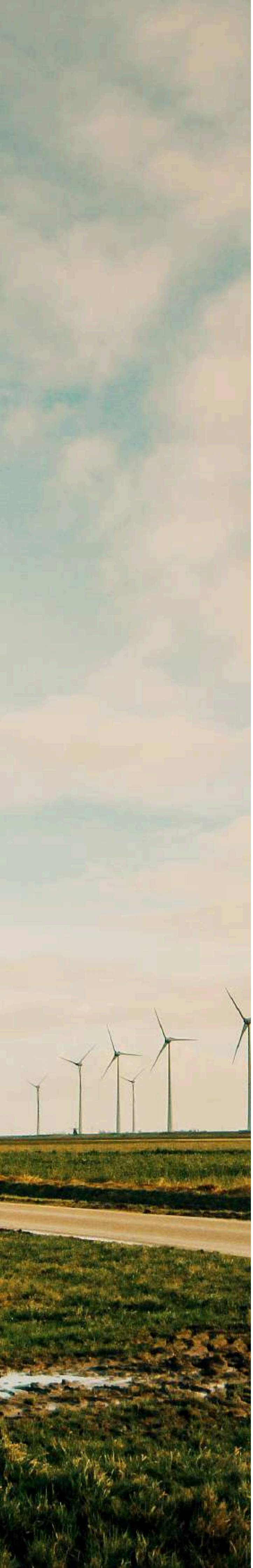
# QuiEstVert's position on the desirable evolution of the Energy Attribute Certificates mechanisms.



# INTRODUCTION

We are currently in the public consultation phase on the GHG Protocol standard on the traceability of electricity, more specifically the so-called scope 2 standard. This will be harmonized with the standards of ISO, which has already chosen the GHG Protocol as a reference. It is therefore planned that a common standard for the GHG Protocol and ISO will be created. This is an opportunity to take stock of the state of the GO market, its vocation and what would be desirable in the near future. The topics discussed are valid for the debate on an international standard, but they also concern European regulations.

We will begin with some preliminary remarks, which are essential to clarify the foundations of our reasoning. In the first part, we will demonstrate how the guarantee of origin is a key mechanism allowing economic actors to voluntarily commit to the energy transition. A second part will be devoted to proposals for changes aimed at strengthening its effectiveness. We will then examine, in a third part, the proposal for a transition to hourly guarantees of origin, a direction favoured by a working group formed by the GHG Protocol, to assess the issues and implications. Finally, our conclusion will formulate guiding principles for a new standard.

In the article we are using two terms that have similar meaning and can in many cases be replaced by the other. The Energy Attribute Certificates (EACs) is a contractual instrument that provides information about a unit of energy, including the resources used to create the energy and the emissions associated with its production and use. This generic term includes Guarantees of Origin (GOs), Renewable Energy Certificates (RECs), International Renewable Energy Certificates (I-RECs) and some other. Since this article uses a lot of information from the European market, we often refer to Guarantees of Origin (GOs) that is similar to EACs but specific to the European Union.

**Acknowledgements**
We would like to thank RECS Energy Certificate Association for their support during the event held in Paris on 15 October 2025 on the topic of Guarantees of Origin granularity. Their involvement contributed to the development of this article.

# Preliminary remarks on physical reality, electricity markets and carbon accounting

01

# *PRELIMINARY REMARKS ON PHYSICAL REALITY AND ELECTRICITY MARKETS*

It is necessary to dispel certain persistent **preconceived ideas**.

The first is to **assert the existence of a physical electricity market**. However, this does not exist. A producer do inject physical power in the grid and and a consumer do withdraw physical power from the grid, but a specific consumer do not withdraw the power injected by one specific producer. The second assumes that it would be possible to ensure **a traceability of the origin of electricity that faithfully reflects physical reality**. Again, this statement is incorrect. Finally, the third misconception postulates that there is **carbon accounting applicable to the consumer, strictly aligned with the physical reality** of the electricity consumed. All three assertions are unfounded.

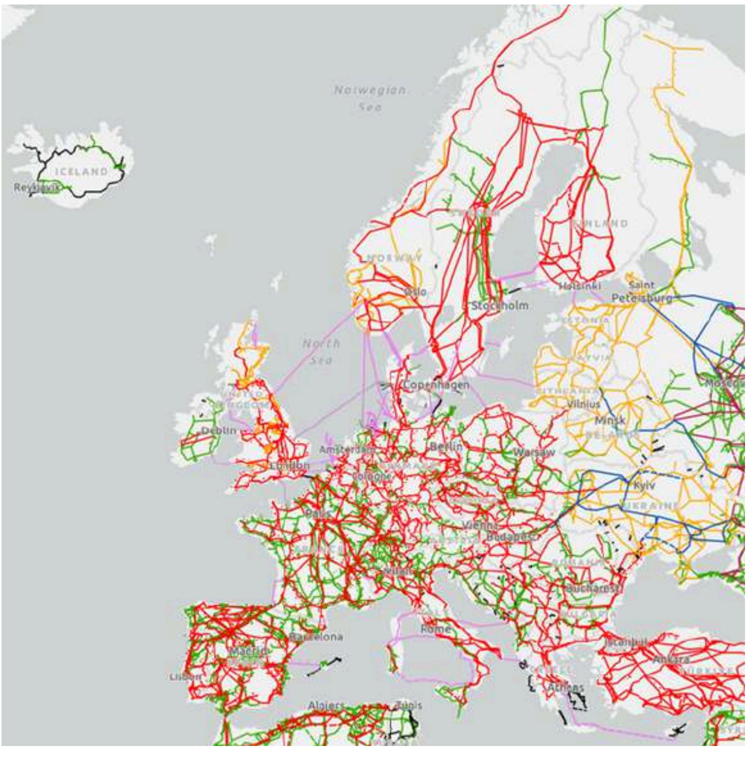
All the mechanisms mentioned, and their subsequent markets, are based on the principle of mass balancing. This makes it possible to monitor and allocate the flows of energy, materials or emissions within a system, the parameters of which are defined according to the objective pursued by the calculation. For example, this is how a power producer can be paid for injections in a grid.  To be valid, this principle must imperatively respect the principle of additivity and exhaustive accounting, excluding any double counting.

We would like to recall some fundamental elements relating to the physical reality of the propagation of electricity.

The **speed of propagation of electrical energy in copper reaches 200,000 kilometers per second,** or two-thirds of the speed of light. To illustrate this speed, it should be noted that at such a speed, it would be possible to fly 18,000 times around the world in a single hour, or to travel the distance between the Sun and Jupiter. In terms of physical reality, it is also worth highlighting the **strong electricity interconnection on a European scale.**

This is mainly based on synchronous areas covering most of continental Europe, although frequent saturations are observed, both within and between countries. Moreover, this interconnection remains weak with the rest of the world, limited to connections with Morocco, Tunisia and Turkey. In this regard, it is relevant to remember that the Baltic countries have definitively disconnected their grid from that of Russia, thus marking the end of the BRELL ring. Finally, one last observation is necessary: the European electricity grid is responsible for **nearly 30% of the continent's $CO_2$ emissions**, or more than 3 gigatons per year.

***Interconnections in Europe***




*Source: ENTSO-E*

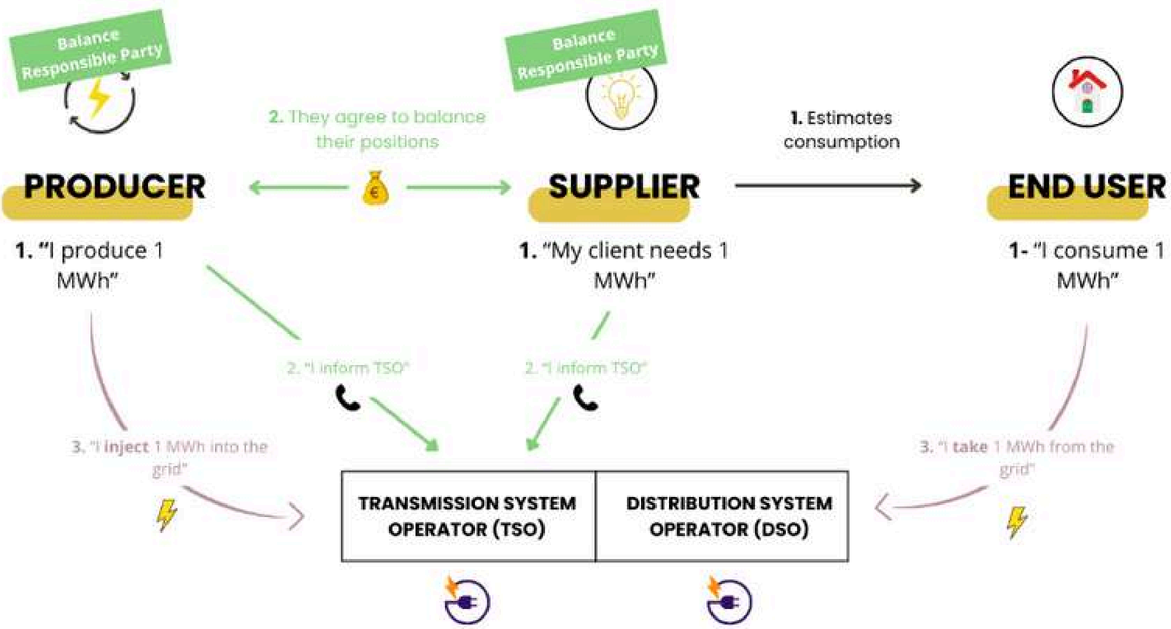
In the absence of a physical electricity market, which is impossible in the context of a shared grid, convention markets have been set up to enhance some of its characteristics. These complementary agreements are based on separate rules that are adapted to their purpose.

The first, known as "**balance responsibility**", aims to enhance the place and time of electricity delivery. The so-called electricity market is built around this agreement. It allows economic players to **contribute financially to grid balancing**. In this context, electricity is defined by two exclusive criteria:

1. **A spatial criterion**, corresponding to the balancing zone — a simplified abstraction of the physical delivery area of electricity (e.g., France or Northern Italy). These zones, generally based on national or regional borders, can sometimes include several countries, as is the case for Germany and Luxembourg.
2. **A time criterion**, now set in Europe on the scale of a quarter of an hour.

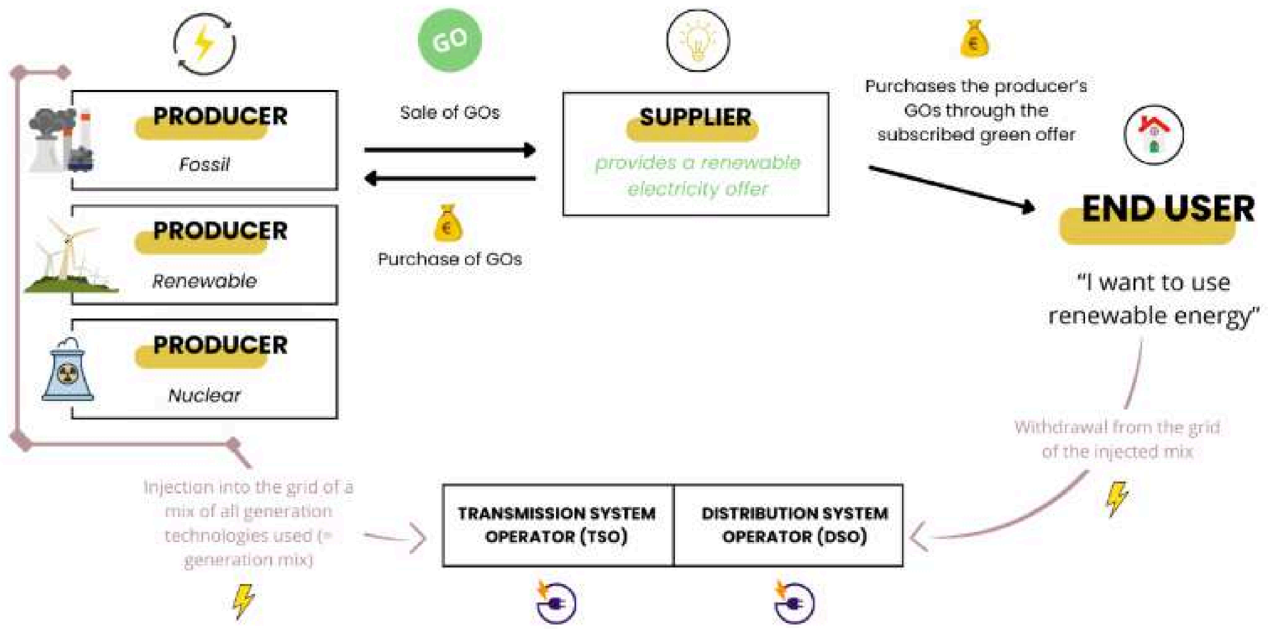
This extreme simplification of the definition of electricity makes it possible to have a functioning market, not for electricity itself, but for balancing the grid. They are the result of a compromise between considering physical reality and the need to facilitate trade on a market. However, due to the limitations of these criteria, this convention is **unable to value other attributes of electricity**, such as its origin and consequently, its environmental quality or its place of production.

