

Granular Tracking and Matching of Renewable Electricity -**Timing is of the Essence**

An Enel Green Power business case for 24/7 Carbon-Free Energy tracking and matching platform development.



Abstract

24/7 Carbon-Free Energy is getting a lot of attention from authorities and associations whose initiatives spotlight the future. In the long run, the impact of corporate efforts to decarbonize their Scope 2 footprints will be measured by new industry standards and rules. These standards will put more focus on the time granularity of Energy Attribute Certificates (EACs) used in their claims.

Since the first half of 2021, Enel Green Power (EGP) has been developing a scalable solution to enable renewable electricity generation tracking and matching of a customer's consumption. This platform provides different time granularities (down to hourly resolution), while taking into consideration customer preferences and contractual arrangements for Time-based Energy Attribute Certificates (T-EACs) allocation. Those TEACs can also be generated managed using blockchain technology.

EGP's solution integrates these new advanced features together with classical management and dashboard tools to monitor the issue, transfer, redemption, and cancellation of existing EAC schemes: Guarantees of Origin in Europe, Renewable Energy Certificates (RECs) in the USA or International RECs (I-RECs) in other geographies, all managed by official issuing bodies through specific registries.

The platform allows various user roles – such as producer, supplier/ retailer, consumer, and auditor/verifier – with appropriate responsibilities and functionality for each group's specific needs. It also provides reporting and data visualization through an integrated dashboard.

At the end of 2021, Enel Green Power started testing this solution with five corporate clients in Chile, providing hourly tracking and matching of renewable electricity generation and client consumption. This paper describes the inception, milestones and lessons learned during EGP's Renewable Energy Attribute Certificates Tracking & Matching Platform development, as well as implementation and testing. Next steps for the evolution of the platform are also discussed.

Table of contents

1.	Introduction	04
2.	Why Develop a Granular Tracking and Matching Platform for Energy Attribute Certificates?	06
3.	Enel Green Powers's Renewable Electricity Attribute Certificates Tracking and Matching Platform	09
4.	Solution Testing with Real Customers	15
5.	Main Takeaways and Next Steps	22

Introduction

Currently, the electricity consumed at any point on a power grid cannot be tracked and classified by source. Instead, it is stamped and tracked at the interconnection points where generation power plants are connected to the grid.

With regards to renewable power plants, this certification tracking is performed by specific entities (issuing bodies) entitled to issue Energy Attribute Certificates (EACs). Examples of EACs include Guarantees of Origin in Europe, Renewable Energy Certificates (RECs) in the USA, or International RECs (I–RECs) in other geographies. These are created under specific certification schemes and standards, and use the electricity market metering information, usually audited by system operator entities.

EACs typically contain information about the renewable power plant (location and technology), as well as a time stamp recording the time period when the certified electricity volume was generated. EACs follow a lifecycle. They have a maximum lifetime (usually one year) and can be transferred, redeemed, or cancelled using specific registries. EAC schemes enable customers to purchase the right and title to a portion of the renewable electricity being produced and injected into a power grid. In addition, EAC schemes allow customers to use those volumes for the calculation of their Scope 2 CO2 emissions related to their electricity consumption in that power grid, using the United Nations Greenhouse Gas (GHG) protocol's market-based methodology.

In this way, customers can claim carbon footprint reductions for emissions associated with their electricity consumption by purchasing EACs. Those EACs may be standalone or bundled with electricity in a supply agreement. However, those EACs must be generated by renewable plants injecting electricity into the same power grid and during the same time interval when electricity was consumed. There are three aspects of this framework with obvious implications for the reliability and credibility of claims and the declared impact:

Additionality.

Whether a customers' declared emission reductions also mean a reduction for the entire system to follow the 1.5°C trajectory recommended in the Paris Climate Agreement. In other words, would the renewable power plant have been built at all without the supply agreement with this customer?

Location.

The definition of electric power grid boundaries. *Is the customer's electricity consumption point located in the same electric power grid where the purchased renewable electricity is produced?*

Time.

Definition of an EACs' time-stamp granularity. Which time interval should be used for matching purchased renewable electricity and customer's electricity consumption?

