SCIENCE BASED TARGETS

DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

Evidence Synthesis Report Part 2: Environmental Attribute Certificates – Electricity

A synthesis of the relevant evidence on environmental attribute certificates for electricity submitted to the Science Based Targets initiative during the 2023 call for evidence on the effectiveness of environmental attribute certificates in corporate climate targets.

Version 1.0

March 2025

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ABOUT SBTi

The Science Based Targets initiative (SBTi) is a corporate climate action organization that enables companies and financial institutions worldwide to play their part in combating the climate crisis.

We develop standards, tools and guidance which allow companies to set greenhouse gas (GHG) emissions reductions targets in line with what is needed to keep global heating below catastrophic levels and reach net-zero by 2050 at latest.

The SBTi is incorporated as a UK charity, with a subsidiary SBTi Services Limited, which hosts our target validation services. Partner organizations who facilitated SBTi's growth and development are CDP, the United Nations Global Compact, the We Mean Business Coalition, the World Resources Institute (WRI), and the World Wide Fund for Nature (WWF).

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ACRONYMS AND ABBREVIATIONS

Acronym	Description
ACORE	American Council on Renewable Energy
ACT	Australian Capital Territory
AIB	Association of Issuing Bodies
AVERT	Avoided Emissions and Generation Tool
BTM	Behind-the-meter
C&I	Corporate and industry
CEBA	Clean Energy Buyers Association
CEBI	Clean Energy Buyers Institute
CFE	Carbon-Free Energy
E3	Energy and Environmental Economics
EAC	Energy attribute certificate[1]
EIA	Energy Information Administration
ENTSO-E	European Network of Transmission System Operators for Electricity
EPA	Environmental Protection Agency
EPP	Energy Peace Partners
GC	Green Certificate
GHG	Greenhouse gas
GHGP	Greenhouse Gas Protocol
GO	Guarantees of Origin
IEA	International Energy Agency
I-REC	International Renewable Energy Certificate
IRR	Internal rate of return
LGC	Large-scale Generation Certificate
LME	Locational Marginal Emissions
NREL	National Renewable Energy Laboratory

[1] Note: In the context of electricity, EAC refers to the more specific Energy Attribute Certificates, rather than Environmental Attribute Certificates.

PC-EAC	Purchaser Caused Environmental Attribute Certificate
PEC	Power Emission Certificate
PPA	Power purchase agreement
P-REC	Peace Renewable Energy Credit
REC	Renewable Energy Certificate
RECS	RECs Energy Certificate Association
RES	Renewable Energy Sources
SBTi	Science Based Targets initiative
T-EAC	Time-based Environmental Attribute Certificate
UKGBC	UK Green Building Council
vPPA	Virtual power purchase agreement

1. ABOUT THIS DOCUMENT

This document is a chapter of Evidence Synthesis Report Part 2: Energy Carriers and Commodities Certificates which has been published in a separate document for ease of use. A description of the call for evidence, review methodology, and main findings may be found in the main paper.

2. EVIDENCE QUANTIFICATION

Quantification overall

In total, 418 pieces of evidence were considered in the evidence review of environmental attribute certificates for fuels, electricity, and commodities. This total includes unique evidence submitted as part of a list or pack of evidence, referred to as “nested” evidence; these pieces of nested evidence were reviewed individually. Note that many pieces of evidence were submitted by multiple respondents or submitted as both standalone evidence and a piece of nested evidence; these pieces of evidence have not been counted twice towards the total.

Of the evidence considered in this review, 220 pieces of evidence were labelled by the submitter as relevant to electricity, 190 relevant to fuels, and 44 relevant to commodities. Since some evidence was labelled as relevant to more than one type of environmental attribute certificates, the summed numbers in this paragraph do not equal the total number submitted. Following the evidence review, 181 pieces of evidence were determined to be relevant or partially relevant to the topic of electricity EACs, 150 relevant to fuels, and 28 relevant to commodities. Some evidence was reviewed and determined to be relevant to topics other or additional to what it was originally labelled, and some was determined to not be relevant to environmental attribute certificates or the research questions considered in this review.

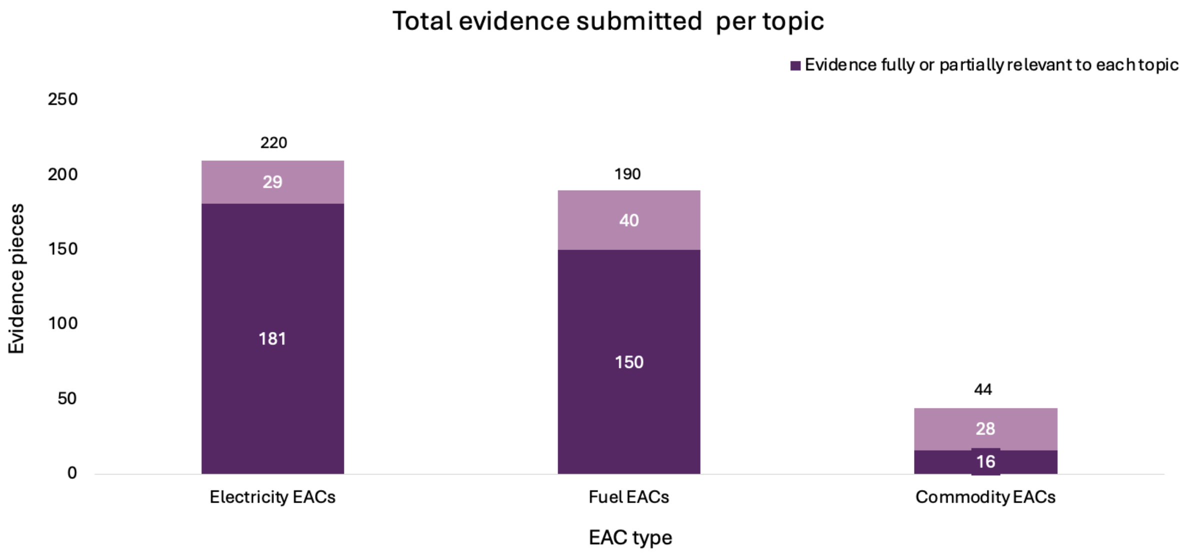

Figure 1: overall data on evidence submitted to the call for evidence

Quantification per topic:

Of the 181 pieces of evidence assessed and deemed relevant/partially relevant for electricity, the most common type of evidence was a report or white paper (92 out of 181), followed by commentaries (37/181). The least common types of submission were a literature review (1/181) or controlled research study (2/181).

The majority of evidence assessed for relevance to electricity EACs was categorized as Tier C (136/181). Although several laws/regulations and peer-reviewed publications were submitted as evidence (and so were initially designated Tier A), typically the lack of relevance to four or more research questions resulted in these pieces of evidence being downgraded to Tier B or C. Please refer to SBTi's review methodology for more information on the Tier categorization.

Each piece of evidence was assessed for its relevance towards the eight research questions. Of the evidence assessed for electricity, over half of the evidence was deemed relevant to Q1 (117/181) with numerous relevant to Q3 and Q5 also (100/181 and 99/181, respectively). Q7 had the lowest number of relevant evidence (34/181).

A full table of the 181 pieces of evidence and their relevance to each research question is included in Annex A (Table 2). A separate table of the 25 pieces of evidence assessed under electricity and deemed not relevant to the research questions is also included in the Annex (Table 3).

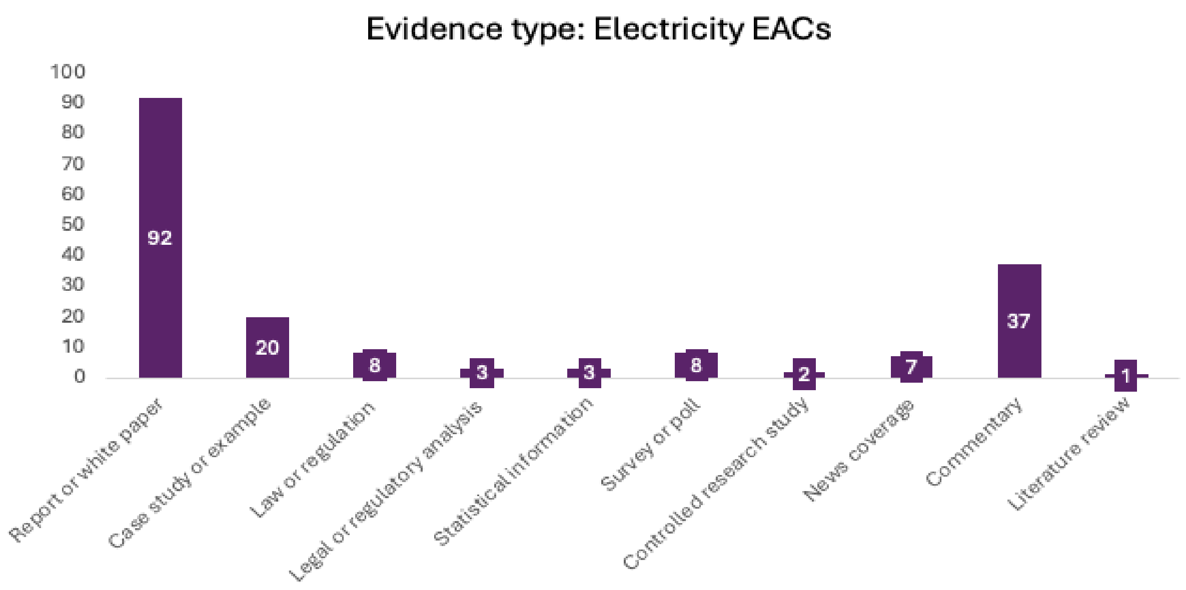

Figure 2: number of pieces of evidence per evidence type (electricity)

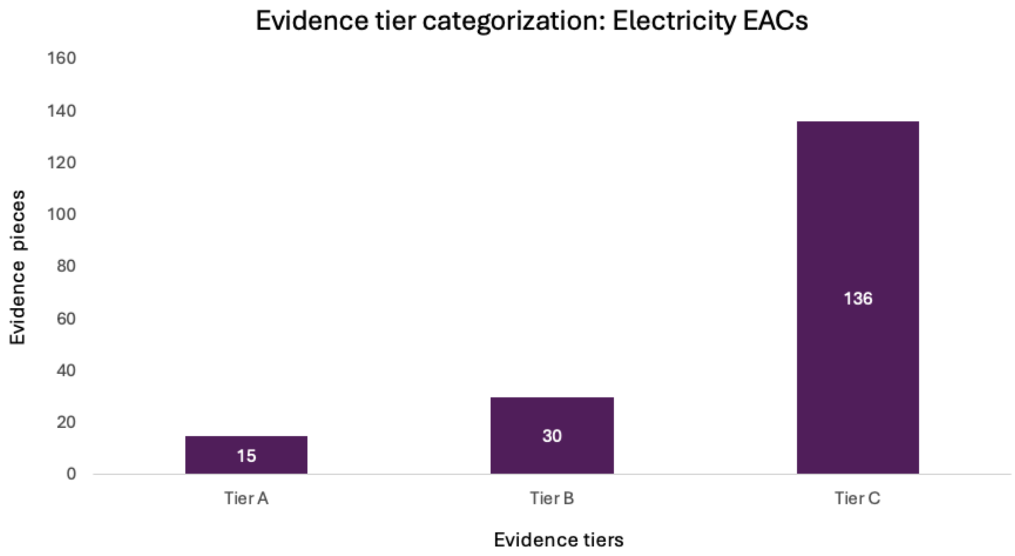

Figure 3: Number of pieces of evidence per tier (electricity)

3. KEY THEMES FROM ELECTRICITY

This report summarizes the findings across the key themes that emerged from the review of evidence. Selected highly relevant pieces of evidence have been quoted to highlight the recurring points that were made. The report does not exhaustively cover every point made by every piece of evidence, instead it summarizes the main points that were frequently made across submissions. Italicized text in this report does not represent direct extracts from the evidence submissions but serves to aid understanding and interpretation of the findings.

This report defines EACs as the more specific energy attribute certificates, rather than the broader term environmental attribute certificates. The major points discussed across the evidence are presented as five themes, as set out below.

- **Theme 1** explores the CoC model for energy attribute certificates (EACs), in particular the need to use a book-and-claim system, and the safeguards that must be put in place to ensure their effectiveness.
- **Theme 2** discusses how electricity EACs are currently used and the emissions attributes they represent.
- **Theme 3** explores how accurately EACs represent the physical electricity that has been consumed and thus the strength of the claim to the EAC emissions factor.
- **Theme 4** discusses the potential for electricity EACs to lead to system-level impacts.
- **Theme 5** considers the potential of electricity EACs to scale-up climate financing and the risk of climate finance dilution.

4. EVIDENCE REVIEW

4.1. Theme 1: EACs are necessary to track the attributes of renewable electricity but a thorough tracking system is needed to prevent double counting

Research questions related to this theme

This theme explores the CoC model for electricity EACs, and the safeguards that need to be in place to ensure their accuracy and effectiveness. This is related to the below research questions from SBTi's call for evidence:

- Question 1: What evidence exists about the effectiveness or ineffectiveness of environmental attribute certificates in delivering measurable emission reductions?
- Question 2: What evidence supports or opposes a causal link between specific operating conditions (geographies, regulatory schemes, presence or absence of tracking mechanisms or registries, etc.) and the effectiveness of environmental attribute certificates to deliver emission reductions? Which conditions?
- Question 3: What regulatory safeguards and market infrastructure, if any, would need to be put in place for environmental attribute certificates to be effective and sustainable?

Summary

Consumers of grid-supplied electricity cannot distinguish the source of that electricity, and "it is impossible to track energy flows through the grid" (197, Hamburger, 2019) *[Tier A]*. This is because once the electricity has been generated and distributed on a shared grid network, it is physically indistinguishable. An accounting-based approach is therefore necessary to verify the link between a unit of electricity generation with a specific emissions profile and the claim of electricity consumption with that emissions profile. *The accounting-based approach may involve either a mass balance model or a book-and-claim model. A mass balance model is where certified and non-certified products can be physically mixed. For example, EACs that are claimed for consumption are physically connected to the same electricity transmission and distribution grid as the generating asset that issued the EAC. Alternatively, under a book-and-claim model, physical products—whether certified or not – are not tracked and do not flow in the same physical grid. Instead, EACs are traded separately according to the amount of certified product fed into the supply chain, whilst ensuring that the quantity of certificates purchased matches the quantity entered into the system. This is the case for unbundled EACs, as well as for EACs sourced via power purchase agreements but claimed against consumption in a different grid. This terminology was not widely used in the evidence reviewed but allows easier comparison across the other reports.*

To avoid claiming the emissions associated with a unit of renewable electricity more than once, referred to in this summary as "double counting",[2] a tracking system or registry for

[2] See definition in Definitions section under the Introduction report

electricity EACs is required. These registries must ensure that EACs are uniquely issued, retired and claimed, including monitoring the trading of certificates between entities and sometimes across electricity markets. Different geographies and certification systems may have their own registries (for example, North America has ten different tracking systems for RECs) with different standards for certification or rules on trading. The GHG Protocol currently requires separation between the management of the certificate registries and market players using the instruments, to ensure a fair system.