***The balance responsibility***



A second convention, called the “Energy Attribute Certificate” (EAC) or "Guarantee of Origin" (GO) in Europe, defines electricity according to the exact origin of its production, but according to criteria that are less strict than those of balance responsibility. Thus, regarding the GO for example, the spatial criterion extends to the entire European economic area, while the temporal criterion is limited to compliance with a period of 18 rolling months before the expiry of the guarantee. Unlike balancing responsibility, this agreement does not value the place or time of delivery, but the way in which the electricity is generated. It is not intended to value grid balancing, as this function is already carried out by the balancing responsibility.

### *The Guarantee of origin (GO)*




It is interesting to note that in these two markets, the company qualified as a supplier is in fact only a financial intermediary, namely a trading company, and does not perform any physical function. Even if a company has both producting and supplying activities, it remains a financial intermediary for a consummer using the grid.

# PRELIMINARY REMARKS ON PHYSICAL REALITY AND CARBON ACCOUNTING

Currently, carbon accounting uses two calculations, namely the location-based and market-based calculation.

## LOCATION-BASED CALCULATION

**Location-based calculation** consists of assigning an average carbon emission factor based on the location of an electricity consumer. He uses a lot of abstraction that derives from physical reality. First, an area that is considered homogeneous although it contains saturated cable areas. Thus, physically speaking, it is misleading to apply a single carbon emission factor for this area. However, this area will be considered a grid for calculation purposes. This limitation is explained not only by the fact that the physical criteria are inevitably truncated due to gross simplification (to ensure scalability), but also by the incorporation of non-physical criteria, including political and contractual boundaries such as national borders or areas managed by TSOs.

**This calculation is not only very far from being a true representation of physical reality, but it unfairly distributes emission factors among grid users**. Let's take the example of France, a country that is strongly linked to its neighboring countries. It often has unsaturated capacity on its borders with neighboring countries. In this case, the emission factor should be the same between consumers located near the border of these two countries. Indeed, since the electrical signal propagates almost instantaneously (200,000km/s), everyone has a similar impact on a shared energy mix, regardless of the distance, if the electrical energy can propagate freely. However, this is not currently the case because location-based calculation considers the marginal impact through the calculation of the imported volume, which favors French consumers due to the predominance of renewable and nuclear power plants within France's political borders. Secondly, an energy mix is calculated over a period according to the principle of equivalence between what has been injected and what has been withdrawn from the grid. The standard period is one calendar year. Once again, this abstraction leads to an alienation from physical reality since consumption profiles vary and so does the energy mix of a grid. Third, the emission factor of this energy mix is done by integrating the average GHG emissions by plant category, which is a new abstraction. This non-exhaustive list of examples shows how physical reality is necessarily abstract to have practical indicators. This calculation can therefore be considered neither fair nor representative of physical reality. But it remains useful because of its methodological simplicity. As an example of its usefulness, in an area where there is no residual mix calculation, the principle of additivity is not respected and there will be double counting of the same energy source by one consumer using EACs and an other that doesn't. Using the location-based calculation by both consumers, one as a only source and the other both communicating on its EACs and on the location-based calculation, allows a fair comparison.

## MARKET-BASED CALCULATION

**Market-based calculation** incorporates physical criteria like the location-based method, as it is based on the location-based method. It may be worth mentioning that the term "market-based" is quite misleading. The term "contractual" would be more appropriate, as it is a monitoring mechanism using contractual instruments that respect a mechanism that considers physical reality. The fact that these contractual instruments can be traded on a market does not explain the mechanism. In addition, **the term market-based can give the impression of a false tracking of the financial world, especially when we wrongly oppose it to location-based calculation by claiming that the latter reflects physical reality**. However, it differs fundamentally in the way carbon emission factors are assigned: it introduces the possibility of claiming the origin of the electricity used based on a contractual reality. The contractual instruments allowing this choice are commonly referred to as Energy Attribute Certificates (EACs). Its function is to evaluate how electricity is produced. Market-based calculation must be considered rigorously. It offers some advantages, but its application can quickly reveal defects. It is crucial to avoid double counting, to respect physical criteria that have been considered and to ensure that there is a fair comparison between consumers. For example, EU member states benefit from European directives such as RED 3. In each Member State, a residual mix is calculated, which ensures that consumers who have not explicitly traced their electricity by cancelling GOs still participate in implicit tracing. First, a production mix is calculated based on an area considered as a grid defined by a political criterion, the national border. Then, we consider the commercial energy flow of the connected areas to define a consumption mix. This is basically location-based calculation. From this base, the market-based calculation starts by deducting the cancelled GOs in that area, and replacing the similar volume with a default European mix called the European Attribute Mix (EAM) to obtain a residual mix. This is how double counting is avoided. An electricity consumer based in this area will either use this residual mix or cancel the GOs to claim its own energy mix. Interestingly, some countries such as Austria, the Netherlands or Switzerland have gone further by legally requiring full disclosure, an even more transparent mechanism where each electricity consumer must allocate GOs for each MWh of electricity consumed via the grid. In this case, it is no longer necessary to calculate the residual mix. The distribution of responsibilities is fairer as it is the result of an action by energy users that consists of making the effort to track their energy source in a contractual way, and even legally in the case of consumers located in EU Member States.

### *From physical reality to carbon accounting through mass balance-based conventions*

**Calculation based on the consumer's location (location-based) :**

**Calculation based on the consumer's location & contracts (market-based*) :**

1. **Determination of a zone based on various parameters including:**
   Physical: density of electrical interconnections in an area
   Political: national or regional boundaries
   Contractual: zone managed by a legal entity with a contractual mandate as Transmission System Operator (TSO/GRT)

2. **Consideration of electricity flows at the margins of these zones with neighboring zones****

3. **Equal allocation of the CO2 emission factor for all consumers present in this zone*****

3. **Allocation of the CO2 emission factor based on the contractual instruments used (GO, RECs, I-RECs, etc.) or, failing that, based on its location using a residual mix******

* The term "market-based" is inelegant, as it is the use of dedicated contractual instruments that enables the allocation of an energy mix and its associated carbon footprint

**Debatable choice from a physical perspective: if two zones are not physically saturated, why discriminate between two consumers present in each of the zones?

***The emission factor is an approximate calculation based on averages by power plant category (wind, hydro, CCGT, nuclear, lignite, coal, fuel oil…)

****The residual mix calculation starts from the location-based mix from which volumes used by contractual instruments are subtracted to avoid double counting and respect the additivity principle

# The EAC: a mechanism to support the energy transition voluntarily

02

# *THE EAC: A MECHANISM TO SUPPORT THE ENERGY TRANSITION VOLUNTARILY*

This section is part of an analysis of the relevance of voluntary approaches. It does not deal with financing based on coercive levers, such as taxation, or compliance mechanisms.

We **see voluntary mechanisms as a complementary alternative to subsidies**. It is not a question of abolishing public support mechanisms, but of enriching them with approaches based on the voluntary commitment of the actors.

**The interest of a voluntary market is multiple** and manifest itself at several levels.

First, it allows **additional financing** for virtuous electricity production, by structuring and valuing power purchase agreements (**PPAs**) in particular. In Europe, the GO, by ensuring legal traceability between consumers and producers, plays a key role in this process. Secondly, this market contributes to **improving the budgets of the States** thanks to the auctions organised by the latter to subsidise electrical energy, which they then resell. The EAC also makes it possible to **structure labels** establishing specifications according to their environmental qualities and their benefits in terms of investment in renewable energies.

In short, beyond the economic impacts, a voluntary contract for guarantees of origin promotes societal **values**. It offers economic players involved in this approach the opportunity to **communicate positively** about renewable energies and a decarbonised energy transition.

The advantages are:

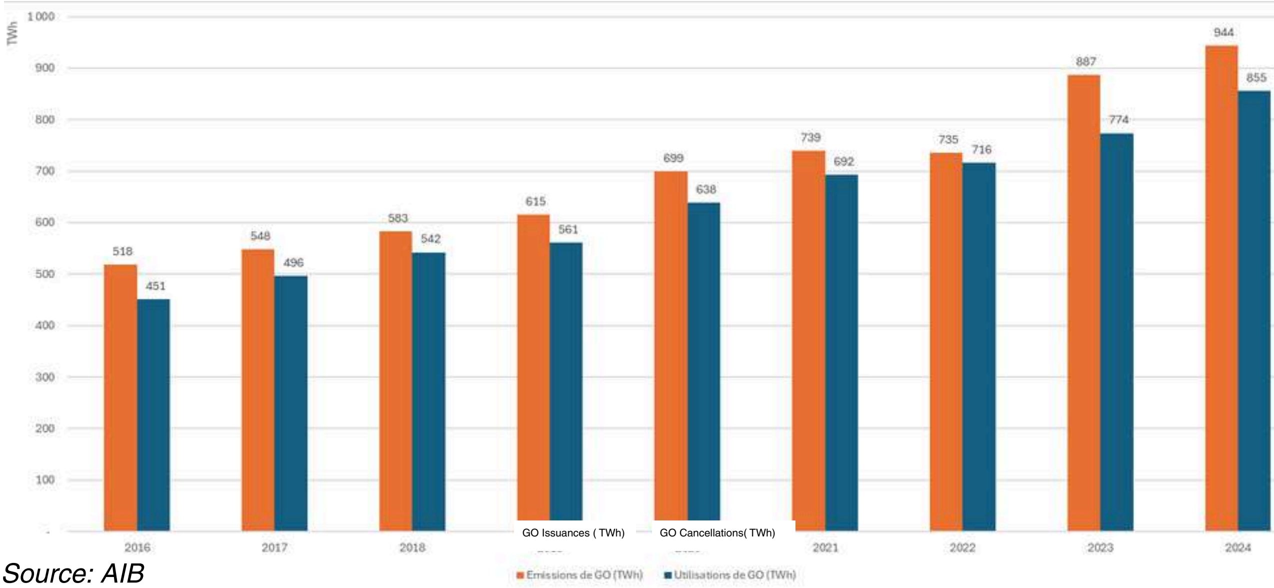
- **Increasing investment** through a voluntary source of funding, complementary to enforcement mechanisms.
- **A possible reduction in the tax burden** for taxpayers, which, combined with positive communication, can **improve the social acceptability** of the effort necessary for the decarbonised energy transition.
- A voluntary mechanism offers **increased robustness in the face of political uncertainty**, which is likely to weaken policies to support this transition.

It should be stressed that the issue of social acceptability of the tax burden cannot be underestimated. In France for example, large-scale protest movements have emerged in response to fiscal measures related to the fight against global warming. The most emblematic remains that of the yellow vests, but we can also mention the red caps.

As far as political uncertainty is concerned, it is relevant to note the rise in popularity until the election of climate-sceptic parties, whose positions call into question energy transition policies. These political and social dynamics can have major repercussions on public policies, in particular by influencing the financing of the energy transition.

First, it is possible to note that the mechanism of guarantees of origin is widely acclaimed in Europe. Demand, which is constantly growing, is getting closer to the available supply every year.

