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From the physics and traceability to the market: what is at stake in the past and current debates about the guarantees of origin for renewable electricity

Louis Malissard[1,*], Ivan Debay[2,3,⁑], Vincent Bertrand[4,5,‡], Etienne Durand[6,7,‡], Helena Martinez[8,±]

- Guarantees of Origin (GOs) have enabled contractual traceability of electricity in Europe, giving rise to "green offers" from suppliers, supporting renewable consumption for households, and structuring new decarbonization strategies for companies.
- The GO market is characterized by historically low prices, reflecting a structural oversupply driven by the lack of harmonization of matching rules between countries.
- The EU's objective of creating a revenue stream for the energy transition has not been achieved. The impact of GO consumption on the development of new renewable capacities remains limited despite the rise of voluntary demand.
- Moreover, the traceability tool remains a subject of debate. We highlight the contrast between "market-based" and "location-based" accounting involving methodological gaps that weaken the credibility and comparability of decarbonization efforts across countries.
- We discuss potential reforms to address current shortcomings. On the supply side, the main options from the literature rely on eligibility restrictions (*e.g.* reserving GOs for new capacities or excluding already subsidized volumes) and harmonization of matching rules. On the demand side, we explore instruments such as Full Consumption Disclosure, and we propose original solutions that are based on the introduction of labels (with a minimum number of labelized GOs in the overall volumes of sales), and the use of reputational mechanisms, which could increase transparency and support a stronger valuation of GOs.

KEYWORDS:

GUARANTEES OF ORIGIN # ENERGY ATTRIBUTE CERTIFICATES # RENEWABLE ENERGY # GRANULARITY # FULL-DISCLOSURE # LABELING # REFORMS

[1] Intern research fellow, Réseau EDEN.i, REEL.i Chair, Climate Economics Chair

[2] CEO and founder of Origo

[3] President of QuiEstVert

[4] Associate professor (HDR) in energy economics, Université Marie et Louis Pasteur

[5] Founder of Réseau EDEN.i and REEL.i chair

[6] Associate professor in law, University of Essex

[7] Research program director at Réseau EDEN.i

[8] Director of QuiEstVert

* louismalissard@gmail.com / ⁑ ivan@quiestvert.fr / ‡ vincent.bertrand@umlp.fr / ‡ etienne.durand@essex.ac.uk / ± helena@quiestvert.fr

Introduction

Small and large energy consumers are increasingly attentive to the origin of the electricity they consume and the associated “Scope 2” carbon emissions. This results in a rising interest in Guarantees of Origin (GOs), which are used to certify renewable electricity through direct use by the consumer, Power Purchase Agreements (PPAs) or green offers from electricity suppliers. GOs have enabled consumers to claim low-carbon electricity while allowing renewable electricity producers to benefit from additional revenues through the market system. As reflected in European directives, GOs are thus associated, on one hand, with the primary objective of ensuring contractual transparency in the source of electricity, and, on the other, with the indirect ambition of supporting renewable energy financing. Furthermore, if the GO prices are sufficiently high, the mechanism may become a driver for investment in new renewable generation capacity and maintenance of existing one. However, the use of GOs also raises questions about their actual effectiveness in achieving such objectives. Regarding traceability (the simplifying term we will use to describe contractual source-tracking), GOs suffer from a disconnect between physical reality and its implications on carbon accounting that underpins their consumption. Companies, institutions, and even governments remain divided on whether to accept the “market-based” methodology that recognizes decarbonized electricity from certificates, as it departs from the physical reality of the grid and is often perceived as misleading in terms of impact and environmental goals. Another controversy involves the financial aspect of GOs, especially their lack of additionality. The GO market is often criticized for its limited effect on creating new renewable investments and, as a result, its weak role in the energy transition and climate change mitigation. Most GO transactions are based on existing, depreciated generation capacity and have historically traded at prices below 1€/MWh. In these cases, GO trading simply shifts the claim to zero-carbon renewable electricity from the seller to the buyer, without prompting any new investment that would replace emitting power sources. For this reason, GOs are frequently viewed as a tool for greenwashing, allowing consumers to claim questionable and low-cost decarbonization. Nevertheless, this criticism may also overlook their potential to generate additional market revenue and the opportunities to implement measures that could significantly enhance their effectiveness.

Historically, the GO system is legally defined as a mechanism dedicated solely to demonstrating the renewable origin of electricity. Promoting additionality became an objective in a second phase, using the market as a tool for the energy transition. Then, GOs are, in practice, a neutral tool that can lead to no, limited, or substantial additionality, depending entirely on how they are designed and implemented. While they have ensured traceability, they have not had a significant impact on investment so far; these two facts are often treated separately, yet they are interdependent. When assessing the overall quality of the GO system, several elements must be taken into consideration, both technical and political in nature. This article will delve into these considerations; however, it is also crucial to understand the intertwined relationships between them. For example, issues such as additionality and traceability are by definition sensitive to the surrounding legal and technical context of the GO market itself. Harmonizing regulations, reducing temporal granularity, and implementing reforms to prevent double-counting would strengthen traceability, inevitably shape the prospects for additionality, and vice versa. At their core, the debates on traceability and additionality converge in a single failing point: the certificate trading market, where structural oversupply and weak price signals compromise the integrity of the system. Addressing the shortcomings of GOs, therefore, means clarifying the role we want to assign to them as a disclosure tool, as a financing mechanism, or both, since their market value ultimately reflects this dual function.

