Building more accurate and effective greenhouse gas accounting

Google's comments on the Greenhouse Gas Protocol Update

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Google

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Executive Summary

Google provides these comments in response to WRI's Survey on Need for Greenhouse Gas Protocol (GHGP) Corporate Standards and Guidance Updates.

The Greenhouse Gas Protocol is the world's most established and widely used greenhouse gas (GHG) accounting standard, serving as the foundation for the private sector's most prominent carbon disclosure platforms and clean energy leadership programs. Google is providing comments based on our experience with current GHGP standards. We identify targeted adjustments aimed at increasing the accuracy and usefulness of the GHGP while avoiding undue costs, burdens, or delays for the growing number of companies that utilize it.

Our comments reflect that the information and insights gleaned from carbon footprints are an important input into GHG reduction strategies, consistent with one of the GHGP's core stated objectives.[1] In effect, the GHGP does not just guide how companies[2] calculate their GHG footprints; it also provides companies and other stakeholders with information that can inform both company-level and industry-wide decision making. It is therefore important that the GHGP update take into account not only carbon accounting principles and methodologies, but also the ways in which carbon accounting informs GHG reduction strategies.

Our comments span the Corporate Standard, Scope 2 Guidance, and Corporate Value Chain (Scope 3) Standard. They involve three parts:

In Part I, we lay out three precepts that we believe should guide decision making pertaining to updates to GHGP standards and guidance:

- **True and fair representation:** The GHGP should enable emissions inventories that provide a true and fair representation of an organization's carbon footprint.

- **Real and measurable action:** Recognizing that GHG inventories inform decision making, they should provide useful information that enables strategies that lead to real and measurable emissions reductions.
- **Functionality:** The GHGP should be accessible for a wide range of companies to implement and a wide range of stakeholders to understand.

In Part II, we offer detailed suggestions for how scope 2 guidance can better embody these precepts. Specifically, we:

- Discuss how scope 2 market-based guidance has played a key role in driving voluntary corporate clean energy procurement, but as currently structured does not result in accurate scope 2 inventories.
- Explain how more geographically and temporally granular scope 2 accounting will lead to more accurate inventories, drawing on academic research and expert perspectives from grid operators around the world.
- Show how data and tools to enable more granular scope 2 accounting are available in many places today, and how momentum is growing rapidly towards their universal accessibility.

We focus our comments most heavily on this section. This reflects the importance of electricity to Google's operations, the central role of clean electricity in mitigating global climate change, and the relative maturity of scope 2 accounting. The solutions we identify are incremental in nature, reflecting that they are building on well-established scope 2 practice underpinned by clear and explicit guidance, a robust ecosystem of technologies, suppliers, data solutions, and platform providers, and a strong evidence base reflecting decades of academic research. We suggest that they be phased in over time, to ensure a smooth transition for all stakeholders.

In Part III, we focus on needs and opportunities pertaining to scope 3 inventories. Starting from the premise that scope 3 accounting is at an earlier stage of maturity than scopes 1 and 2, we:

- Highlight areas where we believe that improvements are needed today, e.g., clarifying companies' scope 3 boundaries and expanding mitigation options for scope 3.
- Identify important issues where further research, experimentation, and stakeholder engagement are required to determine the best path forward.

Across our comments, we encourage the GHGP to operate with agility. This will enable GHGP standards and guidance to remain fit for purpose as technologies, markets, and corporate footprinting practices continue to evolve rapidly. Greater agility will also engender positive feedback loops whereby new research, technologies, and market developments drive continued iteration of the GHGP towards greater accuracy and effectiveness.

The next decade is critical in driving the rapid decarbonization that is necessary to limit global warming to 1.5°C. Our aim in submitting these comments is to offer practical solutions that can inform the GHGP update process, with the ultimate goals of ensuring that GHG footprints are accurate and equipping stakeholders with the information they need to make informed decisions about how to address them.

Part I: Prioritize true and fair representation, meaningful action, and functionality

I. Introduction

The next decade is critical in limiting global warming to 1.5°C, which according to the IPCC will require the rapid decarbonization of every region and industry sector.[3] Companies have a critical role to play in meeting this challenge, and carbon accounting is one of the most important tools that they use to measure, analyze, and understand their greenhouse gas (GHG) footprints.

The Greenhouse Gas Protocol (GHGP) is the world's most established and widely used GHG accounting standard. It serves as the basis for the private sector's most prominent carbon and clean energy disclosure platforms (e.g.,, Carbon Disclosure Project) and leadership programs (e.g., Science Based Targets Initiative), and may also become a key foundation for mandatory regulatory reporting requirements currently under development in numerous jurisdictions around the world.

The goals of the GHGP are multifaceted: it aims to enable standardized accounting of companies' carbon footprint, while acknowledging that companies use the resulting data to develop emissions reduction strategies. This multifaceted role is reflected in one of its stated objectives: to "provide business with information that can be used to build an effective strategy to manage and reduce GHG emissions."[4] By providing relevant inventory data, the GHGP has played a foundational role in shaping corporate strategies, actions, and investments in climate mitigation since 2001.

As potential GHGP updates are considered, the ways in which companies use the GHGP must be given thoughtful consideration. Our hope is that the updated GHGP will drive continued improvements in the accuracy of GHG footprints, giving companies useful information that enables them to make decisions that drive real, measurable GHG reductions. This is a high priority for Google because we measure our footprint not only to understand it but also to inform how we go about reducing it.

Today, the GHGP establishes five principles that corporate carbon footprints must be based on: relevance, completeness, consistency, transparency, and accuracy. These principles should remain at the heart of GHG footprinting. As the GHGP contemplates updates to standards and guidance, we believe that the following precepts are particularly important to guide decision making:

- True and fair representation
- Real and measurable action
- Functionality

II. True and fair representation

A stated objective of the GHGP today is "to help companies prepare a GHG inventory that represents a true and fair account of their emissions."[5] We believe this concept is at the heart of the GHGP's purpose, and this update should prioritize advancing it further. Important elements of a true and fair representation include accuracy, credibility, and comparability of emissions and reductions, including those resulting from market-based interventions. We focus principally on two aspects of true and fair representation:

Inventory accuracy

Inventory accuracy is critical for the GHGP and its stakeholders. It is also challenging, because carbon accounting is still an emerging field that continues to evolve rapidly. Achieving accuracy is therefore best understood as an ongoing refinement process rather than a fixed-end state. As such, the GHGP should encourage and enable companies to continuously improve the accuracy of their inventories as data and methodologies mature over time, while recognizing that appropriate accuracy levels will vary across scopes and should be right-sized based on the degree to which they are material to footprinting and decision making. Ultimately, more accurate measurement of scopes 1, 2 and 3 footprints will result in more credible inventories, and give companies and other stakeholders information they can use to take more targeted and effective actions to reduce emissions.

Standardization of measurement

More standardized metrics and measurement methodologies are critical to enable more accurate and consistent footprinting and improve the credibility and comparability of companies' footprints. Because measurement capabilities and accuracy levels differ across scopes and categories,[6] standardization needs to be targeted and responsive to specific context.

True and fair representation has become especially important in recent years, as the credibility of both the GHGP and company-level carbon footprints have come under increased scrutiny.[7,8] Criticism is frequently focused on inaccuracies in scope 2 inventories, where claims of reductions in reported footprints are not matched by commensurate real-world reductions. These discrepancies often stem from the use of high-level data that do not reflect physical flows of electricity, and the crediting of interventions that are widely seen as ineffective at reducing GHG emissions (e.g., traditional unbundled EACs).[9,10] We provide more detailed analysis of these issues and proposed solutions in Part II below.