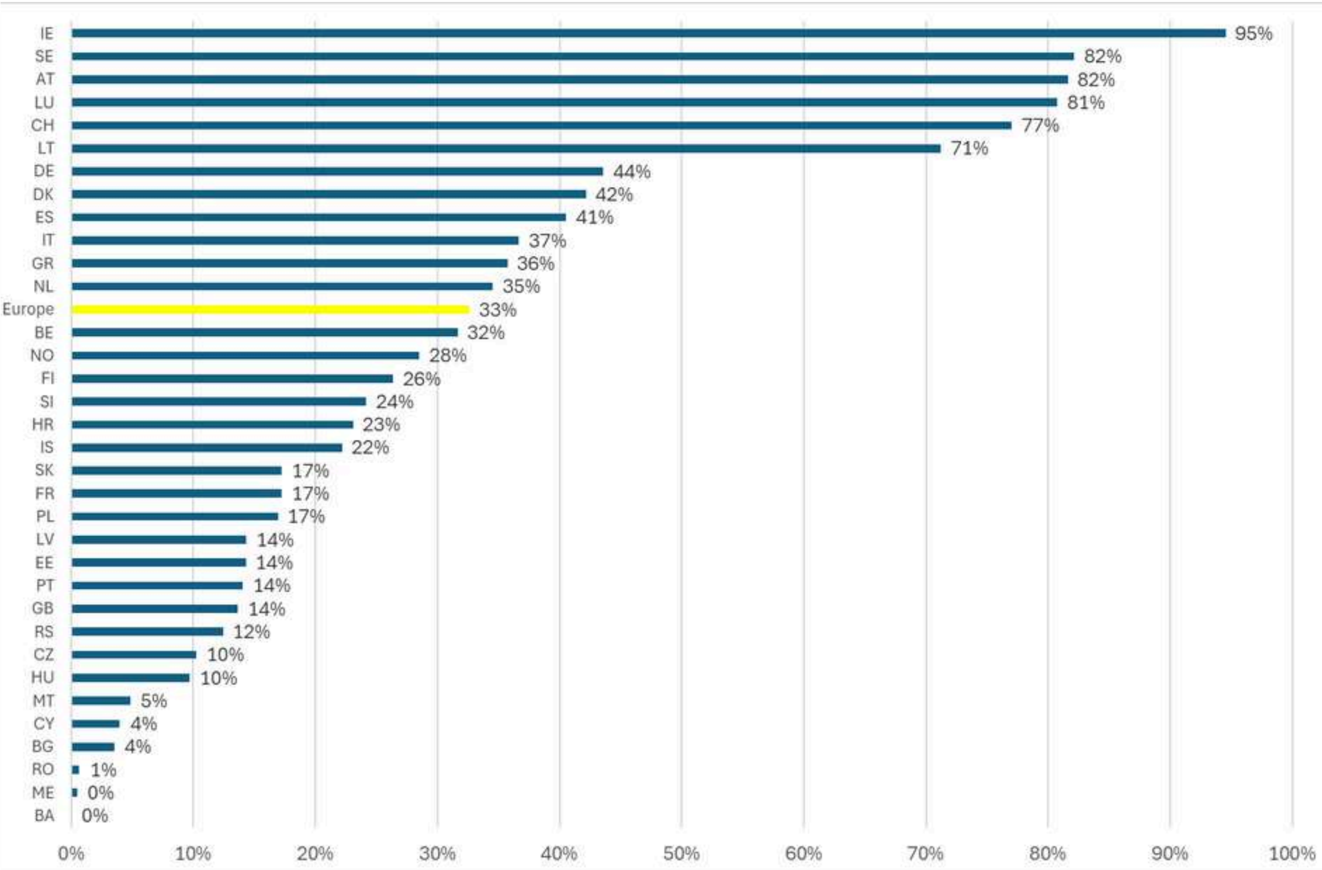
### *GO supply and demand in the AIB zone*




*Source: AIB*

This massive support for the mechanism makes it possible to put into perspective the criticisms made by certain actors, who tend to highlight a feeling of discontent. It is important not to overestimate the influence of a vocal minority, whose positions do not necessarily reflect the general trend.

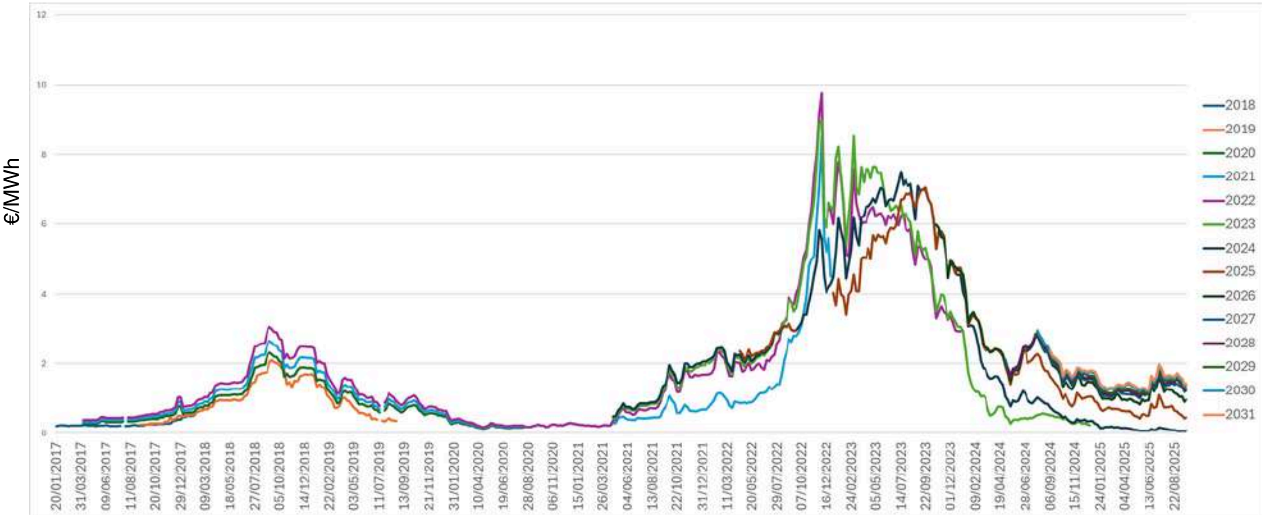
### *Voluntary consumption of electricity from renewable sources in Europe (2024)*




*Source: AIB*

Not only is the demand high, but the multiple and prolonged empirical observations allow us to affirm that **the consumer fully assumes the cost of his voluntary commitment.** Thus, as illustrated in the graph below, the **willingness to pay** is between **5 and 10€/MWh.** This estimate is even conservative, because it is based on a wholesale price, whereas the retail price — the one borne by the consumer — is often higher.

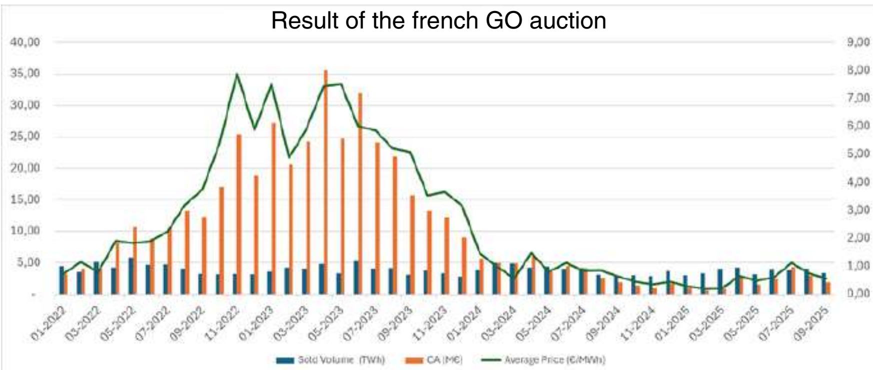
***The price of AIB renewable GOs (EECS)***




*Sources: Icap, Commerg*

The success of voluntary demand and the propensity to pay have an **impact on the energy transition**. The first measurable effect lies in the ability of the Guarantees of Origin market to generate **revenue for States.** Indeed, the sums recovered through the sale of these guarantees must be included in the accounting balance of public aid for renewable energies. While the costs for taxpayers are reflected in the amount of taxes levied, the revenues – from both the sale of electricity and the sale of guarantees of origin – are in return to reduce the tax burden or increase the means available to finance the energy transition.

***Result of the European GO auctions***




*Sources: EEX, Omip, GSE and other state auction organisers*

**France:**
Sold volume : 235 TWh
Revenue for the State: **479 M€**

**Portugal:**
Sold volume: 206 TWh
Revenue for the State**: 101M€**

**Italy:**
Sold volume: 214 TWh
Revenue for the State: **195M€**

**Others ( HU,HR,LU,SK,GR) :**
Revenue for the State: 62M€

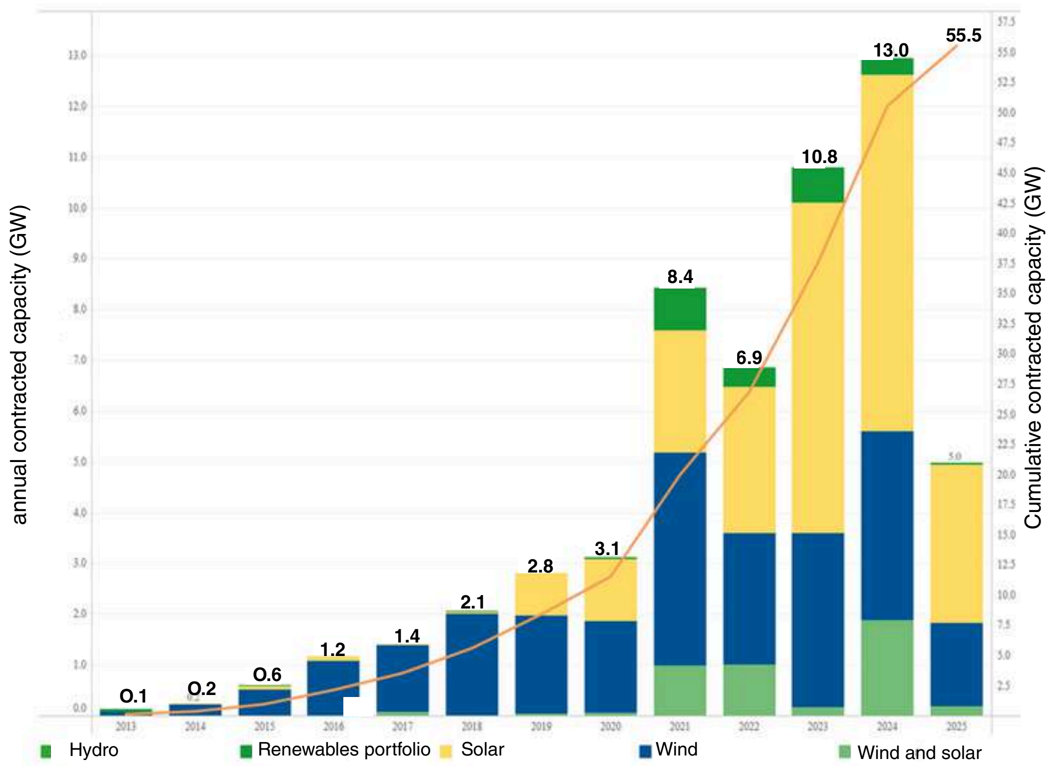
Another measurable impact concerns **the essential role of EACs in the contractual structuring of power purchase agreements (PPAs)**. Indeed, they allow the legal attribution of the origin of the electricity consumed, an essential element for the actors involved in the signing of such contracts. Beyond this essential legal link, guarantees of origin bring financial value to the industrial project. Electricity production will be financed mainly through the electricity market for its contribution to grid balancing, but also through the guarantee of origin for the environmental quality of this production. This value is directly correlated with the market for guarantees of origin, which means that the prices viewed on this wholesale market directly influence the financing conditions of the projects.

### *The classic income structure of a PPA*

| Income sources | Details | Typical share in the financing |
|---|---|---|
| Balance responsibility (Electricity market) | • Defined by the wholesale market<br>• Fixed or indexed price | 85–95%, depending on wholesale market prices |
| EAC | Defined based on the wholesale market, with a possible premium for a specific quality | **2-10%, depending on wholesale market prices** |
| Others | Ex : Primary / secondary reserve, capacity market | Marginal, if any |

Thus, in some cases, a market maintained at high price levels has encouraged the emergence of investments in renewable energies, without recourse — or almost — to public subsidies. The most striking example is that of offshore wind farms developed in the Netherlands, whose financing has largely been based on this dynamic. It is interesting to note that PPAs represent between 10 and 15% of investment in European renewable energy over the period 2013-2025 in all sectors combined.

### *PPAs in Europe*




*Sources: RE-source*

# I - Criticisms and Proposals for the Evolution of the Mechanism

The mechanism must evolve to accelerate its impact on the energy transition. Particularly in Europe, where the market is the most mature, it presents empirical evidence of its functioning. However, although promising, it cannot be considered satisfactory in its contribution to the energy transition. How can we strengthen its impact? Several major criticisms call for concrete solutions.

Firstly, the economic impact of guarantees of origin on the energy transition remains insufficient. Moreover, the message associated with this mechanism is often misinterpreted, especially when the claim of carbon neutrality does not reflect the physical reality of emissions. In addition, there is a laxity in the face of inappropriate behaviours, resulting from a lack of recognition and effective sanctions. Finally, regulations and standards, which are still too poorly harmonized and sometimes contradictory, complicate its implementation.

