Frontier

Buyer principles for responsible clean energy procurement and accounting for carbon dioxide removal

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Context

To avoid the worst effects of climate change we need to develop a gigaton-scale portfolio of durable carbon dioxide removal (CDR) solutions. The focus this decade is to accelerate the development of today's early, small-scale and expensive approaches to understand which can work effectively and affordably at scale.

Many promising carbon removal technologies, like direct air capture or electrochemical ocean alkalinity enhancement, are quite energy intensive and could result in significant electricity-related emissions when operating today. In the long run, once projects have optimized their system's energy use and the grid is fully decarbonized, a project's electricity-related emissions will be small or non-existent. However, in the near term, accounting for these emissions is important for accurately measuring a project's net climate impact and determining how CDR projects can effectively mitigate these emissions. Any project emissions directly reduce the amount of CDR that can be credibly claimed and raise the effective cost per ton.

Accounting for CDR energy use

CDR project developers have a number of options when considering how to best provide energy to power their facilities. First, they have the choice to build behind-the-meter generation or heat production to reduce their grid electricity consumption. In this case, emissions accounting is straightforward, as projects can measure the associated direct emissions and embodied emissions with reasonable certainty.[1]

Another option is to purchase some or all of their electricity from the broader grid and account for the emissions from this consumption in the project's life cycle assessment. However, accounting for grid electricity use represents a more challenging problem, as it requires determining the emissions associated with grid electricity in a specific place and at a specific time. This is further complicated by the questions regarding the impact of new demand on decisions made by electricity grid operators. For example, a grid with high levels of hydroelectric and nuclear

[1] When energy is produced also matters; electricity produced behind the meter only effectively avoids the need for grid electricity use if it matches facility energy use on at least an hourly basis. If behind-the-meter generation exceeds facility use in some hours, it would be treated similarly to externally procured clean energy for the purposes of these principles. Similarly, any hours where behind-the-meter generation is smaller than facility energy use would require accounting for associated grid electricity use emissions.

generation might seem appealing for siting a facility, but if those resources are fully used by customers today, a new load might result in additional gas generation being brought online to meet it. To account for these complex dynamics, we recommend the use of hourly emissions factors to account for project emissions from grid electricity use.[2]

While the electricity sector has been decarbonizing in recent years, it remains too carbon-intensive to cost-effectively use grid electricity for energy-intensive CDR in most regions today. For this reason, many CDR providers have been exploring another option: procuring additional clean energy to counterbalance some or all of their grid electricity emissions.[3] Accounting for this appropriately is difficult, but critical to ensure CDR is deployed in a way that accelerates grid decarbonization.

There are three approaches commonly considered for clean energy procurement:

- Volumetric matching, where clean energy procured (e.g., in the form of a PPA) matches the grid electricity used by the project, calculated and trued-up on an annual basis.
- Emissions matching, where the annual grid emissions (calculated on an hourly basis using marginal emissions factors) associated with the project are counterbalanced by the annual avoided emissions (also calculated on an hourly marginal emissions basis) from procured clean energy generation, calculated and trued-up on an ongoing basis.
- Temporal matching, where hourly use of grid energy of the facility is counterbalanced by procured clean energy generation that occurs in the same hour, calculated and trued-up on an ongoing basis.

Annual volumetric matching of clean energy procurement has been the standard approach used to offset electricity use emissions. However, there are many cases in which the emissions benefit of the clean energy purchased does not match the emissions impact of the energy used by the project with this approach.[4] As a result, this approach has come under significant scrutiny in recent years. Both emissions matching and temporal matching have been proposed as alternative approaches. However, both have barriers to implementation in the near-term, particularly for smaller energy loads like early-stage CDR companies.

A phased approach

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[2] Hourly emissions factors include both average and marginal variants, each of which has advantages and disadvantages in different contexts. Hourly emissions factors should be empirically determined for each hour in which electricity is used. Marginal emissions factors are the rate at which emissions change when there is a small change in electricity demand and reflect the impact of adding new loads to the grid, while average emissions factors reflect the average of all generation operating on the grid in a given hour. When used for grid emissions calculations, marginal emissions factors should reflect an appropriate mix–50/50–of build margin and operating margin.