III. Real and measurable action

Private sector companies are the engines of the global economy. Recognizing the urgent need to mitigate global climate change, a growing number of them are applying their capabilities, investments, and influence to reduce their GHG footprints and contribute to the decarbonization of the regions and markets in which they do business.

For companies that aim to reduce their GHG footprints, the crediting systems embedded within GHG accounting standards are an important factor in decision making about how to pursue reductions. In practice, companies make decisions based on what actions are credited as reductions to their footprint, and thus the

GHGP and associated inventories are a crucial source of insight informing companies' climate strategies and GHG reduction actions.

We focus principally on two priorities for real and measurable action:

Aligning scope 2 crediting with real-world GHG impacts

Under current GHGP methodologies, the actions that are credited as emissions reductions within companies' inventories do not align sufficiently with the real-world GHG impact of those actions. Company strategies and actions that differ widely in effectiveness, both in their impact on a company's own GHG footprint and on broader energy and economic systems, are in many cases credited equally.[11] For example, as we discuss in Part II below, clean electricity purchases aimed at reducing scope 2 emissions are likely to be more effective at reducing a company's real-world GHG footprint and contributing to system-wide decarbonization when they are matched geographically and temporally to a company's energy consumption and accounted for using attributional market instruments. The updated GHGP should remedy this by more closely aligning credit for GHG reductions with real and measurable impacts of company actions. This will help companies make more informed decisions about their strategies and priorities, taking into account the real-world impacts of their actions and receiving credit for actions that result in real and measurable GHG reductions.

Creating new opportunities for scope 3 reductions, corresponding to real-world impacts

Scope 3 is the largest source of emissions for many companies, yet today's GHGP does not provide comprehensive market-based pathways for companies to reduce scope 3 emissions. As a result, there are a range of actions that companies could take which would result in real and measurable GHG reductions but which would not be reflected in their scope 3 footprint. This could be remedied by creating more opportunities for companies to be credited for scope 3 reductions through market-based instruments.

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IV. Functionality

The GHGP needs to be functional in order for it to be widely utilized and effective. There are two key elements of functionality that should be prioritized:

Standards and guidance should be implementable by a wide range of companies

Companies should be able to produce inventories reasonably and without undue burden. Today, companies often require significant support to implement GHGP standards, including to interpret guidance, obtain data, and calculate footprints. The updated GHGP should provide more clarity and ease of use. Inventories should be able to be completed consistently, using standardized solutions and calculations that are readily accessible and feasible. They should not require data sources that are only available through a small number of for-profit providers. For example, in scope 2, maintaining attributional accounting but incrementally increasing its geographic and temporal granularity would ensure the GHGP is functional from both data availability and ease of implementation perspectives. By contrast, attempting to integrate consequential accounting metrics into scope 2 would impose a burden that is difficult to justify vis-à-vis the expected climate benefit, in particular, because it would rely on technical skills, custom models, and data sets largely unavailable to most companies.

Inventories should be understandable to a wide range of stakeholders

While corporate inventories naturally entail a level of complexity, GHGP methodologies and company GHG inventories should be readily understandable to external stakeholders relying on them. By making metrics and methodologies as straightforward as possible, the GHGP will foster the creation of more understandable and useful inventories. This will have at least two important benefits: the GHGP will be more consistently applied, improving comparability across organizations, and companies will be able to better evaluate themselves over time as their operations and footprints evolve - one of the GHGP's primary use cases.

Incorporating the above three precepts into the updated GHGP, and thereby embedding them into company-level practices and decision-making, will make it easier for companies to create accurate inventories that fairly reflect both their real-world footprints and the real-world impact of actions they take to reduce them. This will enable companies and market stakeholders to make more informed and effective decisions.

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Part II: Enable greater accuracy and usefulness of company inventories through incremental improvements to scope 2 guidance

I. Suggested evolutions to scope 2 accounting

We believe that discrete, incremental evolutions to scope 2 accounting will improve the accuracy, actionability, and usefulness of the GHGP. We suggest the GHGP maintain attributional accounting while making the following two evolutions, in order of priority:

1. Refine geographic market boundaries to match the approximate physical deliverability of clean energy to the grids where consumption occurs
2. Transition to hourly tracking over a phase-in period with accessible on-ramps

II. Shortcomings of current scope 2 guidance

Today, scope 2 footprints do not go as far as they could in representing a true and fair account of companies' emissions or the effectiveness of their market-based interventions. The two largest sources of inaccuracy are geographic boundaries that are disconnected from physical markets and annual volumetric tracking. These approaches made sense when clean energy markets were still in their infancy, and they helped drive gigawatts (GW) of new clean energy deployment over the last decade.[12] However, their limitations have become clear as clean energy deployment has scaled, data has improved, and academic research has shed greater light on optimal pathways for pursuing rapid and deep decarbonization of corporate electricity footprints and broader electricity systems.

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Geographic boundaries are not reflective of physical markets

Under today's GHGP guidance, geographic boundaries for scope 2 do not correspond to the physical markets where a company consumes electricity. A company can purchase Energy Attribute Certificates (EACs) far from where it consumes electricity,[13] because the electricity represented by EACs is not required to be deliverable[14] to the grid(s) where the company operates. Thus, EACs that are physically disconnected from underlying electricity consumption function effectively as offsets: they are reductions claimed elsewhere to compensate for a company's electricity-based emissions. This approach has become widespread in practice under today's scope 2 guidance, despite the scope 2 standard ostensibly prohibiting the use of offsets to reduce a company's emissions.

How this works in practice is that each EAC that a company purchases conveys an emissions rate of the associated generator, which in the case of carbon-free sources is zero. Companies account for their consumed MWh at an emissions rate of zero, even if the grid where their electricity consumption occurs is more emissions intensive than the grid from which the EACs are sourced. For example, a company in Spain may purchase EACs from a hydropower facility in Norway to reduce its scope 2 emissions, even though there is no physical connection between these countries' electricity grids. In this case, the grid emissions factor where electricity is consumed (Spain) is significantly higher than the grid emissions factor where the EAC is generated (Norway), so the attribution of the EAC generated in a low-carbon grid to consumed emissions in a high-carbon grid creates a mathematical underestimation of a company's emissions inventory. This is a source of much existing criticism of the scope 2 methodology.[15]

Data demonstrate that many companies do indeed pursue this practice. For example, Norway was responsible for 43% of all guarantees of origin (GOs) exports in Europe in 2022, many of which were purchased by companies whose operations have no connection to the Norwegian grid on which these EACs were produced.[16] This also explains why, even though Norway's grid-level emissions factor is 10 kg CO_2/MWh[17] (98% carbon-free), the residual emissions factor is 402 kg CO_2/MWh (7.4% renewable), reflecting that most EACs produced within the Norwegian grid are claimed and retired outside of the country.[18]

Such a system can and does distort companies' footprints by understating their reliance on fossil-based electricity. This results in companies not addressing the emissions for which they're physically responsible, and not supporting the collective and urgent need to decarbonize electricity systems to the degree that they might otherwise. In the above example, Spanish companies that purchase EACs from Norway are not working to decarbonize the electricity grid in Spain, which still relies on fossil fuels for over one-third of its electricity.[19] This system may also create a perverse incentive for companies to deploy renewable energy in the lowest cost areas, which can lead to an oversaturation of local markets, clean energy curtailment, and increased costs for other ratepayers that the purchasing company does not bear.

