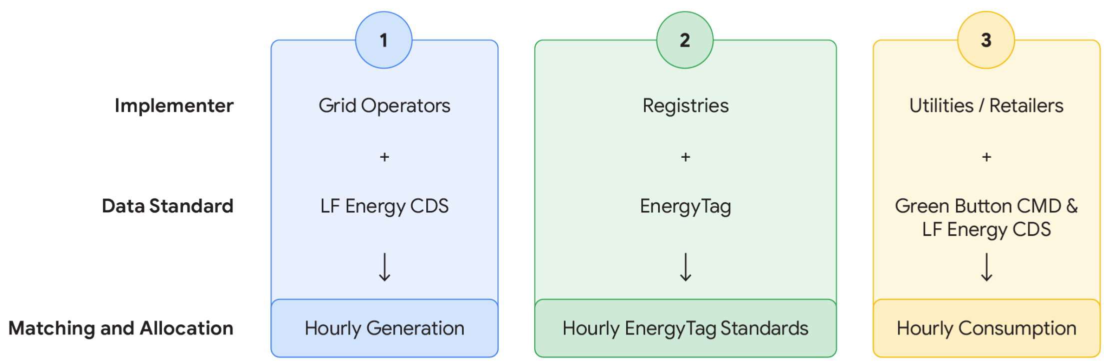

Figure 3: To enable full disclosure of electricity consumption, end users need access to three data sets: first, settlement-grade generation data from grid operators (supported by LF Energy's Carbon Data Specification, or CDS); second, hourly EACs to support claims to that generation (supported by EnergyTag Standards); and third, hourly consumption, to which hourly EACs are allocated and matched (supported by Green Button Connect My Data [CMD] and LF Energy CDS).

2. Policy reforms to enable granular accounting

This section outlines ways that policymakers and regulators can advance the development of robust data ecosystems to support these carbon accounting use cases.

Box 1: Policy Recommendations

Policymakers and regulators can facilitate the establishment of granular accounting and robust data ecosystems by:

1. Creating incentives, guidelines, or regulatory frameworks that promote the adoption of granular accounting methods. For example: through an hourly Clean Energy Standard (CES).
2. Encouraging, incentivizing, or mandating that utilities work with EAC registries on modernization, including the upgrade of those systems to be able to track, issue, and trade hourly EACs, with streamlined and secure third-party access.
3. Requiring utilities to provide customers and third-party service providers with easy, standardized, secure, and private access to granular energy usage data.

Each of these recommendations is discussed further below. Coordinated action by regulators and policymakers, grid operators, registries, utilities, and others can digitize and standardize our electricity data systems. Doing so will create scalable and secure access to the data needed to support grid reliability, minimize system costs, and prioritize clean energy growth.

Regulatory Catalysts

Regulators can play a critical role in advancing more accurate carbon accounting through policy design. There are a number of potential regulatory catalysts that, if implemented efficiently, could ensure the mechanisms are in place to realize emissions tracking goals.

- **Governments can leverage their substantial purchasing power to stimulate demand for local, hourly products dependent on better data access.** For example, the US federal government issued Executive Order 14057,[15] mandating 50%, 24/7 carbon-free energy matching by 2030 for federal agencies. In 2021, the Des Moines City Council unanimously adopted a resolution to transition the city's energy supply to 100% 24/7 carbon-free energy by 2035, citing citywide benefits and the ability to attract and retain sustainability-minded businesses and residents.[16]

- **Governments can play a crucial role in setting or enforcing standards to ensure a level playing field and comparability in the calculations necessary for granular reporting.** For example, research demonstrates that, to ensure that a nascent but growing green hydrogen economy actually realizes economy-wide emissions reductions, three pillars are needed: 1) hourly matched, 2) deliverable, and 3) incremental to existing generation.[17] This finding has led to regional implementation of standard rules for defining green hydrogen, including in Europe and the state of Colorado.[18,19]

- **Decisionmakers can establish an hourly Clean Energy Standard (CES) or reform existing RPS or CES targets to improve the locational and temporal constraints on clean energy procurement.** This may include requiring hourly matching of state consumption to clean energy procurement and setting market boundaries that reflect deliverability of the energy to in-state load. One existing example of incorporating the time value of certain clean energy technologies is Massachusetts' Clean Peak Energy Standard, which provides incentives to clean energy technologies that can supply electricity or reduce demand during seasonal peak demand periods.[20]

- Regulators can require public reporting of historical emissions tracking and projected emissions as an input and output, respectively, to integrated resource planning.