This note aims to provide an overview of how GOs work and what are the origins of this mechanism as a tool to ensure proof and traceability of renewable electricity. We explain the fundamentals of the GO market and review the main past and current events that have been observed on it. We discuss why GOs have so far failed to deliver sufficient impact on the energy transition, we summarize the key issues in the debate on strengthening their role, and we suggest several ways to enhance the mechanism's effectiveness in offering a valuable contribution to the energy transition.

1 The basics of GOs: from physics and traceability to the market

1.1 What is the link between physical realities and legal instruments?

Energy travels through the electrical network at a speed close to that of light, about 200,000 km/s in copper. Its movement is therefore almost instantaneous, and the electricity used at any point in the grid cannot be distinguished by where it came from or how it was generated. Once injected, electric energy flows are fungible, and it is technically impossible to trace a specific unit of consumption back to a particular unit of production.

In practice, what is delivered to the user is not a discrete unit of energy from a recognizable plant, but the outcome of a collective system where injections and withdrawals must remain continuously balanced. This balance is a physical necessity: if generation and demand diverge, even for a short moment, the stability of the grid is compromised. At the same time, the fungibility of flows prevents consumers from knowing the exact source of their electricity.

To address these two fundamental limitations, European law has introduced complementary legal instruments that make up for what physics cannot reveal to market actors. Balance responsibility, the principle that structures the power market, ensures that injections and withdrawals stay synchronized in time and location, protecting the system's stability. Meanwhile, the Guarantee of Origin confirms the renewable nature of production, enabling consumers to establish a verifiable link to specific generation sources.

1.2 The Guarantee of Origin

The Guarantee of Origin is the unique European instrument for certifying the renewable origin of electricity. According to Directive (EU) 2018/2001, it has the *"sole function of showing to a final customer that a given share or quantity of energy was produced from renewable sources"*. Primarily designed to address information asymmetry in electricity markets, the GO provides a standardized and verifiable proof of origin, allowing consumers to identify an energy source in a system where physical flows are indistinguishable.[1] It thus constitutes the only legal basis for disclosure, enabling suppliers to market "100% renewable" contracts or energy attribution on PPA contracts. Operationally, one GO corresponds to one megawatt-hour (MWh) of renewable electricity. Certificates are issued by a national authority at the producer's request, can be transferred between market participants, and are ultimately canceled by final consumers. The scheme is entirely voluntary, as producers request certificates only if they consider it worthwhile, and buyers can cancel them if they want to claim renewable use.

[1] GO has evolved to allow for non-renewables energy to be trace according to domestic policies of each country (see Full Consumption Disclosure in Austria).

Over time, European instances have recognized the market's potential to create additional revenue for producers through consumer market valuation. Thus, the aforementioned directive states that GOs should *"allow the consumer market for renewable electricity to contribute to the development of energy from renewable sources"* (Directive (EU) 2018/2001.

Alongside GOs, the European market relies on balance responsibility, a convention designed to ensure that electricity injections and withdrawals are matched in time within a specific perimeter. Unlike GOs, it does not provide any information about the source of electricity. The two mechanisms are therefore complementary but serve different purposes: balance responsibility contributes to maintain the physical balance of the system without regard to the type of generation, while GOs certify how the electricity was generated in the first place. Since this paper mainly discusses the attribution and trading of certificates attributed to renewable production, the following sections focus exclusively on GOs.

2 Fundamentals and price formation in the GO market

2.1 Fundamentals in traceability

The willingness to trace electricity emerged in the European landscape in the late 1990's, driven by the liberalization of the electricity market and the increasing importance of climate and energy security goals, especially since the 1997 White Paper and Directive 2001/77/EC (Nilsson *et al.*, 2009; Lise *et al.*, 2007). The pursuit of transparency through GOs has allowed the purchase of certificates to match consumption with an equivalent amount of renewable electricity generation and, in turn, to claim the decarbonized nature of one's electricity use.

GOs have thus become the sole legally recognized instrument for demonstrating decarbonization efforts related to electricity use. The clearest example of this is the recognition of GOs within the Scope 2 accounting[2] framework of the Greenhouse Gas Protocol. For instance, if a company cancels a volume of GOs equal to its electricity consumption, it can report zero indirect Scope 2 emissions. However, this number must be understood in context: it only reflects the carbon footprint, related to the legal instruments of decarbonization, which differs from the physical reality of the company's actual environmental impact (Langer *et al.*, 2024; Bjørn *c*, 2022). From a physical standpoint, electricity remains carbon-intensive according to the actual generation mix, regardless of whether GOs are held by the actors consuming it. To conclude, the introduction of GOs and other contractual instruments has led to the division of carbon accounting into two methods: market- and location-based, thereby creating multiple challenges within Europe itself.