Even with the safeguards provided by the widespread requirement for a tracking system to avoid EACs being claimed more than once (i.e., erroneous double counting), there are still some concerns of the potential for double counting of the low emissions associated with renewable electricity.

- One piece of submitted evidence noted concerns that regulation on the use of EACs, such as the EU's Electricity Market Directive, does not avoid double counting, particularly when EACs are traded across different market boundaries (197, Hamburger, 2019) *[Tier A]*. Although the market-based method requires the calculation of a residual mix emission factor (representing the untracked or unclaimed energy and emissions) some geographies may not correctly calculate the residual mix for claimed or exported EACs. This may mean they do not correctly or fully disclose emissions from renewable electricity.
- Other evidence set out concerns about the perception of renewable electricity use and the associated emissions claims across different market boundaries or accounting methods. For example, some evidence noted that some companies reporting scope 2 emissions using market-based accounting methods (using contractual instruments, and a residual mix emission factor) and others reporting location-based scope 2 emissions (using grid average emission factors) double counts the low emissions of the renewable electricity (183, GHG Protocol, 2019) *[Tier B],* (404, UK Green Building Council, 2023) *[Tier C]*. This could mean that consumers in geographies with high renewable penetration do not purchase EACs as they are generally aware that their electricity system has low emissions (110, New Climate Institute, 2022) *[Tier C]*. The low demand for EACs in that geography allows entities to sell EACs to other markets, therefore allowing the emissions attribute of the electricity to be reported twice. As a result, stringent registries may not be sufficient to ensure the emissions attributes of renewable electricity are not "double counted" under the current scope 2 emissions accounting rules. As noted in the introduction, the GHG Protocol recognizes that this is an inherent condition of the two accounting methods.

Detailed evidence

Grid electricity is physically indistinguishable and therefore CoC requires an accounting-based approach

Once generated and distributed on a grid, the source of electricity cannot be physically distinguished. As a result, the only possible chain of custody model to verify the link between the unit of production and the claim of renewable electricity via grid consumption is an accounting-based method using attribute certificates.

- The Greenhouse Gas Protocol Scope 2 Guidance states that "consumers of grid-supplied electricity cannot link, force, or otherwise direct a specified unit of electricity from its point of generation to its point of final use", and that "once energy is generated and distributed in a grid system, it becomes physically indistinguishable". It highlights that "contractual instruments are necessary in order to allocate attributes of production (including GHG emissions) to individual users" (183, GHG Protocol, 2019) *[Tier B]*.
- Several peer-reviewed articles state that the source of electricity on a grid cannot be physically distinguished.
    - Brander et al. state that "it is not possible to trace the electricity consumed by an entity back to any particular grid-connected power plant" (056, Brander et al. 2018) *[Tier A].*
    - Hulshof et al. also note that "consumers cannot credibly distinguish between renewable and non-renewable energy", particularly in the presence of electricity networks where "all energy in the network mingles" (206, Hulshof et al., 2019) *[Tier A].*
    - Hamburger argues that because "it is impossible to track energy flows through the grid", tradable certificates have been developed for tracking energy attributes (197, Hamburger, 2019) *[Tier A].*

A certificate tracking system or registry is required to avoid attributes being claimed more than once, but "double counting" may still occur

The evidence largely agrees that to enable attributes, such as emissions profiles, to be traded separately from the physical electricity, a certificate tracking system is required for EAC issuance, retirement, and claims. A formalized system will avoid the attributes associated with a given certificate being claimed more than once — referred to in this report as "double counting". The tracking system may involve a regulator or independent third party to serve as an issuing body or certifier.

- The GHG Protocol Scope 2 Guidance sets out the requirement that a contractual instrument must be "tracked and redeemed, retired, or canceled by or on behalf of the reporting entity" in order for its associated emission rate attribute (discussed further in Theme 2) to be used in a company's scope 2 emissions claims based on market-based accounting. The tracking system may allow trading of certificates but must ensure that each certificate has a unique tracking number so that they can reside in only one account at a time (183, GHG Protocol, 2019) *[Tier B]*.
    - The Greenhouse Gas Protocol Scope 2 Guidance also requires separation between the management and ownership of the tracking system and the market players using the instruments to "ensure the fair competition of issuance, redemption, and use of contractual instruments" (183, GHG Protocol, 2019) *[Tier B]*.
- A paper from the Oxford Institute of Energy Studies on the use of green certificates in China highlighted the importance of a "reliable third-party verification scheme" to avoid

double counting concerns and ensure reliability of EACs (204, Hove & Xie, 2023) *[Tier C]*.

- Different geographies and certification systems have their own registries and certifiers for EACs, which may have different standards for certification or rules on trading. For example, there are ten tracking systems in North America for renewable energy certificates (183, GHG Protocol, 2019) *[Tier B]*, while the EU's Guarantees of Origin (GOs) certificate system allows each Member State to appoint their own public or private "certifier", responsible for issuing and cancelling certificates. The Association of Issuing Bodies (AIB) represents the GO certifiers and operates a central electronic hub for trading of certificates (206, Hulshof et al., 2019) *[Tier A]*.
  - Hulshof et al.'s peer reviewed analysis found that "adopting a common international standard" and the appointment of a public certifier has a positive impact on the EAC market volumes (206, Hulshof et al., 2019) *[Tier A]*.

Even with the safeguards provided by the widespread requirement for a tracking system that uniquely registers each EAC to avoid attributes being claimed more than once, there are still some concerns of the potential for "double counting" of the low emissions associated with renewable electricity, either through contradictions in regulation or perceptions of renewable electricity.

- Several pieces of evidence highlighted the importance of using a modified emission factor representing the emissions of the untracked energy on the grid (the "residual mix") in the market-based method of accounting for Scope 2 electricity emissions to avoid double counting emissions attributes represented by EACs (183, GHG Protocol, 2019) *[Tier B]*, (197, Hamburger, 2019) *[Tier A].*
- Some evidence noted concerns that regulation on the use of EACs does not sufficiently cover all the points necessary to avoid double counting, particularly when EACs are traded across market boundaries.
  - Hamburger argued that regulatory failures and contradictions between rules in EU-level regulation, such as not all Member States implementing the disclosure regulation in the EU's Electricity Market Directive, leads to a risk of double counting renewable energy emissions due to poor or inconsistent calculation of residual mix emission factors (197, Hamburger, 2019) *[Tier A].*
  - Other concerns included some uncertainty around the issuing of EACs for behind-the-meter[3] (BTM) generation. A report by National Renewable Energy Laboratory (NREL) looked at the impact of different rules around the use of EACs from BTM generation in regulatory compliance and concluded that schemes need to ensure they either account for both the BTM generation and the load it serves, or they account for neither to avoid inaccurate accounting of emissions (175, NREL, Gagon et al., 2020) *[Tier B].*

[3] Behind-the-Meter refers to electricity that has been generated on-site, e.g., rooftop solar. As the grid has not been used, the electricity is not metered by the electricity supplier.

Other evidence set out concerns about the perception of renewable electricity use and the associated emissions claims across different market boundaries or accounting methods, which could lead to some distortion in the perceived system emissions.

- The UK Green Building Council highlighted concerns that allowing some companies to use market-based accounting methods to calculate scope 2 emissions, while others use location-based methods, leads to double counting. This is because the location-based method uses an electricity grid emission factor that is not adjusted to remove the impact of the emissions associated with the energy claimed using EACs—therefore the emissions can effectively be claimed by multiple entities (404, UK Green Building Council, 2023) *[Tier C].* The Greenhouse Gas Protocol Scope 2 Guidance also highlights this point as "the energy attribute certificates from a renewable generation facility are sold to a company who claims them and reports their emission rate in scope 2 (market-based). Consumers using the grid emissions factor (location-based method) will be double counting the emission rate conveyed by the energy attribute certificate (market-based method)". They note that this is an "inherent condition of two methods" and that "each method represents a separate way of allocating energy generation emissions, so depending on geographic or market boundaries, each method's scope 2 result can reflect some of the same emissions reflected in the other method" (183, GHG Protocol, 2019) *[Tier B].*
- NewClimate highlights the risk of "implicit double counting", where EACs could be used to claim emissions that may be perceived elsewhere. They set out an example to illustrate this, arguing that there may be an oversupply of EACs in Europe as a result of decades-old hydropower installations in Scandinavia, and "if Scandinavian customers believe that their energy is unambiguously delivered by renewable energy, they may see little incentive to purchase RECs; consequently, the owners of hydropower installations may sell RECs to foreign customers instead leading to the renewable energy generation being implicitly double counted" (110, NewClimate Institute, 2022) *[Tier C]*.

The evidence agreed that EACs are necessary to track the attributes of renewable electricity due to the inability to physically track electricity from a particular source. To ensure the attributes are effectively and reliably claimed, a registry or tracking system is required that ensures certificates are uniquely issued, procured, and cancelled, and there are a number of widely used registries in place currently. However, the use of EACs in the market-based method to determine scope 2 emissions and a residual mix emission factor may lead to "double counting" the emissions associated with renewable electricity generation and procurement.

4.2. Theme 2: EACs are used to represent the emissions Factor of generated electricity in companies' emissions claims

Research questions related to this theme

This theme explores how electricity EACs are currently used, and the emissions attributes they represent in the context of renewable electricity. This is related to the below research questions from SBTi's call for evidence:

- Question 1: What evidence exists about the effectiveness or ineffectiveness of environmental attribute certificates in delivering measurable emission reductions?
- Question 4: What evidence supports or opposes the ability of environmental attribute certificates to accurately reflect and quantify emission reductions in the context of corporate climate abatement targets?
- Question 6: What specific evidence-based claims can and cannot be made when employing environmental attribute certificates to corporate decarbonization?

Summary

Energy attribute certificates (EACs) are used for "conveying claims about the attributes of the underlying energy generation for consumers purchasing that generation" (183, GHG Protocol, 2019) *[Tier B].*

There are a range of EAC certificate types used across different geographies, including Renewable Electricity Certificates (RECs) used in the United States and Canada, Guarantees of Origin (GOs) in Europe, and the International REC standard (I-RECs) used in a number of countries where no specific market mechanism is in place. There are other national systems in countries including the UK, China (in addition to the use of I-RECs), and Australia.

EACs are currently used in both compliance and voluntary reporting as instruments to certify the generation and procurement of a unit of renewable electricity. Evidence discussed the expansion of recognized renewable energy sources for EACs (083, Clean Energy Buyers Institute, 2023).

EACs are used in regulatory compliance, such as electricity supplier quotas for procurement of renewable electricity e.g., Renewable Energy Portfolio Standards in several US states. Companies often purchase EACs in voluntary markets to make renewable electricity consumption claims, calculate their market-based scope 2 emissions and demonstrate decarbonization progress under frameworks such as SBTi.

EACs can be used in calculating the Scope 2 emissions of an entity, representing the emissions factor of the electricity procured. The GHG Protocol requires that all EACs "convey the direct GHG emission rate attribute associated with the unit of electricity produced", which is typically a "zero emission rate" for renewable electricity (183, GHG Protocol, 2019) *[Tier B]*.[4]

Evidence argued that EACs should represent the reduction in emissions achieved as a result of displacing higher GHG generation on the grid. This reduction could be calculated based on displacing the emissions from the marginal electricity generation on the system. The respondents typically advocate for location and time-specific marginal emissions, although they note that data on this might not be feasible to obtain. These respondents considered that the use of marginal emissions rate would better incentivize system-wide decarbonization compared to the current GHG Protocol guidance of calculating and reporting the emissions arising from the generation of a unit of renewable electricity based on its emission factor (i.e., 0 kgCO_2/MWh), using an attributional approach. Other evidence argued that this consequential or intervention-based accounting approach would require accurately understanding "avoided emissions" compared to a baseline. They consider that this is a different claim from electricity attributes and "should be […] reported separately to the corporate GHG inventory" (056, Brander et al., 2018) *[Tier A]*. *Different opinions on what EACs should represent is discussed more broadly in the Introduction section.*

To ensure transparency in corporate emissions reporting, evidence supported the requirement to disclose emissions under both location-based and market-based accounting methods. They argue this would ensure claims are fully transparent in addition to incentivizing both procuring renewable electricity and other actions to reduce emissions from electricity use, such as demand reduction (110, NewClimate Institute, 2022) *[Tier C]*. Evidence has suggested that using the location-based method only could remove incentives for consumption located in areas with low emission grid factor to pursue low carbon options (e.g. procure EACs) (056, Brander et al., 2019) *[Tier A]*. Other evidence highlighted issues with allowing companies to report their scope 2 emissions using only the market-based method, arguing that financial instruments conflict with "physical GHG accounting rules" (GHG emission inventories) (182, GHG Management Institute, 2023) *[Tier C]*. Some evidence suggested that transparency could be further improved by modifying the method to encompass "full disclosure" of the origin of all electricity consumption, including non-renewable sources.

Detailed evidence

EACs are widely used to represent the attributes of renewable electricity

EACs are widely used to represent the attributes of renewable electricity. EACs are currently used in both compliance and voluntary reporting to demonstrate the generation and procurement of a unit of renewable electricity.

- The Greenhouse Gas Protocol Scope 2 Guidance states that an EAC "serves as the instrument conveying claims about the attributes of the underlying energy generation for consumers purchasing that generation" (183, GHG Protocol, 2019) *[Tier B]*.

[4] This feature of electricity EACs differs from environmental attribute certificates for fuels and commodity certificates. The evidence received on fuel and commodity certificates tends to note that these emissions attributes are calculated on a lifecycle basis.

- The EU Renewable Energy Directive states that European electricity EACs (Guarantees of Origin (GOs)) have the “sole function of showing to a final customer that a given share or quantity of energy was produced from renewable sources” (155, European Union, 2018) *[Tier A].*
- EACs are widely accepted across geographies and certification systems as a valid basis for claiming the use of renewable electricity.
  - NREL states that EACs (Renewable Energy Certificates (RECS) in the US and Canada) “are formally recognized as a valid basis for making renewable energy use claims by the Federal Trade Commission, the U.S. Environmental Protection Agency, the U.S. Federal Energy Regulatory Commission, the U.S. Federal Energy Management Program, the American Bar Association, and at least 35 U.S. states and territories” (372, Sumner et al., NREL, 2023) *[Tier B].*
  - EU Renewable Energy Directive permits the use of EACs (called Guarantees of Origin (GOs) in the EU) to report renewable electricity (155, European Union, 2018) *[Tier A].*
  - In China, Green Certificates (GCs) are used to represent the purchase of renewable electricity (204, Hove & Xie, 2023) *[Tier C]*.
- EACs are used for regulatory compliance in addition to voluntary reporting.
  - EACs (RECs) are used by US states for compliance with Renewable Portfolio Standards (414, US Environmental Protection Agency (EPA), 2021) *[Tier B].*
  - In the Australian Capital Territory (ACT) Large-scale Generation Certificates (LGCs) can be used as proof of compliance in meeting its 100% renewable energy target (028, ACT, n.d.) *[Tier B].*
- There was some discussion of expanding the recognized renewable energy sources for EACs. For example, the Clean Energy Buyers Institute (CEBI) recommends expanding the scope of carbon-free technologies to encourage the sourcing of low carbon electricity from a diverse range of technologies and increase the supply of EACs (083, Clean Energy Buyers Institute, 2023).