- Regulators can require that customers under standard and specific tariffs are entitled to information about the energy being supplied. Energy supply information should include consumption data and reflect reality to protect the customer from greenwashing. Local, time-matched information and standards for data access can support this objective. One example of this is California Senate Bill 1158, which requires, beginning in 2028, every retail supplier to report sources of electricity and their associated emissions used to serve loss-adjusted load for each hour during the previous calendar year.[21]

In each of these examples, clear, standardized data access and tracking guidelines should support mandatory reporting requirements. Tracking should require the use of hourly Energy Attribute Certificates (hourly EACs or Granular Certificates, GCs). Historically, an EAC has referred to an instrument representing one MWh of renewable electricity. However, more generally, an EAC is proof of electricity produced from a specific generating asset with certain attributes, such as fuel type, time of generation, or location.

Box 2: EAC Requirements

Regulators should specify the following requirements to enable functional hourly reporting across carbon accounting use cases:

- All generation assets must register with a nominated (or acceptable) registry by the asset owner.
- Asset owners must authorize (via system operator or metering manufacturer) or provide direct interval meter data access to the registry when available. All entities that are not the asset owner that touch or store the data must uphold reasonable data protection obligations.
- Every registry EAC must include the following attributes: generator ID, generator location, emissions output of generator, the generator's fuel source, date the generator came online, hour of generation, and quantity in watt-hours. Watt-hours is a departure from the standard MWh utilized today, but is necessary when moving to smaller time intervals.
- All registry account holders must identify their location.
- EACs may be transferred between account holders or assigned to a beneficiary; each beneficiary must also identify their location.
- Registries must anonymize and aggregate their data to report EAC issuance and retirements on an hourly basis for each state and grid they operate in.

Registry Dependencies

Effective reporting frameworks that track and allocate energy data and emissions depend on modernized registries. Traditional registries are often renewable-only, and track generation vintage at only the monthly granularity. Therefore, existing registries will need to transition to a new software provider or make investments in data and software in order to support the necessary changes[22] described in Box 3 below.

Box 3: Registry Requirements

To support high-quality, granular electric grid data reporting, registries will need to:

- Expand their capabilities to cover all types of generation assets (i.e., "all-generation" tracking).
- Utilize scalable methods to directly retrieve granular data from generators, metering companies, or grid operators through an API standard with agreed-upon service-level parameters to ensure data quality and streamline the data input process for granular tracking.[23]
- Add hourly certification capabilities.
- Enable new features to allow certificate "bundling" and "splitting."[24]
- Build a user interface designed to interact with larger amounts of data.
- Enable the implementation of registry APIs to facilitate dynamic interaction with data and improve the customer experience.
- Standardize data attributes and formats so that if multiple registries are covering the same geographical area, the data can be easily aggregated by location and hour across registries and cross-referenced to ensure there is no double counting.

There is also an emerging opportunity for software as a service (SaaS) intermediaries, like FlexiDAO, to support EAC allocation and customer data management. To enable this, registries may need to update user roles and permissions to allow third parties to act on a customer's (or beneficiary's) behalf, and to track the location of issuance and the retirement of the EACs.

Notably, the EnergyTag Standard and API specification (discussed further below) outline the minimum requirements for establishing a consistent and robust GC registry system in alignment with these recommendations. Some registries, such as Evident, Certigy, and M-RETS, have already begun implementing these features in alignment with the standard. **Therefore, decision-makers should incorporate the EnergyTag Standard and API specification in applicable regulatory directives,[25] supported by an interoperability certification test,[26] in order to facilitate the modernization of registry systems.**

Utility Dependencies

Registries are the core entity responsible for generation tracking; however, to enable allocation for carbon accounting use cases, it is equally important to be able to track electricity delivery, or consumption, by state, organization, and individual.

Green Button Connect My Data (GB CMD) is an international standard for providing third-party access to utility customer data, such as account, billing, and interval usage data.[27] The standard has made important progress in providing consumers with access to their utility data. When done comprehensively, it provides a digital access point, standardized format, and clear third-party authorization guidelines while ensuring data security and privacy. However, there are still some challenges that hinder its widespread adoption and effectiveness, and that specifically creates barriers for small customers to access critical information for decision-making, for example around energy efficiency measures.