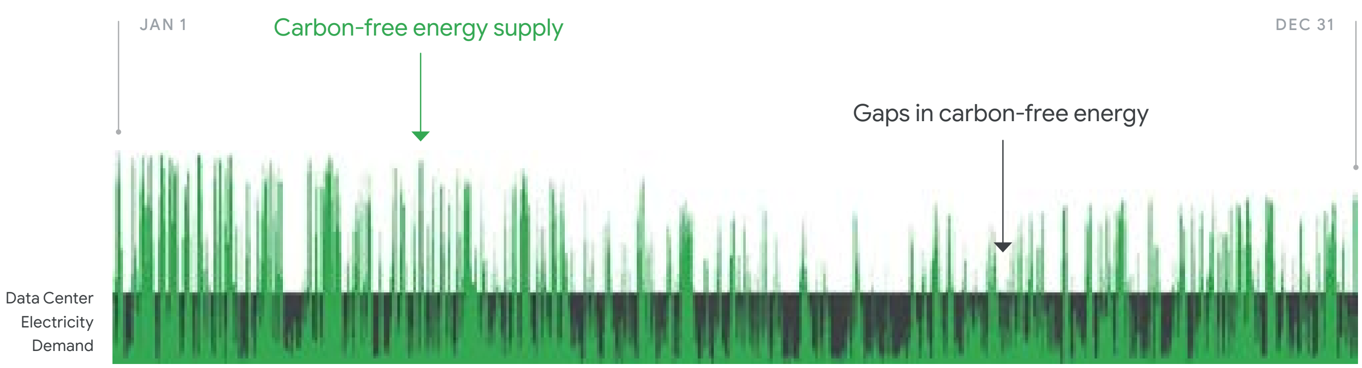
Annual resolution

While the GHGP doesn't explicitly endorse the use of annual emissions factors, in practice companies that report carbon inventories under the GHGP use annual emissions factors. This obscures the fact that electricity-based emissions vary significantly over time, due to daily and seasonal variability in the mix of power plants delivering electricity to a given grid.[20] Using annual accounting can overstate market-based GHG reductions by more than 50% when compared to using hourly accounting.[21] In effect, companies that purchase wind or solar energy to match 100% of their annual electricity consumption may still rely on carbon-emitting grid electricity for over 50% of their demand. Crediting these clean energy purchases as reductions to their inventories - irrespective of the degree to which the associated clean energy generation matches their underlying energy consumption - underestimates their real-world carbon footprints and obscures their reliance on electricity generated by carbon-emitting sources.[22] In 2018, Google released a paper showing how, even though we matched our global annual electricity consumption with renewable energy purchases, we continue to operate on fossil fuels in many locations and at many times, as shown below in Figure 1.[23]

FIG 1

Hourly carbon-free energy performance at an example data center.

While Google buys large amounts of wind and solar power (symbolized by green spikes below), these resources are variable, meaning that our data centers still sometimes rely on carbon-based resources.



In addition to improving transparency about the degree to which a company continues to rely on carbon-emitting electricity sources, more accurate inventories based on more granular temporal matching would give companies the insights they need to target actions that are required to fully decarbonize their own footprints and the broader electricity systems that serve them. These include, for example, the deployment of firm and flexible generation and storage technologies and the shifting of loads to times of day when clean electricity is amply available on the grid.

In summary, today's scope 2 guidance does not result, as much as it could, in a true and fair account of companies' GHG footprints or the GHG reduction impact of their market interventions.

III. Improvements to scope 2 guidance will create more accurate and useful emissions inventories

To address the shortcomings described above, the GHGP can introduce greater geographic and temporal resolution to scope 2 accounting, and thereby align GHG inventories more closely with the physical realities of electricity grids. These changes reflect the reality that the electricity emissions for which a company is responsible depend significantly on the time and location of their electricity consumption. As RE100[24] and CDP[25] observe, "Renewable electricity procurement must more closely match physical flows of electricity to reduce the environmental impacts resultant from companies' use of electricity."[26]

The core principles that should guide this evolution are:

Location matching

An accurate inventory of electricity emissions and electricity market interventions depends heavily on location, as grid mixes vary widely across regions. Boundaries narrowed to the electricity grid balancing authorities where companies consume electricity would reasonably reflect the deliverability of purchased clean energy to the electricity consumer. Purchasing clean energy on the same grid where consumption occurs is the best way to create an inventory that accurately reflects the physical realities of the grid and directly addresses the emissions associated with a company's operations.

Time matching

The emissions associated with the consumption of electricity and electricity market interventions in a given location can vary widely based on the time of day when the electricity is generated or consumed, depending on the mix of resources providing electricity to the grid at a given time. Hourly accounting provides a more accurate estimate of the carbon emissions associated with companies' electricity consumption, and creates a closer connection between companies' clean electricity purchasing and their actual electricity consumption.

We believe that introducing more granular geographic and temporal boundaries for scope 2 will result in inventories that more accurately represent the GHG emissions and reductions for which a company is responsible, increasing the credibility of market instruments and enabling greater real-world GHG reductions. Specifically, connecting scope 2 accounting more closely to the physical reality of the electricity systems that serve companies' operations will result in:

- Inventories that provide a more true and fair representation of company emissions
- Greater alignment between companies' clean energy procurement and their real-world scope 2 footprints, and thus greater credibility of associated emissions reductions claims
- More meaningful comparisons of footprints and reductions across companies, sectors, and geographies
- Encouragement of actions that help decarbonize electricity grids, including, but not limited to demand response, load-shifting, and policy and regulatory intervention to advance clean energy
- New momentum towards system-level decarbonization across the full range of grids which serve companies' operations around the world

By narrowing electricity market boundaries and transitioning to hourly accounting, the GHGP will strengthen the connection between companies' electricity consumption and their GHG reduction actions and create a more true and fair representation of both the emissions and the reductions for which they are responsible.[27] This would address concerns that companies are greenwashing by effectively using EACs as offsets, rather than more directly reducing the GHG emissions for which they are responsible.[28] As described further in Part V of this essay, these changes will also give companies helpful information that will enable them, if they so wish, to design their carbon reduction strategies in ways that increase their impact on global GHG reduction by maximizing their contribution to the decarbonization of global electricity systems.

IV. A phased approach to implementation

We recognize that even incremental changes cannot occur overnight, and companies, energy suppliers, and marketplaces will need time to adjust to the new requirements. As such, we suggest the GHGP consider a phased approach to our proposed changes, quickly implementing the most important and immediately practicable change, refining geographic boundaries, while phasing in hourly tracking more gradually. This is illustrated below in Figure 2. A phased approach with practical on-ramps will be more accessible and enable all types of companies to transition successfully.

FIG 2

Implementation stages to update scope 2 accounting

Implement today	Transition phase	Target year
Step 1	Step 2	Step 3
Refine geographic boundaries to reflect electricity grids	**Improve temporal tracking** to monthly	**Track hourly** using primary data or estimated profiles

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Priority 1: Refine geographic boundaries in the near term

It is possible today to implement geographic boundaries that provide a more accurate representation of the GHG emissions and reductions for which a company is responsible.[29] This may entail modest operational changes to how an inventory is calculated, but these are incremental in nature, and there are no widespread or significant technological or data barriers. One issue that would need to be addressed is how to reconcile existing long-term clean energy contracts with these proposed changes to geographic boundaries. We believe that the GHGP could identify fair and reasonable pathways to addressing this, in consultation with impacted companies. Solutions could include grandfathering existing contracts or applying newly excess unbundled EACs elsewhere in an inventory, e.g., to scope 3 electricity emissions.