Should EACs represent electricity with an emissions factor calculated through attributional LCA, or instead represent the reduction in emissions resulting from the renewable generation?

As set out above, EACs can be used in calculating the Scope 2 emissions of an entity, representing the emissions factor of the electricity procured. The GHG Protocol requires all EACs to “convey the direct GHG emission rate attribute associated with the unit of electricity produced”, which is typically a “zero emission rate” for renewable electricity. However, several pieces of evidence state that the reduction in emissions resulting from the renewable generation should be represented in the EAC.

- Several pieces of evidence argued that EACs should be used to represent a reduction in emissions or “avoided emissions”, based on the displaced higher GHG generation in the location of the renewable generation, as this would better incentivize system-wide decarbonization and decarbonizing the most carbon-intensive grids.

- REsurety argues that an entity's scope 2 emissions should be calculated by considering the marginal emissions rate at the location of consumption and of generation, to understand an EAC's "carbon abatement value". This would involve the use of locational marginal emissions, but REsurety states that "more geographically granular emissions data has significant value *[…]* many of the benefits of using marginal data can be achieved using marginal emissions rate data at more aggregated geographic granularity" (273, Oates, REsurety, 2024) *[Tier C].*
- Ballentine advocates for assessing "the extent to which a clean generation project will displace fossil emissions", and that current reporting systems assign the same value to EACs with little incremental climate benefit as those leading to "actual emissions reductions" (034, Ballentine, 2023) *[Tier C].*
- He et al., argue that a "carbon matching" electricity procurement strategy, where an entity must reach "carbon neutrality. This would be defined as having avoided emissions (carbon emissions displaced by incremental clean energy procurement) that equal or exceed the carbon emissions attributable to their load on an annual basis". The authors go on to say that carbon matching within the "local balancing authority" is the "most effective strategy in terms of both strategy cost and carbon abatement potential" (205, He et al., 2023) *[Tier B].*
- Clean Incentive have proposed the idea of Power Emission Certificates (PECs) which would include "greenhouse gas emissions avoided due to the operation of renewable energy projects" as a key attribute. This would be calculated using "Locational Marginal Emissions (LME), which provides an estimate of the emissions associated with each unit of energy consumed and those that would have occurred if the renewable energy project was not in operation". The "locational marginal emissions" used would be specific to the local grid and time; however, they note that hourly data can be difficult to obtain and so monthly or annual data could be used instead (089, Clean Incentive, 2023) *[Tier C].*

• Others argued that the use of EACs to accurately represent an "avoided emission" would require consequential or intervention-based accounting, and therefore is a different claim from energy attributes.

- The Greenhouse Gas Protocol Scope 2 Guidance highlights that any claims of avoided emissions are only credible if the purchase of the offset credit was the intervention that made the project happen (discussed further in *Theme: System-level Impacts of EACs*), and "offsets represent a different claim (avoided GHG emissions compared to a baseline scenario) than energy generation attributes (X GHG emissions from Y unit of energy generation)". (183, GHG Protocol, 2019) *[Tier B]*.
- The IEA highlighted that marginal accounting of corporate emissions would require "assessing all interventions" (221, IEA, 2022) *[Tier C].*
- Brander et al. argue in their peer-reviewed paper that "actions that genuinely result in additional grid-connected renewable energy generation should be quantified using a consequential accounting method, and reported separately to the corporate GHG inventory", as corporate GHG inventories are attributional and therefore "only need

to allocate total emissions between reporting entities without double counting" (056, Brander et al., 2018) *[Tier A].* Similarly, Brander and Bjorn propose reporting changes in emissions caused by company actions separately from the GHG inventory, including changes caused by the purchase of EACs (054, Brander & Bjorn, 2023) *[Tier B].*

- Nordenstram et al., explain that "identifying reduction opportunities, setting GHG targets and building a strategy to manage and reduce GHG emissions [including the use of EACs] are examples of emissions reduction decisions for which a consequential assessment method appears to be better suited." (271, Nordenstam et al., 2018) [Tier A].
- Some evidence explicitly suggested that EACs should be used in the same way as carbon credits (addressed in the SBTi's earlier dedicated synthesis report), as it would allow customers to "match their REC procurement and carbon credit procurement under one framework" (350, Sol Systems, 2022) *[Tier C].*

Disclosure is necessary to ensure transparency when making corporate emissions claims

The GHG Protocol describes how corporate entities must report their scope 2 emissions using both market-based (based on contractual instruments including EACs), and location-based accounting methods—"dual reporting" (183, GHG Protocol, 2019) *[Tier B]*. However, evidence presented questioned whether the use of the market-based method to account for the electricity emissions of a company is sufficiently transparent.

- Several pieces of evidence supported disclosure of both market-based and location-based emissions in corporate reporting, as this leads to a "clear incentive to both maximize energy efficiency improvements and to procure renewable electricity" (110, NewClimate Institute, 2022) *[Tier C].* This way, consumption located in areas with low location-based emission grid factor will still be incentivized to pursue low-carbon options (e.g., procure EACs) as they will be required to report using market-based mechanisms (i.e., residual mix emission factor).
- However, some evidence noted problems with the market-based method for emissions accounting, with the GHG protocol noting that the market-based method may result in "reallocation of attributes between those consumers who care about claiming low-carbon energy, and those who are unaware of or uninterested in the opportunity to make these claims" (183, GHG Protocol, 2019) *[Tier B]*. A number of pieces of evidence argued that the market-based method using contractual emissions such as EACs should not be used in Scope 2 emissions accounting or should be modified.
  - Brander et al. argue in their peer-reviewed article that the "market-based accounting method fails to provide accurate or relevant information in GHG reports", as they do not relate to changes in consumption of electricity, unlike other mitigation efforts such as demand reduction initiatives, and the use of a residual mix emission factor leads to increases in other company's reported emissions. It also may unfairly disadvantage companies that have implemented initiatives other than contractual instruments to reduce their emissions, such as demand reduction, as their reported

emissions are worse than a company who has procured EACs (056, Brander et al., 2019) *[Tier A]*.

- The GHG Management Institute argued that the allocation of lower GHG emissions to companies should not be done on a purely financial basis using EACs, as this is in conflict with physical GHG accounting rules (182, GHG Management Institute, 2023) *[Tier C]*.
- RECS Energy Certificate Association (RECS) are in favor of market-based accounting, however, suggest the use of “full disclosure regulation” where the origin of all electricity consumption is verified, including non-renewable sources, through the procurement of EACs (300, RECS, 2023) *[Tier C].*

Overall, EACs are used to certify the procurement of the attributes associated with the generation of electricity from a particular source. They therefore can be used to represent the associated emissions factor of the generated electricity, e.g., zero emissions from renewable electricity, in attributional accounting of companies’ emissions. The use of EACs to represent a reduction in emissions is a separate claim that requires consequential accounting of the EAC as an intervention.

4.3 Theme 3: Increasing temporal and geographic matching of EACs would improve how accurately EACs represent the physical consumption of electricity

Research questions related to this theme

This theme explores how accurately[5] EACs represent the physical electricity that has been consumed. This theme also explores if the accuracy and effectiveness of EACs is impacted by specific operating conditions, safeguards, or market infrastructure.

This theme does not discuss whether EACs with higher accuracy lead to greater emissions reductions at a system level—this is discussed in the next theme.

This is related to the below research questions from SBTi:

- Question 1: What evidence exists about the effectiveness or ineffectiveness of environmental attribute certificates in delivering measurable emission reductions?
- Question 2: What evidence supports or opposes a causal link between specific operating conditions (geographies, regulatory schemes, presence or absence of tracking mechanisms or registries, etc.) and the effectiveness of environmental attribute certificates to deliver emission reductions? Which conditions?
- Question 3: What regulatory safeguards and market infrastructure, if any, would need to be put in place for environmental attribute certificates to be effective and sustainable?
- Question 4: What evidence supports or opposes the ability of environmental attribute certificates to accurately reflect and quantify emission reductions in the context of corporate climate abatement targets?

Summary

Accuracy is a guiding principle of GHG accounting, to "ensure that the quantification of GHG emissions is systematically neither over nor under actual emissions" (183, GHG Protocol, 2019) [Tier B]. We define accuracy in the context of energy attribute certificates (EACs) as how closely an EAC represents the consumption of the physical electricity that was generated when the EAC was created, given that electricity cannot be physically tracked.[7]

Temporal and geographic bounds are two key parameters in determining accuracy of GHG accounting. The GHGP framework for EACs states "temporal accuracy" can be achieved by ensuring the generation on which the emissions factor is based is "close in time to the reporting period for which the certificates (or emissions) are claimed" (183, GHG Protocol, 2019) [Tier B]. In the case of geographic accuracy, the GHGP states that EACs should be "sourced from regions reasonably linked to the reporting entity's electricity consumption" (183, GHG Protocol, 2019) [Tier B]. However, evidence questioned the accuracy of EAC implementation stating temporal limitations, particularly with the current industry standard of annual matching. Geographic limitations were also highlighted, such as retiring EAC generated outside the grid of the EAC user.

<u>Temporal Accuracy</u>

Due to the daily and seasonal variability in renewable electricity generation, there is concern that a "buyer of a GO *[or, generally, an EAC]* may theoretically match its consumption with certified production on an annual average basis while still being dependent on production from fossil fuel in practice" (139, ENTSO-E, 2022) *[Tier B]*. Therefore, the current

[5] See a discussion of accuracy in the context of electricity EACs in the main report.

implementation of EACs is not providing accurate information about a company's carbon footprint (241, Langer et al., 2024) [Tier A], (404, UK Green Building Council, 2023) *[Tier C].*

Evidence suggested the addition of a timestamp to EACs will make them more closely represent the availability of clean energy (241, Langer et al., 2024) [Tier A]. The IEA state that hourly time stamped EACs will provide a "stronger reflection of time-value generation", as EACs will have to be redeemed at the same time they were generated, defined as Time-EACs (T-EACs), enabling "higher granularity [which] increases transparency" of emissions accounting (221, IEA, 2022) *[Tier B],* use (404, UK Green Building Council, 2023) *[Tier C]*. Respondents suggested that "hourly granularity is the longest time period allowed to ensure that GCs accurately account for the commercial and physical flows of electricity markets" (137, EnergyTag, 2021) *[Tier C]*.

The challenges, both physically and financially, of achieving 24/7 hourly matched EACs were highlighted by respondents (221, IEA, 2022) *[Tier B]*, (222, IEA, 2022) *[Tier B]*. A key issue is the required overbuild of renewable assets if 24/7 matching is done in silo by each company. One study noted that in Ireland, in 2025, commercial and industrial consumers would need a portfolio three times the capacity of an annually matched capacity to reach 24/7 hourly matching. This would cost three times the price of an annual matched portfolio due to the inclusion of low carbon dispatchable technologies such as gas generation with carbon capture and storage (316, Riepin and Brown, 2022) *[Tier C]*.

Improving temporal accuracy, but not requiring full 100% hourly matching was suggested by respondents (221, IEA, 2022) *[Tier B]*, (222, IEA, 2022) *[Tier B]*. Respondents stated 90% or 95% matching would still improve accuracy whilst not neglecting the use of interconnectors and that aggregated load is better for efficiency. A study conducted by a respondent detailed that a 95% 24/7 hourly matched portfolio results in a similar sized portfolio to annual matching but the inclusion of dispatchable technologies is less comprehensive, only needing batteries, so the mix only increases the cost by ~50% compared to an annual portfolio (316, Riepin and Brown, 2022) *[Tier C]*.

<u>Geographical Accuracy</u>

Evidence notes that a lack of geographic constraints on EACs makes it difficult to accurately reflect emissions. This is because companies can buy unbundled RECs in one area and apply them to their energy usage in another area. One respondent noted that EACs can be an "appropriate allocation instrument for attributional GHG accounting by companies" if the consumer and generator of renewables are on the same distribution or transmission grid (040, Benchimol et al., Greenhouse Gas Institute, Stockholm Environment Institute, 2022) *[Tier C].* Research provided by another respondent found that matching the EAC generation and retiring areas within the same bidding zone[6] (or in highly interconnected bidding zones) more accurately reflects emissions (136, Energy Track & Trace, 2022) *[Tier C]*.

Other pieces of evidence explained that transmission network capacity needs to be considered in the trading of EACs, to ensure that there is a plausible physical link between

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[6] Bidding zones are areas defined by electricity market trade and are normally national or sub-national.

generation and consumption (198, Hamburger, 2019) *[Tier A].* Respondents noted that this can be achieved by constraining the sale of EACs by the physically possible flow of electricity e.g., limited by grid connection capacities (010, AFRY, Granular Energy, Nord Pool, 2023) *[Tier C]*.

Respondents highlighted that a consequence of no geographical restraints on EAC use is that renewable energy will begin to cluster in cheap locations; however, this impact and other impacts of higher accuracy EACs are discussed in more detail in theme 4.

It was also noted that increasing the temporal and geographic accuracy of EACs will require significant developments in EAC frameworks, including improving data access, earlier issuance of EACs to facilitate trading, and decisions on the appropriate geographical restrictions for certificate transfer (010, AFRY, Granular Energy, Nord Pool, 2023) *[Tier C]*.

Detailed evidence

Without restricting the use of EACs to more closely represent the physical delivery (considering temporal and/or locational and/or network capacities), EACs may not accurately reflect the emissions of a company.

Improving temporal granularity of EACs from the current annual matching would enhance the accuracy and thus the claim to the emissions factor of the EAC.

Respondents raised concerns on EACs currently using annual matching for energy use and emissions. Hourly matching was the most prominent suggestion to improve the temporal accuracy of EACs. However, concerns about the implication of 100% hourly matching were raised by respondents.

Issues with annual matching

Respondents highlighted that while annual matching is the current industry standard, there is a significant drawback in an EAC accurately representing the physical electricity that it was generated from, due to the daily and seasonal variability in renewable electricity generation.