The primary challenge is that most utilities still do not offer GB CMD, or have implemented it with limited functionality. Although costs are often cited as a prohibitor, the Department of Energy's (DOE) Smart Grid Investment Grant program covers up to 50% of GB CMD implementation costs.[28]

The absence of comprehensive implementations nationwide creates a patchwork system across the country.[29] This reduces its quality and consistency, making it challenging for third-party applications to effectively utilize the data. In most cases the process for getting streamlined access to your own data is opaque and complicated. The key to user engagement is for the market to have better access to this data and then to develop solutions for the applications that are in high demand, such as carbon accounting. Robust security measures, clear data ownership guidelines, anti-blocking rules, and transparency about data usage can also help build trust for data sharing. Despite these challenges, GB CMD remains a valuable tool for empowering consumers with their energy data.[30] Ontario's parliamentary government provides acknowledgment of that value through a clear legislative directive that ensures technical consistency in implementation of GB CMD across the province's 58 utilities.[31]

Today GB CMD focuses on three pillars of data access: consumption, tariff information, and bills. An important new data layer to enable more accurate carbon accounting is the allocated generation, or full consumption disclosure.[32] Utilities could integrate with registries to pull EAC data into their portals and assign specific granular EACs to customers, based on the state the customer is in and the tariff the customer is on. The allocation of EACs should be proportional to, or not in excess of, what the customer consumed on an hourly basis. Full consumption disclosure would increasingly replace the residual mix as a more accurate means of providing evidence of the electricity source.

Box 4: Utility Requirements

- Transparent processes for individual data access and authorization of data access to third parties.
- Access to key data to serve granular accounting use case: consumption, allocated generation, tariff information, and bills.
- Standardized access to allow for interoperability, according to industry best practices, with reference to the Green Button Connect or LF Energy CDS standard.
- Zero- or low-cost access.

One effort that could help enable full consumption disclosure is the Linux Foundation Energy (LF Energy) Carbon Data Specification (CDS) Consortium, which is a collaborative project to increase the effectiveness of data sharing by focusing on the full functionality needed to enable the carbon accounting use case, while ensuring robust security and privacy measures.

Decision-makers should actively promote the implementation and adoption of GB CMD. When doing so, they should reference certification with the most recent version of the GB CMD standard to ensure consistency and enable consumption data access nationwide for hourly matching. In addition, DOE should conduct a review of the quality of existing GB CMD implementations in order to assess whether they meet the needs of third parties and data consumers. DOE should then incorporate these lessons learned into future grant requirements to utilities.

Summary Table of Standards and Data Requirements

Catalyst	Implementer	Relevant Standard	Data Requirements
Purchasing power demand	System Operators	LF Energy Carbon Data Specification	Include generation mix, demand, net imports/exports, curtailment Provide authorization for individual generators' data Add API access to settlement data for authorized end users (e.g., registries)
Accounting standards and CES mandates	Registries	EnergyTag	Add more granular locational and temporal data Expand to all generator types Standardize attributes across registries Report aggregated residual mix Add API and authorization for third parties
Accounting standards and PUC directives	Utilities	LF Energy Carbon Data Specification and Green Button Connect My Data	Provide a transparent, standardized, scalable process for data access with clear, secure, and private authorization Add full consumption disclosure, incorporating EACs where available

3. Standards to support the shift to granular carbon accounting

This section describes in detail the standards and methods that should be referenced and built upon in any carbon-accounting-related regulation in order to ensure a robust and consistent framework.

EnergyTag Registry Standards

EnergyTag is a nonprofit organization leading the development of the Granular Certificate (GC). In its simplest form, this includes adding a timestamp to EACs in order to leverage data to drive consumer choice and investment to the times and places where clean energy is needed most. EnergyTag publishes and maintains the EnergyTag standard and audit process to ensure trusted and harmonized GC tracking systems are implemented globally. EnergyTag has worked with 500+ organizations to develop GCs as a credible, high-impact solution for accelerating grid decarbonization.[33] This standard development can be linked to more than six government agencies who adopted granular energy-related standards to support zero-carbon economies.