Priority 2: Transition to hourly tracking over a phase-in period with accessible on-ramps

In recent years, many companies, governments, utilities, and energy suppliers have committed to more closely match their procurement of clean electricity with the times and places in which they consume electricity. New global and regional efforts have developed to speed the progress that is underway in granular energy tracking, certification, and contracting. This includes the UN 24/7 Carbon-free Energy Compact[30] and the European 24/7 Hub and Academy.[31] These early examples have contributed to the rapid advancement of ecosystem tools which enable more granular footprinting than is required under today's scope 2 guidance. The data, certification mechanisms, and contractual structures to implement more granular temporal carbon accounting are available today in many markets and are scaling rapidly.[32] In the Appendix, we review the global availability and implementation readiness of these elements.

Recognizing that not all companies are ready for full implementation of hourly resolution today, we suggest a near-term shift to monthly resolution as an initial step. This aligns with the timelines of similar transitions towards hourly accounting that have been adopted by regulators, such as the European Union's new rules on grid-based hydrogen production, which allows monthly tracking until 2030 when hourly resolution becomes required.[33] We also recognize that primary data are not available or easily accessible to every company today. Where needed, companies should be able to estimate electricity demand or production using models or shape profiles.[34] Representative hourly demand profiles currently exist for large retail stores, commercial office buildings, and other customer types.[35] This may be especially helpful in cases where companies have varied load profiles or loads that are highly geographically distributed.

V. Why updating scope 2 matters - market perspectives on accuracy and impact

As we have highlighted, increasing the geographic and temporal granularity of scope 2 attributional accounting will result in GHG inventories that are more accurate and useful to stakeholders. In this section, we discuss how increased accuracy will also provide companies that wish to have a more consequential impact on electricity system decarbonization and global GHG reduction with information and insights that help them better design their market interventions towards these objectives.

This is important because the electricity system is central to economy-wide decarbonization and therefore climate change mitigation. Globally, over 40% of energy-related GHG emissions result from the burning of fossil fuels for electricity.[36] Electricity is also critical for decarbonizing other sectors of the economy - from buildings to transport to industry - via electrification with progressively lower-carbon electricity. In its landmark report on achieving a net zero emissions global economy by 2050, the International Energy Agency (IEA) found that achieving this goal will require global electricity systems to fully decarbonize even faster - by 2040 - while growing significantly to become the core of the global energy system.[37]

Companies have a central role to play in driving this transition, as they represent the majority of electricity consumption in many countries.[38] For over a decade, companies have supported the deployment of large and growing quantities of clean electricity on grids around the world.[39] A more granular scope 2 guidance would enable and incentivize companies to better align their investments and purchasing decisions with what is needed to decarbonize global electricity systems.

Granular geographic and temporal boundaries will accelerate system-level decarbonization

A significant and growing body of academic research employing robust energy system modeling approaches[40] has shown that corporate matching of electricity use on a locational and hourly basis, even at levels below 100%, can drive greater grid decarbonization and accelerated technology innovation compared to matching electricity demand at an annual level.[41]

Four studies released in the last two years by Princeton University,[42] Technical University of Berlin,[43] the International Energy Agency,[44] and Peninsula Clean Energy[45] examine the impact of same-grid, hourly matched clean energy procurement. The studies model different grids in the US, Europe, and Asia, and ultimately converge on similar findings across these diverse regions. According to these studies, compared to 100% annual matching, local hourly matching leads to:

- Deeper reductions of CO_2 emissions associated with a user's electricity use
- Deeper reductions of CO_2 emissions for the overall electricity system[46]
- Significantly greater retirement of CO_2-emitting generating capacity
- Early deployment of advanced clean electricity technologies, stimulating innovation from which the whole electricity system would benefit.[47]

- 100% hourly matching can cost more than 100% RE annual matching, but its cost can be reduced by using a broad suite of carbon-free energy technologies.
- High levels of hourly matching (80-95%) can be achieved in many places at a similar cost to 100% annual matching and with greater system-level decarbonization impact.

The studies conclude that hourly matching advances a broad portfolio of carbon-free energy technologies - including wind, solar, storage, and firm, dispatchable CFE technologies - that energy system modeling indicates are required to deeply decarbonize electricity systems.[48] They also indicate that hourly matching can pull forward the commercialization of less mature technologies, reducing their costs and enabling them to better contribute to long-term decarbonization at the full system level. Importantly, hourly matching supports clean power portfolios that also enable carbon-emitting assets to be removed, ensuring that business growth does not lock in reliance on carbon-emitting infrastructure.[49]

The climate benefits of hourly matching have been further validated by new research focused on the emissions impact of the emerging electrolytic hydrogen industry. This research concludes that hourly matching of electrolyzer demand with additional clean energy resources on the same grid is the only way to ensure that emissions from grid-based hydrogen production are minimized.[50,51,52] The European Union has issued new rules for the production of grid-based renewable hydrogen that will require electrolyzers to match their electricity demand with clean energy on the same grid and at an hourly level starting in 2030.[53] The UK government has issued similar rules, and the US government is considering a similar approach.[54,55] In light of these recent developments, we believe that alignment between the GHGP and emerging regulatory criteria would allow for valuable efficiencies in the implementation of new requirements, rather than conflicting or duplicative obligations.

Research has also shown that reaching high shares of hourly matching need not be prohibitively expensive. TU Berlin finds that reaching 90-95% hourly matching can be achieved at the same cost or only a small cost premium compared to 100% annual matching in Ireland, Germany, Denmark, and the Netherlands, while reducing significantly more emissions. Peninsula Clean Energy, an electricity provider in California, found that it can achieve 99% hourly matching at only 2% greater cost than 100% annual matching, while increasing avoided CO_2 emissions by over 80%.[56] And the IEA found that 90% hourly matching could be achieved at a 10% cost premium in Indonesia.[57]

In summary, the research is decisive: location- and time-matched clean energy purchasing leads to greater decarbonization of corporate electricity consumption and accelerates the transition to carbon-free electricity grids, at a minimal cost premium to 100% annual matching.

Grid operators argue that granular matching aligns with electricity system realities

According to European transmission system operators (TSOs), the entities that manage electricity systems across Europe, matching electricity demand within a narrower market boundary would "introduce an incentive for the development, production, and consumption of renewable electricity at the efficient geographical location," while temporal matching of clean generation to load at an hourly (or more granular) level would "reflect the real value of producing and consuming green electricity dynamically at each moment in time."[58] Additionally, a number of grid operators have found that locating clean generation far from consumption in areas with limited interconnection can increase system costs, further underscoring the benefits of tighter geographic boundaries.[59]

For over twenty years, the GHGP has played an important role in informing corporate actions and investments in climate mitigation. By making the practical changes suggested in this essay, the GHGP can significantly enhance its accuracy, usefulness, and value to companies and the broader marketplace.

Part III: Advance scope 3 accounting through technical improvements and greater research, experimentation, and stakeholder engagement

I. Introduction

Our comments on scope 3 are brief. We focus on a small number of areas where further clarity is needed in the short term and identify key issues where further research, experimentation, and stakeholder engagement will support the development of a longer-term vision for scope 3 accounting that can be integrated through agile and responsive governance structures. We hope to have further opportunity to engage on scope 3 with the GHGP and other stakeholders active in GHG footprinting on these topics.