There are several ongoing discussions about these three topics at different levels within the energy sector. Generators, suppliers, consumers, service providers, policy makers, regulators, market operators, Transmission System Operators (TSOs), and Distribution System Operators (DSOs) are all involved. It is outside the scope of this paper to examine those debates. But we will explain how Enel Green Power is tackling some of those challenges. EGP is doing that by enhancing its value proposition with new solutions and more accurate tools for the entire value chain to run the last miles of the marathon to zero carbon emissions.



Why Develop a Granular Tracking and Matching Platform for Energy Attribute Certificates?

A NEW FRONTIER FOR THE INDUSTRY: 24/7 CARBON-FREE ENERGY (CFE)

Current EAC schemes and auditing methodologies provide tracking on either a monthly or annual basis. However, electric power systems rely on the real-time balance of power consumed (withdrawn) from the grid and power generated (injected), second by second, 24 x 7 x 365. The 24/7 CFE concept aims to provide enhanced **timestamping** for carbon-free electricity monitoring through **greater granularity**, thus allowing greater resolution than current EACs' schemes. This will enable **more accurate matching of renewable energy generation and consumption** – in line with electricity market trading intervals, typically hourly. **Furthermore, the ramp up of new technologies, such as batteries, and new energy vectors, such as green hydrogen, will probably require a steady evolution of time granularity if new industry standards come up in the future.**

This is a hot topic for authorities and associations. Their initiatives give a glimpse into the future where the impact of decarbonization will be measured according to new industry standards and rules:

- The United Nations launched a 24/7 Global Compact in October 2021.¹
- ENTSO-E, the European association of system operators released a position paper in July 2022² which was commented by the Association of issuing bodies the following month³.
- The ITRE committee of the European Parliament published its position in March 2022 ⁴ on RED III, which is under review by the European Parliament⁵.
- The United States Federal Sustainability Plan from December 2021 outlines a target of 100% renewable energy on annual basis and 50% 24/7 CFE sourcing by 2030 for Federal facilities.
- Eurelectric initiated a 24/7 CFE dedicated taskforce in early 2021.⁶
- Energytag was founded in 2020 and runs 3 working groups on the topic⁷.

- https://www.un.org/en/energy-compacts/page/compact-247-carbon-free-energy
- https://eepublicdownloads.blob. core.windows.net/public-cdn-container/clean-documents/ Publications/Position%20papers%20and%20reports/2022/ entso-e_pp_guarantees_of_ origin_220715%20for%20publication.pdf
- https://www.aib-net. org/newsletter/web. html?n2g=exu6l9s3-bam-8si42-158k#ENTSO_E
- 4. https://www.europarl.europa. eu/doceo/document/ITRE-PR-719550_EN.pdf
- https://www.europarl. europa.eu/news/en/press-room/20220712IPR35201/ renewable-energy-and-energy-efficiency-directives-press-conference
- https://247.eurelectric.org/
 https://energytag.org/

But let's not forget that any new industry standard or rule for EACs, as well as for carbon accounting, needs to be planned and deployed in a timely manner. Timing is of the essence to allow all stakeholders to adapt their strategies, procurement policies and internal tools at an affordable cost, with a reasonable level of effort, ultimately ensuring sustainability and adoption success.

This applies to the highest degree to **issuing bodies**, which will need to adapt their processes, databases, and registries to deal with the massive amount of metering data with greater granularity. Similarly, corporate **customers**, **no matter the size or the industry, will need to plan** for new market instruments, while ensuring continued acceleration of new renewable power plants and decarbonization of power grids through their investments and renewable electricity purchases (EACs, power purchase agreements and others) under existing schemes.

Once critical mass is reached, both in terms of grid penetration and corporate demand of renewable energy, 24/7 CFE refinement and complexity, with greater certificate time-stamp granularity, will become a key driver to finally reach zero carbon.

NEW 'TOOLS' ON THE BLOCK

Designing today the standards of tomorrow, such as 24/7 CFE, can only be achieved by developing new processes and tools to manage **Time Based Energy Attribute Certificates (T-EACs)**, also called Granular Certificates (GCs). This means engaging the entire value chain, from authorities, issuing bodies and regulators, to generators, TSOs/DSOs, consumers, and service providers.