EnergyTag also published a Registry API specification and System Architecture report to demonstrate the recommended minimum requirements necessary to implement a consistent GC registry system.[34] The report describes the higher-level data structures, GC lifecycle processes, and the causes of and mitigations for failures that can occur. The API specification details sample request endpoints for a GC registry, and provides graphical examples that illustrate how to handle the increased complexity in the EAC lifecycle.

Broader implementation of the EnergyTag standards could greatly streamline and increase the necessary functionality for the next generation of hourly carbon accounting.

LF Energy Carbon Data Specification

Linux Foundation Energy (LF Energy) is driving open-source, technical solutions, including software and standards, to accelerate the energy transition. This nonprofit organization draws on expertise from energy producers, utility companies, tech experts, and academics. LF Energy serves as a hub for collaboration, building communities around the development of the tools, such as the Carbon Data Specification (CDS) project, that can make the grid cleaner, smarter, and more efficient.

The CDS is building an API specification for reporting energy data, as well as securely and privately providing data access to customer-authorized third parties for the purposes of quantifying and tracking carbon emissions from energy production and consumption.[35] It is meant to improve upon current standards, such as GB CMD, in order to enable more granular carbon accounting. The specification is broken down into multiple parts: server metadata, client registration, customer data, and power systems data.

The server metadata specification describes how utility customer data servers ("Servers") provide a structured reference of information about the server, what functionality it offers, and how other companies and technical users ("Clients") can interoperate with it. Additionally, it provides a structured metadata object on the territory, services, and customer segments for which the utility or entity provides support (i.e., "what it covers"). This would eliminate the need for corporate carbon reporters to manually investigate the capabilities of each data provider, often numbering in the hundreds or thousands.

The client registration specification outlines how Clients can securely and privately connect and access data from Servers. It builds on the server metadata, which allows Clients to discover basic information about Servers, by adding details on how Clients can register with Servers and get authorized to access specific data.

Utilities and other entities have different ways of managing data access and user permissions. This provides a standardized approach for Clients to register with a Server and be granted access to request various scopes of data from that Server, efficiently using the OAuth protocol, regardless of the specific system they're interacting with. This makes it easier for companies to develop applications and services that rely on user data from utilities and other central entities.

Next, the customer data specification describes how Clients can request access to specific customer data from Servers, such as account data, billing data, usage intervals, and allocated generation (i.e., consumption mix and apportioned EAC data). Lastly, the power systems data specification describes a structured set of endpoints for access to grid topology, asset, and market data. Unlocking these datasets is important for enabling granular, accurate carbon accounting, which is key to empowering consumers to make more responsible choices towards decarbonizing the grid.[36]

Standardized Methods

The Greenhouse Gas Protocol (GHGP) Scope 2 Guidance remains the most utilized standard for measuring carbon emissions associated with electricity consumption. It provides a methodology for inventory reporting for organizations to measure their footprint over time, which reflects the actions they take. However, the protocol is evolving to keep pace with a changing energy landscape.

One area of focus is improving the accuracy of emission reductions claimed through the use of energy attribute certificates (EACs) at higher levels of granularity (temporal and locational).[37] While the specifics of the updated protocol remain under development, we've identified practical improvements that would increase the accuracy and usefulness of accounting standards for electricity-related emissions, better align accounting metrics with the physical realities of electricity grids, and equip companies with the information they need to make informed decisions about how to reduce emissions:[38]

- Clearly defined and reported market boundaries. For utilities, or load-serving entities (LSEs), this corresponds to the electricity delivery area. States and organizations should use relevant boundaries that align procurement instruments with existing regulatory or market structures, such as state lines or the electricity market (ISOs in liberalized markets and Balancing Authority in traditionally regulated markets), respectively.
- EACs that ensure matching of generation to consumption within the specified market boundary. This can be done by checking that the retiree of the EAC, or the beneficiary, has the same "location" as what is marked as the location of the generating asset on the EAC. Future systems, where registries are standardized and interoperable, could enable EAC trading across grids, informed by real-world power flows. For example, an hourly trading cap of solar EACs from Grid X to Grid Y in the spot market (backward-looking) could be based on Grid X total exports and proportion of Grid X generation in that hour that was produced by solar. This limited pool of available solar EACs could be auctioned on a willingness-to-pay and first-come-first-serve basis. This advanced model, while requiring additional coordination and setup, could offer greater procurement flexibility not only in region, but also from neighboring regions, while maintaining a realistic representation of the physical grid. Alternatively, a company or LSE could qualify EACs out of market if bundled with supply that is deliverable to the same market boundary as load, i.e., scheduled to the same market boundary as consumption with firm transmission rights.
- Hourly matching of EACs to electricity consumption. When hourly data isn't available, validated models should be allowed in order to estimate hourly variations from monthly metered data.[39]
- Application of the supplier emissions rate to consumption, backed by EACs. If that is unavailable, for consumption that is not met by EACs ("untracked consumption"), the residual mix ("RM") may be used.[40,41] In the case that both supplier emissions rate and RM are not available, a fossil-based emissions factor may be used. In the United States, when all generation is tracked, the residual mix calculation takes the generation on the grid and excludes any energy that is retired or exported to other