Compared to scopes 1 and 2, scope 3 is at an earlier stage of maturity. While the field of Life Cycle Analysis (LCA) emerged decades ago,[60] formalized concepts of value chain accountability and mitigation and their practical application to corporate footprints have only developed relatively recently. Few companies have the degree of experience, knowledge, and competency related to scope 3[61] that they do for scopes 1 and 2,[62] and most companies are in early stages of understanding and reducing their value chain footprints.[63,64]

The nascency of scope 3 is evidenced by the paucity of independent academic research analyzing and evaluating scope 3 design,[65] methodologies, and interventions,[66] and the low maturity levels of existing approaches to measuring and mitigating value chain emissions. Measuring and reducing scope 3 emissions effectively and at scale requires the same level (or greater) of experimentation, research and innovation that characterized the development of today's more mature scope 2 ecosystem, and scope 3 guidance should evolve dynamically in response to new evidence and the maturation of scope 3 tools, capabilities, and best practices.

II. Focus and standardize the scope 3 organizational boundaries

Value chain emissions form the majority of many companies' footprints, so it is important that scope 3 inventories provide true and fair representations of these emissions. By addressing the following two needs, the GHGP could advance the development of more true and fair representation of scope 3 inventories:

Need for greater focus of scope 3 boundaries

Companies and other stakeholders need more clarity and refinement on scope 3 "boundaries", i.e., what is and is not included in a scope 3 footprint. Like scope 2, scope 3 double counts emissions by design. However, unlike scope 1 and 2 boundaries - which are bounded and clearly defined - scope 3 boundaries are broad and inclusive. For example, a company's scope 3 emissions can consist of its tier 1 suppliers, then tier 2 suppliers, up to tier "n" and it is often not clear when the upstream chain ends. This can create confusion when an unknown number of organizations - potentially thousands - take responsibility over the same unit of carbon. This approach was originally implemented as a design feature of the GHGP, on the basis that it would enable simultaneous action by multiple organizations.[67] But, while scope 3 data do reveal emissions hotspots and provide insights that can inform action and engagement, this approach has also led to confusion with respect to double counting and poses major challenges to true and fair representation. It has also raised the question of whether resulting inventories are providing the most useful information to decision-makers.

Need for greater standardization of scope 3 accounting

In the absence of clearly defined scope 3 boundaries, interpretations of boundaries vary widely across organizations and sectors. This results in inventories that are not always decision-useful at the individual company level or comparable across multiple companies. For example, we may not be able to compare embodied emissions of similar products offered by multiple vendors, due to differences in their calculation methodologies and which categories are included.[68] This could skew pricing or buying decisions for individual companies, and at the industry-wide level it results in scope 3 inventories being less functional than they could be.

We see a strong need for the GHGP to provide more specific guidance on scope 3 boundaries, to enable a more true and fair representation of companies' footprints and responsibilities. Greater standardization would also be beneficial by reducing the company-level discretion currently required to decide which emissions to include in scope 3. This would make it easier for more companies to measure and manage their scope 3 emissions, while also enabling companies to identify and address carbon hotspots with greater credibility.

III. Expand mitigation options for scope 3

Many companies aim to reduce their value chain emissions, and scope 3 decarbonization has the potential to unlock significant private investment into new technologies and solutions, particularly in emerging markets and nascent carbon-free industries. Scope 3 accounting should evolve to better credit companies for actions that result in real and measurable GHG reductions.

Scope 3 is distinct and warrants differentiated approaches to calculation and mitigation

Current GHGP guidance acknowledges that scope 3 emissions are distinct from operational scopes 1 and 2 emissions. That is why today's GHGP provides a different structure for scope 3 accounting and identifies calculation methodologies that are specific to scope 3. Importantly, one company's scope 3 emissions are another company's scope 1 and 2 emissions, so while the potential activities to mitigate them may be the same, a different framework is needed to accurately account for reductions that are driven by actors working to reduce their value chain emissions (scope 3) as opposed to actors working to reduce their operational emissions (scope 1 and 2).

Three key differences between scope 3 and scopes 1 and 2 provide the rationale for the differentiation of crediting reductions resulting from mitigation actions targeting scope 3 emissions:

- **Data:** Unlike operational scope 1 and 2 emissions, for which companies have direct access to the data required for accurate measurement,[69] scope 3 emissions cannot be as readily determined based on primary data and are often estimated or must be provided by suppliers or vendors.
- **Distribution:** Scope 3 emissions are distributed across a large number of entities and regions and are often less physically proximate to business operations than operational emissions.
- **Influence:** Companies' abilities to influence scope 3 emissions vary widely, with many lacking meaningful operational control over those emissions.

Despite these fundamental differences, the scope 3 mitigation mechanisms defined in the GHGP are similar to those available for scopes 1 and 2, i.e., absolute reductions resulting from supplier engagement or product redesign, and market intervention with EACs (the applicability and credibility of which is ambiguous[70]). We believe that crediting for scope 3 reductions should be more flexible than for scopes 1 and 2, to better match the specific characteristics of value chain emissions vis-à-vis operational scopes 1 and 2 emissions. For example, the evolutions of accounting and crediting towards more granular boundaries that we identify for scope 2 would not be appropriate for scope 3, because the required data are not always readily available, and in many cases companies do not have sufficient operational influence over their scope 3 emissions to mitigate them in this manner.

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More scope 3 mitigation options are needed

Companies need accurate accounting that enables them to accrue scope 3 reductions through a wider range of actions that lead to real and measurable GHG reductions. A market-based scope 3 is a reasonable solution to investigate for this purpose. Definitive guidance is needed as it exists for scope 2, and could include a range of mitigation mechanisms beyond EACs, such as renewable natural gas (RNG) credits, or emerging sustainable aviation fuel (SAF) credits. For portions of scope 3 with inherently less precise data, updated guidance could also consider the treatment of investments or procurements that accelerate real and measurable reductions, including the commercialization or deployment of advanced carbon-free technologies.[71]

As in scope 2, appropriate and defined requirements would be needed to ensure the credibility of scope 3 market-based reduction claims and their comparability across companies. These requirements, or constraints, would need to cover multiple dimensions. For example, the GHGP will need to specify the geographic boundaries of interventions, especially when the data quality and resolution do not provide visibility into where the emissions themselves originate. Similarly, specifications related to the sectoral boundaries under which interventions made in one sector are credited against scope 3 emissions from the same sector. Further research and industry engagement in this area would be helpful in generating credible solutions that, if validated, could be incorporated into guidance.

Whether through a market-based scope 3 or other solutions, companies need more clarity on how to accurately account for a broad set of reductions they are undertaking to mitigate scope 3 emissions, both when emissions data are clear and when they are not. We hope for an accurate and credible system that remains agile and responsive to market and technology changes.

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IV. Scope 3 warrants more research, experimentation, and stakeholder engagement

As with scopes 1 and 2, scope 3 guidance should be agile and dynamic, improving over time through iterative changes in response to a growing evidence base and ongoing evolutions in technology, markets, and corporate practice. Because scope 3 accounting is both less mature and more complex than scope 2, significant amounts of new research, experimentation, and stakeholder engagement will be required to determine the best paths forward for measuring and accounting for scope 3 emissions and reductions and addressing current shortcomings.

Research on these topics will take time, and it should not stall necessary progress in bringing more clarity and standardization to scope 3 methodologies and guidance. However, as companies continue to increase their focus on scope 3, it is important to surface open questions that, if addressed through immediate research and continued experimentation and engagement, can help inform longer-term improvements to scope 3 accounting.