- Langer et al., used a set of indicators to compare the extent to which different modelled REC purchase conditions resulted in additional renewable energy generation (REG) and emission reductions as compared to a counterfactual where there is no REC market. Results suggested that annual matching does not “lead to significant emission reductions compared to a counterfactual without a REC market". This is because "investments are made almost exclusively in the cheapest available renewable resource, cannibalizing market-driven projects that would have been economically viable in the absence of a REC market", therefore annual matching has a "negligible system advantage over purchasing electricity without a REC market" (241, Langer et al., 2024) [Tier A].
- Electricity Maps submitted the European Network of Transmission System Operators for Electricity’s (ENTSO-E) position paper on a future-proof market design for GOs. ENTSO-E believes that the “buyer of a GO [or generally an EAC] may theoretically match its consumption with certified production on an annual average basis while still

being dependent on production from fossil fuel in practice". It argues that the introduction of temporal matching would better reflect the value of producing and consuming green electricity (139, ENTSO-E, 2022) *[Tier B]*.

- Granular Energy submitted summary guidance from the UK Green Building Council (UKGBC) on renewable energy procurement. UKGBC argues that the current resolution of REGOs does not reflect the variability in the carbon intensity of the UK grid. They argue that the consumer is "exposed to a proportion of fossil fuels in their generation mix, even if they are procuring a '100 per cent renewable' product" (404, UK Green Building Council, 2023) *[Tier C]*.

<u>Benefits of hourly matching</u>

Participants suggested the use of hourly stamped EACs would enable them to more accurately represent the physical electricity *thus improving the claim of the purchaser to use the associated emissions factor*.

- The IEA discussed the use of hourly matching as the likely next phase for RECs, defined as time-based EACs (T-EACs). The IEA state that T-EACs will provide a "stronger reflection of time-value generation", as EACs will have to be redeemed at the same time they were generated and that T-EACs will enable "higher granularity [which] increases transparency" of emissions accounting (221, IEA, 2022) *[Tier B]*.
- EnergyTag propose granular energy certificates (GCs), which add a timestamp to EACs. They argue that "hourly granularity is the longest time period allowed to ensure that GCs accurately account for the commercial and physical flows of electricity markets". They also argue the introduction of GCs will result in competition between suppliers and corporate bodies to have the highest hourly carbon-free percentage consumption (137, EnergyTag, 2021) *[Tier C]*.
- UKGBC's summary guidance on renewable energy procurement states that the use of hourly or better time-matched procurement will more accurately reflect the emissions associated with buildings' electricity use (404, UK Green Building Council, 2023) *[Tier C]*.

<u>Limitations with hourly matching</u>

Respondents noted that while 100% 24/7 hourly matched EACs does ensure that the physical electricity is precisely tracked, it can result in an overbuild of renewables which increases costs. Respondents suggested a threshold for hourly matching:

- The IEA notes that time based EACs can result in an overbuild of renewables, which increases curtailment and can make the transition more expensive. This is because exact hourly matching requires a large overbuild and neglects the use of interconnectors and that aggregated load is better for efficiency, i.e., it is better to have one large plant with interconnectors than a large oversupply of renewables in multiple localities (221, IEA, 2022) *[Tier B]*.
- Riepin and Brown's study concludes that while 100% hourly matched Carbon-Free Energy (CFE) reduces emissions to zero it comes at a significant cost compared to achieving 95% hourly matching as large capacity portfolios are needed with dispatchable technologies. The authors modelled that in Ireland, in 2025, a corporate and industry

(C&I) would need a portfolio three times the size of an annually matched capacity to reach 100% hourly matching (316, Riepin and Brown, 2022) *[Tier C]*.

- Riepin and Brown's state that 95% hourly matching results in a similar sized portfolio to annual matching. To achieve 95% low-carbon dispatchable technologies are needed, e.g., hydrogen and carbon capture and storage. The 100% hourly matched portfolio is twice as expensive as the 98% matched portfolio (and three times as expensive as the annually matched portfolio). The authors note that low-carbon dispatchable helps reduce costs more than long-term energy storage. Finally, the authors note that similar trends exist in all European countries, but variables include the local resources, renewable potentials, climate policies and the degree of interconnections (316, Riepin and Brown, 2022) *[Tier C]*.
- The IEA suggests that tolerances could be introduced for companies to limit the impact of building too much redundancy into a system, e.g., companies only need to meet 90% of their power from T-EACs. The tolerance would mean most of the power would have to be time matched, but some share can be met by interconnectors or an aggregated load peaking plant (221, IEA, 2022) *[Tier B]*. Another study by the IEA notes hourly matching on a consumer-by-consumer basis is highly inefficient as it misses the benefits of large, interconnected power systems. 100% matching should not take place in a siloed approach (222, IEA, 2022) *[Tier B]*.

Improving geographical granularity of EACs would enhance the claim that the physical electricity has been delivered.

Several pieces of evidence note that a lack of geographic constraints on EACs makes it difficult to accurately reflect.

<u>Issues with large geographic bounds</u>

Evidence consistently noted that without geographic matching, a consumer's claimed emissions do not accurately match the emissions of their physical electricity consumption.

- Carbon Market Watch and NewClimate Institute have submitted an FAQ document on green power purchasing claims and GHG accounting. This states that EACs could be an "appropriate allocation instrument for attributional GHG accounting by companies" if the consumer and generator of renewables are on the same distribution or transmission grid, certificates are allocated for all generation (not only renewables), and if the accounting of Scope 2 emissions was performed by all organizations using certificates (040, Benchimol et al, Greenhouse Gas Institute, Stockholm Environment Institute, 2022) *[Tier C].*
- UKGBC's guidance on renewable energy procurement argues that trading across borders may lead to issues with accurately accounting for emissions (404, UK Green Building Council, 2023) *[Tier C]*.

<u>Network capacity</u>

Respondents suggested that transmission network capacity and physical power flows need to be considered when EACs are issued. Otherwise EACs could be redeemed despite the chance of the generation physically supplying the offtake region being very low or impossible, e.g., 1) Norway generating renewable power and the EACs being redeemed in Italy, 2) Norway generating EACs greater than its capacity for grid export to other countries.

- Hamburger's peer-reviewed paper investigates how the use of GOs in Europe meet policy aims of informing final consumers and driving new investments in renewable energy generation. This found that the export and import of GOs in Europe significantly exceeded the physical flow of electricity: "72.26% of exported GOs were traded over electricity flows", "62.72% of imported GOs was over the physical import flows of electricity". In several cases (e.g., Iceland and Cyprus), "GO trade even occurs from or to countries lacking any interconnector capacities" or also to distant countries not within Europe. The study concludes that limiting the trade of GOs to reflect the physical limits of electricity flows would allow consumers to get more reliable disclosure information (197, Hamburger, 2019) *[Tier A].*
- Nord Pool, Granular Energy, and AFRY's white paper argues the importance of ensuring "cross-zonal certificates transfers are linked to the commercial power flows happening in the power market" to avoid Renewable Energy Sources (RES) deployment in areas without consideration of the available capacities of transmission systems. They note work is needed, including improving data access, earlier issuance of EACs to facilitate spot trading, and decisions on the appropriate geographical restrictions for certificate transfer (010, AFRY, Granular Energy, Nord Pool, 2023) *[Tier C]*.

Some evidence highlighted that EACs also do not account for losses on the grid, as certificates of renewable energy generation are used to validate claims of consumption (175, NREL, 2020) *[Tier B]*, (131, Energy and Environmental Economics, ACORE, 2023) *[Tier C]*. They argue that this leads to inaccurate emissions accounting.[7]

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[7] It should be noted that under the GHG Protocol, emissions as a result of transmission and distribution losses are included in scope 3 emissions. See Greenhouse Gas Protocol, Technical Guidance for Calculating Scope 3 Emissions, 2013.

4.4 Theme 4: EACs may lead to system-level decarbonization, particularly when they are bundled and have higher temporal and geographical correlation

Research questions related to this theme

This theme explores the potential for EACs to lead to system-level impacts. It includes discussion of the differing impacts of contractual arrangements for purchasing EACs (bundled with electricity or unbundled) and whether using EACs to more closely represent physical consumption of electricity has different impacts on system-level emissions. This theme does not discuss how accurately EACs represent the physical electricity that was consumed—this is discussed in the previous theme.

This is related to the below research question from SBTi:

- Question 5: What evidence exists that uptake of attribute certificates leads to or hinders the transformation needed to reach climate stabilization?
- Question 6: What specific evidence-based claims can and cannot be made when employing environmental attribute certificates to corporate decarbonization?

Summary

System-level decarbonization is caused by actions such as the growth of low-carbon technologies, retiring of high-carbon technologies, or demand reduction. Actions that cause system-wide decarbonization are typically referred to as achieving 'additionality'.[8] In the case of renewable energy, these actions would increase the share of low-carbon electricity in the global system, either by deploying new renewables to meet growing demand, by displacing fossil generation that meets the current demand or deploying other low-carbon dispatchable technologies, such as batteries. There are conflicting positions on the role that energy attributes certificates (EACs) play in realizing the actions needed for the transformation to climate stabilization.

Impact of bundled and unbundled EACs

As discussed in Theme 1, unbundled EACs typically follow a book-and-claim system whereas bundled EACs may also follow a mass balance system. This terminology was not used by the respondents but is noted here for comparability with fuels and commodities EAC reports.

Respondents claimed that unbundled EACs can support system-wide decarbonization, as "RECs provide an important source of revenue to support the development of clean energy projects and has been demonstrated to be a significant factor for growing renewable energy capacity", therefore reducing system-level emissions (131, Energy and Environmental

[8] According to the SBTi glossary, additionality is the extent to which something happens as a result of an intervention that would not have occurred in the absence of that intervention. Additionality is a defining concept when assessing interventions quantified with consequential accounting, including carbon credit projects and programs.

Economics, ACORE, 2023) *[Tier C]*.[9] It was also noted by several authors that unbundled EACs are vital for companies to provide market signals in absence of being able to sign large scale power purchase agreements for bundled EACs. Finally, some submitters highlighted that EACs are key for driving intervention in regulated markets where bilateral PPAs cannot be signed, such as Vietnam (334, Schneider Electric, 2023) *[Tier C]*.

However, evidence highlighted problems with unbundled EACs and that *"*widespread use by companies with science-based targets has led to an inflated estimate of the effectiveness of mitigation effort*"* (044, Bjorn et al., 2023) *[Tier A]*. The main issue raised with unbundled EACs is that the price of unbundled EACs is too low, such that *"*consumer commitment does not affect RES [Renewable Energy Sources] development for the time being" (198, Hamburger et al., 2018) *[Tier B]* and therefore market-based attributes conveyed by EACs are not correlating with actual emission reductions (338, Seebach and Timpe, 2016) *[Tier B]*.

The lack of intervention caused by low-priced unbundled EACs was particularly highlighted in the European market by respondents (263, Mulder & Zoma, 2016) *[Tier A]*. Several authors noted that the oversupply of GOs from Norway and projects that have already received project funding have deflated the price of GO sufficiently (estimated at ~1.7% of generation cost) that it is *"*unlikely that the GO system had an impact on growth of electricity production capacity from RES*"* (176, Galzi, 2023) *[Tier A],* (197, Hamburger, 2019) *[Tier A]*. Subsequently, buying unbundled GOs in Europe does not result in emissions reductions and system-level decarbonization (198, Hamburger et al., 2018) *[Tier B]*.[10]

Respondents claimed that system-wide decarbonization has occurred where EACs are bundled with renewable electricity, in the form of a power purchase agreement (031, Backstrom et al., 2024) *[Tier B],* (016, Akamai Technologies, Sustainability Roundtable, 2023) *[Tier C]*. For example, *"*Corporate-backed PPAs, effectuated by EACs for electricity, have resulted in significant clean energy build-out", evidenced by "the carbon intensity of U.S. electricity generation fell 24% from 2014 to 2021*"* (399, EIA, 2022) *[Tier C].*

Impact of locational and temporal matching

Several pieces of evidence stated that the current implementation of EACs is an inefficient way of achieving system-level emissions reductions. This is because EACs are resulting in project clustering in least cost locations, rather than in the most effective locations for emissions reductions. This means regions with more challenging development conditions, where the benefit of the investments may be greater, tend to benefit less (222, IEA, 2022) *[Tier B]*. Also important, however, is the trade-off between value for money in low-cost renewable energy generation locations meaning that more renewables can be built with higher short-term emissions savings, versus ensuring that, in the long-term, market signals are in place for renewable energy also to be built in higher cost locations near the demand, or for energy intensive users to be sited near low cost renewable electricity.

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[9] For further discussion, see comments on EACs supporting the scale up of renewables Theme 5: Scaling Up Climate Finance.
[10] For further discussion see comments on low pricing of EACs in voluntary markets in Theme 5: Scaling Up Climate Finance.

Respondents expressed that annual matching of energy consumption and EAC retirement has been effective in supporting renewable build out and providing a pathway for companies to decarbonize their electricity (221, IEA, 2022) *[Tier B]*. However, it was also suggested that more granular temporal correlation, such as hourly matching of EACs, will also help with the build out of a more diverse range of renewable energy technologies (372, Sumner et al., NREL, 2023) *[Tier B]*. This is because an over reliance on annual matching leads to a build out of renewables with limited supply flexibility (i.e., solar always produces in the middle part of the day and cannot respond to changes in demand) (222, IEA, 2022) *[Tier B]*.

Evidence was submitted on how EACs can more effectively deliver interventions that promote system wide decarbonization. This included suggestions for the inclusion of carbon emissions reduction attribute of EACs to "better capture, reflect and value the carbon emissions that this new renewable energy capacity is displacing" (350, Sol Systems, 2022) *[Tier C]*. However, it was noted that the level of assistance that an EAC has provided in supporting an intervention is very hard to track (334, Schneider Electric, 2023) *[Tier C]*.[11]

Wider benefits

Some pieces of evidence suggested that wider benefits should be considered in EACs such as the social and community benefits of projects. However, it was noted that "socially motivated procurement" would require "new market and legal frameworks to validate social claims" (372, Sumner et al., NREL, 2023) *[Tier B]*.

Detailed evidence

Differing impact of bundled and unbundled EACs

Unbundled EACs

Respondents explained how unbundled EACs result in a build out of renewables, which results in emissions reductions, demonstrating that system level decarbonization has occurred. It was also noted that unbundled EACs are the only option in some markets, and for small companies that cannot sign deals for bundled EACs.

- Energy and Environmental Economics (E3) conducted a study on behalf of the American Council on Renewable Energy (ACORE) analyzing the GHG emissions impact of hydrogen production when RECs are procured. E3 argues that "sale of RECs provides an important source of revenue to support the development of clean energy projects and has been demonstrated to be a significant factor for growing renewable energy capacity". The modeling study suggested that the purchase of RECs led to clean energy injection into the grid, reducing energy production and emissions from emitting generation sources (131, Energy and Environmental Economics, ACORE, 2023) *[Tier C]*.
- Schneider Electric states that, without the use of unbundled EACs, small companies or ones in restrictive locations will not be able to decarbonize. For example, buyers of <1GWh/year of renewable power or real estate across the world cannot access large

[11] For further discussion see comments on carbon as an EAC attribute in Theme 2: Emissions Attributes

scale PPAs, so are reliant on unbundled EACs. Additionally, in countries that limit bilateral PPAs, such as Thailand and Vietnam, the use of unbundled EACs is the only option for companies to reduce scope 2 emissions. Increased EAC demand from voluntary corporate buyers in these scenarios has served as a market signal and contributed to the development of new renewable energy regulations to accelerate renewable energy in the region (334, Schneider Electric, 2023) *[Tier C].*

However, several pieces of evidence detailed that unbundled EACs do not contribute to system wide decarbonization.