grids. Only energy imports from areas with a compatible Certificate Tracking System will lead to unit-specific certificates that get retired (and excluded) in the RM grid. All other imports should be assigned the residual (if available) or system mix of the exporting region.[42]

With the recommended reporting requirements and infrastructure improvements in this paper, reporters should be able to report on an hourly basis:				
Energy supply volume by fuel type and emissions. This includes everything retired by the energy supplier on behalf of a particular program.[43]	State-level residual mix by fuel type and emissions. This includes anything issued in state that is not retired, or issued in state and retired as part of a state RPS or CES.	Grid-level residual mix by fuel type and emissions. This includes anything issued in the grid that is not retired or exported, and accounting for the residual mix or system mix of imports.	State volume by fuel type and emissions. This includes the state-level residual mix plus anything that is retired by an owner/ beneficiary located in state.	Customer volume by fuel type and emissions. This includes everything retired by the customer or on the customer's behalf.

Conclusion

High-quality, transparent, and accessible data is a necessary foundation for decarbonizing our electricity systems. To better measure carbon footprints and make energy purchases and planning decisions that accelerate grid decarbonization, energy consumers need access to granular data on their energy consumption, power system mix, and energy attribute certificates for claims. Moreover, standardized and accurate accounting practices across states build trust in state and federal policies, further enabling a cleaner electricity future.

In summary, the following initiatives can enable more accurate carbon footprint measurement and management through high-fidelity disclosure and provide needed transparency to accelerate the clean energy transition:

- A regulatory catalyst with clear, standardized data access and tracking requirements to support hourly reporting

- Registry software modernization to support hourly all-generation tracking, with third-party integration functionality, according to the EnergyTag standard
- Utility software modernization to support hourly matching of generation to consumption (full consumption disclosure) and general customer data access according to the LF Energy data standards
- Standardized methods for full consumption disclosure and, in its absence, residual mix.

Showing clear customer demand and support for these initiatives can help increase momentum towards these goals. This can come in the form of regulatory intervention, sponsorship for consumer data advocates, and engaging in conversations with utilities to understand offerings. Ultimately, unlocking more transparent, accessible energy data drives the collective action and policy change needed to pave the way for a clean energy future.

Endnotes

1 International Energy Agency, Greenhouse Gas Emissions from Energy Data Explorer (2023).

2 The term *granular* generally refers to temporal granularity of data at the hourly or subhourly level.

3 International Energy Agency, "Large Consumers Can Help Drive the Clean Energy Transition—But They Need Better Data" (2023).

4 Google, "A Policy Roadmap for 24/7 Carbon-free Energy" (2022).

5 A 2023 study by Singularity and The Brattle Group introduces the concept of physical deliverability and criteria to evaluate the degree to which clean energy procurement is deliverable to an energy buyer's consumption. See https://singularity.energy/boundaries-report.

6 This is because today's Scope 2 carbon accounting rules allow companies to reduce their carbon footprint with renewable electricity purchases within broad boundaries that do not necessarily align with the grids where they physically consume energy.

7 Electricity Maps, "How to trace back the origin of electricity" (2021).

8 Lawrence Berkeley National Lab, "U.S. State Renewables Portfolio & Clean Electricity Standards: 2023 Status Update" (2023).

9 Bloomberg New Energy Finance, "Corporations Brush Aside Energy Crisis, Buy Record Clean Power" (2023).

10 Sumner et. al., "Status and Trends in the U.S. Voluntary Green Power Market (2021 Data)," National Renewable Energy Laboratory (2023).

11 The CSRD in Europe and SEC in the United States are examples of increasing regulation on environmental data disclosure.