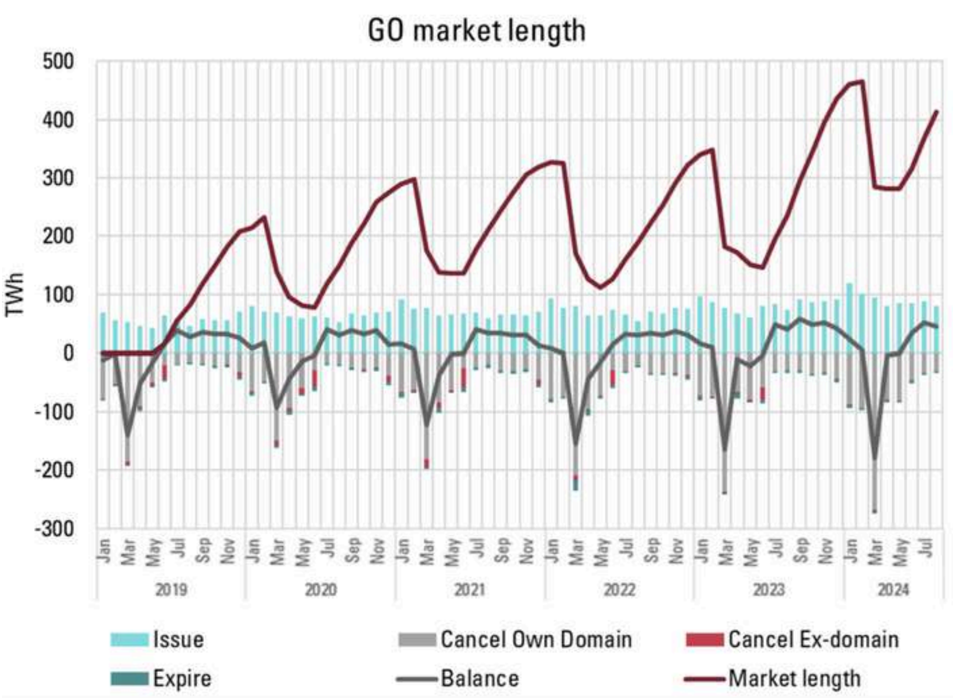
The objective of this part is to explore avenues for improvement. We first propose strengthening the rules of the system, by introducing:

- **A strict annual matching** and a **rigorous physical link** between the place of use of the EAC and the place of production of electricity that allowed their issuances. These measures would increase the economic impact of the mechanism but also its credibility by strengthening the consideration of physical reality.
- **Rigorous monitoring by credible organizations is essential**. Improving the rules is not enough: they must be applied systematically. And above all, it is understandable to say that the mechanism has had an insufficient impact. Nevertheless, this criticism has its limits because no objective has been determined and no one is following its progress.
- We need more transparent communication and to speak correctly about physical reality. It is essential to clarify the principles of communication. Rather than opposing location-based and market-based methods, **we suggest a two-pronged approach**: the **attribution of the origin of electricity** and its $CO_2$ emission factor, on the one hand, and the **evaluation of the concrete actions** (consequential approach) carried out by each organization to decarbonize the energy system it uses, on the other hand. This balanced communication would make it possible to put physical reality back at the heart of the debate, while avoiding the pitfalls of sterile opposition.

### *1. Establish a strict annual matching*

In Europe for example, the GO market is structurally unbalanced. Contrary to popular belief, the current mechanism does not impose a strict calendar annual matching between the period of electricity consumption and that of its production. This shortcoming has led to a structural build-up of unused volumes, particularly in the European market, transforming the market into a fundamentally "long" system. Indeed, the remaining volumes of one year are systematically carried over to the following year in several countries. However, a market where supply exceeds demand for a long time cannot generate significant price signals — a major brake on investment in carbon-free means of production.

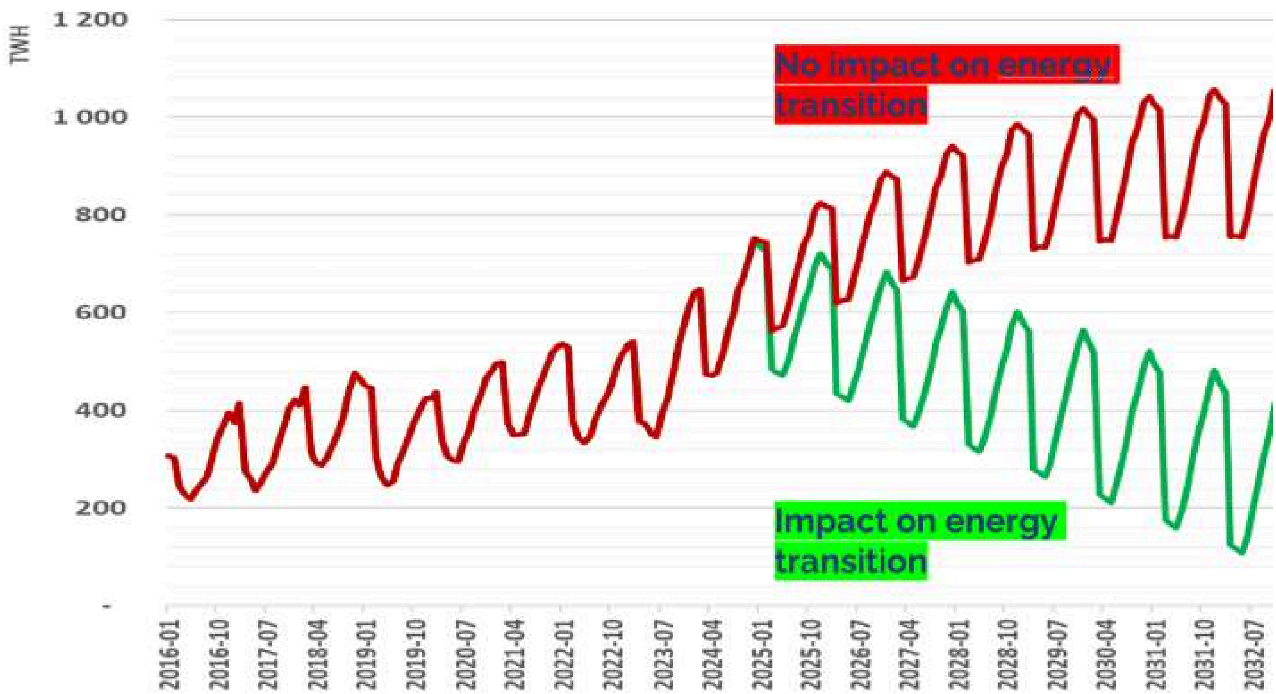
### *The GO market length*




*Source: European Commission*

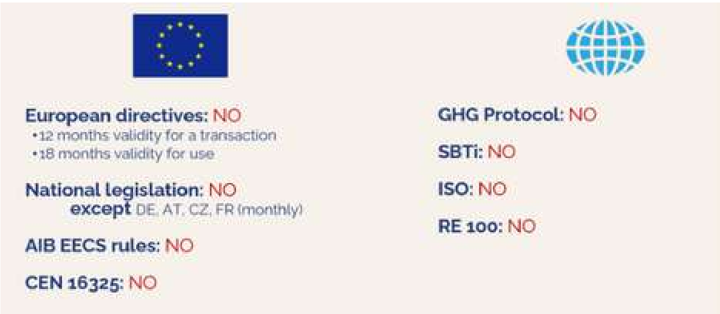
**The successive rollovers of the lengths accumulated in previous years condemn the GO market**. The graph below illustrates the evolution of the volumes of renewable GOs available on the registries of the AIB European Hub (emissions deducted from uses and expirations). There is a seasonal "wave" due to the concentration of the use of guarantees of origin in March and April of the year following consumption. It is during this period that most of the work of allocating GOs to consumers is carried out. Worse, the market length continues to increase, directly attributable to the carry-over of unused volumes from one year to the next. Without correction, this dynamic is likely to continue, even if demand increases.

### *Market length projections with and without strict annual matching*



**A balance is necessary to maintain incentive prices**. The introduction of a **strict annual matching** would change the situation. Given the relatively small annual differences between emissions and uses (in the range of **50 to 70 TWh**), such a framework would naturally regulate supply and demand. As a result, the market would be **systematically balanced,** and prices — historically above **€3 or €4/MWh** in a balanced situation — could remain at this level. This would finally create a **strong economic signal** for renewable energy investors.

**Where is the annual matching applied?**




**The observation is damning because the annual matching is an exception rather than a norm**. To date, only a few countries (such as Germany and France) apply at least a strict annual matching. Its widespread adoption, beyond its economic benefits, **will further enhance the credibility of the mechanism** on a global scale.

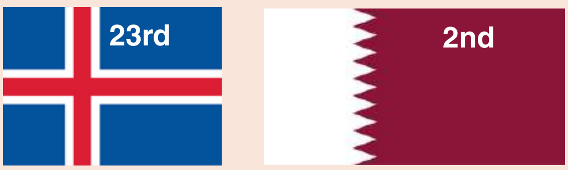
This measure is more urgent as its current absence undermines confidence in the system and limits its effectiveness for the energy transition.

## *2. Establishing a mandatory physical link: a condition of credibility*

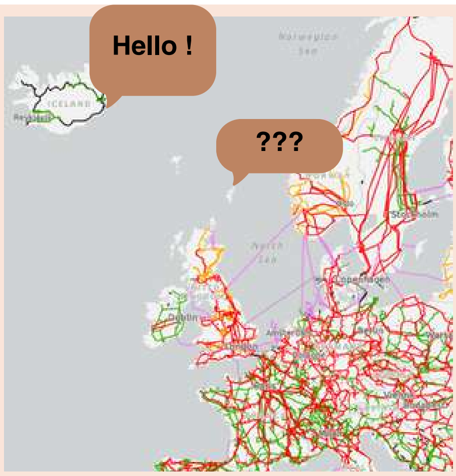
This principle is simple and consistent. To strengthen the legitimacy of the mechanism, one rule is necessary: to require a physical link between the production and consumption of electricity, i.e. an **effective electricity connection**. This measure would directly respond to a recurring criticism: that of a system disconnected from physical reality, where "electric islands" – such as Iceland – participate in the market without contributing to the decarbonisation of the European grid.

**The example of Iceland is emblematic.** Its energy mix is already almost entirely decarbonised and therefore has no problem to solve at this level. But rather than stopping there, it exports guarantees of origin to Europe. However, this participation does not solve any climate challenge for the continent. Worse, it unbalances the market by injecting additional volumes, delaying its structural equilibrium; and it weakens the credibility of the mechanism, by allowing actors to claim emission reductions without any real impact on European infrastructure.

***The impact of the GO market on Iceland's carbon footprint***




**9,4 tCO2/capita** **35,5 tCO2/capita**




- 2023 production mix : **0,2 gCO2/kWh**
- 2023 consumption mix: **432,2gCO2/kWh**
- Electricity consumption in 2023: **19,85 TWh**
- Population in 2022: **380 356**
- (mix C- mix P) x CE / Pop = **22,5 tCO2/capita**

- market-based carbon footprint : 9,4+22,5 = **31,9 tCO2 => 3rd**

*Sources: AIB, worldmeters.info*

While the introduction of a strict annual matching would have a major economic impact, the physical link is just as crucial for the image of the market. It would ensure that each guarantee of origin reflects a tangible reality – electricity fed into the relevant grid – and eliminate distortions created by external actors. In short, this rule will increase confidence in the system, while accelerating its ability to meet its climate goals.

### *3. Setting clear objectives and measuring impact: a necessity for the credibility of the mechanism*

**It is now fundamental to set expectations and evaluate results** Beyond strengthening the rules, it is imperative to establish rigorous monitoring of the mechanism and its impact. Without specific objectives, it is impossible to evaluate its effectiveness. What is the purpose of EACs?

Is it about:

- Reducing avoided emissions?
- Stimulate the installation of new renewable capacity?
- To support investors financially?

Probably all three. To achieve this, it is essential to **formalize these objectives** and entrust their evaluation to independent and credible bodies.

**Here are some concrete proposals for effective monitoring:**

#### The impact on investments and installed capacity

We should monitor the evolution of the renewable capacity installed thanks to EACs, by analysing the volumes and dates of installation of projects; the associated power purchase agreements (PPAs), including the average price of the integrated EAC; public and private investments mobilised, in particular via state auctions (e.g. revenues generated by the sale of EACs from subsidised projects).

#### Conversion of investments into avoided emissions

We should know the impact of new capacity on additional decarbonised production and then estimate the $CO_2$ emissions avoided on the European grid.