- Bjorn et al. state that "widespread use [of unbundled RECs] by companies with science-based targets has led to an inflated estimate of the effectiveness of mitigation effort". This is due to historically low prices for unbundled RECs which is failing to stimulate development of new renewable and thus system level decarbonization (044, Bjorn et al., 2023) *[Tier A].*
- The peer-reviewed paper by Hamburger et al. analysed the factors affecting the development of renewable electricity sources, using an empirical analysis of data from 30 European countries over 2009–2016. The analysis found that "consumer commitment *[*e.g., using GOs and other mechanisms*]* does not affect RES development for the time being" (198, Hamburger et al., 2018) *[Tier B].*
- Seebach and Timpe's report outlines the challenges in accounting for renewable energy electricity in climate balances. The report explains how market-based attributes conveyed by EACs are not correlating with actual emission reductions (338, Seebach and Timpe, 2016) *[Tier B].*
- The NewClimate Institute's Corporate Climate Responsibility Monitor 2023 states that the procurement of unbundled RECs is unlikely to contribute to additional renewable electricity supply capacity. The purchase of RECs could, in theory, send a signal to developers of demand for renewable energy, there are indications this is not the case in practice due to issues including "oversupply of certificates and associated low prices, and implicit double counting" (268, NewClimate Institute, 2023) *[Tier C]*.
- UKGBC's guidance on renewable energy procurement highlight the importance of additionality to ensure "net change in emissions at a system level", and that "purchasing unbundled REGOs does not actively drive the electricity system to decarbonize" (404, UK Green Building Council, 2023) *[Tier C]*.

<u>Region specific evidence—issues in Europe</u>

Many pieces of evidence highlighted that the GO market in Europe is oversaturated with GOs so the cost is very low and thus the system level impact of buying GOs on emissions is likely negligible. The low cost is attributed to an oversupply of GOs from large hydropower plants in Norway. The observed low price of GOs is discussed in more detail in the following theme; however, the impact of this on renewable deployment is discussed here.

- Mulder & Zoma's paper analysed the contribution of green labels in electricity retail markets in the Netherlands to fostering renewable energy. The paper states that the use of GOs for green electricity retail products are *"*not effective to foster renewable electricity sources*"*. This is caused by the low premium for GOs (~1.7% of generator revenue) due to the abundant supply of certificates at low marginal costs from Norway—subsequently, GOs cannot incentivize investments in new renewable capacity and stimulate system-wide decarbonization (263, Mulder & Zoma, 2016) *[Tier A]*.

- Galzi's paper assesses whether the GO system in France contributes to the development of renewable electricity in France. The study concludes that the GO system and therefore green electricity consumers in France "did not contribute to the expansion of renewable energy over the period 2014 – 2021". This is because cancelled GOs are largely from hydro plants (over 90% between 2014 and 2021), and over 80% of GOs canceled in 2021 were from installations commissioned before 1990. However, they note that the price of GOs in France has increased significantly since 2021, and so "revenues from GOs could become significant" (176, Galzi, 2023) *[Tier A].*
- Hamburger's paper investigates how the use of GOs in Europe meet their policy aims of informing final consumers and driving new investments in renewable energy generation. This review found that "green electricity products based on GOs could not bring any incentives for new RES development", as a result of oversupply of GOs from old, already profitable, hydropower installations (largely in Norway) leading to low premiums. Therefore, GOs don't support system-wide decarbonization in Europe (197, Hamburger, 2019) *[Tier A]*.
- A report published by the Industry Decarbonization Newsletter argues that guarantees of origin are often issued for power plants that existed even before this system was created. The vast bulk of guarantees of origin come from existing hydropower plants in Norway. This does not lead to any new renewable energy generation being built. Therefore, there is no additionality. "There is no point in buying guarantees of origin if all you are doing is shuffling ownership. Certificate systems without additionality can even have negative effects on emission reduction efforts (049, Hanno Bock, 2023) *[Tier C].*

<u>Bundled EACs</u>

Respondents make a specific distinction that system-level impacts can be achieved but only the purchase of bundled EACs which they consider can drive additional renewable deployment.

- Backstrom et al., conducted a study on the effectiveness of PPAs in causing additionality and thus system-wide decarbonization. While they do not address emissions reduction directly, the study is still useful to understand the impact of PPAs. The study used data on PPA agreements and renewable deployment (U.S. only). Key findings detailed that: 1) Overall, PPAs increase renewable roll out. States that have enabled PPAs have seen the fastest growth of renewables. 2) PPAs are resulting in additional build out beyond the contracted amount, e.g., 1 MW PPA is resulting in > 1MW RE build out. The authors do not delve into why this is the case. 3) Utility scale PPAs result in the largest additionality. 4) Solar PPAs produce the largest additionality (031, Backstrom et al., 2024) *[Tier B]*.

- A case study of Akamai Technologies' 18 MW VPPA calculated the impact of the company signing a VPPA on emissions reductions and thus system-wide decarbonization. The study reveals that the VPPA led to avoided emissions of 25,000 tonnes of CO_2e over its operation from January 2022–August 2023, as a result of displacing nearly 50,000 MWh of gas and coal generation. Other modeling calculated an avoided emissions of 38,000 tonnes of CO_2e over Akamai's 12-year financial commitment to the renewable project (016, Akamai Technologies, Sustainability Roundtable, 2023) *[Tier C].*
- The Clean Energy Buyers Association (CEBA) submitted a report from the US Energy Information Administration (EIA), U.S. Energy-Related Carbon Dioxide Emissions, 2021. The report documents the general trend of decline in carbon emissions in the US energy sector and in the electric generation sector, in particular. CEBA explains that this documents the decline and when combined with other evidence the group has submitted show the impact and effectiveness of EACs. CEBA writes in their submission, "Corporate-backed PPAs, effectuated by EACs for electricity, have resulted in significant clean energy build-out associated with measurable and quantifiable GHG emissions reductions over the 2014-2023 period in the U.S." (399, EIA, 2022) *[Tier C].*
- The National Renewable Energy Laboratory explains that in 2013, the use of bundled RECs to satisfy USA renewable portfolio standards, a compliance market, resulted in a 58MtCO_2 reduction in emissions. The emissions abatement was calculated using the EPA's Avoided Emissions and Generation Tool (AVERT). The states that had more ambitious RPS targets had the largest shares of fossil displacement (266, National Renewable Energy Laboratory, 2016) *[Tier C]*.

Impact of locational and temporal matching

Locational and temporal are relevant to both bundled and unbundled EACs. The evidence discussing these two constraints are detailed below.

<u>Lack of geographic bounds limits system-level impacts</u>

Respondents explained that limited geographic bounds on EACs results in renewables being deployed in the least cost location, rather than focusing on other locations that could have greater emissions reductions.

- The IEA states annual matching with no geographic constraint results in a build out of solar and wind, as they are the cheapest RE options. However, this comes with limitations: 1) the rate of emissions reduction on the grid where procurement and consumption take place may differ. This can result in a discrepancy in the reported emissions avoided. 2) Development location—it is much easier to obtain low cost PPAs in some regions than others. No geographic constraint can result in a concentration of PPAs in regions where development is most accessible. As a result, regions with more challenging development conditions, where the benefit of the investments will be greater, tend to benefit less (222, IEA, 2022) *[Tier B]*.
- Clean Incentive states that RECs result in mis-accounting of emissions as a solar farm in a coal-heavy region can displace more emissions than a similar farm in a region with a

cleaner grid mix—RECs do not capture this variability (089, Clean Incentive, 2023) *[Tier C]*.

- ENTSO-E's position paper on a future-proof market design for GOs argues that the "absence of a locational dimension is currently causing negative side effects", and implementing appropriate geographic granularity would act as an incentive for the "development, production and consumption of RES at the efficient geographical location" (139, ENTSO-E, 2022) *[Tier B]*.
- NREL's report on the status and trends in the US voluntary green power market in 2021 argues that in an increasingly decarbonizing grid, "project clustering causes the marginal impacts of projects to decline as more solar and wind projects come online" since the "first wind farm in a region will displace more fossil fuel output than the tenth wind farm in that region". They suggest that "customer-aligned procurement", which forces buyers to "procure resources that match the geographic and temporal profiles of customer electricity use" would incentivize more diverse resource portfolios and reshaping of customer demand profiles (372, Sumner et al., NREL, 2023) *[Tier B]*.
- He et al. explain that in current use, EACs are annually matched and do not consider carbon. This results in an optimization of least cost, so the cheapest renewable energy technology is chosen and deployed in the least cost area—this results in a lot of PV in Texas. This does not guarantee carbon neutrality as the customer load location and the point of generation can have different marginal emissions (209, He et al., 2023) *[Tier C]*.

<u>Lack of temporal bounds limits system-level impacts</u>

Respondents highlighted that annual matching, which is the current industry standard, has helped with the initial build out of renewables. However, many pieces of evidence explained this does not incentivize the deployment of a variety of low carbon technologies which are needed to displace fossil fuel generation, e.g., batteries, bioenergy, etc.

- The IEA comments on how annually matched EACs, as used currently, have been a great instrument to help with the initial build out of renewables and emissions reductions (221, IEA, 2022) *[Tier B]*.
- However, the IEA also notes that hourly matching is much more beneficial for the electricity system than annual matching. This is because an overreliance on annual matching leads to a build out of renewables with limited supply flexibility (i.e., solar always produces in the middle part of the day and cannot respond to changes in demand). The large build out of solar displaces fossil production, which is flexible, making the grid more vulnerable to sharp rises in demand. To maintain its flexibility, large payments have to be made to operators on standby (who have now lost income from generation during times renewables are operating). This cost is not borne by the renewable developers and often has to be paid by service operators or ratepayers. However, in an hourly-matched system, a portfolio of renewable flexibility is encouraged, as it is needed to meet demand outside of typical solar and wind profiles. This increases the cost of the portfolio to the offtaker but is more supportive to the system (222, IEA, 2022) *[Tier B]*.

- Ballentine advocates for assessing “the extent to which a clean generation project will displace fossil emissions”. The author adds that current reporting systems should encourage companies to calculate the emissions impacts of their clean generation investments. The author argues that some EACs may have only a very little incremental climate benefit, such as a new wind farm in a wind-saturated region (RECs in West Texas), because the additional energy generated likely displaces another renewable source. However, a new renewable project in a fossil-heavy region, such as West Virginia, is likely to displace coal or gas generation, leading to emission reduction. The author argues that EACs generated from these two projects will enable companies to make similar claims regarding their scope 2 emissions, even though they do not have the same impact on the climate (034, Ballentine, 2023) *[Tier C].*
- Clean Incentive states that RECs result in mis-accounting of emissions, as a wind farm that generates in peak demand hours avoids more emissions than one that generates in off-peak hours—RECs do not capture this variability (089, Clean Incentive, 2023) *[Tier C]*.
- CEBI states that EACs have been effective in scaling up renewables and the associated carbon reduction. However, the current voluntary market systems do not stimulate the growth of a wide variety of renewables and do not empower customers to support hourly matching. Adding more solar in places like California and Spain and more wind in Texas and the Netherlands will not result in a power grid that is fully decarbonized. The authors detail that EACs need to be updated to reflect market demands and to enable more effective emissions reductions in the future (257, Clean Energy Buyers Institute, 2022) *[Tier C]*.

<u>Carbon abated could be added to track system-level impacts</u>

Several pieces of evidence explained that EACs should have an avoided carbon metric which would enable EACs to be bought that have the highest system-wide impact. How and whether EACs could be used to represent an avoided emissions attribute is discussed in Theme 2; however, the discussion below focuses on whether this addition would result in further system-level impacts.

- Clean Incentive states that RECs result in mis-accounting of emissions as PPAs and even hourly-matched RECs fail to consider the emissions avoided by renewable generation, displacing the counterfactual and therefore the impact on total emissions (089, Clean Incentive, 2023) *[Tier C]*.
- Sol Systems have provided a commentary on the effectiveness of RECs and the design of future RECs markets. Sol Systems argue that RECs “must better capture, reflect and value the carbon emissions that this new renewable energy capacity is displacing – also referred to as ‘avoided emissions’”. They argue that RECs should be tagged with the carbon intensity of the grid at the “time and location of their production”, as this would incentivize the better distribution of renewable energy investment in high carbon intensity grids, align better with Scope 2 requirements as they argue “Scope 2 requirements focus on carbon displaced”, and allow customers to “match their REC procurement and carbon

credit procurement under one framework to achieve verifiable carbon neutrality” (350, Sol Systems, 2022) *[Tier C]*.

- NREL’s analysis of the status and trends of the voluntary green power procurement market in the US in 2020 suggests that the impacts of off-site power purchase agreements can be evaluated through analysis of “Avoided CO_2 emissions, defined as the long-run avoided emissions metric" and "‘Grid value’ defined as the energy and capacity contributions of the project to the grid". They suggest that this can be used to understand the differing impact of location of renewable assets and estimate that wind in the U.S. has the highest “estimated avoided CO_2”. They argue that the impact can be increased by “updating guidance on corporate greenhouse gas and renewable energy claims”, specifically for “time-based claims and energy storage claims” (201, Heeter et al., NREL, 2021) *[Tier C].*
- A case study of Akamai Technologies’ 18 MW VPPA sets out an example of “Purchaser Caused” EACs (PC-EACs). PC-EACs are currently being developed by Sustainability Roundtable in partnership with other industry players and aim to certify EACs as having enabled new grid capacity. This aims to encourage investment in new renewable capacity, instead of supporting existing projects. Akamai procures EACs from regions that are as or more carbon intensive than its facilities, and Sustainability Roundtable argues that allowing scoring of emissions avoided in the location where a renewable energy project operates will mitigate more carbon emissions by causing new renewable energy in markets with greater carbon intensity (016, Akamai Technologies, Sustainability Roundtable, 2023) *[Tier C]*.

Wider benefits

Some pieces of evidence suggested that wider benefits should be considered in EACs, such as the social and community benefits of projects. However, it was noted that these impacts may be difficult to determine and verify.