Building on the aforementioned foundation of a new accounting system, GOs have increasingly become integrated into regulatory and corporate practices to the point of becoming a cornerstone of corporate climate strategies. The prospect of decarbonizing business activities by canceling certificates is a major factor driving demand for GO. Private initiatives such as RE100 and the Science Based Targets initiative (SBTi) have further consolidated this position. Nevertheless, much of the decarbonization progress displayed by companies rests on certificate purchases, indicating that GOs mainly serve as tools for disclosure and reputation disconnected from physical decarbonization (Egli *et al.*, 2023). Simultaneously, the mechanism has been incorporated into the EU's broader sustainability governance framework,

[2] The Scope 2 Guidance standardizes how corporations measure emissions from purchased or acquired electricity, steam, heat and cooling (GHG Protocol Scope 2 Guidance, https://ghgprotocol.org/scope-2-guidance)

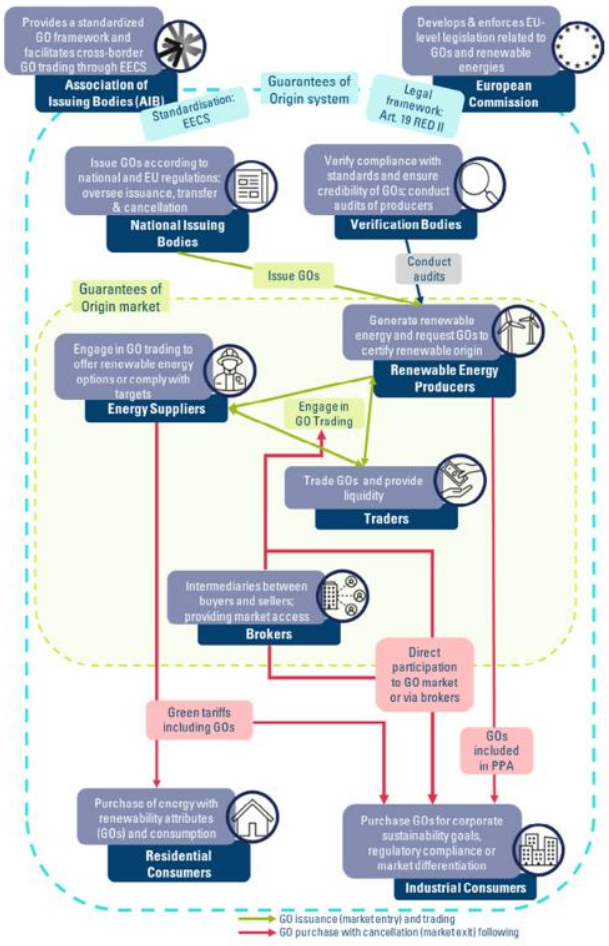
especially through the Corporate Sustainability Reporting Directive (CSRD) and the Sustainable Finance Taxonomy, where canceling GOs can facilitate access to green finance and better lending conditions (European Commission, 2025).

The GO, therefore, carries dual significance in both supporting environmental claims through Scope 2 decarbonization and involving indirect financial interests by influencing corporate reputation, access to green finance, and competitive positioning. In this context, examining the GO market becomes essential: is the mechanism widely adopted? Does it meet the decarbonization expectations inherent in Scope 2 reporting? Given that the sole function of GOs is to certify contractual origin, can their market use still generate incentives consistent with expanding renewable capacity?

2.2 Market for Renewable Certificates

The GO market rests on a clear architecture. Producers of renewable electricity request the issuance of certificates for each MWh generated. These certificates then circulate through intermediaries (suppliers, specialized platforms, or brokers) before being cancelled on behalf of final consumers, mainly companies. In most cases, electricity suppliers execute cancellations for their clients, although large corporate consumers may also cancel certificates directly via national registries. Transactions are conducted predominantly over-the-counter (OTC), with a smaller share taking place through auctions.

Figure 1: Structure scheme of the GO market (source: European Commission, 2025)

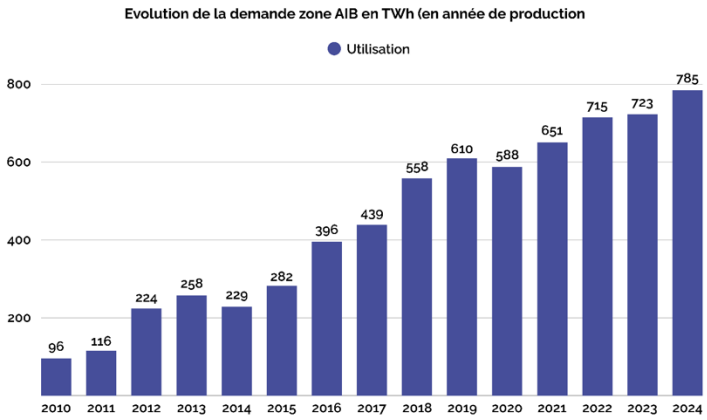


On the supply side, certificate issuance across the AIB zone – which covers most EU countries (with the notable exception of Poland) and includes Norway, Iceland, and Switzerland – is dominated by hydropower, wind, and solar. In 2024, hydropower still accounted for nearly 52% of issued volumes, reflecting the weight of old and depreciated assets, while wind represented around 29%, solar around 12%, and biomass less than 6% (AIB, 2025). Hydropower remains the backbone of the system, but the expansion of wind and solar mainly drives the growth in volumes. This composition reflects the historical structure of Europe's renewable fleet. Also, as the electric generation is renewable, natural variability drives supply, causing seasonal and intra-annual fluctuations in certificate issuance.