#### The energy mix of consumption by country.

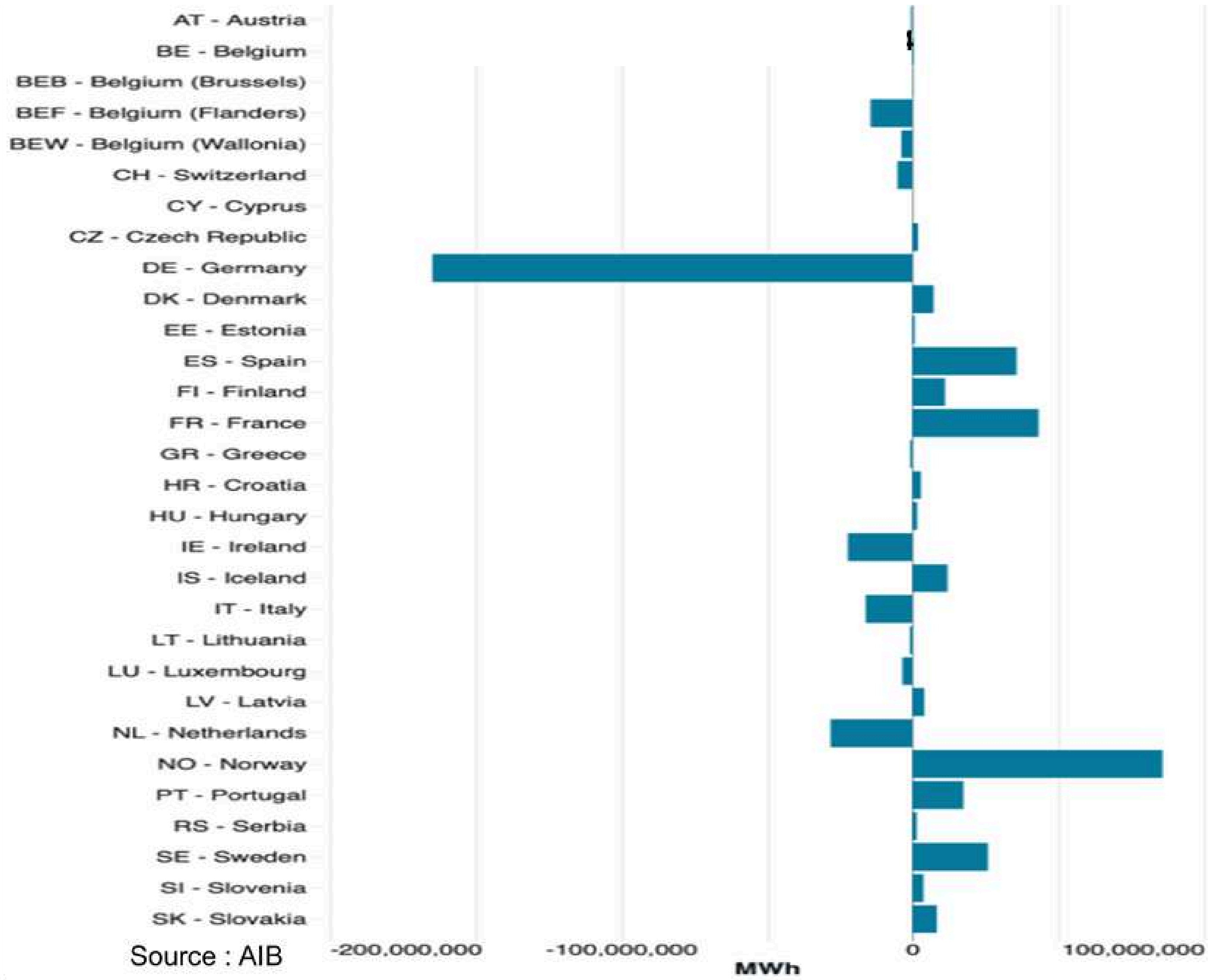
**Analysing the evolution of the energy mix and carbon footprint by country**, before and after gEACs transactions, would reveal imbalances that could lead to political issues (e.g. net exporting countries vs. importers).

#### Harmonization of regulatory frameworks

**Mapping standards and laws** can help identify **inconsistencies** or gaps in traceability and attribution.

Better monitoring would not only validate **the effectiveness of the mechanism** but also alert it to its **perverse effects** (e.g. distortions between countries, double counting). In short, a rigorous assessment is the key to **adjusting the rules** and maximising the climate impact of guarantees of origin. The Norwegian example illustrates the idea that the absence of follow-up encourages counterproductive behaviour.

***GO's Net Import/Export in 2024***




Source : AIB

Here we can observe a flagrant imbalance between German imports and Norwegian exports. The current situation in Europe is a perfect illustration of the shortcomings in the monitoring of guarantees of origin. On the one hand, Germany, a net importer, is behaving virtuously by supporting the demand for renewables. On the other hand, **Norway stands out for its massive exports that are disproportionate to the size of its market.** Over the last ten years, using the market based calculation, the country has imported more than 400 Mt of $CO_2$, which amounts to more than doubling its footprint, via this mechanism, for revenues estimated at 1 billion euros.

***Norway's GO exports and their impact on the country's carbon footprint***

| | Net export (TWh) | CO2 import (Mtonnes) | Average GO price (3-year average, in €/MWh) | Approximate gain (M€) |
|---|---|---|---|---|
| 2015 | 93 | 51 | 0,25 | 23 |
| 2016 | 91 | 51 | 0,25 | 23 |
| 2017 | 101 | 51 | 0,47 | 48 |
| 2018 | 53 | 26 | 0,62 | 33 |
| 2019 | 66 | 27 | 0,73 | 48 |
| 2020 | 51 | 21 | 0,42 | 22 |
| 2021 | 66 | 29 | 1,00 | 66 |
| 2022 | 90 | 48 | 3,21 | 289 |
| 2023 | 89 | 53 | 3,34 | 296 |
| 2024 | 91 | 49 | 2,50 | 228 |
| **Total** | **791** | **405** | | **1 076** |

*Sources: AIB, Icap, Commerg*

While this amount may seem high (more than 1 billion euros of income), it is actually negligible compared to the scale of "imported" emissions. In term of carbon acconting, Norway becomes one of the most poluting country in the world. Physically speaking, the climate impact is a huge drop of the European GO market price leading to less financial incentive to invest in renewable energy. Current trade is creating a political distortion: Norway is profiting from its historical hydropower infrastructure, while outsourcing its carbon footprint to Europe. Worse, the Norwegian government, under the leadership of Mr. Støre, is officially promoting a location-based communication to enhance the value of its national industry, while benefiting financially from the European GO market — a double discourse that undermines the credibility of the system.

***Norwegian government officially supporting location-based communication for domestic companies***

New measures to preserve Norwegian renewable energy as a competitive advantage for business

Press release | Date: 20.03.2025 | Energidepartementet (http://www.regjeringen.no/no/dep/ed/id750/)

The government, in collaboration with the Confederation of Norwegian Industries, the Confederation of Norwegian Industries and the Norwegian Confederation of Trade Unions, has come up with several measures to ensure that clean energy continues to be a competitive advantage for Norwegian business.

– There should be no doubt that Norwegian electricity is renewable. It is crucial that we preserve renewable Norwegian power as a competitive advantage for Norwegian business, says Energy Minister Terje Aasland.

The government has long worked to ensure that the guarantee of origin scheme for electricity does not prevent Norwegian businesses from reporting that the electricity they use is renewable. In collaboration with Norsk Industri, Fellesforbundet and Forbundet Styrke, the government is now introducing several measures to safeguard clean and renewable power as a competitive advantage for Norwegian businesses.

One of the measures is to prepare a guide for Norwegian businesses on methods for calculating greenhouse gas emissions related to electricity use. The guide will help to highlight that Norwegian electricity is emission-free. In addition, the website that shows the product declaration for electricity based on trade with guarantees of origin will be changed so that it also shows the physically delivered electricity in Norway. The government will also work internationally to promote location-based reporting of electricity use, where physically delivered electricity is emphasized in sustainability reporting.

*Source: Norwegian Government*

The problem is less the attitude of Norwegian consumers than the lack of serious consideration of the mechanism by all Europeans, because this situation has been observable for a long time and has not had any media impact, for example. This case reveals a lack of consideration for the collective impact of the mechanism, but also the urgency of transparent and binding monitoring. Without this, opportunistic behaviour will continue, to the detriment of the energy transition. It should be noted that **mandatory full consumption disclosure could have a significant effect in Norway**, for example, because consumers in the country will have to make the explicit choice to turn away from local renewable production.

## *4. To overcome the sterile opposition between market-based and location-based calculations*

A common framework is essential, hence the need to establish an international standard for calculating the carbon footprint of organizations. This is why **what is being decided within the GHG Protocol and ISO is decisive for the involvement of economic players in the energy transition**.

The dichotomy between so-called location-based and market-based calculations is a source of confusion and regularly leads to misrepresentations. It is therefore essential to remember that neither of these two methods reflects physical reality in a satisfactory way. Using them to claim carbon neutrality without nuance is greenwashing. It should be added here that the market-based calculation should rather be described as "contract-based", because it is based on the attribution of the origin of the electricity via contracts (guarantees of origin, PPAs, etc.). Location-based and market-based calculations are useful but are not opposable methods in terms of communication. To do so is to be tempted by fallacious declarations of proximity to physical reality while limiting the positive dynamic of voluntary action in favor of the energy transition.

It is true that the current mechanism may seem unfair: putting a company covering 100% of its consumption with EACs on the same level as another investing in new means of production (via PPAs for example) raises questions. This criticism is legitimate but incomplete. Comparing a company committed to being 100% renewable over the long term (even via EACs) to another whose PPAs represent only 5% of its consumption is also unfair. A massive commitment, even if it seems "unadditional" in the short term, can have a systemic impact on renewable investments. The Dutch example perfectly illustrates this dynamic where collective demand has an impact on the energy transition. In this country, many large consumers, including the electricity grid and the railway company, have chosen to cover 100% by GOs, including for gr losses. As a result, the country has seen the emergence of an active market for unsubsidized PPAs and an accelerated growth in renewable capacity. This example shows that fragmented but massive demand creates a strong price signal, stimulating investment without direct attribution to a single actor.

We propose to evolve towards two methods with two complementary objectives. Location-based and market-based calculations find their place in a coherent and harmonious way.

- **Attribution method**: this method consists of distributing CO2 emissions according to the origin of the electricity produced which is attributed to a consumer.
  - **Objective**: To spread $CO_2$ emissions to bring out the **responsibility of each consumer, and in particular companies**.
  - **Effect**: A common basis allows for **a transparent comparison** between actors and exerts collective **emulation** to decarbonize the system.
  - **Key principle**: strict compliance with additivity, i.e. exhaustive accounting without double counting of CO2 emissions.
  - **Limitation**: It does not measure the direct impact of an actor

**The attribution mechanism must be universal and robust**. To properly compare companies around the world, it is necessary to define a single, transparent method for attributing $CO_2$ emissions to each player, based on their actual electricity consumption. This rule should be applicable to all organizations, regardless of their sector or size. It must also be robust and therefore based on verifiable data (e.g. local energy mix, recognised contractual tool).

**Why is attribution alone not enough?** While this mechanism is essential for establishing accountability, it must be complemented by an assessment of concrete and additional actions. An international standard should therefore include attribution as a common base but also additionality as a lever for excellence (e.g. investments in new means of production).

- **Consequential method**: this method consists of assessing the impact in terms of decarbonization attributable to a specific consumer thanks to its action (avoided emissions).
  - Objective: To assess the **impact of an action directly attributable to an actor** (e.g. emissions avoided through a PPA or a reduction in consumption).
  - Effect: Promotes additional actions (investments, innovation) and encourages exemplarity.

There is a synergy between the two methods. Attribution is often the prerequisite for initiating consequential actions (e.g., PPA, self-consumption). Consistency is necessary. These two approaches are not opposed but reinforced. The attribution stimulates demand and creates collective emulation to support the energy transition and in particular investment in renewable energies. The consequential method accelerates the transition by targeting measurable emission reductions. Example: A company that initially covers 100% of its consumption with EACs can then invest in a dedicated solar park, thus combining collective responsibility and individual impact.

**This approach uses location and market-based calculations according to the maturity of the regulatory frameworks.**

To ensure both **fairness** and **effectiveness**, an international standard should distinguish between two contexts:

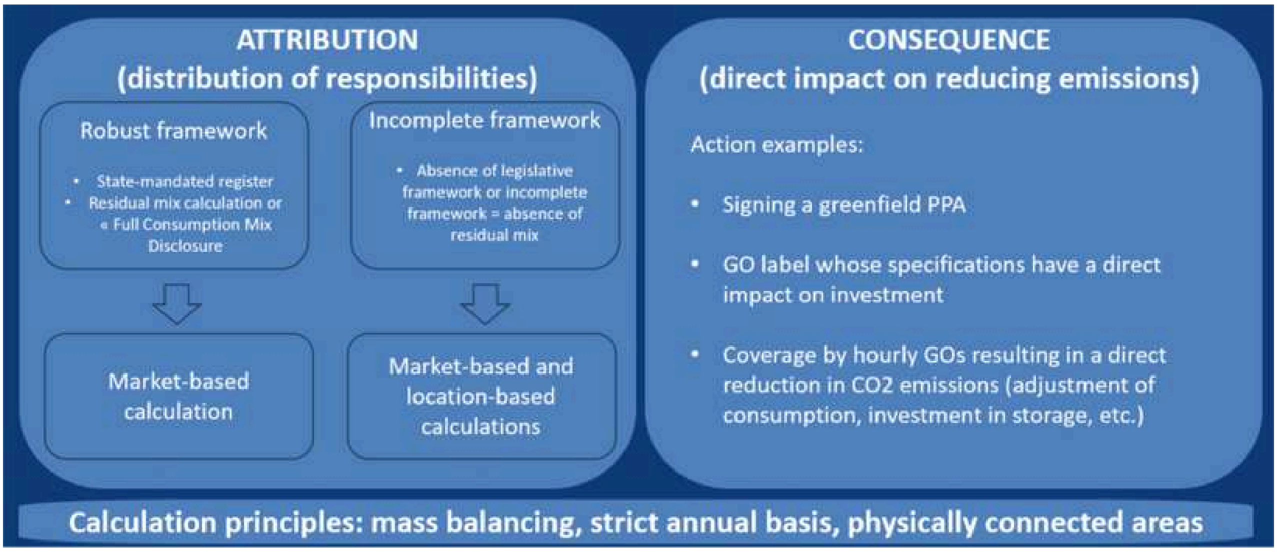
> **There are areas with a robust regulatory framework.** In regions where the principle of additivity is protected (e.g. calculated residual mix or full consumption mix disclosure), **only the market-based method should be used for the attribution of the carbon footprint.** One of the advantages is the stimulation of demand for renewable energies, promoting a dynamic market. By way of example, we can mention the European Union (with the AIB), where we are already observing the strong potential of what we can call a collective additionality that does not emanate from the action of a specific consumer but from the acceptance of all to participate together in a virtuous mechanism. In addition, allowing parallel communication using location-based calculation allows companies to avoid assuming their responsible electricity purchasing policy. The case of the Norwegian industry and the support of their government is an example.
>
> **In addition, there are areas where the regulatory framework is incomplete.** In regions where the principle of additivity is not guaranteed (no residual mix, risk of double counting), **the market-based calculation must be accompanied by a location-based calculation.** Location-based calculation will ensure a minimum comparability of carbon footprints without double counting (compliance with additivity) and the market-based calculation will still encourage consumers to act, especially international companies with a large presence around the world.