[3] This is a common practice today in corporate Scope 2 emissions accounting and proposed by the US and Europe for the lifecycle accounting of green hydrogen production.

[4] For example, under annual volumetric matching a project could claim to counterbalance natural gas usage at night with procured solar generation during the day, even if the emissions impact of that solar (due to high levels of mid-day solar generation in places like California and Texas) is much smaller than the emissions from the use of gas generation on the grid.

This challenge is not unique to CDR. There is an ongoing debate about the best long-run approach to clean energy procurement and accounting for sectors with greater electricity loads, like data centers and clean hydrogen. Given this, the emerging CDR industry is likely to be a rule taker rather than a rule maker in the long-run. Regulatory efforts like the US's 45V hydrogen tax credit and the EU Renewable Fuels of Non-Biological Origin (RFNBOs) directive both require the phasing in of more strict standards for clean energy accounting – in this case, temporal matching – beginning in 2030. Similarly, an ongoing process to revise the Scope 2 guidance in the Greenhouse Gas Protocol will help set standards for best practices.

Prior to these broader rules being finalized, we need unified standards to help the first wave of energy-intensive CDR projects approach this problem with integrity. As early buyers and supporters of this emerging market, we recognize the importance of establishing meaningful guardrails on energy procurement and accounting. While some flexibility is needed for the near-term given the reality of power procurement markets today, we must ensure that suboptimal approaches do not become locked in for the long-run.The expectations set for carbon removal in the near-term have implications for the credibility of tonnage claims, as well as for the cost and development speed of early projects.

Below are a set of principles for responsible energy accounting and qualified clean energy procurement for energy intensive CDR facilities that we believe allow us to accelerate CDR development and innovation today while building the capacity to adhere to increasingly stringent rules over time as the scale of projects grows.

Proposed principles for near-term clean energy procurement

#1 New, co-located procurement: Clean energy procured must be incremental and regionally deliverable.[5]

- It is critical that projects result in net-new clean energy generation and do not take credit for existing or planned clean energy intended for other uses. Clean energy environmental attribute certificates (EACs) procured must come from a generation facility with a commercial operations date (COD) that is no more than 36 months before the CDR production facility for which the EAC is retired was placed in service. Alternatively, EACs can be procured from projects that result from the uprating or life extension of existing nuclear power plants or the installation of new CCS units on existing natural gas plants.
- Clean energy procured should at a minimum be located in the same grid subregion or balancing authority as the project facility. Geographic proximity of procured clean energy to the facility helps ensure that the emissions impact of grid electricity use and procured clean energy remain correlated over time.

[5] These requirements are adapted from the 45V rules for green hydrogen production.

#2 Counterbalance facility grid emissions: Clean energy procured should match the emissions impact of grid energy used. Annual volumetric matching alone is insufficient.

The goal of clean energy procurement is to accurately counterbalance the emissions impact of facility grid energy use. Doing this right is particularly critical to the integrity of CDR, but the most common approach today – matching electrons at coarse timescales (e.g., annual volumetric matching) -- is insufficient. Project verifiers and registries should work to ensure that any procurement approach matches the impact of grid electricity use, and that any differences between the two are reflected in net CDR calculations.

Our near-term recommendation is that CDR suppliers should either temporally match their use of grid electricity with the generation of procured clean energy on an hourly basis, or supplement volumetric matching with an emissions screen.[6]

- Temporal matching. Projects procure hourly energy attribute certificates (EACs) from clean energy projects to match some or all of their hourly grid electricity use.[7]
    - Projects must calculate the emissions from any unmatched or partially matched hours using hourly average emissions factors from the relevant grid boundary and subtract them from net project CDR.
- Annual volumetric matching with an emissions screen. Projects procure a volume of clean energy that matches or exceeds their facility's annual grid energy use (volumetric matching). In addition, projects calculate an over-procurement factor that ensures the volume of clean energy procured would effectively counterbalance the emissions impact of the facility's grid electricity use today.
    - Projects should use a representative snapshot of the hourly emissions intensity in their grid region over the past few years to demonstrate that the procured energy results in avoided emissions equal to or greater than the emissions from the project's grid energy use.
    - To be conservative, projects should use both average and marginal[8] hourly emissions factors for the calculation, and choose whichever gives a larger over-procurement factor.
    - Projects undertaking volumetric matching can exclude any hourly-matched behind-the-meter facility generation, but must match at least 100% of grid electricity consumption.
    - Larger projects (e.g., >100k tons per year) will need to reassess their emissions impacts periodically (i.e. after three to five years) to ensure that their level of clean