More broadly, the supply is constrained by national policies on double-counting, such as the *Doppelvermarktungsverbot* in Germany, where electricity already subsidized cannot claim GO revenue, or French policies that split issuance between OTC and the auction system.

The demand side has expanded rapidly, mainly fueled by companies that integrate certificates into their compliance and reputational strategies. Cancellations have multiplied in recent years, from 96 TWh in 2010 to 785 TWh in 2024 within the AIB hub.

Figure 2: Demand level per year of production (source AIB Market Statistics)



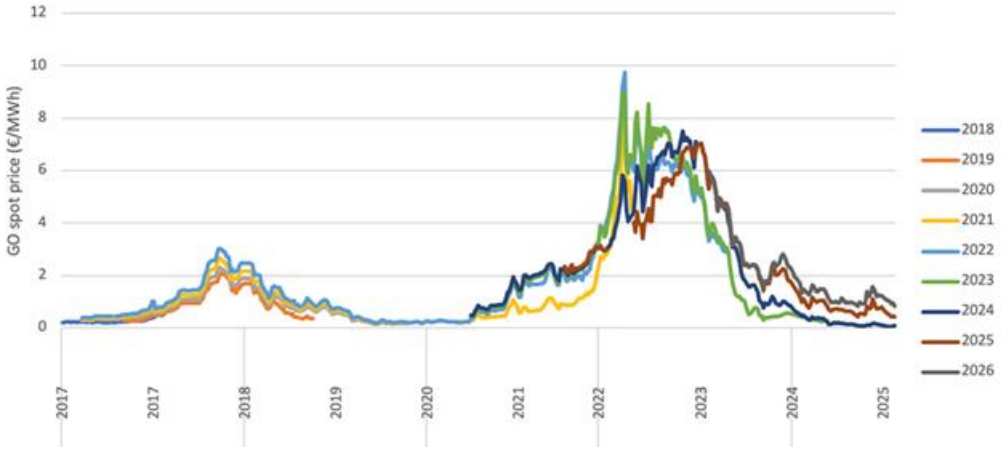
Overall, the average voluntary consumption of green electricity in Europe has risen steadily in recent years, reaching 32.6% of the total green electricity production in 2024. This magnitude shows that the GO system is no longer a market of minor importance but has become a systemic component of European energy governance. Yet its growing scale raises a critical question: does today's price signal match the societal importance of the mechanism, and is the revenue generated sufficient to significantly drive the development of new renewable capacity in Europe?

3 Past and recent developments in the GO market

Since their creation, GOs have been characterized by low prices. Historical data show that, apart from the 2018 and 2022-2023 episodes, the average price of tradable renewable certificates in Europe has hovered around a few tens of euro cents per MWh. This stagnation is the direct result of a structural excess of supply relative to demand. The market was initially

shaped by an existing supply that had to be progressively matched with voluntary demand. As long as the market remains long, the market price stagnates at a low level since the marginal cost of issuing a GO is almost null.

Figure 3: Historic daily GO spot price (source: AIB statistics)