Key areas that we believe would benefit from further research, experimentation, and stakeholder engagement include:

- Optimal organizational boundaries for scope 3, responding to the need for greater focus and standardization
- Appropriate constraints for scope 3 mitigation mechanisms which enable a true and fair representation of interventions. Two potential constraints include geographic constraints for interventions (i.e., physical matching - how closely mapped the interventions need to be to the physical source of emissions) and sectoral constraints (i.e., sectoral matching - whether the interventions need to map sectorally to the emissions source)
- Evaluation of whether attributional methodologies for scope 3 are uniquely relevant, whether there is a role for consequential methodologies (as has been suggested by some organizations), and if so, what constraints, data pipelines, implementation feasibility, and other considerations should be evaluated to

determine the accuracy and usefulness of consequential accounting methodologies and metrics

- Systems analysis evaluating the most effective ways to produce useful data on the impacts of interventions on value chain emissions. For example, between inclusive scope 3 boundaries vs. focused coverage, which is more likely to provide decision-useful data which leads to accelerated and measurable climate benefits?

- What organizational and governance processes need to be developed within WRI and the GHGP to ensure scope 3 accounting keeps pace with the rapid development of market-based mechanisms

These are just a few examples of areas that would benefit from more research, experimentation, and stakeholder engagement as the GHGP works to refine scope 3 standards, methodologies, and guidance. We would welcome additional opportunities to collaborate with GHGP and other stakeholders to advance useful knowledge and practices in these and other relevant areas.

Appendix: Key elements of granular GHG accounting implementation

In this Appendix, we summarize the status of key elements needed for implementing granular temporal tracking for scope 2 accounting as discussed in Part II.

Customer data:

Where advanced metering infrastructure is available,[72] customers can work directly with utilities and developers to source hourly meter data. In the US, this can be enabled by programs like the Green Button initiative.[73] In Europe,[74] many countries are establishing data hubs that centralize and streamline data access.[75] Hourly tracking is also being piloted in other countries across the world, including Australia,[76] India,[77] Taiwan,[78] Singapore,[79] and Thailand.[80] Granular data would be more readily available if policymakers require it. The EU's recent rules on hydrogen, for example, will require and thus accelerate hourly tracking and certification.[81]

Grid data:

This includes system-level production mix data, interchange, consumption mix data, and associated emissions factors. Today, there are already publicly available hourly data sets covering the United States[82] and Europe.[83] There are also paid solutions with greater global coverage.[84] Despite rapid progress in some areas, there are still gaps in public access to these data in some regions, including large parts of Africa, Asia, and the Middle East.

T-EACs (Time-based Energy Attribute Certificates):

Leveraging granular electricity data, market-based mechanisms are evolving to enable the verification of clean energy matching at granular locational and hourly levels with the addition of time- and location-stamping for each watt-hour of clean energy generation. These instruments are known variously as Time-based Energy Attribute Certificates (T-EACs), Granular Guarantees of Origin

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(GGOs), and Granular Certificates. EnergyTag, an independent, non-profit, industry-led initiative to define and build a market for these instruments, published a global standard for T-EACs implementation, in close coordination with stakeholders, that showcased the potential for T-EACs to scale.[85] Google has also piloted T-EACs registry and software solutions with partners around the world, and we expect to have T-EACs issued for a majority of our purchased clean energy generation by 2025.[86]

Registries:

Registries, the issuing organizations of traditional RECs and GOs, are adopting and enabling T-EACs implementation. M-RETs, the world's largest registry operator, can offer hourly tracking across most of the US today.[87] PJM, the largest electricity market operator in the United States, will provide T-EACs starting in 2023.[88] The I-REC registry, which operates in over 55 countries, is offering its T-EACs solution to customers around the world.[89] Certigy, a European EAC registry, has enabled hourly certification across many EU countries.[90] Legislation is also accelerating this; the European Union's soon to be passed Renewable Energy Directive will allow for the issuance of time-stamped guarantees of origin.[91] European transmission system operators are supportive of this evolution.[92]

Software Solutions:

There are fully integrated solutions that include measurement, planning, and optimization, from meter data integrations to registry coordination to hourly T-EACs issuance and reporting.[93] Organizations including FlexiDAO, LevelTen, and Accenture are offering end-to-end platforms to help companies operationalize hourly clean energy matching, from tracking to planning and optimization.

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Mainstreaming granular data:

Data transparency policies, data standards, and open source solutions currently under development will enable the mainstreaming of both locational and hourly tracking. The Linux Foundation Energy (LFE) is developing open source technology and data specifications such as the Carbon Data Specification, which seeks to improve granular customer and power system data access and quality through standardization.[94] Open source modeling tools are available to support procurement planning and decision making, including electricity system and portfolio planning models like the PCE MATCH model, NREL Cambium, GenX, and PyPSA.

Emission Factors - rationale for average emissions factors:

We have identified average hourly emission factors as the most accurate for assessing carbon footprints. While average hourly emissions factors do not fully capture the precise changes induced by a particular market intervention, they provide a reliable and verifiable metric to accurately allocate emissions to consumers across the grid, i.e., an "attributional" method.[95] Additionally, the average signal incorporates all power plants on the grid, which provides decision-useful information to companies that wish to shape their electricity consumption based on grid carbon intensity.

Supply products - examples from Google's procurement:

Energy suppliers have developed market products and executed contracts with commitments to deliver local, clean energy to match demand. Google has signed three such agreements so far, with AES in the PJM electricity market, with Engie in Germany, and with Silicon Valley Clean Energy (SVCE) in California.[96]

Supply products - examples from other buyers in multiple sectors and countries:

Other clean energy buyers have signed supply agreements that match location and time of consumption. Microsoft signed agreements with AES to advance their hourly matching goals in PJM and California,[97] and developed an hourly matching product with Vattenfall in Sweden.[98] In Germany, Statkraft developed hourly matching for Mercedes Benz.[99] Iron Mountain developed a market solution with RPD, Direct Energy, and ClearTrace to increase hourly matched clean energy across multiple facilities.[100] Rivian signed an agreement in Illinois that will match up to 75% of their local manufacturing operations with clean energy on an hourly basis.[101]

Supply products - retail and utility:

Energy suppliers are also building or contracting for hourly matched portfolios for their retail energy customers. Peninsula Clean Energy, a Community Choice Aggregator in California, is contracting for a portfolio of clean energy projects to meet 99% hourly clean energy by 2025.[102] The Sacramento Municipal Utility District (SMUD) plans to reach zero carbon emissions by 2030, using hourly carbon accounting.[103] Investor-owned electric utilities in vertically integrated service territories, including a number of geographies in the United States, are also developing products to meet customer requests for around-the-clock clean power.[104]

Supply products - unbundled T-EACs:

T-EACs provide a sourcing option for companies unable to sign long-term PPAs, for example, those new to clean energy purchasing or with more distributed electricity consumption.[105] As T-EACs continue to scale, companies of all sizes and levels of energy procurement capability could purchase unbundled T-EACs that are matched in both location and time to their electricity consumption. A liquid exchange for T-EACs would allow for excess T-EACs that are not used by a company to be monetized and valued by another entity, increasing the accessibility and affordability of locational and hourly matching for everyone.[106] This concept has already been tested with Nord Pool and Granular Energy in the UK.[107]