- Energy Peace Partners (EPP) have developed Peace Renewable Energy Credits (P-RECs). They submitted several pieces of evidence about the use of P-RECs, providing several case studies and an analysis of their benefits. They argue that P-RECs expand renewable energy access by helping to “partially finance new renewable energy generation assets”, leading to wide societal benefits as a result of improved electricity access including improved safety, education, and economic activity. They also note that P-RECs can be used “post-financing” for the renewable energy project to help fund projects with shared community benefit (148, EPP, 2023) *[Tier C].* The EPP also submitted a summary of insights from research they conducted with Columbia University’s School of International and Public Affairs. The research investigated how companies can use P-RECs for verifiable claims as part of their reporting for ESG disclosure frameworks. By reviewing voluntary and regulatory ESG-related disclosure frameworks, they concluded that companies can transact P-RECs to “decarbonize their purchased electricity” and that P-RECS “send positive demand signals for power sector decarbonization through the additional revenue they deliver to renewable energy developers and operators” (133, EPP, 2023) *[Tier C]*.

However, robust frameworks would be necessary to determine and verify impact claims. NREL's report on the status and trends in the U.S.' voluntary green power market in 2021 states that "socially motivated procurement" would again require "new market and legal frameworks to validate social claims", e.g., P-RECs (372, Sumner et al., NREL, 2023) *[Tier B].*

4.5 Theme 5: If sufficiently priced, EACs have the potential to scale up climate finance

Research questions related to this theme
This theme explores the potential of EACs to scale up climate financing. This is related to the below research questions from SBTi:

- Question 7: Is there evidence that supports or undermines that the market value of this type of instrument is commensurate with the abatement costs of the underlying activity?
- Question 8: Is there evidence that shows that the use of these instruments could contribute to scale-up of climate finance compared to alternative interventions? Or could it result in climate finance dilution?

Summary
EACs have the potential to provide investment in or scale up the financing of low-carbon electricity systems. However, different pieces of evidence have differing arguments about the extent to which EACs are able to contribute to the scale-up of climate finance.
There is evidence which argues that the voluntary procurement of EACs increases the accessibility of climate financing, by allowing companies that would not otherwise be able to enter the market the opportunity to provide investment in a low-carbon electricity system. EACs may be the "only procurement mechanism available to hundreds of thousands of companies" (002, 3Degrees, n.d.) [Tier C], in particular, smaller or new companies, companies in locations where the procurement of electricity is restricted by the local utility, or companies that need flexible procurement without "fear of the financial risks of long-term contracts" (030, Bachus, Lim, 2023) [Tier B].
There was significant discussion about the ability of voluntary EACs to provide an additional revenue stream for owners of renewable electricity assets. Several pieces of Tier C evidence stated that EACs provided "essential revenue for project assets" (301, EMA, 2023) [Tier C]. They stated that the EAC market was able to generate a significant amount of revenue which could be re-invested in new renewable generation or may be important in the financing of pre-existing assets. Long-term contracts such as power purchase agreements (PPAs) were highlighted as being more effective in the scale up of climate finance as they provide a continuing set revenue stream rather than an uncertain and volatile revenue from the sale of unbundled EACs. It was also noted that the revenue from voluntary EACs could be important for securing other investment in renewable energy projects, as "project financiers quantify the value of voluntary REC market access as they evaluate project proposals", (009, ACORE, 2023) [Tier C] therefore directly scaling up climate financing.
Although respondents suggested that EACs could in theory provide additional revenue for renewable energy asset owners, analysis of the performance of the EAC market in Europe and certificate prices in voluntary markets in the U.S. and Europe suggested that the markets are not functioning efficiently, and that current prices are too low. The low prices may lead to finance dilution, defined by SBTi as the "risk that the expenditure on unbundled certificates results in a lower amount of mitigation finance compared to the actual sourcing of a low-carbon activity or commodity".[12] This was particularly highlighted as a problem in Europe, where several Tier A pieces of evidence highlighted an oversupply of GOs from old, already profitable, hydropower stations, largely in Norway. The low EAC price premium in

[12] Science Based Targets initiative (SBTi). (2024). Aligning corporate value chains to global climate goals. SBTi Research: Scope 3 Discussion Paper.

comparison with the costs of producing green electricity suggests that “the price of green electricity [as represented by the price of EACs] is not related to the costs of green electricity” (263, Mulder & Zoma, 2016) [Tier A].
However, the price of voluntary EACs appears to have increased significantly over recent years across several geographic markets, including Italy, France, and the U.S. This suggests that, in the future, “revenues from [EACs] could become significant” (176, Galzi, 2023) [Tier A]. The volatile nature of the voluntary market means it is unclear if these higher prices will be maintained.

Detailed evidence

As EACs are a financial mechanism, they have the potential to provide investment in or scale up the financing of low-carbon electricity systems. However, there is some discussion across the different pieces of evidence about the extent to which EACs are able to contribute to the scale-up of climate finance.

EACs may scale up climate finance by improving market accessibility and by providing an additional revenue

Several pieces of evidence argue that the voluntary procurement of EACs offer companies that would not otherwise be able to enter the market the opportunity to provide investment in low-carbon electricity systems. In particular, the purchase of unbundled EACs or virtual PPAs provides a flexible opportunity to procure renewable electricity, particularly advantageous for small or new market participants, or those located in markets with limited opportunity to directly invest in the electricity procured.

- 3Degrees argue that EACs are the “only procurement mechanism available to hundreds of thousands of companies” and allows new or smaller market participants to engage in the clean energy market (002, 3Degrees, n.d.) *[Tier C].*
- Backus and Lim argue that virtual power purchase agreements (vPPAs) and unbundled EACs allow organizations that do not have directly available renewable energy infrastructure to finance renewable energy. They highlight that this is particularly useful for organizations in areas where the local utility provider cannot offer green energy, or for companies to procure electricity flexibly and without “fear of the financial risks of long-term contracts” (030, Bachus, Lim, 2023) *[Tier B]*.
- The United States Environmental Protection Agency (EPA) Green Power Partnership argue that vPPAs are “appealing to organizations in states that do not permit direct retail access” and “appealing to buyers that have multiple load centers” across different markets (416, U.S. EPA Green Power Partnership, n.d.) *[Tier B]*.

Some evidence argued that the purchase of EACs provides an additional revenue stream for producers of renewable electricity, either to directly finance the construction of new renewable assets (discussed in more detail in *Theme 4: System-level Impacts of EACs*) or to help secure other investment in projects.

- Several pieces of Tier C evidence stated that EACs provided “essential revenue for project assets” (301, EMA, 2023) *[Tier C]* and that the EAC market was able to generate a significant amount of money which could be re-invested in new renewable generation

(141, EMA, 2023) *[Tier C],* (301, RECS, n.d.)*[Tier C],* (364, STX Group, n.d.) *[Tier C],* (250, Ecohz, Lindberg et al., 2023)*[Tier C].* However, they do not clearly differentiate between the money generated by the voluntary procurement of EACs by companies and the purchase of EACs for regulatory compliance.

  - The I-REC Standard Foundation estimated that the "annual contribution of voluntary market REC redemptions was about $5.08 billion for 2022", considering "annual EAC redemptions" and estimated prices for U.S. RECs, European GOs, and I-RECs (209, I-REC Standard Foundation, 2023) *[Tier C]*.
  - The STX Group conducted an analysis which estimated that from January to August 2023, GOs contributed a weighted average of 9% of the monthly revenue of a solar plant in Spain. They also estimated that the internal rate of return (IRR) of a Spanish solar asset is 7% in 2023 without consideration of revenue from GOs. They therefore concluded that the "Guarantee of Origin revenue significantly contributes to the overall project return" (358, STX Group, n.d.) *[Tier C].*

- Some evidence argued that longer-term contracts such as PPAs may be more effective in scaling up climate finance as they provide renewable electricity asset developers with a long-term revenue stream rather than an uncertain and volatile revenue from the purchase of unbundled EACs.
  - The EPA Green Power Partnership states that PPAs "secure a long-term stream of revenue for an energy project" (416, US EPA Green Power Partnership, n.d.) *[Tier B].*
  - In contrast, Energy Track & Trace note that revenues from "free-floating Granular Certificates" (i.e., unbundled certificates) offer a "relatively uncertain volatile revenue" (136, Energy Track & Trace, 2022) *[Tier C]*.
- Some respondents suggested that even limited revenues from the purchase of EACs are important in securing other investment for the construction of renewables assets, therefore scaling up climate finance.
  - STX Group stated that financial institutions, particularly banks, recognize the economic value of GOs when lending for renewable projects. However, due to confidentiality, the author was unable to provide direct evidence from the banks (358, STX Group, n.d.) *[Tier C].*
  - The American Council on Renewable Energy (ACORE) argues that RECs incentivize new renewable energy generation, as "project financiers quantify the value of voluntary REC market access as they evaluate project proposals". They highlight that reduced REC sales would lead to increased financing costs as a result of the higher risks for new developments (009, ACORE, 2023) *[Tier C].*
  - A case study of a ten-year PPA provided by Ørsted agreement for German chemical company Covestro from a newly built wind farm in the North Sea (Borkum Riffgrund 3) stated that "Covestro will assume partial power pricing risk for Borkum Riffgrund 3 to help secure final investment for the project" (281, Ørsted, n.d.) *[Tier C]*.
- Sol Systems also highlighted that revenues from the sale of EACs could be important for pre-existing renewable electricity assets in addition to new generation, as "the current

market for unbundled RECs was a core part of the initial underwriting and financing of the project when it was developed years ago" (350, Sol Systems, 2022) *[Tier C]*.

Poor voluntary market performance and low prices due to an oversupply of EACs may lead to climate finance dilution

Analysis of the performance of the EAC market and certificate prices suggested that the markets are not functioning efficiently, and that current prices are too low to provide a significant revenue stream to renewable electricity developers. The low prices may lead to finance dilution, defined by SBTi as the "risk that the expenditure on unbundled certificates results in a lower amount of mitigation finance compared to the actual sourcing of a low-carbon activity or commodity". However, some evidence suggested that EAC prices have increased recently, which could allow revenues from the trading of EACs to become more important to renewable assets.

- Hulshof et al. analyzed the performance of markets for GOs in 20 European countries over 2001–2016 and found that although there was an increasing amount of renewable electricity receiving certification, GO markets suffer from very poor liquidity as measured by the churn rate, which is "far below levels generally associated with a mature and liquid market" across the region as a whole and in individual countries. They also found that GO certificate prices are "very volatile and there are no clear signs of improvement over time". They conclude that "European certificate markets are not yet functioning efficiently", although performance is improved by the implementation of a common international certificate standard, as well as the appointment of a public certifier (206, Hulshof et al., 2019) *[Tier A].*
    - However, NREL's analysis of trends in the U.S. voluntary green power market found that 44% of total RECs sales in the U.S. were in the voluntary market in 2022, rather than for compliance (an increase from 38% in 2021, and 35% in 2020) (228, Jena, NREL, 2023) (372, Sumner et al., NREL, 2023) (201, Heeter et al., NREL, 2021) *[Tier C].*
- The low value of EACs in voluntary markets is widely discussed in the evidence, and generally concludes that the low prices limit the ability of EACs to contribute significantly to revenues of renewable electricity assets.
    - S&P Global analysis found that the compliance market in the U.S. makes up 95% of the EAC market and has a commensurate average value of $33.94/MWh. This has a significant impact on the decision for new renewable generation to occur. The voluntary market has been less successful and has achieved low EAC prices, an average of $3/MWh (432, Wilson and Lenoir, 2022) *[Tier C]*.
    - Guidance from the GHG Management Institute and the Stockholm Environment Institute stated that "voluntary certificates do not, and under feasible economic conditions, will not, influence renewable energy investment or generation". They argue that the value of EACs is too low to have a significant impact on renewable investment, and that there are "no expectations of a near- or long-term scarcity in voluntary REC or GO markets", which could increase the financial influence of the

    - certificates (040, Benchimol et al., Greenhouse Gas Institute, Stockholm Environment Institute, 2022) *[Tier C]*.
    - The NewClimate Institute highlights that although RECs could theoretically send a demand signal to renewable energy developers, in practice, this does not happen due to an "oversupply of certificates and associated low prices" (268, NewClimate Institute, 2023) *[Tier C]*.
- Several pieces of analysis link the low prices of EACs to an oversupply from older renewable assets that are already profitable. The evidence agreed that this was particularly an issue in Europe, where Norway is able to export a large number of EACs from older hydropower stations.
- Hamburger's peer-reviewed article conducted a literature review which concluded that "green electricity products based on GOs could not bring any incentives for new RES development", as a result of oversupply of GOs from old, already profitable, hydropower installations (largely in Norway) leading to low premiums (197, Hamburger, 2019) *[Tier A].*
    - Mulder & Zoma's peer-reviewed analysis found that 69% of the renewable energy in the Dutch retail markets in 2014 were based on imported GOs, largely from Norway. Their analysis concluded that the maximum cost of GOs was low and therefore "the price of green electricity *[*as represented by the price of GOs*]* is not related to the costs of green electricity". They additionally assessed that there was an oversupply of GOs, due to the large number of GOs that expire without being used across Europe. They concluded that the premium for GOs, due to the abundant supply of certificates at low marginal costs from Norway, is too low to incentivize investments in new renewable capacity (263, Mulder & Zoma, 2016) *[Tier A].*
    - Hulshof et al.'s analysis of the performance of markets for GO certificates in 20 European countries over 2001–2016 found that due to the high expiration rate, markets have been in a "relatively stable state of oversupply" (206, Hulshof et al., 2019) [Tier A].
    - Granular Energy highlighted RE100's criteria that EACs should come from plants less than 15 years old and argued that this could help to support project financing and prevent oversupply of EACs (169, Ferenczi, Granular Energy, 2023) *[Tier C]*.
- However, several pieces of evidence suggest that the price of EACs has increased recently and therefore argue that EACs could provide more significant revenues in the future for renewable electricity assets.
    - AirTrunk submitted data showing the premium provided by purchase of EACs in Hong Kong and Singapore is 29–38% above the price of grid electricity, suggesting this would be a significant additional revenue stream for renewable energy project owners (367, AirTrunk, 2023) *[Tier C].* Similarly, Granular Energy provided an example of the price of GOs in Italy (data from Mercato Elettrico) increasing dramatically between 2021–2022. Granular Energy argues that, as the price of EACs increase, their effectiveness in supporting the deployment of renewable energy increases as they become a meaningful revenue source as a proportion of

wholesale electricity costs (191, Granular Energy, 2023) *[Tier C]*. NREL found that in the U.S., REC prices increased from $1.50/MWh in December 2020 to $6.60/MWh in August 2021 (372, Sumner et al., NREL, 2023) *[Tier C]*.

  - Galzi's peer-reviewed paper also notes that the price of GOs in France has increased significantly since 2021, and so "revenues from GOs could become significant" (176, Galzi, 2023) *[Tier A].*

Although the voluntary purchase of EACs offer renewable energy asset owners an additional revenue stream, which could be used to directly finance new assets as well as securing additional investment, the low prices and poor market performance of voluntary EACs means that EACs have a limited ability to scale up climate finance. Recent increases in the price of voluntary EACs could mean that, in the future, revenues from voluntary EACs could become significant to renewable asset owners. However, the volatile nature of the market means it is unclear if these higher prices will be maintained.