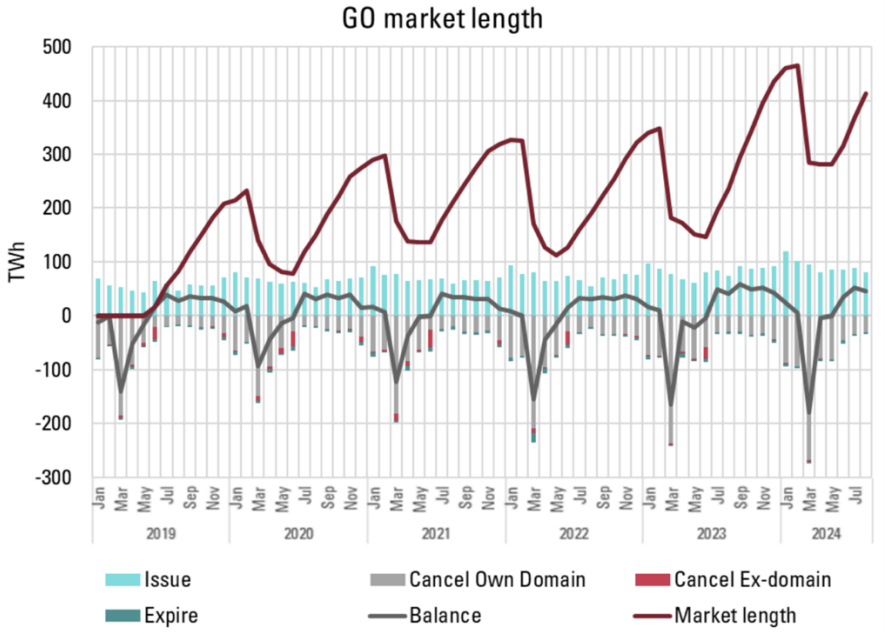


3.1 Oversupply, matching rules, and surplus

The main reason for the persistent weakness of prices on the GO market is not insufficient demand but rather matching and expiration policies. In many AIB countries, such as Belgium, Italy, the Netherlands, Portugal, and Scandinavian states, certificates can be used beyond the calendar year in which they were issued. At the EU level, article 19 of the Renewable Energy Directive (RED) states that "guarantees of origin shall be valid for transactions for 12 months after the production of the relevant energy unit.[3] Member States shall ensure that all guarantees of origin that have not been cancelled expire at the latest 18 months after the production of the energy unit". There is no obligation for a strict yearly calendar match between production and consumption periods. Since the annual supply of certificates has always exceeded demand, this results in a structural accumulating surplus of GOs in the market. Even when some countries implement stricter rules (such as France, which enforces a monthly step), these measures face the risk of dumping by consumers due to non-harmonized regulations across Europe.

[3] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023L2413&qid=1699364355105 amending https://eur-lex.europa.eu/eli/dir/2018/2001/oj/eng

Figure 4: Evolution of tradable renewable GOs within the AIB hub (length) (source: European Commission)



In addition to this structural imbalance, the very nature of supply adds complexity. Most certificates originate from historical hydropower facilities, mainly in Norway, whose very low marginal costs lead to the generation of large volumes of GOs that flood the market and keep price levels low (Paris *et al.*, 2024). More generally, the inherent variability of renewable technologies also conditions the price dynamics. Hydrological shocks, seasonal variations, or other production cycles can temporarily affect the availability of certificates. Still, these effects are always mitigated by residual GO stocks, which enable actors to smooth their procurement. The only recent significant exception remains the hydrological crisis of 2022–2023, when drought in Scandinavia reduced hydro production and caused an unprecedented price peak above €8/MWh, followed by maintenance of high prices over a year before the market returns to its structural length.

Ultimately, the GO prices do not reflect consumers' willingness to pay or the cost of new renewable capacity. Instead, they mainly indicate a structurally oversupplied market, driven by permissive matching rules and dominated by low-marginal-cost renewable assets, where demand, although increasing, is consistently overshadowed by supply (Wimmers and Madlener, 2023; Holzapfel *et al.*, 2024). In fact, several long-lasting high prices at EU level, in 2018 and 2022/23, and at national level in the Netherlands, Switzerland, the UK or Austria, show that this willingness to pay might be quite significant. However, despite low prices, the main objectives of GOs remain traceability and the development of renewable energies in Europe. We therefore need to examine more specifically the overall effect of this market failure on both the legitimacy of the traceability tool and the additionality resulting from its consumption.

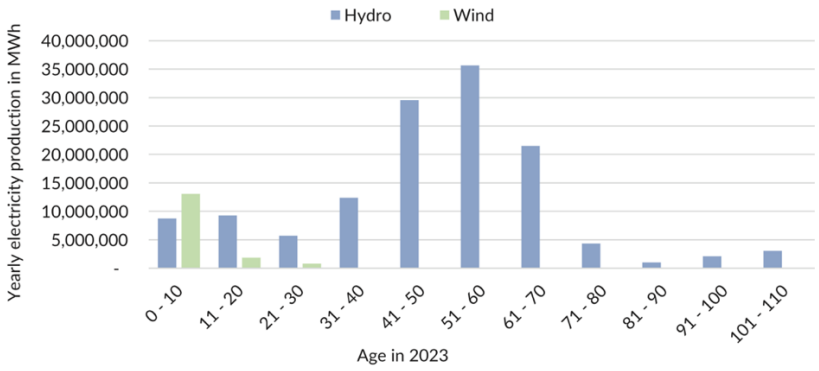
3.2 Lack of additionality and gap between market and location-based emissions

3.2.1 Failures in the market instrument

After analyzing the market structure, it is necessary to evaluate its outcomes in light of the European Union's climate goals. The main argument in favor of GOs is that they transfer part of the consumer's wealth to the producer, thus allowing a voluntary contribution from the private sector to the energy transition. In theory, this mechanism has the capacity to help develop new renewable capacity. In practice, the evidence shows otherwise: the consumption of GOs is not additional (Aasen *et al.*, 2010; Mulder and Zomer, 2016; Bjørn *et al.*, 2022). In other words, up to now, no link between GO consumption and the expansion of the European renewable energy fleet has been empirically measured. To contrast, there is unfortunately no study on the pricing of GOs in PPAs in Europe, despite the emergence of testimonies.[4] The only measurable effect of the GO market is the revenue made by States-auctions, which can be considered as a financing of subsidized generation.

The revenue from certificate sales remains too low and too uncertain to significantly incentivize investment. Producers, therefore, do not see this income as a reliable and stable signal: it only adds a small supplement to their existing revenues and does not influence their investment choices. The incentive is further weakened by the capture of revenues, even modest ones, by older installations, mainly hydropower plants that are already depreciated (Figure 5). These plants capture the majority of market revenues, while new facilities, which really require such support to fund their investments, are mostly deprived of it.