12 Green tariffs and PPAs should also use EACs for tracking purposes.

13 G. Miller, K. Novan, A. Jenn, Hourly accounting of carbon emissions from electricity consumption, Environmental Research Letters (2022).

14 Q. Xu, W. Ricks, A. Manocha, N. Patankar, J. Jenkins, System-level Impacts of Voluntary Carbon-free Electricity Procurement Strategies Joule (2024); I. Riepin and T. Brown, System-level impacts of 24/7 carbon-free electricity procurement in Europe, Technical University of Berlin (2022); International Energy Agency, Advancing Decarbonisation through Clean Electricity Procurement (2022).

15 The White House, Executive Order on Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability (2021).

16 K. Weaverling, History made as Des Moines adopts 24/7 carbon-free energy resolution, becoming first in nation, Iowa Environment Council (2021).

17 Wilson et al. (2022), Brauer et al. (2022), Zeyen et al. (2023), Cybulsky et al. (2023).

18 See the European Commission's Delegated Acts on Renewable Hydrogen.

19 See the State of Colorado's Measures to Advance Clean Hydrogen.

20 See more on Massachusetts' Clean Peak Energy Standard at https://www.mass.gov/clean-peak-energy-standard.

21 See more on California's Senate Bill 1158 at https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220SB1158.

22 R. Terada. Readiness for Hourly: U.S. Renewable Energy Tracking Systems, Center for Resource Solutions (2023).

23 See an example of an API standard for power systems data at https://powersystemsdata.carbondataspec.org/.

24 This terminology refers to the ability to convert ("split") from monthly ("bundled") to hourly EACs in smaller increments, e.g., for unit generation smaller than one MWh, with methods to trace these changes.

25 EnergyTag Standards can be found at https://energytag.org/standards/.

26 This would be a test performed by an independent third party to ensure registries have correctly implemented the standard in such a way that data from the registry can be usefully exchanged across registries, utilities, and service providers to enable downstream applications.

27 See more on Green Button at https://www.energy.gov/data/green-button.

28 See Topic Area 2, from Section 40107 of the 2021 Infrastructure Investment and Jobs Act: https://www.energy.gov/gdo/smart-grid-grants

29 American Council for an Energy Efficient Economy, Data Access. Accessed in December, 2023 at https://database.aceee.org/state/data-access.

30 M. Murray, J. Hawley, Got Data? The Value of Energy Data Access to Consumers, Mission:data (2016).

31 See Ontario Regulation 633/21 at https://www.ontario.ca/laws/regulation/r21633.

32 RECS International, What full disclosure means, and why it is so important (2020).

33 Including Google, Microsoft, The AES Corporation, M-RETS, Constellation Energy, among others.

34 EnergyTag, GC Registry API Specification, Version 2 (2023).

35 See more on LF Energy's Carbon Data Specification at https://github.com/carbon-data-specification.

36 In the absence of actual energy consumption data, improving access to synthetic or anonymous interval energy usage data, such as the Anonymous Data Service that ComEd provides, can also support new tools that enable the market to deliver greater value to customers.

37 World Resources Institute, Summary of Proposal Submissions Related to Scope 2 Guidance (2023).

38 M. Terrell, Building more accurate and effective greenhouse gas accounting, Google (2023).

39 In all restructured states with retail choice, utilities must have a method to determine hourly supply obligations for all customers as they switch from one supplier to another. See example in ERCOT here: https://www.ercot.com/mktinfo/loadprofile. In the United States, the National Renewable Energy Laboratory (NREL) has also developed End-Use Load Profiles as a highly validated dataset to represent the 15-minute consumption profiles across a variety of geographies and end uses.

40 At the time of publication, the authors are not aware of anywhere in the United States where there is an accurate hourly residual mix with proper allocation of clean energy attributes.

41 One criticism of residual mix today is that it can often include "non-bypassable" carbon-free energy, or carbon-free energy that customers pay for through their utility rates but that is not allocated to those customers with attribute credits.

42 Clean Energy Accounting Project, Residual Mix Applications and Existing Data, Center for Resource Solutions (2023).

43 A "program" may refer to the standard default rate, the entire portfolio of assets, or the assets specific to a utility program or tariff. Every customer should be provided the full program transparency and volume that shall be allocated to each customer proportionally based on the customer's share of load in the program total on an hourly basis.