Annex A

Table 2 below gives the evidence #, name, date, and title of evidence reviewed as relevant or partially relevant to electricity EACs. The table indicates "Y" where the evidence was relevant or partially relevant to each of the eight research questions.
Table 3 lists the pieces of evidence reviewed under electricity EACs that were not deemed relevant to any of the research questions, and so are not discussed above in the Evidence Review.

Table 2: Evidence reviewed as relevant to ELECTRICITY EACs

Evidence relevant to electricity EACs				Relevant/partially relevant to research question							
#	**Author**	**Date**	**Title**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**
001	3Degrees	2023	Proterra drives the transition toward clean transportation with market-based incentives	Y							Y
002	3Degrees	n.d.	First-ever Peace REC (P-REC) transaction drives renewable energy					Y			Y

			development in Africa								
003	3Degrees	2023	Renewable Markets Insight Report U.S. EDITION - 2024	Y							
009	ACORE	2023	ACORE Statement on the Value of Renewable Energy Certificates	Y				Y			Y
010	AFRY, Granular Energy and Nord Pool	2023	About time: How incorporating timestamped energy certificates into electricity markets could accelerate the	Y	Y	Y	Y	Y		Y	Y

			energy transition								
014	AirTrunk	2023	Powering a Clean Energy Future		Y	Y		Y			Y
016	Akamai Technologies and Sustainability Roundtable, Inc.	2023	SBTi Call for Evidence Submission	Y	Y	Y			Y	Y	Y
027	Australian Bureau of Statistics	2022	Value of renewable energy construction					Y			
028	Australian Capital Territory (ACT) Government	n.d.	Large-scale feed-in tariffs and reverse auctions	Y	Y						
029	Australian Energy Market Operator (AEMO)	2021	Victorian Annual Planning Report	Y							
030	Bachus and Lim	2023	Achieving Corporate Climate Commitments: Risks and	Y			Y		Y		Y

			Benefits of Using Virtual Power Purchase Agreements and Unbundled Renewable Energy Certificates								
031	Backstrom et al.	2023	Corporate Power Purchase Agreements and Renewable Energy Growth	Y	Y	Y	Y	Y	Y	Y	Y
034	Ballentine	2023	The unusual suspects: Are well-meaning environmental stakeholders and institutions undercutting the	Y	Y	Y	Y	Y	Y		Y

			contributions that companies can make to fighting climate change?								
035	Ballentine et al.	2022	Modernizing How Electricity Buyers Account and are Recognized for Decarbonization Impact and Climate Leadership	Y	Y	Y	Y	Y	Y		Y
036	Barbose	2021	U.S. Renewables Portfolio Standards 2021 Status Update: Early Release		Y					Y	
037	Barreto et al.	2018	A study of carbon	Y	Y	Y	Y	Y	Y	Y	Y

			offsets and RECs to meet Boston's mandate for carbon neutrality by 2050								
039	Bayer	2023	Press Release: Idaho Renewable Energy Agreement Underscores Bayer's Global Commitment to Sustainability and Rural Communities	Y			Y	Y	Y		Y
040	Benchimol et al.	2022	Frequently Asked Questions: Green Power Purchasing	Y	Y			Y			Y

			Claims and Greenhouse Gas Accounting								
043	Bjorn et al.	2022	Renewable energy certificates allow companies to overstate their emission reductions	Y	Y	Y	Y	Y	Y	Y	Y
044	Bjørn et al.	2022	Renewable energy certificates threaten the integrity of corporate science-based targets	Y	Y	Y	Y	Y	Y	Y	Y
047	BloombergNEF and Business Council for	2023	Sustainable Energy in America: 2023 Factbook				Y	Y			

	Sustainable Energy										
048	Böck	2023	How Iceland sold the same Green Electricity twice	Y	Y	Y	Y	Y	Y		
049	Böck	2023	Double Counting and other problems with Green Electricity Certificates		Y						Y
053	Brander	2022	The most important GHG accounting concept you may not have heard of: The attributional-consequential distinction						Y		
054	Brander and Bjørn	2023	Principles for				Y		Y		

			accurate GHG inventories and options for market-based accounting						
055	Brander and Bjørn	2022	Principles for accurate corporate GHG inventories and options for market-based accounting – Working Paper				Y		Y
056	Brander et al.	2018	Creative accounting: A critical perspective on the market-based method for	Y		Y	Y		Y

			reporting purchased electricity (scope 2) emissions								
057	Brander et al.	2015	Open Letter Rejecting the Use of Contractual Emission Factors in Reporting GHG Protocol Scope 2 Emissions	Y		Y	Y		Y		
060	Business Council for Sustainable Energy	2023	Submission to the Science Based Target Initiative in Response to the Call for Evidence on the Effectiven	Y	Y	Y	Y	Y	Y		Y

			ess of Environmental Attribute Certificates (EACs)								
061	C2ES	2023	SBTi Call for Evidence Submission	Y			Y	Y	Y		Y
064	California Air Resources Board	2023	Tier 1 Simplified CI Calculator Instruction Manual	Y	Y						
076	Center for Resource Solutions (CRS)	2022	2022 Green-e Verification Report	Y		Y					
077	Center for Resource Solutions (CRS)	2023	Readiness for hourly: U.S. renewable energy tracking systems		Y	Y					
078	Center for Resource	2017	Green-e Framework for		Y	Y			Y		

	Solutions (CRS)		Renewable Energy Certification								
079	Centrica	2023	SBTi Call for Evidence Submission	Y				Y			
083	Clean Energy Buyers Institute (CEBI)	2023	CEBI Scope 2 Proposal to the GHG Protocol	Y	Y	Y	Y	Y	Y	Y	Y
084	Clean Energy Buyers Institute (CEBI)	2023	Market-Based Accounting GHGP Proposal	Y	Y	Y	Y	Y	Y	Y	Y
085	Clean Energy Buyers Institute (CEBI)	n.d.	Principles for Purpose-Driven Energy Procurement					Y			
089	Clean Incentive	n.d.	Power Emissions Certificates: A New Registry to	Y	Y	Y	Y	Y	Y	Y	Y

090	Clean Incentive	n.d.	Maximize the Carbon Impact of Renewable Energy Power Emissions Certificates - Use Case Guide Version 1.2	Y	Y	Y	Y	Y	Y	Y	Y
092	Climate Active	2023	Electricity Accounting	Y	Y	Y	Y		Y		
097	COGEN Europe	2023	COGEN Europe Position Paper on GHG Accounting: Addressing Misconceptions in Claimed Zero Rating	Y			Y	Y		Y	Y
098	Commonwealth of Australia	2000	Renewable Energy (Electricit	Y	Y	Y		Y	Y		

			y) Act 2000								
099	Commonwealth of Australia	2023	Clean Energy Regulator Report 2023 Highlights	Y							
100	O'Shaughnessy et al.	2021	Corporate acceleration of the renewable energy transition and implications for electric grids	Y	Y	Y		Y			
101	Cox and Esterly	2016	Renewable Electricity Standards: Good Practices and Design Considerations					Y			
105	Dagoumas and Koltsaklis	2017	Price Signal of Tradable Guarantees of		Y	Y		Y			Y

			Origin for Hedging Risk of Renewable Energy Sources Investments								
108	Davis and Fountain	2021	The Relationship Between Voluntary and Compliance Renewable Energy Markets						Y		
110	Day et al.	2022	Corporate Climate Responsibility Monitor 2022	Y	Y	Y	Y	Y	Y		Y
117	DHL	2023	Evidence Submission on Renewable Electricity			Y			Y		
119	Dyson et al.	2021	Clean Power by the Hour -	Y	Y	Y	Y	Y			

			Assessing the Costs and Emissions Impacts of Hourly Carbon-Free Energy Procurement Strategies								
120	Ecohz	2023	A booming Guarantees of Origin market could drive record investments in renewable energy production in Europe								Y
122	Edison Electric Institute	2023	SBTi Survey Response	Y	Y			Y			Y

131	Energy and Environmental Economics, Inc and the American Council on Renewable Energy	2023	Analysis of Hourly and Annual GHG Emissions Accounting for Hydrogen Production	Y	Y			Y			
132	Energy Peace Partners (EPP)	2023	Peace REC Project Level Impact Tracking					Y			Y
133	Energy Peace Partners (EPP)	2023	Evidence submission: Peace RECs for Verifiable ESG Claims	Y			Y	Y			Y
136	Energy Track and Trace	2022	System Benefits of Granular Certification Version 1.0	Y	Y	Y	Y	Y			Y

137	EnergyTag	2021	EnergyTag and granular energy certificates: Accelerating the transition to 24/7 clean power	Y	Y	Y	Y	Y			Y
139	ENTSO-E	2022	Views on a Future-Proof Market Design for Guarantees of Origin	Y	Y	Y	Y	Y			Y
141	Environmental Markets Association	2023	Primer: REC Financing Mechanics for Renewable Energy Projects		Y	Y	Y				Y
143	Environmental Markets Association	2023	Voluntary RECs Protect Against Regulator								Y

			y Risk (page 67)								
144	Environmental Markets Association	2023	Unbundled 24-7 CFE Supply Agreement Google VA Data Centers Case Study (see pages 71 and 72)						Y		
145	Environmental Markets Association	2023	US Voluntary REC Pricing and Market Formation Events (see page 77)		Y	Y					Y
148	Energy Peace Partners (EPP)	2023	Peace REC Project Case Studies	Y		Y	Y	Y			Y
149	Equinix	2023	SBTi's Call for Evidence on the Effectiven	Y			Y				Y

			ess of the Use of Environmental Attribute Certificates in Corporate Climate Targets								
150	Equinix	2022	Sustainability Report FY2022	Y			Y				
155	European Union	2018	Directive 2018-2001 of the European Parliament and of the Council of 11 December 2018	Y	Y	Y		Y			
165	Evident EV Ltd.	2023	Registrant Survey Results								Y
166	Evident EV Ltd.	2023	Issuer Case Studies			Y	Y				Y
168	Evident EV Ltd.	2023	Participant Survey Results				Y				

169	Ferenczi	2023	Rethinking Additionality: Or how is buying clean energy like buying oat milk	Y	Y	Y	Y				Y
175	Gagnon et al.	2020	Behind-the-Meter Solar Accounting in Renewable Portfolio Standards	Y	Y	Y		Y			
176	Galzi	2023	Do green electricity consumers contribute to the increase in electricity generation capacity from renewabl	Y	Y	Y		Y			Y

			e energy sources - Evidence from France								
182	GHG Management Institute	2023	What is Greenhouse Gas Accounting - Fitting to Purposes	Y			Y				
183	GHG Protocol	2023	Scope 2 Guidance Webpage	Y		Y	Y		Y		Y
186	Gillenwater	2022	Examining the impact of GHG accounting principles				Y		Y		
191	Granular Energy	2023	Recent price increases in certificates	Y	Y		Y	Y			Y
193	Greene and Shaver	2022	Aggregated Renewables Purchasing: 5 Key Question								Y

			s, Answered								
194	GreenPower	2023	Our impact webpage								Y
197	Hamburger	2019	Is guarantee of origin really an effective energy policy tool in Europe - A critical approach	Y	Y	Y	Y	Y	Y		Y
198	Hamburger and Harangozo	2018	Factors Affecting the Evolution of Renewable Electricity Generating Capacities: A Panel Data Analysis of European Countries	Y				Y			Y

201	Heeter et al.	2021	Status and Trends in the Voluntary Market (2020 Data)	Y	Y	Y					
203	Herbes et al.	2020	Are voluntary markets effective in replacing state-led support for the expansion of renewables – A comparative analysis of voluntary green electricity markets in the UK, Germany, France and Italy	Y	Y	Y		Y			
204	Hove and Xie	2023	Green certificate	Y	Y	Y		Y			Y

			s with Chinese characteristics: Will green certificates help China’s clean energy transition								
205	He et al.	2023	Paths to Carbon Neutrality: A Comparison of Strategies for Tackling Corporate Scope II Carbon Emissions	Y	Y	Y	Y	Y	Y	Y	Y
206	Hulshof et al.	2019	Performance of markets for European renewable energy certificates	Y	Y	Y					Y

207	He and Huntington	2023	US corporate procurement will drive renewable development through the decade	Y							
209	I-REC Standard Foundation	2023	I-REC Standard Foundation Scope 2 Proposal to the GHG Protocol	Y	Y	Y	Y	Y	Y	Y	Y
211	Intergovernmental Panel on Climate Change (IPCC)	2006	Guidelines for National Greenhouse Gas Inventories, Chapter 2: Approaches to data collection				Y				
221	International	2022	Advancing	Y	Y	Y	Y	Y	Y	Y	Y

	Energy Agency		Decarbonisation Through Clean Electricity Procurement								
222	International Energy Agency	2022	Methodology to assess the system value of different corporate procurement strategies in developing economies	Y	Y	Y	Y	Y	Y	Y	Y
228	Jena	2023	Status and Trends in the Voluntary Market (2022 Data)					Y			
232	Jones et al.	2023	The Legal Basis for Renewab	Y		Y					

			le Energy Certificates								
234	Kansal	2018	Introduction to the virtual power purchase agreement	Y		Y		Y	Y		Y
235	Kelly and Gonzalez	2023	The Role of Hourly EAC Markets in Facilitating the Clean Energy Transition _ Identifying the Value Potential of Future-Proofed Market Design	Y	Y	Y	Y	Y	Y	Y	Y
236	Kobus et al.	2021	The Role of Corporate Renewab	Y			Y	Y	Y	Y	Y

			le Power Purchase Agreements in Supporting US Wind and Solar Deployment								
237	Konet et al.	2023	Charging towards zero: Harnessing batteries and carbon contracts to accelerate grid decarbonization	Y	Y			Y			Y
241	Langer et al.	2023	Does the purchase of voluntary renewable energy certificates lead to emission reductions? A	Y	Y	Y	Y	Y	Y	Y	Y

			review of studies quantifying the impact							
243	Lee et al.	2022	Optimal sourcing strategy for enterprises to achieve 100% renewable energy					Y		
246	LevelTen Energy	2023	Renewable Energy Developer Survey	Y						
248	LevelTen Energy	2020	4 Ways to Get Renewable Energy Certificates: Pros and Cons of Each	Y	Y	Y	Y	Y		Y
249	LevelTen Energy	2019	10 Steps to Secure a Virtual Power Purchase Agreement	Y			Y	Y		