Figure 5: Age distribution of production installations per technology (source: Paris *et al.*,2024)



Apart from investment concerns, the transparency offered by GOs also raises important issues. The low acquisition price enables companies to claim "100% renewable" consumption at minimal expense, often driven by reputational motives or carbon reporting requirements. Persistent and growing residual surplus (Figure 4) creates a disconnection between the market price and societal valuation. Moreover, overly flexible matching rules remove the signals of seasonal production

[4] Gilbert, Chiara, Corporate PPA Origination at SSE Renewables [Conference presentation]. RECS Market Meeting 2025, Beurs van Berlage, Amsterdam, Netherlands. https://recmarket.eu/wp-content/uploads/2025/03/FINAL_RMM25-programme.pdf

challenges or short-term variations related to climatic events. If the market were balanced, the GO price would reflect both the benefits companies gain from being carbon-compliant and the societal value of renewable electricity. From the producer's perspective, it would also account for actual production limitations and marginal costs. However, in practice the persistently low price of GOs allows companies to make renewable claims without inducing real changes in generation or investment. This weak link between consumption claims and financial effort has led to growing criticism, with some observers considering it as a form of greenwashing.

3.2.2 Debate on market vs location-based accounting

Showing that matching rules erase signals in price formation highlights a parallel issue in carbon accounting. The more flexible the rules applied to GOs, the greater the disparity between the "market-based" method and the perception of physical reality. Although this criticism undermines GO's credibility, which is essential to boost voluntary commitment from the consumers, the disconnection is completely assumed. In practice, GOs remain a legal means of offering an alternative way to account for electricity-related emissions through trade traceability, when the current location-based system remains questionable.

There is often confusion between the location-based method and physical reality that leads to false reasoning. The location-based method does not consider contractual agreements of GOs. Nevertheless, it includes contractual realities like the areas covered by TSO and political realities such as national borders. Moreover, the calculation of emission factors uses oversimplified representations of physical aspects, such as temporal and spatial matching or the impact of saturated transmission lines. As an example, a consumer based in France will be considered having a low carbon footprint, thanks to a production mix of renewables and nuclear power plants in their national territory, while its German neighbor, even if transmission lines at the border are not saturated between the two countries, will suffer from a heavy carbon footprint. From a physical point of view, carbon emission factors should be the same if the electric energy flows freely in an area covering France and Germany.

To summarize, the two solutions have distinct drawbacks: one fails to reflect local reality accurately, and the other suffers from issues related to trade interconnection. Nevertheless, the uniformization of accounting between the two remains a matter of debate across Europe, depending on the state's perception. For example, several countries meet their renewable electricity targets based on the location-based method but fall short once the GO trade is considered (Holzapfel *et al.*, 2024). It also causes tensions, with some states benefiting from market logic while others claim they are supported by physical logic, although they use a confusing location-based method. Germany appears virtuous in market-based accounting as a significant net importer of GOs, benefiting from its domestic policy of restricting supply to avoid double-counting. Conversely, Norway maintains an excellent location-based accounting thanks to hydropower, but its market-based footprint is severely affected by large exports of GOs.

Going deeper into the example of Norway, we can observe an interesting and strategic use of a non-harmonized accounting system. In this country, the market-based method considers an increase of almost 50 Mt CO_2eq per year because of the net exports of GOs[5]. Thus, on one hand, Norway is more than doubling its carbon footprint each year for

[5] Calculation from AIB statistics (https://www.aib-net.org/facts/european-residual-mix/2024)

the market opportunity given by the EU GO market. On the other hand, the Norwegian government officially promotes the idea that its national industry shall communicate on the location-based method. Not only does the Norwegian government send a contradictory and opportunist signal in terms of communication, but it also delays for years the virtuous potential of the GO market for the energy transition of the European grid by flooding it with GOs from old hydropower plants.

3.3 What can we expect in the future?

Criticism of the GO market mainly focuses on a structural imbalance between supply and demand. These issues are now well recognized, and they do not imply an intrinsic inefficiency of the instrument. If supply and demand were balanced, GOs could fully play their role as a price signal and become an efficient tool for society. Voluntary demand continues to increase each year, and the mechanism is becoming more integrated into consumption and reporting practices, demonstrating its potential to be a trustworthy market for traceability with a stable income for producers.

The exceptional drought in Europe provided a real test of the market. The sharp decline in GO supply pushed prices near €10/MWh, staying above €5/MWh for nearly a year. However, demand remained steady in 2023 despite this increase. This resilience may indicate stronger integration into regulatory frameworks, a belief in the value of GOs, or a potentially limited understanding of price dynamics by buyers. In any case, the stability of demand suggests a growing societal anchoring of the mechanism. Similar patterns are observed in other certificate markets, such as the UK's REGO or national full disclosure schemes, where high prices have not triggered demand collapse, and equilibrium levels sometimes surpass the European average.