**An attribution method is a foundation for virtuous actions.** This approach allows for a fair comparison between consumers, based on transparent rules as well as the emergence of a minimum price signal, encouraging players to take additional action. **But we must strive for a better assessment of the direct impact of each consumer**. Virtuous actions — directly attributable to an organization — must be identified and valued separately via a consequential method. There are many examples of actions such as investment in new carbon-free means of production (PPA, self-consumption), demand reduction (energy efficiency, behavioural change) or technological innovations (storage, flexibility). The consequential method can use market-based calculation and adapted contractual tools because they are effective. Thus, an EAC is required for the signing of a PPA. It makes it possible to have an impact on the attribution of a carbon footprint reduction while highlighting that the PPA has a measurable impact on the decarbonization of the electricity grid.

For an effective energy transition, the rules of the game must be clarified by clearly explaining the role of each method (allocation vs. consequential) while valuing progressive commitments (from total coverage to additional actions). A company could thus communicate on its attributed carbon footprint (according to the standardised method) as well as on its avoided emissions thanks to additional actions (PPA, energy efficiency). Attribution creates a framework for accountability. Additionality, on the other hand, allows actors to differentiate themselves through more concrete actions. Together, these methods accelerate the transition by combining collective pressure and individual leadership.

In conclusion, we propose the following framework for the basis of an international standard.

***Principles for an International Norm***



# II - Hourly EACs: a false good idea

## *1. A tool that is out of step with the realities of the electricity market*

The proposal to introduce hourly EACs — i.e. to match the average power consumption during one hour to an average power production over the same hour — is based on an attractive argument: to get closer to physical reality to promote the decarbonized balancing of the grid. Apart from the fact that an EAC can in no way allow a consumer to dream of an exclusive and direct physical link with a producer, this approach raises major structural problems in terms of market architecture.

First, it is important to remember that the current purpose of EACs is not to contribute to the grid balancing, this function being already provided by the so called power market built around the concept balance responsibility. We talked about this in the opening remarks at the beginning of the article. If we want EACs to make it possible to finance part of the energy transition, it is necessary that a price emerges from the market balance. We observe that this is possible with an EAC at an annual matching. We talked about this in Part I of the article. If no market value emerges, then the EAC only allows a simple reallocation of the origin of the electricity used by consumers without any impact. This is where the criticism of greenwashing makes sense, and this criticism is valid for both an annual and hourly mechanism. So, to distinguish a mechanism that is greenwashing from a potentially virtuous mechanism, we will reflect on the ability of an hourly EAC to bring out market price signals, at least in theory.

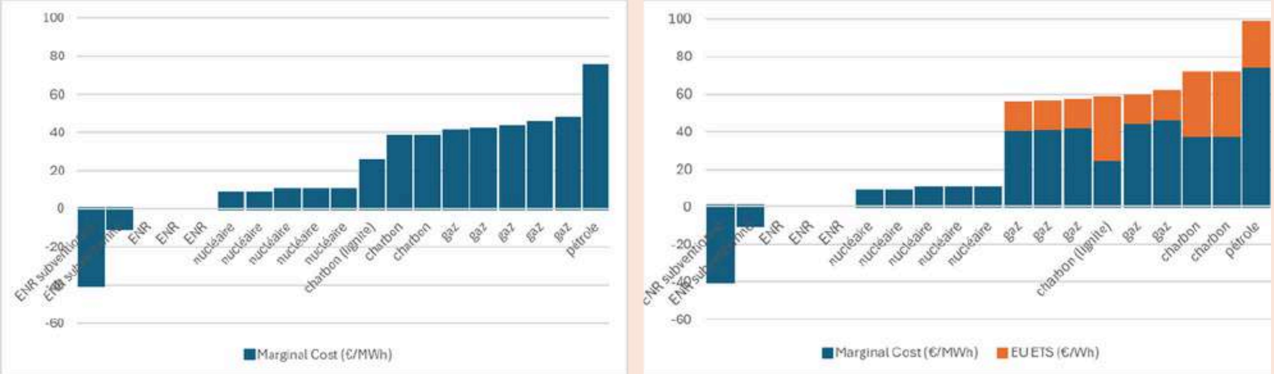
**The power market is already designed for decarbonised balancing.**

The power market operates on the principle of balancing responsibility, where players are financially sanctioned in the event of an imbalance. This mechanism:

- Naturally favours carbon-free production that have low marginal cost, unlike fossil fuels.
- Already includes a strong price signal in the EU via the carbon market (EU ETS : obligation to purchase $CO_2$ allowances for each MWh of fossil fuel produced).
- Generates meaningful hourly prices (positive or negative) because the balance responsible is contractually committed to financially assuming the balancing cost under penalty of facing the legal system. It is the strength of this contractual commitment compared to EACs

### *Formation of the electricity market price (balancing responsibility)*

**Power market hourly price = marginal cost (mc) of the most expensive power plant activated**




Note 1: The mc of carbon-free production methods is significantly lower than that of fossil fuels.
Note 2: The CO2 market (EU ETS) further increases the mc of fossil fuels.
Note 3: willingness to pay depends on **fear of balancing costs (power market) and fear of penalties (EU ETS)**, hence the significant prices achieved in this market.

**This market provides significant hourly price signals for decarbonised balancing.**

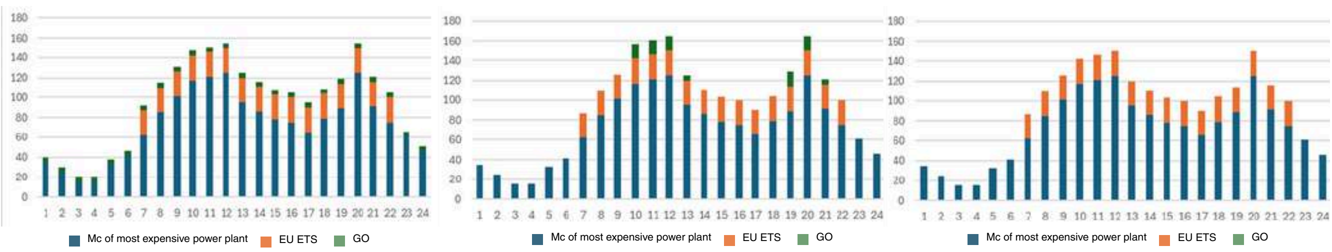
**Hourly EACs, on the other hand, cannot intrinsically generate significant hourly prices. This is a fundamental error in market architecture for two reasons.**

**First, the shift to hourly EACs with flexible targets (X% instead of 100%) leads to a decrease in demand.** The reason why an annual matching EAC mechanism can reach a market balance is that most corporates or power suppliers commit to be covered at 100%. This leads to a significant volume of EACs demand that can lead to high market prices. This is particularly visible in Europe. The idea of introducing an hourly EAC implies having a different price for each hour and is accompanied by a renunciation of having a target of 100% coverage by renewable EACs. For example, the RE100 initiative (446 companies committed to 100% renewable) is based on clear and engaging targets. In this case, there is a reputational risk for companies that would eventually renounce this commitment. With hourly EACs, the target to be reached becomes flexible and the comparability of targets between consumers disappears i.e. coverage of 84% one year and 87% the following year (without additional effort) becomes justifiable, emptying the mechanism of its substance. Companies that have already reached their target of 100% coverage will be invited to reduce this engagement rate without reputational risk. This will necessarily reduce the volume of demand. In addition, this transition could encourage some companies to abandon this voluntary commitment or, at least, take time to put it in place. During this transition phase, as they have no incentive to maintain their annual coverage at 100% on an annual basis, as it is no longer recognized to decarbonize, they will renounce this commitment as well. This drop in volume destroys the market balance and therefore there is no hope of a significant price. This effect should be more important in emerging countries because the cost and complexity of hourly EACs will be a major obstacle.

**Secondly, and above all, hourly EAC opens the possibility for the consumer to avoid any financial effort by arbitrating, or in other words cherry pick, each hour. Cherry picking is the fact of giving up the purchase of the EACs necessary to cover the volume of used electricity each time the task proves arduous.** As a reminder, the electricity market puts a lot of pressure on buyers (balance responsibles) because there is the fear of having to pay the balancing cost. The EAC market is different. In a voluntary market, there is no direct financial penalty for non-coverage of hours, the equivalence of being imbalanced in the power market. The only consequence of not purchasing an hourly EAC is a slight increase in the carbon footprint through the market-based calculation. The incentive for cherry-picking exists because players can systematically avoid hours that are difficult to cover, without impacting on their overall commitment and without facing reputational risk. A more flexible target, as explained in the previous paragraph, will make it easy to avoid any EAC that could be priced significantly.

***Hourly market price for renewable power production***

***Three scenarios in Europe: one with annual GOs (left) and two with hourly GOs (center and right)***




Where the annual or monthly EAC makes it possible to provide a baseload value to the production of renewable sources (left-hand graph), the hourly EAC erases any value because the consumer will simply avoid complicated hours (right-hand graph). Worse still, if a highly committed consumer insists on paying for a few complicated hours, this value will directly enrich either an intermediary (trader) or a producer, but this will not have an incentive effect to decarbonized balancing means, since the effort of this consumer to hedge himself will not be followed by the others. An EAC offered at a high price to an instant, which an uninformed consumer would be likely to accept, does not mean that the market price will be high. Some will pay this price because they will be the victim of information dichotomy at their expense. To use a trader's term, they will be "arbitrated" by better-informed players who get rich at their expense. But in general, the difficulty in obtaining the EAC sought will simply lead to the renunciation on the part of consumers who do not fear significant repercussions. Thus, the possible price signal over a few hours (center graph) will be sporadic and ephemeral at best. As the market consensus for hourly EACs will inevitably tend towards €0/MWh, it is the assured death of any price signal for investment in renewable energies, decarbonized flexibility solutions (batteries) and more generally for the energy transition.

**Why is the risk of cherry picking specific to hourly EACs?** This risk does not apply in the context of an annual or monthly matching because if the price reaches a significant level, 6€/MWh for example, the consumer's decision will be to give up the target he has set for himself, which is generally 100% by a given horizon. The reputational risk then becomes more obvious. In this case, there is no market design error. The EAC market complements the electricity market, which already values the contribution of a means of production to the balancing of the grid.

**In short: Why is an hourly EAC as a standard doomed to failure?**

### The incompatibility with the voluntary logic...

A market where companies are committed to 100% coverage with annual EACs creates a price signal for renewables if the market is balanced, i.e. if demand is close to supply. We have observed that this is the case in the European hub of the AIB, the problem being the non-existence of the rule of strict annual matching. In this configuration, the consumer is not encouraged to arbitrate according to price unless he clearly renounces his environmental commitment. With a shift to hourly EACs, the consumer will avoid any difficulties because of the cherry picking opportunity inherent in this system.

### … and consequently the illusion of a significant price…

**The obvious error in the theory of the interest of an hourly EAC lies in the fact that all the value is concentrated in the hours that consumers will necessarily avoid**. In addition, the available volumes (hydro, nuclear, existing renewable energies) will quickly saturate demand for years to come, while consumers apply this new approach, preventing any scarcity (and therefore any incentive price).

Proposing a voluntary system of hourly EACs is like playing football with soap bubbles: each shot given (a rare and therefore expensive EAC) bursts the bubble (renunciation of the purchase), without being able to score a goal (significant market price consensus).