[6] Note that the use of volumetric matching requires procuring clean energy volumes equal to or exceeding 100% of annual grid electricity use, while temporal matching allows facilities the option of taking the net-negativity hit for some hours of unmatched grid electricity use.
[7] In the absence of hourly EACs being issued by a registry, companies can also use annual or monthly EACs with associated hourly meter data demonstrating that the EAC was produced in a particular hour, following config 3 in the EnergyTag standard.
[8] Calculations for both the facility grid electricity use and clean energy procurement should be based on 50% operating margin and 50% build margin to be conservative.

energy procurement is sufficient.[9]

The table below provides a simplified example of how these approaches might be applied in practice by a CDR supplier for a project:

	Temporal matching	**Volumetric matching with an emissions screen**
Project scope	DAC facility operating in Texas and using 100 GWh of grid electricity per year	
Grid electricity use	100 GWh / year	
Facility energy use and emissions	Estimate hourly facility electricity use over the course of the year and calculate emissions using average hourly emissions factors.	Calculate grid hourly emissions factors for past three years[10]: • Typical facility emissions factor = 0.5 tCO_2e/MWh Calculate facility emissions using hourly emissions factors: • 100 GWh/year energy use x 0.5 tCO_2/MWh = 50,000 tCO_2/year
Clean energy procurement	Determine which hours it makes financial sense to purchase hourly EACs for new clean energy for. For any unmatched hours, use hourly average emissions factors to reduce facility net CDR. • For example, for an unmatched hour where the emissions factor = 0.2 tCO_2e/MWh and facility energy use is 2 MWh/ton, net CDR for that hour would be reduced by 40% (0.2*2).	Calculate emissions impact using hourly emissions factors for clean energy procurement: • Typical avoided emissions factor = 0.4 tCO_2e/MWh Calculate avoided emissions for 100% annual matching: • 100 GWh/year energy use x 0.4 tCO_2/MWh = 40,000 tCO_2/year Calculate an over-procurement factor based on the delta between facility and clean energy emissions: • Over-procurement: 50,000 tCO_2 / 40,000 tCO_2 = 125% Procure 125% of annual facility use of new clean energy from a PPA.[11]
Notes	This is relatively straightforward to implement in cases where there is a liquid market for hourly-matched EACs, but could be more difficult for smaller loads today.	Perform this analysis separately using both average hourly emissions factors and marginal hourly emissions factors. Choose the higher of the two over-procurement factors to use.

The use of annual volumetric matching with an emissions screen should not be seen as a long-term solution. By 2030, companies should phase out any use of annual volumetric matching and instead adopt more rigorous rules for emissions measurement and procurement (e.g., temporal matching or full emissions matching) as standards for these are finalized and adopted in other sectors.

#3 Ensure robust data sharing: Share energy procurement strategies, accounting methods, and hourly energy use data with buyers, registries, and verifiers.

[9] The goal here is to not create too large a barrier for first-of-a-kind facilities to be built and tested, while avoiding cases where large numbers of tons that do not effectively counterbalance grid emissions could be sold.

[10] Note that this is a simplification of the actual calculations involved, which would sum up emissions over the entire year given historical marginal and average grid emissions for each hour and projected hourly facility energy use.

[11] Any shortfall in annual PPA production should be subtracted from project net CDR. For example, if a project uses 100 GWh in a given year but the PPA only produces 95 GWh due to climate conditions, the emissions associated with the 5 GWh of unmatched grid electricity use should be counted against project CDR.

- Projects should publish the methods used to account for energy use emissions in their CDR claims, including the specific data sources or models used to estimate grid impacts of operation or clean energy procurement.
- In addition, projects must collect hourly facility energy use data which builds the capacity for temporal matching long-term and enables an accurate understanding of project emissions and modeling the cost of different clean energy procurement options near-term.
- Projects should provide buyers, registries, and verifiers involved in the project with hourly facility energy use data and PPA energy production data upon request to enable more thorough assessment of project emissions.