Beyond price, GOs provide the legal foundation for renewable contracting. They support green electricity offers, power purchase agreements (PPAs), and collective self-consumption, since each requires precise tracking of energy production and its allocation to consumers. To the best of our knowledge, there is no study that has analyzed the number of PPAs including a GO value. Nevertheless, there are testimonies that GOs helped finance unsubsidized PPAs and that GOs could reach up to 10% of the financing of PPAs[6]. Without GOs, there would be no reliable way to assign market value to renewable electricity. Countries that facilitated their use in PPAs, such as Norway, Sweden, Finland, and the Netherlands, have taken a clear lead over Germany and France, where national rules have long acted as barriers.

GOs also support a more balanced contribution to the energy transition. They can channel the growing interest of companies and citizens toward voluntary consumption and corporate climate strategies, while distributing efforts between governments and private entities. Germany, for example, treats GOs as a perfect substitute for public spending by forbidding the combination of both as revenue sources.

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6 https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/guarantees-of-origin-playing-a-vital-role-in-decarbonization?utm_source=chatgpt.com

4 Avenues to improve GOs and increase their impact on the energy transition: what is at stake in the current debate

4.1 Harmonization of matching rules and restriction in supply

Discussions about the future of GOs often focus on one main idea: acting on the supply side to strengthen their impact. The goal is twofold: to ensure credible tracking of electricity use and to promote additionality by guiding demand toward new renewable capacities. Several recent works (Holzapfel *et al.*, 2024; Paris *et al.*, 2024; Wimmer and Madlener, 2023) therefore suggest limiting the issuance or trading of certificates, such as reserving them for new installations only, excluding already subsidized capacities, restricting exchanges to physical electricity flows, or differentiating GOs by age, technology, or location of assets. These measures aim to decrease the supply surplus and make GO consumption a more effective investment driver. However, they also challenge two core principles of the system: its voluntary nature and its universal traceability function. Excessive supply restrictions would break the contractual neutrality that GOs rely on, while binding rules could undermine market acceptance.

One of the main challenges of the GO system lies in the non-harmonized legislation on the matching rules, creating time gaps between renewable energy production and certified consumption. Currently, most countries use an annual matching rule, and sometimes a rolling one, which allows a GO from a specific year to be canceled for the next year. This flexibility further accentuates the disconnect between carbon accounting and the physical reality of the electricity sector, as well as the market equilibrium through residual supply that rolls over the next year.

From an environmental viewpoint, temporal harmonization should be understood as a multi-level tool. Several reform options are considered, depending on the level of ambition. A strict annual matching rule would be an initial step toward coherence, preventing interannual carry-overs that undermine the system's credibility. A monthly step would improve seasonal signals by incorporating stress periods, such as winter deficits, into prices. Finally, an hourly matching rule, as presented by the technical group in the reform of the GHG Protocol, would represent a nearly complete alignment with balance responsibility used for the electricity market. Each step has further implications for the GO market, multiplying the potential drawbacks to achieving significant revenue for renewable development.

Yet tightening matching rules also has major economic implications. Reducing the validity period would limit residual supply, which could help rebalance a structurally oversupplied market and support GO prices. This would likely result in generally higher prices, improving the remuneration of low-carbon technologies. In this context, a first step is to reduce the supply by adjusting existing rules that currently leave inconsistencies. Thus, a first clear improvement is to harmonize the temporal matching rule and impose a strict calendar year matching between the production year and the consumption year at European level.

However, finer granularity also increases administrative complexity and strengthens the role of intermediaries, to the detriment of direct consumer participation (European Commission, 2025). In short, harmonizing matching rules highlights the fundamental trade-off between environmental integrity and economic sustainability. The more the signal reflects the physical reality of the electricity system, the stronger its climate value; however, it also comes with greater volatility and a potential drop in demand. Addressing the matching issue, therefore, means striking a balance between ensuring credible

traceability and preserving the role of GOs as an effective support instrument for the energy transition. A major concern is related to mandatory hourly matching, which may reduce demand and create drawbacks if the targets are not clear and binding (Legett and Gillenwater, 2025).

The second rule is to impose a physical link between areas that are allowed to transfer GOs. This will limit the surplus brought by Iceland specifically, but also in all electrical islands, even if they are part of a country that is connected to other grids. A good example is France, which has many islands around the world. Those two rules will have a significant impact on supply and will increase the credibility of the mechanism.

4.2 Promoting additionality through demand: full consumption disclosure, labelling, and reputation

Beyond supply-side reforms, another way to strengthen the impact of GOs is to act on demand. The challenge is either to respect the voluntary principle on which the mechanism is built, while recognizing that demand is becoming increasingly specific and technically complex, or to question this voluntariness by implementing stricter requirements. In both cases, the aim is to design instruments that can steer consumer choices and increase their effective contribution. These tools, whether regulatory or market-based, seek to make demand more transparent, more selective, and more credible. Three options stand out in the current discussion: Full Consumption Disclosure (FCD), which expands the obligation of cancellation; labeling, which introduces qualitative criteria to differentiate certificates; and shaming and reputation mechanisms, which rely on public comparison and social incentives for climate performance.