### …and finally, a destruction of value.

Not only is this proposed standard a theoretical error on the ability of hourly EACs to generate significant prices in a voluntary market, but its passage will destroy all the potential value of the current mechanism. The expected effects of a voluntary market will therefore be postponed until... never. **Wind/solar PPAs (long-term purchase contracts) would lose their attractiveness,** as buyers turn to "low-cost" solutions (existing EACs, without additionality). **They complicate the market** without bringing any benefit for a decarbonised balancing. **They risk diverting budgets** to intermediaries rather than to new renewable projects.

Hourly EACs are seductive only because of the illusion they give of faithfully representing physical reality, but, at the cost of this illusion, they add a lie, that of being a sensible economic solution. Hourly EACs are a mirror of larks: they give the illusion of increased precision but destroy a mechanism that already works even if it absolutely needs to be perfected, in particular by imposing strict annual matching. For a decarbonised balancing, it is better to rely on existing tools: balancing responsibility, $CO_2$ quotas, and strict calendar annual matching EACs.

| Problems | Consequence | Further explanation |
|---|---|---|
| **Hourly Cherry-picking** | Players avoid complicated hours → no strong price signal. | A company covers X% of its "easy" hours, but ignores peaks in demand. |
| **Decline in demand** | **Destruction of the market balance** | This balance, already fragile and which suffers from the absence of a strict annual matching, will be destroyed for a long time with the transition of an international standard to hourly EACs |
| **Risk of exclusion of countries** | Such an international standard risks excluding many emerging countries for a while | The implementation of legislation and technical tools will be an obstacle. |
| **Dependence on intermediaries** | The budgets allocated to hourly EACs benefit the providers of the IT service necessary to keep up with the hourly matching and not to make the transition. | A consumer will use the services of a dedicated IT service company to which it will have to communicate strategic information and will risk creating a relationship of dependency. |
| **Administrative complexity** | High implementation costs (hourly monitoring, audits) → reduction in traded volumes. | Most of the consumer's budget will finance either a market intermediary (trader) or, and above all, the IT service company that he will have to pay to implement time tracking. |

The promoters of hourly EACs are aware of the existence of this structural problem. Having no rational answer, it is not uncommon to obtain the objection that the academic world supports their product. This rhetoric is commonly named the argument of authority. We propose to analyze if this academic support really exist in the next part.

## *2. Critical Analysis of Academic Studies on hourly EACs: Biases, Limitations, and Perspectives*

### Limited and biased academic support

Among the list of academic work supposedly in favor of the establishment of an hourly EAC as an international standard according to Energy Tag (see Annex), a limited number of studies attempt to demonstrate the economic interest of hourly EACs in reducing CO2 emissions from an electricity grid. The other publications deal either with the topic of hydrogen or with the way in which the hourly EAC mechanism can be implemented. In fact, only eight publications attempt to demonstrate this, and the sources are very concentrated because seven of them come from two teams, that of Dr. Jesse Jenkins (Princeton University) and that of Dr. Iegor Riepin (University of Berlin), both supported and funded by Google. The other publications (Denmark Technical University and TU Munich) refer mainly to the work of Dr. Jenkins' team without significant contribution. These studies share similar methodologies, common biases, and conclusions that are overly favorable to the hourly matching according to their own results. We will come back to these biases. Insofar as it is essentially the work of those two teams that brings together the key ideas of all the publications reviewed, we return to some essential points of two major studies. The criticisms relating to his two studies proved to be valid for all subsequent works.

*System-level Impacts of 24/7 Carbon-free Electricity Procurement*

*Authors: Qingyu Xua, Aneesha Manocha, Neha Patankarc, Jesse D. Jenkins*
*Release date: 16/11/2021*
*Funding: Google*
*Aknowledgments: "The authors wish to acknowledge members of the Google energy team for thoughtful comments and inputs on earlier drafts of this report."*

The approach of the study consists of simulating, in a model, the effect on the decarbonization of an electricity grid of the coverage by consumers of a part of their electricity consumption with carbon-free energy. It should be noted that this coverage is necessarily done by means of EACs. The authors first simulate the impact of 100% coverage with EACs at annual matching and then with hourly EACs according to several coverage rates. The costs associated with the procedures are also simulated and require a critical eye.

We propose here to come back to an analysis of a simulation carried out on the Californian grid. The authors choose to estimate the impact in two cases, that of voluntary consumer participation of 10% and 25%. This study, as well as other subsequent studies, simulate other grids. We have not observed any cases that strongly contradict those proposed here.


C&I Cost Increase Compared to the Reference in California (2020US$/MWh)

| **Reference**<br>Reference California Participating C&I Cost = $48.7/MWh | | 100% Annual Matching (*ex post* CFE = 75%) | 24/7 Hourly Matching (Target CFE = 88%) | 24/7 Hourly Matching (Target CFE = 98%) | 24/7 Hourly Matching (Target CFE = 100%) |
|---|---|---|---|---|---|
| Available Technology | Current Technologies | 1.4 (+3%) | 10.3 (+21%) | 19.2 (+39%) | 31.0 (+64%) |
| | Advanced Technologies, No Combustion | 1.4 (+3%) | 10.1 (+21%) | 18.9 (+39%) | 29.1 (+60%) |
| | Advanced Technologies, Full Portfolio | 1.4 (+3%) | 8.0 (+16%) | 14.3 (+29%) | 18.8 (+39%) |

We can make the following observations:

1. While 25% of consumers cover themselves at 100% on an annual matching basis, 5 million tonnes of emissions are avoided on the grid (1) at a cost of around $52/MWh, i.e. a premium of less than $3/MWh (2).
2. 25% of consumers need to be covered at 86% on an hourly basis to achieve a similar level of emission reduction (4) which, in theory, adds a premium of about $9/MWh depending on the technologies available (5).
3. 10% of consumers must be covered 100% on an hourly basis to achieve a similar level of emission reduction (3), which, in theory, would cost between $18.8 and $31/MWh depending on the technologies available (see table).

The conclusions from the simulation results therefore seem:

- That the hedging mechanism at annual matching has a significant effect on the decarbonization of an electricity grid.
- That the mechanism of hedging on an hourly basis has an even more significant effect only when the premiums to be paid by the consumer become very important.
- The premiums are based on average costs per technology, which implies a purchasing process limited to large consumers with an initial financing capacity (cash, credit) and a long-term vision.
- The premiums are estimated in the long term, which leads to a high degree of uncertainty about the realisation of these premiums and the necessary confidence in the models.

Finally, we propose a critical analysis of the authors' conclusions

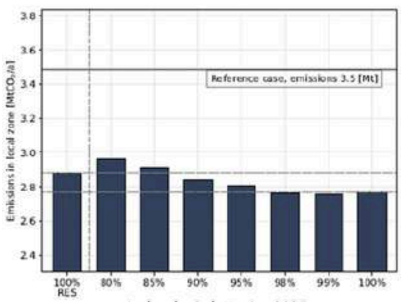
| **A 24/7 supply of carbon-free electricity (CFE):** | **Comments from QuiEstVert** |
|---|---|
| Can eliminate carbon dioxide emissions associated with a buyer's electricity consumption, going beyond the impact of procurement of renewable energy to meet 100% of annual volumetric demand. | This first comment is strange since it's the authors that define the hour as a unit. Logically, annual matching EACs cover only part of the hourly units of a consumption profile. If the unit would be the second, an hour matching EAC would couver only part of the consumtion profile. |
| Can drive greater system-level emissions reductions than 100% annual matching if the CFE target is high enough. | It all depends on the ability of the mechanism to encourage a consumer to voluntarily stick to a sufficiently high objective. This ability is not tested in the study thus this key finding is irrelevant. |
| Drives early deployment of advanced, 'clean firm' generation and/or long-duration energy storage, creating initial markets for deployment, innovation, and cost-reductions that make it easier for societal at largeto follow the path to 100% carbon-free electricity. | Again this is before all related to the wilingness of a consumer to stick to a high objectif and its wilingness to pay the premium. Since the study does not test this, the key finding is irrelevant. |
| Better matches participating demand during periods of limited supply and thus drives significantly more retirement of natural gas generating capacity than 100% annual matching | For the same reasons mentionned above, this key finding is irrelevant. |
| Comes at a more significant cost premium relative to100% annual matching; this premium is significantly reduced if a full portfolio of clean firm resources is available and procured and/or CFE targets below 100%are selected. | If the cost is greatly reduced by lowering the target, it is because this target no longer becomes an incentive for the energy transition |

### *System-level impacts of 24/7 carbon-free electricity procurement in Europe*

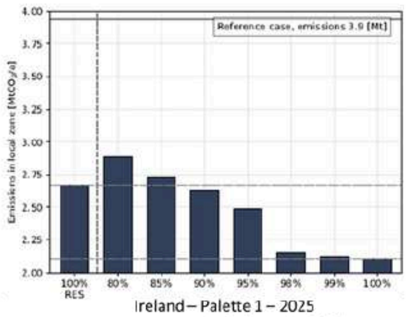
*Authors: Iegor Riepin, Tom Brown*
*Release date: 11/10/2022*
*Funding: Google*
*Acknowledgements: The authors thank members of the Google energy markets and policy team for their feedback and inputs on earlier drafts of this report."*

The approach of the study is very similar to the previous one. It consists once again of simulating in a model the effect on the decarbonization of an electricity grid of the coverage by consumers of part of their electricity consumption with carbon-free energy. The authors first simulate the impact of 100% coverage with EACs on an annual matching and then with hourly EACs according to several coverage rates. The costs associated with the procedures are also simulated.

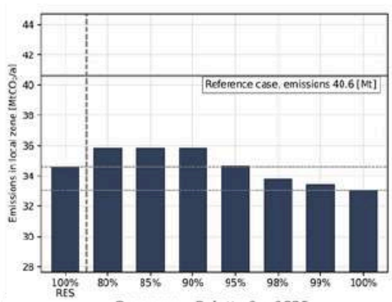
We offer you an analysis of a simulation carried out on the Irish and German grids. We have not observed any cases that strongly contradict those proposed here.




Ireland – Palette 1 – 2025
consumer participation rate: 10%

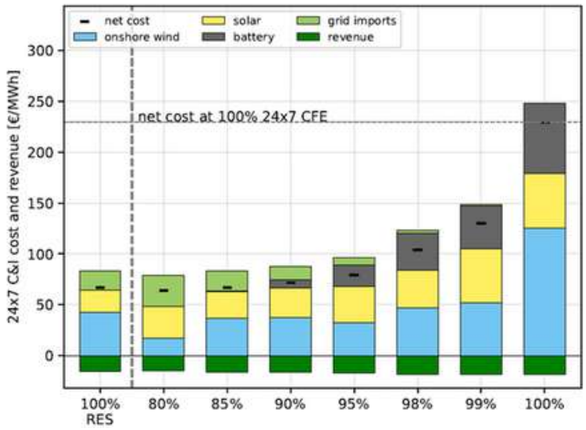



Ireland – Palette 1 – 2025
consumer participation rate: 25%




Germany – Palette 3 – 2025
consumer participation rate: 25%

| Zone | Palette | 100% RES | 98% CFE 2 | 100% CFE |
|---|---|---|---|---|
| IE | Palette 1 | 67.1 | 104.2(+55%) | 229.4(+242%) |
| IE | Palette 2 | 67.1 | 84.6(+26%) | 98.6(+47%) |
| IE | Palette 3 | 67.1 | 81.0(+21%) | 88.1(+31%) |
| DE | Palette 1 | 80.5 | 98.3(+22%) | 193.5(+141%) |
| DE | Palette 2 | 80.5 | 92.2(+15%) | 113.5(+41%) |
| DE | Palette 3 | 80.5 | 82.9(+3%) | 88.6(+10%) |
| DK1 | Palette 1 | 56.0 | 70.3(+26%) | 153.7(+175%) |
| DK1 | Palette 2 | 56.0 | 65.2(+16%) | 84.7(+51%) |
| DK1 | Palette 3 | 56.0 | 62.7(+12%) | 77.1(+38%) |
| NL | Palette 1 | 63.7 | 91.1(+43%) | 172.1(+170%) |
| NL | Palette 2 | 63.7 | 78.6(+23%) | 92.2(+45%) |
| NL | Palette 3 | 63.7 | 73.5(+15%) | 82.5(+29%) |




Ireland – Palette 1 – 2025
consumer participation rate: 10%

We can make the following observations:

1. A significant effect of 100 % annual matching coverage compared to a scenario without coverage on emissions to local areas (difference with the reference case)
2. There is little difference in impact between an annual matching at 100% and an hourly matching up to a target of 95% coverage in Germany and Ireland.
3. A noticeable effect based on an hourly matcing target of 98% (1) but with significant premiums (2).