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Endnotes

1. The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (page 3)
2. "Companies" refers to businesses, although the GHGP can be used as the basis of GHG footprinting by many types of entities. Non-corporate entities are beyond the scope of his paper.
3. Summary for Policymakers (page 24, C.3), IPCC, 2022
4. The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (page 3)
5. The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (page 3)
6. The Corporate Value Chain (Scope 3) Accounting and Reporting Standard (page 34, Table 5.4) defines 15 categories of scope 3 emissions.
7. What Really Happens When Emissions Vanish. Bloomberg, 2022
8. Creative accounting: A critical perspective on the market-based method for reporting purchased electricity (scope 2) emissions. Brander et al., 2018
9. Renewable energy certificates threaten the integrity of corporate science-based targets. Bjørn, Lloyd, Brander et al., 2022
10. Probabilistic decision model of wind power investment and influence of green power market. Gillenwater, 2013
11. Throughout this paper, we refer to the effectiveness of interventions, and throughout the paper we define it as we do here, which is the effectiveness of both GHG reductions within a company footprint and the long-term impact of the intervention on broader energy and economic systems.
12. Corporate Clean Energy Buying Tops 30GW Mark in Record Year. BloombergNEF, 2022
13. For example, the United States and Canada are treated as one market boundary, even though both countries comprise many different grids and balancing authorities. Similarly, Europe is considered as one market boundary, even though it contains many different electricity pricing zones and each country has its own transmission system operator (TSO) that plans and operates the national electricity system.

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14. The EU interconnection target is 15% by 2030, meaning each country should have in place electricity cables that allow min 15% of the electricity produced on its territory to be transported across its borders to neighboring countries. It is significantly more likely that electricity generated in one European country will be consumed there, in spite of a liquid market for EACs or a coupled day-ahead electricity market (SDAC).
15. See endnotes 7-10
16. Activity statistics. Association of Issuing Bodies (AIB), 2022
17. Emissions Factors 2022 (2019 data). International Energy Agency (IEA)
18. European Residual Mixes 2020. Association of Issuing Bodies (AIB), 2021
19. Spain: Energy Country Profile. Our World in Data
20. University of California at Davis analysis of US grid regions found that average annual grid emissions factors can over- or under-estimate carbon inventories as much as 35%. Importantly, they also find that this bias will get worse as more variable renewable energy generation is deployed onto electricity grids, causing significant hourly variability in grid carbon-intensity. Hourly accounting of carbon emissions from electricity consumption. Miller et al., 2022
21. Why 100% Renewable Energy Is Not Enough. de Chalendar and Benson, 2019
22. Advancing Corporate Procurement of Zero-Carbon Electricity in the United States: Moving from RE100 to ZC100. Lott and Phillips, 2021
23. Moving toward 24x7 Carbon-Free Energy at Google Data Centers: Progress and Insights. Google, 2018
24. RE100
25. CDP
26. Results of public consultation on proposed changes to the RE100 technical criteria. RE100, 2022
27. A Vision for how ambitious organizations can accurately measure electricity emissions to take genuine action. WattTime and Tomorrow (now Electricity Maps), 2021
28. See endnotes 7-10

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29. For example, EECS Rules in Europe (page 28, section C3.5.4.(j)), I-REC(E) Code for global EACs (section 7), and RECs standards in the US, include sufficient geographic detail for more refined boundary matching to be implemented today. Also, granular grid emissions factors are already available at the balancing authority level in many countries.
30. 24/7 Carbon-Free Energy Compact, is a global community of companies, organizations, and governments that is dedicated to advancing 24/7 Carbon-free Energy. It was launched in September 2021 at the UN High Level Dialogue on Energy, and now has over 110 signatories from across the world, including energy consumers, energy suppliers, technology providers, governments, and non-governmental organizations.
31. European 24/7 Hub is a partnership to raise awareness of the benefits and challenges of granular energy matching via a dedicated go-to Hub that maps, coordinates and aligns all European 24/7 initiatives.
32. For example, Electricity Maps recently announced that they are creating a data portal for free access to granular electricity data.
33. Delegated regulation on Union methodology for RNFBOs. European Commision, 2023
34. Examples include: NREL End-Use Load Profiles for the U.S. Building Stock, Renewables.ninja, NREL PVWatts Calculator, FlexiDAO CFEscore
35. NREL End-Use Load Profiles for the U.S. Building Stock
36. Global energy-related CO2 emissions by sector. International Energy Agency (IEA), 2022
37. Net Zero by 2050 - A Roadmap for the Global Energy Sector (page 55, Figure 2.3). International Energy Agency (IEA), 2021
38. Electric Power Monthly - Table 5.1. Sales of Electricity to Ultimate Customers. US Energy Information Administration (EIA), 2022
39. In 2022 companies signed agreements to purchase electricity from 36.7 GW of new renewable energy projects across the globe, a new annual record. Corporations Brush Aside Energy Crisis, Buy Record Clean Power. BloombergNEF, 2023
40. The models used for these studies are detailed combined capacity expansion and production cost optimization models, the same type that are used by utilities and grid operators to model future electricity demand and portfolio resource needs.

41. The studies from Princeton, Technical University (TU) Berlin, IEA, and Peninsula Clean Energy (endnotes 42-45) compare the decarbonization benefits of hourly matching to annual demand matching within the same electricity grid. The benefits of same-grid hourly matching would be greater when compared to procurements from distant grids, which is common under the current scope 2 guidance with respect to US and Europe, which are each treated as one grid.
42. System-level Impacts of 24/7 Carbon-free Electricity Procurement. Xu et al., 2021
43. System-level impacts of 24/7 carbon-free electricity procurement in Europe. Riepin and Brown, 2022
44. Advancing Decarbonisation through Clean Electricity Procurement. International Energy Agency (IEA), 2022
45. Achieving 24/7 Renewable Energy by 2025. Peninsula Clean Energy, 2023
46. Notably, matching 100% of hourly demand is not required to achieve greater levels of decarbonization than 100% annual matching. A number of studies indicate that, depending on the electricity grid, clean energy buyer can have a greater impact at hourly matching levels around 80-90%.
47. These include firm, dispatchable carbon-free electricity technologies as well as long-duration energy storage technologies, both of which are needed to cost-effectively reach 100% carbon-free electricity grids in many regions of the world.
48. What is different about different net-zero carbon electricity systems?. Baik et al., 2021
49. For example, Princeton University finds that wind and solar exclusively procured by 100% annual matching have relatively low capacity substitution value, whereas clean firm generation in 24/7 portfolios displaces natural gas capacity on a one-for-one basis.
50. Minimizing emissions from grid-based hydrogen production in the United States. Wilson et al., 2023
51. Hourly versus annually matched renewable supply for electrolytic hydrogen. Zeyen et al., 2022
52. The research from Wilson et al. and Zeyen et al. (endnotes 50 and 51) also finds that annual matching could lead to emissions increases that are worse than the current fossil-based method

of hydrogen production, and could lead to significant increases in electricity prices.