One option is Full Consumption Disclosure (FCD). It aims to establish comprehensive electricity consumption traceability by requiring the cancellation of one certificate for every delivered MWh, regardless of its source, thereby eliminating the use of the "residual mix." This principle turns a historically voluntary market into a universal framework where each supplier must attest to the exact composition of its energy mix. In Europe, some countries, such as Austria and the Netherlands, have already implemented FCD which has proved to offer two main benefits. First, FCD provides full transparency for consumers by increasing the value of decarbonized portfolios, and explicitly exposing carbon-intensive mixes, thereby enhancing traceability. Second, by mandating certificate demand and aligning canceled volumes more closely with actual consumption, the mechanism has the potential to reduce structural surplus. This standardization of demand stabilizes the market, reduces reliance on voluntary cycles, and reinforces the price signal function of GOs. However, its limitations include administrative complexity and the limited appeal of fossil certificates, whose market value is likely to remain small.

In another area, one can consider differentiation in product and specifically labeling. Labeling serves as an independent form of identification within the guarantees of origin system, created to add a quality layer to existing certificates. While standard GOs merely attest to the renewable origin of one MWh, labels impose extra criteria: additionality (new installations outside public support), locality (national or zonal production), temporal granularity, or the technology type. These filters create a premium sub-market within the voluntary market, where labeled certificates can command a price premium, which may be passed on to producers who meet the criteria (BEUC, 2016; Hamburger, 2019). Labels thus aim to strengthen the credibility of environmental claims and to channel demand toward projects with a greater climate impact. However, their success still depends on transparent governance, harmonized standards, and limited verification costs to

prevent market fragmentation or value capture by intermediaries. Moreover, an original option would be to define the quality of a GO by its level of additionality, dividing certificates into two categories: “old” (from amortized installations) and “new” (from recent capacities). Based on this, and in line with the labeling initiatives that are increasing across Europe (European Commission, 2025), the regulator could require that a minimum proportion of “new” GOs be included in every transaction. Such a mechanism would maintain universal traceability while ensuring that GO consumption is at least partly linked to the financing of new capacity. This approach paves the way for a reform that can reconcile the two functions that are the proof of origin system and the price incentive for the energy transition, in a way that does not compromise the voluntary nature of GOs. This will be further explained in a future working paper. More practically, an existing project of establishing a « Union-wide green label », set out in Article 19(13) of Directive 2018/2001, may offer a valuable opportunity to study. As it is referred to in Article 19(13), such a label is due to promote the use of renewable energy « coming from new installations ». As the directive mandates the European Commission to conduct a report assessing options to establish such a label, we strongly recommend that such considerations be incorporated into the development of EU law.

A third approach relies on transparency and reputation through what can be called a shaming mechanism. Both FCD and labeling increase the disclosure of certificate quality, enabling consumers to distinguish between products and rank suppliers based on their environmental efforts. For households, this differentiation creates a disutility in choosing carbon-intensive portfolios once cleaner alternatives are visible, reinforcing the social value of renewable consumption. For companies, the ability to compare electricity mixes intensifies competitive pressure: reliance on fossil-based GOs can negatively affect reporting, ESG scores, and marketing strategies. The financial sector's experience demonstrates the potential of such mechanisms, as naming and shaming practices, showing significantly impacted investment decisions. Applied to the GO market, similar disclosure could create a reputational premium for low-carbon suppliers and penalize those relying on carbon-intensive ones. However, this effect depends on clear and credible information; without transparency and trust in the differentiation system, the reputational mechanism may be ineffective or even misleading.

Conclusion

This paper has demonstrated that the Guarantees of Origin system fulfills its foundational purpose of providing contractual traceability; however, it has so far failed to deliver a meaningful contribution to the energy transition. Two distinct but equally important shortcomings explain this situation. On the one hand, GOs have not generated sufficient additionality: abundant supply, low prices, and fragmented rules have prevented the mechanism from channeling revenues into new renewable investments that could replace carbon-intensive generation. On the other hand, the traceability function, built on the "market-based" approach, was initially conceived as a valuable complement to the location-based method, offering a coherent way to account for Scope 2 based on tradable certificates that trace electricity across all of Europe. Yet its fragmented recognition between countries and its reliance on a weak price signal to support private decarbonization have undermined its credibility. In both cases, the problem lies not in the principle of the mechanism but in the way it has been applied, and specifically in market failures.

Nevertheless, it would be premature to conclude that this ambitious tool has failed. The market remains young and unbalanced, with its main issues stemming from regulatory gaps, particularly in temporal validity rules. Its voluntary nature is a strength, but it needs reforms to be clear and acceptable to consumers. The priority should be to restore trust in the signal. A strict European-wide annual matching rule should be the initial step, as the major issue in this market is the rollover of excess certificates accumulating from one year to the next, before moving to more detailed levels. Jumping straight to hourly matching, as proposed under the GHG Protocol, could undermine acceptance and make the system overly complicated without strong evidence of its effectiveness. A progressive, stepwise, and pragmatic approach is therefore preferable.

Finally, it is important to recognize that both the research and the available data on the impacts of reform are limited. Tools to stimulate demand (full consumption disclosure, labeling, reputational mechanisms) or to restrict supply are still underdeveloped by both researchers and regulators. Testing these solutions, measuring their effects, and refining their implementation will be crucial for enabling GOs to fully assume their dual role: providing credible traceability and effectively supporting renewable energy development in a decarbonizing Europe.

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