We can observe from the simulations that here again the authors' conclusions omit the interest of the annual matching and deny the problem of consumers' willingness to pay.

We again propose a critical analysis of the authors' conclusions

| Key findings from the authors | Comments from QuiEstVert |
|---|---|
| 24/7 carbon-free energy (CFE) procurement leads to lower emissions for both the buyer and the system, as well as reducing the needs for flexibility in the rest of the system. | This requires being confronted with the willingness of consumers to pay voluntarily, a willingness that must include the internal organization for the management of this mechanism |
| Reaching CFE for 90-95% of the time can be done with only a small cost premium compared to annually matching 100% renewable energy. 90-95% CFE can bemet by supplementing wind and solar with battery storage. | Yes, but the study shows limited results on the decarbonization of grid when consumers reach percentages under 95%. |
| Reaching 100% CFE target is possible but costly with existing renewable and storage technologies, with costs increasing rapidly above 95%. | We observe that the significant impact on emissions reduction starts only at that moment. Thus, without the proof of a consumers williingness to pay, this key finding is irrelevant |
| 100% CFE target could have a much smaller cost premium if long duration storage or clean dispatchable technologies like advanced geothermal are available. | Yes, but they are not. It is not hourly EACs that will solve this industrial problem. |
| 24/7 CFE procurement would create an early market for advanced technologies, stimulating innovation and learning from which the whole electricity system would benefit. | There is no clear link between this conclusion and the study. The cherry picking loophole created by an hourly GOs and the unproven willingness to pay are too heavy factors to consider this key finding relevant. |

**As a conclusion those studies should not conclude that an hourly EAC would be introduced as an international standard.**

The studies in question systematically conclude that hourly EACs have a greater impact on the decarbonisation of an electricity grid if there is a significant participation rate and if consumers pay a significant premium. However:

- **There is no analysis that assesses consumers' willingness** to bear these additional costs (propensity to pay). This is essential when analysing a voluntary market.
- **A biased long-term vision**: Costs are calculated based on the estimated average production costs over the life cycle of the installations. As an electricity buyer, this reasoning only **concerns a few large consumers** (e.g. data centers) capable of financing dedicated infrastructures. Most players cannot commit to such investments and buy electricity based on its market price with horizons generally ranging from 1 to 4 years.
- **An implicit preference for the annual matching**: Ironically, the most credible simulations of these same studies show that: massive decarbonization is possible with annual EACs, as long as a large number of participants commit (e.g.: 25% participation rate for 100% coverage at annual time). However, these participation rates are much more credible than those related to hourly EACs.

## The propaganda of the "physical link" of hourly EACs masks the economic error concerning it.

The myth of physical link between a specific consumer and a specific producer is persistent discourse. The promoters of hourly EACs systematically brandish the argument of physical reality to justify the existence of this product. However, this claim is based on two errors.

### Mistake n°1: The hourly EAC does not create any more physical link between a power consummer and a power station than an annual matching EAC

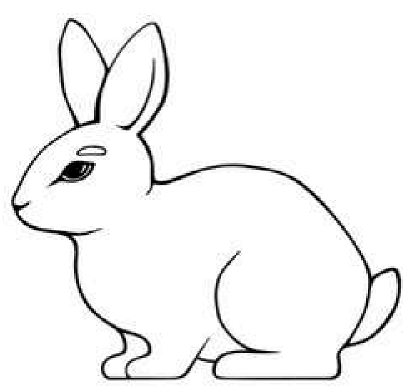
Whether it is **annual, monthly or hourly,** an EAC remains an **accounting tool** based on the principle of mass balance:

- **No "green" electrons are physically traced** to the consumer. It is also wrong to consider that we use electrons. This rhetoric leads to fallacious reasoning such as using Kirchhoff's laws to justify that we use the electrical energy of the nearest power plants. As soon as we use a sufficiently interconnected grid, geographical distance no longer matters because we, as consumers, have a direct and instantaneous impact on the entire electricity grid.
- **The link to a specific plant is an abstraction**: whether the EAC is hourly or annual, the consumer does not receive electricity from a specific wind or solar farm. For example, a company buying an hourly EAC to cover its consumption from 2 p.m. to 3 p.m. does not physically consume the electricity of a wind farm that generates power within that time period.

### Mistake n°2: The illusion of an economic impact on decarbonization

Beyond the false physical promise, the hourly EAC cannot solve the challenge of the decarbonized balancing of the grid because it is a tool intrinsically incapable of having significant market prices.
As we explained earlier, it does not generate any strong economic signals in the context of a voluntary market. Unlike the electricity market, cherry-picking (avoidance of expensive hours) and the absence of constraints (targets below 100%) prevent any scarcity, and therefore any incentive market price.

***An anecdotal approach to the real world***



Which of these images is closest to a real white rabbit?
If you want a real white rabbit at home, and you are offered one of these images to stick on your wall, would you be satisfied?

The value proposition of hourly EAC is limited to satisfying a metaphysical fantasy consisting in making people believe that we are getting closer to physical reality. What is serious is that the debate on hourly EACs diverts attention from the real tools of the decarbonized balancing:

| Tool | Real impact | Effectiveness |
|---|---|---|
| **Carbon allowances** | Sanctions fossil emissions → **effective reduction of $CO_2$.** | if carbon price incentives |
| **Balance responsibility** | Penalises imbalances → promotes low-carbon flexibility. | Especially when the price of fuels is high (gas, coal, oil) |
| **annual matching EAC** | Creates a price signal for each MWh of electricity produced from a virtuous source. It is a complement to the electricity market that makes it possible to reduce or avoid subsidies. | If the market is balanced |
| **PPA** | Directly finances new wind/solar farms. | Additionality when it relates to new means of production |

**What is the interest in the hourly matching?**

While hourly EACs should not be used to establish standards or laws applicable to all consumers, they can nevertheless be of interest. For very specific sectors (data centers), a complementary approach (in addition to annual EACs) could help optimize balancing for highly concentrated and flexible consumption. This is on the condition that greenwashing is avoided by covering only the volumes that are easy to access at an hourly pace.

# Conclusion : Stop the illusions, let's focus on what works !

The voluntary market for guarantees of origin is popular and is showing concrete effects. Unfortunately, these are not satisfactory. The mechanism must be improved: it must be made more robust, more credible and its impact on the energy transition must be better monitored. To do this, it is necessary to set objectives for this voluntary mechanism.

It is imperative that the strict annual matching and the existence of physical links be the norms for exchanging and using EACs. We must also get out of the toxic opposition of location and market-based calculations, which are simply complementary accounting calculations that should be used for consumer action. These calculations find their place in carbon accounting methods that should be based on attribution principles in order to share responsibilities and act collectively for the energy transition, as well as in consequential carbon accounting methods that make it possible to value actions that have an impact on the decarbonization of the electricity grid that are attributable to a specific consumer.

Hourly EACs are a niche tool at best. They do not bring us closer to physical reality (the mass balance remains an abstraction). They do not solve the issue of decarbonising the electricity grid (no hourly price signal because of cherry picking, no additional investments in renewable energies). To put it another way, they do not provide better traceability from an attributional point of view and do not have an obvious impact from a consequential point of view. Moreover, by making it a standard, they will sabotage what has been achieved (annual EACs, PPAs) by fragmenting the market and diverting budgets to intermediaries. We will lose precious time. It's certainly not an innovation. Hourly guarantees of origin have been in existence for more than 15 years now and have never shown any interest (very limited demand) or impact.

The energy transition needs concrete solutions, not accounting fantasies. Hourly EACs are a red herring, carried by lobbies that prefer illusions to real actions. To decarbonize the grid, we need to focus on what works: balancing responsibility, $CO_2$ quotas, and long-term commitments (PPA, annual EAC). The update of ISO standards and the GHG Protocol is a great opportunity to support the voluntary commitments of businesses and consumers. And we in the EU need the rule of strict annual matching to be imposed in legislation.

Let's not miss the boat! The energy transition is an emergency; we don't have time to procrastinate!

# Annex : Academic papers supporting mandatory hourly EACs according to Energy Tag

| Title | Authors | Paper | Institution | Publication year | Subjet |
|---|---|---|---|---|---|
| System-level Impacts of 24/7 Carbon-free Electricity Procurement | Qingyu Xu, Wilson Ricks, Aneesha Manocha, Neha Patankar, Jesse D. Jenkins | Self published | Princeton University | 2021 | Impact of 24/7 EAC on grid decarbonization |
| Green hydrogen – How grey can it be? | Manuel Villavicencio, Johannes Brauer, Johannes Trüby | Robert Schuman Centre for Advanced Studies Research Paper No. 2022/44 | The Florence School of Regulation | 2022 | Hydrogen |
| Electricity System and Market Impacts of Time-based Attribute Trading and 24/7 Carbon-free Electricity Procurement | Qingyu Xu<br>Jesse D. Jenkins | Self published | Princeton University | 2022 | Impact of 24/7 EAC on grid decarbonization |
| System-level impacts of 24/7 carbon-free electricity procurement in Europe | Iegor Riepin, Tom Brown | Zenodo | TU Berlin | 2022 | Impact of 24/7 EAC on grid decarbonization |
| Hourly versus annually matched renewable supply for electrolytic hydrogen | Elisabeth Zeyen<br>Iegor Riepin<br>Tom Brown | Report TUB | Faculty of Process Engineering, TU Berlin | 2022 | Hydrogen |
| Minimizing emissions from grid-based hydrogen production in the United States | Wilson Ricks, Qingyu Xu, and Jesse D. Jenkins | Environmental Research Letters | Princeton University | 2023 | Hydrogen |
| The value of space-time load-shifting flexibility for 24/7 carbon-free electricity procurement | Iegor Riepin, Tom Brown | Zenodo | TU Berlin | 2023 | 24/7 EAC implementation |
| Impacts of IRA's 45V Clean Hydrogen Production Tax Credit | GEOFF BLANFORD and JOHN BISTLINE from EPRI | LCRI White Paper | Low Carbon Resources Initiative (LCRI) : It's Electric Power Research Institute (EPRI) + GTI Energy | 2023 | Hydrogen |
| The influence of additionality and time-matching requirements on the emissions from grid-connected hydrogen production | Michael A. Giovanniello, Anna N. Cybulsky, Tim Schittekatte & Dharik S. Mallapragada | Nature Energy | MIT | 2024 | Hydrogen |
| System-level impacts of voluntary carbon-free electricity procurement strategies | Qingyu Xu, Wilson Ricks, Aneesha Manocha, Neha Patankar, Jesse D. Jenkins | Joule | Princeton University | 2024 | Impact of 24/7 EAC on grid decarbonization |

| Title | Authors | Paper | Institution | Publication year | Subjet |
|---|---|---|---|---|---|
| Spatio-temporal load shifting for truly clean computing | Iegor Riepin, Tom Brown, Victor Zavala | Elsevier - Advances in Applied Energy | TU Berlin | 2024 | 24/7 EAC implementation |
| On the means, costs, and system-level impacts of 24/7 carbon-free energy procurement | Iegor Riepin, Tom Brown | Nature energy | TU Berlin | 2024 | Impact of 24/7 EAC on grid decarbonization |
| Does the purchase of voluntary renewable energy certificates lead to emission reductions? A review of studies quantifying the impact | Lissy Langer, Matthew Brander, Shannon M. Lloyd, Dogan Keles, H. Damon Matthews, Anders Bjørn | Journal of Cleaner Pr | Denmark Technical University | 2024 | Impact of 24/7 EAC on grid decarbonization |
| The Influence of Demand-Side Data Granularity on the Efficacy of 24/7 Carbon-Free Electricity Procurement | Ricks, Wilson & Jenkins, Jesse D. | Self published | Princeton University | 2024 | Impact of 24/7 EAC on grid decarbonization |
| 24/7 carbon-free electricity matching accelerates adoption of advanced clean energy technologies | Iegor Riepin, Tom Brown, Jenkins, Jesse D., Devon Swezey | Joule | TU Berlin / Princeton University / Google | 2025 | Impact of 24/7 EAC on grid decarbonization |
| The impact of temporal hydrogen regulation on hydrogen exporters and energy transition | Leon Schumm , Hazem Abdel-Khalek, Tom Brown Falko Ueckerdt, Michael Sterner, Maximilian Parzen5 & Davide Fioriti | Nature communications | TU Berlin / Potsdam Institute for Climate Impact Research / University of Applied Sciences (OTH) Regensburg / Open Energy Transition | 2025 | Hydrogen |
| Impacts From Procuring Clean Electricity Under Different Inventory Accounting Methods | Pieter Gagno Maxwell Brown | Self published | National Renewable Energy Lab / Colorado School of Mines | 2025 | Impact of 24/7 EAC on grid decarbonization |
| Temporal matching as an accounting principle for green electricity claims | Hanna F. Scholta, Maximilian J. Blaschke | Nature communications | TU Munich | 2025 | Impact of 24/7 EAC on grid decarbonization |