250	Lindberg et al.	2023	Unleashing the market: An estimation of Guarantees of Origin potential					Y		Y	Y
256	McDonald’s	2023	SBTi Call for Evidence Submission	Y	Y	Y	Y	Y	Y	Y	Y
259	Miller et al.	2022	The Next Generation Carbon-Free Electricity Procurement Activation Guide	Y	Y	Y	Y	Y	Y		
263	Mulder and Zomer	2016	Contribution of green labels in electricity retail markets to fostering	Y	Y	Y		Y		Y	Y

			renewable energy								
266	National Renewable Energy Laboratory and Lawrence Berkeley National Laboratory	2016	A Retrospective Analysis of the Benefits and Impacts of U.S. Renewable Portfolio Standards	Y	Y						
268	NewClimate Institute and Carbon Market Watch	2023	Corporate Climate Responsibility Monitor 2023	Y	Y		Y	Y	Y		Y
271	Nordenstam et al.	2018	Corporate greenhouse gas inventories, guarantees of origin and combined heat and power	Y	Y	Y	Y	Y	Y		

			production - Analysis of impacts on total carbon dioxide emissions								
272	O'Shaughnessy	2023	Preview of Research Conducted by Clean Kilowatts, LLC	Y				Y		Y	
273	Oates	n.d.	Making It Count: Updating Scope 2 accounting to drive the next phase of decarbonization	Y	Y	Y	Y	Y	Y		
280	Ørsted	2019	Cleaning up the future		Y	Y	Y				Y
281	Ørsted	n.d.	Covestro partners with Ørsted to		Y	Y	Y				Y

			power its ambitious green strategy								
282	OVO Energy	2023	Insight paper: REGOs and Decarbonisation								Y
285	Perez et al.	2016	The Economic Effects of Interregional Trading of Renewable Energy Certificates in the U.S.	Y	Y			Y			
296	RE-Source	2023	WECC Case Studies					Y			
297	RE-Source	2021	Guarantees of Origin and Corporate Procurement Options	Y	Y	Y	Y	Y	Y	Y	Y

298	RE100	2022	Technical Criteria Version 4.1			Y					
299	RE100	2023	Driving renewables in a time of change		Y						
300	RECS Energy Certificate Association	2023	Debate over Scope 2 emissions accounting	Y	Y	Y	Y	Y	Y		Y
301	RECS Energy Certificate Association	n.d.	GHG Protocol Scope 2 guidance review		Y	Y	Y		Y		Y
302	RECS Energy Certificate Association	2022	An Introduction to RECS and the renewable energy markets we support			Y					
303	RECS Energy Certificat	2021	How time-stamping	Y	Y	Y		Y			

	e Association		works in EAC markets								
304	RECS International	n.d.	Guarantee of Origin plays significant role in 700-MW subsidy-free offshore wind project (interview)								Y
305	RECS International	2022	Full disclosure in the Netherlands	Y	Y	Y					Y
306	Reed et al.	2023	Environmental Attribute Credits - Analysis of Program Design Features and Impacts	Y	Y	Y	Y	Y		Y	Y
309	REI Co-op	2023	REI Co-op					Y			

			celebrates 10-year anniversary of 100% renewable power	
310	REI Co-op	2023	REI formalizes science-based climate targets; expands local and international climate leadership	Y
311	REI Co-op	2023	REI Co-op opens state-of-the-art distribution center	Y
312	REI Co-op	2020	REI Co-op achieves 14-year carbon neutrality commitm	Y

			ent, announces ambitious new climate platform								
315	Ricks et al.	2023	Minimizing emissions from grid-based hydrogen production in the United States	Y	Y	Y	Y	Y	Y	Y	Y
316	Riepin and Brown	2022	System-level impacts of 24/7 carbon-free electricity procurement in Europe	Y	Y	Y	Y	Y	Y	Y	
318	Rocky Mountain Institute	2023	RMI Horizon Zero Aluminum Working Group	Y	Y	Y		Y	Y		

			Session 4 notes and feedback								
319	Rocky Mountain Institute	2022	Scaling Clean: Assessing Market Options for Clean Energy and Capacity in PJM	Y	Y	Y	Y	Y	Y	Y	Y
330	Ruhnau and Schiele	2023	Flexible green hydrogen: The effect of relaxing simultaneity requirements on project design, economics, and power sector emissions	Y	Y	Y	Y	Y	Y	Y	Y
334	Schneider Electric	2023	Elevating Industry Standards:	Y	Y	Y	Y	Y	Y	Y	Y

337	Seebach	2015	Schneider Electric's Contribution to the SBTi's Dialogue on EAC Effectiveness in the Clean Energy Transition Electricity Disclosure and Carbon Footprinting: Effects and incentives resulting from different approaches to account for electricity consumption in carbon footprints	Y	Y	Y	Y	Y	Y	Y	Y

338	Seebach and Timpe	2016	Herausforderungen bei der Anrechnung von erneuerbarem Strombezug in Klimabilanzen	Y	Y			Y			
350	Sol Systems	2022	Reimagining REC Markets: Integrating Additionality and Emissionality into a New Carbon-Free Paradigm	Y	Y	Y	Y	Y	Y		Y
351	Solar Stewards	2023	Baltimore Case Study					Y	Y		
352	Sotos	2015	GHG Protocol Scope 2 Guidance	Y	Y	Y					
355	State of California	2023	California Senate Bill No. 253,				Y				

356	State of Washington	2023	Chapter 382 Chapter 19.405 RCW - Washington Clean Energy Transformation Act	Y		Y					
358	STX Group	2023	Effectiveness of the use of Environment Attributes Certificates in corporate climate targets		Y	Y	Y				Y
360	STX Group	n.d.	An analysis of EU Guarantees of Origin (GOs) domestic auctions	Y	Y	Y	Y				Y
361	STX Group	n.d.	Debate over Scope 2 emission	Y	Y	Y					Y

			s accounting - RECS guidance for members								
363	STX Group	n.d.	Barriers to PPA			Y					Y
364	STX Group	n.d.	GHG Protocol Scope 2 guidance review – RECS' general position	Y	Y	Y	Y	Y		Y	Y
367	Submitted by AirTrunk	n.d.	EAC premium for Singapore and Hong Kong								Y
369	Submitted by the European Biogas Association	n.d.	Energy attribute certificates for electricity	Y	Y	Y	Y	Y			
372	Sumner et al.	2023	Status and Trends in the U.S. Voluntary Green	Y	Y	Y		Y	Y		Y

			Power Market (2021 Data)			
378	Texier	2021	A timely new approach to certifying clean energy			Y
385	The International REC Standard	2023	How the EU's Carbon Border Adjustment Mechanism (CBAM) supports actual emissions reporting through PPAs and Energy Attribute Certificates (EACs)			Y
387	The White House	2022	Implementing Instructio	Y	Y	Y

	Council on Environmental Quality		ns for Executive Order 14057: Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability			
390	Tomago Aluminium	2022	Industry Briefing Session	Y		
398	U.K. Chamber of Shipping	2023	SBTi Call for Evidence Submission		Y	Y
399	U.S. Energy Information Administration	2022	U.S. Energy-Related Carbon Dioxide Emissions, 2021	Y		
401	UK Department for Business, Energy and	2021	Designing a Framework for Transparency of Carbon		Y	Y

	Industrial Strategy		Content in Energy Products: A call for evidence					
404	UK Green Building Council	2023	Renewable Energy Procurement. Summary Report	Y	Y	Y	Y	Y
409	United States Department of Energy - Lawrence Berkeley National Laboratory	2023	U.S. State Renewables Portfolio and Clean Electricity Standards- 2023 Status Update				Y	
412	United States Environmental Protection Agency	2022	Renewable Electricity Procurement on Behalf of Others: A Corporate Reporting Guide	Y		Y	Y	

414	United States Environmental Protection Agency	2021	Clean Energy Finance: Using Renewable Energy Certificates to Achieve Local Environmental Goals	Y		Y	Y				
416	United States Environmental Protection Agency Green Power Partnership (GPP)	n.d.	Introduction to Virtual Power Purchase Agreements	Y	Y	Y	Y	Y			Y
417	United States Environmental Protection Agency Green Power Partnership (GPP)	2023	Financial PPA	Y	Y	Y	Y				
418	United States	2012	Guides for the						Y		

	Federal Trade Commission		Use of Environmental Marketing Claims								
425	WattCarbon	n.d.	How EACs will promote scale up of low-carbon technologies					Y			Y
427	WattCarbon	n.d.	Measurable Electrification Carbon Reductions	Y							
432	Wilson and Lenoir	2022	US renewable energy credit market size to double to $26 billion by 2030	Y	Y	Y	Y	Y	Y	Y	Y
433	World Business Council for	2023	Report on WBCSD Member Survey			Y		Y			Y

		Sustainable Development (WBCSD)		and Focus Groups In Response to SBTI's Call for Evidence		
436		Xu and Jenkins	2022	Electricity System and Market Impacts of Time-based Attribute Trading and 24/7 Carbon-free Electricity Procurement		Y
	438	Xu et al.	2023	Working Paper: System-level Impacts of Voluntary Carbon-free Electricity Procurem	Y	Y

			ent Strategies								
439	3Degrees	2023	Renewable Markets Insight Report U.S. EDITION -2023	Y				Y			
142d	EMA	2023	The Importance of Market-Based Accounting and Tradable Environmental Instruments for the Achievement of Scope 1, 2, and 3 Emission Reductions				Y		Y		Y
167b	Department of Energy (UAE)	n.d.	Regulatory Policy for Clean Energy	Y		Y					

			Certificates								
167c	Li et al.	2022	Accelerating the adoption of renewable energy certificate: Insights from a survey of corporate renewable procurement in Singapore	Y		Y		Y			
167d	US EPA	n.d.	Credible claims						Y		
167e	RECs	n.d.	Interview: GO important factor in subsidy free tender Nuon								Y
167f	Eneco	n.d.	Offshore wind farms accelerate the								Y

			energy transition								
167j	AIB	n.d.	Auctions of GOs by AIB members								Y
167l	McKinsey & Company	2022	Decarbonizing the grid with 24/7 clean power purchase agreements			Y					
182a	GHG Management Institute	2024	What is GHG Accounting? Market-based mistake	Y			Y				
359a	US EPA	n.d.	Accomplishments of the Landfill Methane Outreach Program	Y							

Table 3: Evidence reviewed as not relevant to ELECTRICITY EACs

#	Author	Date	Title	Rationale for exclusion
024	Argus Media, Cornwall Insight, Greenfact, S&P Global	2022	Price Reports of Biomethane EACs	Not relevant to research questions.
042	Berkeley Carbon Trading Project	n.d.	Repository of Articles on Offset Quality	Does not discuss electricity EACs.
045	Bleu Equipage Communication	n.d.	QUELS ENGAGEMENTS POUR ÊTRE LABÉLISÉ VertVolt	Not relevant to research questions.
058	BRC-Canada	2023	Deal Tracker - Q3 2023 Corporate Renewable Energy Deals in Canada	Not relevant to research questions.
067	California Air Resources Board	2022	2022 Scoping Plan for Achieving Carbon Neutrality	Does not discuss electricity EACs.
073	Carbon Market Watch	2021	Two shades of green: How hot air forest credits are being used to avoid carbon taxes in Colombia	Does not discuss electricity EACs.
081	Clancy	2023	Apple, Nike and others push Asian suppliers to buy clean energy	Not relevant to research questions.
082	Clean Energy Buyers Association	2023	Deal Tracker 2016 through Q2 2023	Not relevant to research questions.
086	Clean Energy Finance Corporation	2022	Woolworths leads with global first	Does not discuss electricity EACs.

087	Clean Energy Finance Corporation, Property Council of Australia, and Seed Advisory	2019	Distributed energy in the property sector: Unlocking the potential	Does not discuss electricity EACs.
093	Climate Council of Australia Ltd.	2016	Territory Trailblazer: How the ACT became the renewable capital of Australia	Not relevant to research questions.
104	D-REC Organization	2023	Cumulative Impact Assessment of D-REC Transactions to Date	Not relevant to research questions.
121	Ecosystem Marketplace	2023	Press Release - New research: Carbon credits are associated with businesses decarbonizing faster	Does not discuss electricity EACs.
125	EKOenergy	2023	Concrete Impact Made Thanks to EKOenergy Users 2013-2023	Does not discuss electricity EACs.
127	Energetics	2023	Corporate Renewable PPA Deal Tracker	Not relevant to research questions.
134	Energy Peace Partners (EPP)	2022	Energy Access, Renewable Energy and Social Impact - A Literature Review	Not relevant to research questions.
135	Energy Peace Partners (EPP)	2023	Renewable energy and peace: Empirical analysis of global data, Peace Impact Working Paper 1	Not relevant to research questions.

233	Kane et al.	2022	Biochar as a Renewable Substitute for Carbon Black in Lithium-Ion Battery Electrodes. Supporting Information	Does not discuss electricity EACs.
247	LevelTen Energy	2022	Despite Headwinds, Clean Energy Buyers, Developers, and Financiers are Closing 2022 with a Gust of Momentum	Not relevant to research questions.
254	Marks and Rasel	2014	Financing Wind Projects With Synthetic PPAs	Not relevant to research questions.
293	Ramboll	2023	Literature review – “On track” Indicator development study	Does not discuss electricity EACs.
294	Rathnayake et al.	2023	Biochar from animal manure: A critical assessment on technical feasibility, economic viability, and ecological impact	Does not discuss electricity EACs.
348	Sol Systems	2023	Reimagining REC Markets: Integrating Additionality and Emissionality into a New Carbon-Free Paradigm	Individual pieces of evidence reviewed separately.

349	Sol Systems and District of Columbia Department of General Services (DGS)	2017	D.C. department of general services develops solar project using a power purchase agreement	Not relevant to research questions.
377	Sylvera	2023	Carbon Credits: Permission to Pollute, or Pivotal for Progress	Does not discuss electricity EACs.
394	Trouwloon et al.	2023	Understanding the Use of Carbon Credits by Companies: A Review of the Defining Elements of Corporate Climate Claims	Does not discuss electricity EACs.
406	UN High-Level Expert Group on the Net-Zero Emissions Commitments of Non-State Entities (HLEG)	2022	Integrity Matters: Net Zero Commitments by Businesses, Financial Institutions, Cities and Regions	Does not discuss electricity EACs.
415	United States Environmental Protection Agency	2023	Emissions and Generation Resource Integrated Database (eGRID)	Not relevant to research questions.
423	Walmart	2022	Gigaton PPA: Walmart, Ørsted and Schneider Electric Announce First Cohort for Renewable Energy Supply Chain Program	Not relevant to research questions.
424	WattCarbon	2023	The value of Environmental Attribute Certificates in accelerating	Not relevant to research questions.

			decarbonization in market based procurement	
426	WattCarbon	2023	Sample of EAC records in WattCarbon marketplace	Not relevant to research questions.
429	Wesfarmers	2021	Wesfarmers issues inaugural sustainability-linked bonds	Not relevant to research questions.
167g	Tenaga Nasional	n.d.	Green Electricity Tariff	Not relevant to research questions.
167i	Pan et al.	2023	Green finance policy coupling effect of fossil energy use rights trading and renewable energy certificates trading on low carbon economy: Taking China as an example	Does not discuss electricity EACs.
167k	Nasirov et al.	2018	Renewable energy transition: a market-driven solution for the energy and environmental concerns in Chile	Does not discuss electricity EACs.