53. Delegated regulation on Union methodology for RNFBOs. European Commision, 2023
54. RTFO Guidance for Renewable Fuels of Non-Biological Origin. UK Department of Transport, 2022
55. How a tax break meant to curb climate change could make it worse. Washington Post, 2023
56. Achieving 24/7 Renewable Energy by 2025. Peninsula Clean Energy, 2023
57. The IEA finds that the system benefits of annual matching portfolios are substantially below the cost to serve corporate demand with standard grid supply, while hourly matching portfolios bring a much higher value to the electricity system. This suggests that the additional costs of hourly matching could be compensated through remuneration mechanisms that reflect the higher value these portfolios bring to the electricity system. Advancing Decarbonisation through Clean Electricity Procurement. International Energy Agency (IEA), 2022
58. Views on a Future-Proof Market Design for Guarantees of Origin. European Network of Transmission System Operators for Electricity (ENTSO-E), 2022
59. System Benefits of Granular Certification. Energy Track and Trace, 2022
60. Life Cycle Assessment: Past, Present, and Future. Guinée et al., 2021
61. This is partly due to the fact that only some categories of scope 3 can take advantage of modern LCA methodologies (e.g., construction), while other categories often rely on spend-based emissions factors (e.g., most services such as consulting).
62. WRI reported 3,317 companies publicly reported scope 3 values to CDP in 2021 (Trends Show Companies Are Ready for Scope 3 Reporting with US Climate Disclosure Rule, WRI, 2022). CDP disclosed 13,100+ companies reported in 2021 (Just a third of companies (4002/13,100+) that disclosed through CDP in 2021 have climate transition plans, CDP, 2022). Thus, about 25% of companies who reported to CDP in 2021 reported scope 3 values.

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63. Apple, which has a relatively long history of reporting its scope 3 emissions, states in its 2022 Environmental Progress Report that it is actively evolving its scope 3 accounting methodology. “In fiscal year 2017, we started calculating scope 3 emissions not listed above. In fiscal year 2021, these include electricity transmission and distribution losses [...] and life cycle emissions associated with renewable energy. We have not accounted for emissions resulting from employees working from home [...] we are still evolving our methodology.“ Environmental Progress Report (page 84), Apple, 2022.
64. Google has been performing life cycle assessments of our consumer hardware to inform and drive low carbon design since 2018. As part of this initiative, we identified a carbon reduction opportunity in using recycled aluminum in Pixel enclosures. The aluminum in the phone enclosures of Pixel 5, 6, 6 Pro, 7, and 7 Pro is made with 100 percent recycled content, reducing the carbon footprint of the aluminum portion of the enclosures by over 35% compared to 100% primary aluminum. [Disclaimer: Carbon footprint reduction claim based on third-party verified life cycle assessment. Recycled aluminum in the enclosures is at least 9% of applicable product based on weight.]. Supplier Responsibility: Recycled Aluminum, Google, 2021.
65. One notable exception being the concept of E-Liabilities, which offers an alternative methodology for calculating GHG footprints altogether and is not specific to scope 3. Accounting for Climate Change, Harvard Business Review, (2021)
66. Settling Climate Accounts. Heller and Seiger, 2021
67. “In certain cases, two or more companies may account for the same emission within scope 3. For example, the scope 1 emissions of a power generator are the scope 2 emissions of an electrical appliance user, which are in turn the scope 3 emissions of both the appliance manufacturer and the appliance retailer. Each of these four companies has different and often mutually exclusive opportunities to reduce emissions [...] By allowing for GHG accounting of direct and indirect emissions by multiple companies in a value chain, scope 1, scope 2, and scope 3 accounting facilitates the simultaneous action of multiple entities to reduce emissions throughout society.” Corporate Value Chain (Scope 3) Corporate Accounting and Reporting Standard (pages 27-28)

68. Microsoft's 2021 Environmental Sustainability Report includes 11 of the 15 scope 3 categories (page 19), while Google reports business travel and employee commuting as one total and "other" scope 3 emissions in a second total (page 11). Apple (page 84) and Amazon (page 97) report lifecycle emissions from customer trips to physical stores under scope 3 which are not categories prescribed by the GHGP.
69. With some exceptions, as discussed in Part II of this essay.
70. "A reporting organization should not purchase renewable electricity and simply apply it to scope 3 emissions without involvement from its supplier or customer." Renewable Electricity Procurement on Behalf of Others: A Corporate Reporting Guide (page 4), EPA, 2022.
71. Examples of such efforts today include Frontier for carbon removal, the First Movers Coalition for various carbon mitigation technologies, and the Catalyzed Emissions Reduction Framework proposed by Breakthrough Energy Catalyst.
72. In 2021, U.S. electric utilities had about 111 million advanced (smart) metering infrastructure (AMI) installations, equal to about 69% of total electric meters installations. Residential customers accounted for about 88% of total AMI installations, and about 69% of total residential electric meters were AMI meters. How many smart meters are installed in the United States, and who has them?. US Energy Information Administration (EIA), 2022
73. Green Button Data
74. Mapping metering data access in Europe. FlexiDAO, 2021
75. EU grid operators to establish Energy Data Access Alliance. Smart Energy International, 2019
76. Google to use Australian power tracing tech in Sydney trial. pv magazine Australia, 2022
77. Tata Power-DDL, India. Powerledger
78. The Usage of T-REC to Support Company to Achieve 24/7 Carbon-Free Energy. Taiwan Institute of Economic Research (TIER), 2023
79. GoNetZero

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80. Netherlands Embassy – EGAT join hands to implement "24/7 REC Pilot Project," towards the goal of Thailand's Carbon Neutrality - Electricity Generating Authority of Thailand. Electricity Generating Authority of Thailand (EGAT), 2021
81. Delegated regulation on Union methodology for RNFBOs. European Commission, 2023
82. Hourly Electric Grid Monitor. US Energy Information Administration (EIA)
83. ENSTO-E Transparency Platform
84. Electricity Maps, for example
85. EnergyTag
86. Timely progress towards around-the-clock carbon-free energy. Google, 2022
87. M-RETS Hourly Tracking
88. PJM EIS To Produce Energy Certificates Hourly. PJM, 2023
89. Evident I-REC Registry
90. Certigy
91. Renewable energy directive
92. Views on a Future-Proof Market Design for Guarantees of Origin. European Network of Transmission System Operators for Electricity (ENTSO-E), 2022
93. Examples include Flexidao, Powerledger, Enosi, Cleartrace, and Granular Energy. FlexiDAO has also launched a 24/7 CFE Academy to support and educate companies on the data and products available for locational and hourly matching.
94. Linux Foundation Energy (LFE) Carbon Data Specification (CDS)
95. A Vision for how ambitious organizations can accurately measure electricity emissions to take genuine action. WattTime and Tomorrow (now Electricity Maps), 2021
96. The CFE Manager: A New Model for Driving Decarbonization Impact. Google, 2022
97. Microsoft and AES Partner to Bring Around-the-Clock Renewable Energy to Data Centers. Cision PR Newswire, 2021
98. Vattenfall to deliver renewable energy 24/7 to Microsoft's Swedish datacenters. Vattenfall, 2022
99. 100% clean energy 24/7 PPA. Statkraft
100. Iron Mountain's Innovative 24/7 CFE Solution Lightens Its Data Center Customers' Carbon Emissions Load, Serving 100+ U.S. Facilities. Cleartrace, 2023

101. Rivian Inks Wind Energy Deal with Apex Clean Energy to Power Illinois Manufacturing. Business Wire, 2022
102. Achieving 24/7 Renewable Energy by 2025. Peninsula Clean Energy, 2023
103. 2030 Zero Carbon Plan (page 62). Sacramento Municipal Utility District (SMUD), 2021
104. 24/7 Carbon-free Energy: Matching Carbon-free Energy Procurement to Hourly Electric Load. Electric Power Research Institute (EPRI), 2022
105. We are currently engaged in research to evaluate the impact of an unbundled TEACs system to ensure this can drive decarbonization and is not another greenwashing tool.
106. Electricity System and Market Impacts of Time-based Attribute Trading and 24x7 Carbon-free Electricity. Xu and Jenkins, 2022
107. Nord Pool and Granular - exploring renewable hourly certificates. Nord Pool