These emerging new tools can play an important role as bridge solutions to support corporate customers interested in being front runners and gaining deeper knowledge of the real impact of their chosen market instruments. This can occur while policymakers, regulators and issuing bodies update industry standards, rules and tools to embrace better timestamping and granularity for EACs. Our main mission is to support all customers in their decarbonization journey, towards 100% renewable energy, offering solutions for all. This will enable a critical mass to fast-track renewable energy deployment. No company can be left behind, no matter the size, the industry or the experience.

Today **is the time to design, experiment and test**, to ensure T-EAC or GC platforms succeed, and become genuine full decarbonization enabling tools. **EGP's Renewable Electricity Attribute Certificate Tracking & Matching Platform** is one of the few projects that have been launched so far in different geographies. These pilot experiences are key to understanding the many challenges that lie in front of us. Therefore, **Enel Green Power strongly encourages all market participants to play an active role**, by contributing to existing and future industry-led initiatives.

However, the renewable energy industry must avoid the creation of parallel issuing schemes. The keystones and guardians of EAC systems and data integrity are, and must remain, the official issuing bodies.





EGP's Renewable Electricity Attribute Certificates Tracking and Matching Platform

SOLUTION'S HIGHLIGHTS

With the Renewable Electricity Attribute Certificates Tracking and Matching Platform, Enel Green Power has developed a scalable solution capable of:

- Tracking renewable electricity generation
- Matching it with customer consumption with different time granularities (even hourly), according to different customer preferences and contractual arrangements
- Integrating EACs from official issuing bodies with their time-stamp granularity in force at any given moment, while monitoring all the associated operations (issuing, transfers, redemptions, cancellations) between users (producers, suppliers/retailers, and consumers) during their lifetime
- Alternatively (or complementary) using blockchain upon customer request, or when no such national official body exists
- Providing all needed reporting and information presentation features through an integrated dashboard

In the first half of 2021, EGP started developing those features based on a tracking technology for the Guarantees of Origin market in Spain developed by Endesa, an Enel subsidiary. The current release of EGP's Tracking and Matching Platform has been designed both internally and with external support from Indra, a leading firm in digital transformation consultancy and information technologies.

The **renewable electricity generation is time and location tracked** according to EGP's power plants' official metering data, accessible via a data-lake. **The matching is provided by an in-house customizable ranking allocation algorithm. This algorithm inputs include** tracked electricity production and consumer-provided consumption data. **Constraints** derived from the customer's preferences and contractual arrangements, such as preferred/avoided generation sources and the year the renewable power plant started delivering energy to the grid are also included. The tool also allows **interactive exchange of all the documented evidence of any operations related to EACs**, (such as the issuing process with issuing bodies, and registration of accounts), **as well as concrete contractual obligation performance** (transfers, redemptions, cancellations).

Finally, a dashboard provides customers with easy access to the matching information and official EACs related information. In addition, key reporting indicators (KPIs) and exporting capabilities are included to provide state of the art decarbonization reporting capabilities to both internal and external stakeholders.

PROCESSES FLOW

3.

EGP's Tracking & Matching Platform offers the flexibility required:

- To manage information from EACs issued by official bodies (IB-EACs), performing the tracking and matching processes with the time-stamp granularity defined in the protocol or certification rules in force. This includes RECs in North America, Guarantees of Origin in the EU, and I -RECs and other national schemes in many other geographies
- To deal with Time-based Energy Attribute Certificates (T-E-ACs), all the way down to hourly tracking and matching based on both generation and consumption metering information. Specific inputs and/or constraints defined in the renewable electricity supply arrangements with each customer are also included.



Figure 1: Tracking & Matching Platform The process flow implemented in the solution is structured in 5 successive stages:

1. Collection of input data

3.

- 2. Renewable electricity production allocation
- 3. Allocation matching with customer's consumption according to supply arrangements
- 4. Transfer of T-EACs to customer's wallet (either in the form of blockchain tokens if requested or 3rd party audited voluntary certificates), and/or transfer, redemption or cancellation of IB-EACs in the proper registry in line with supply contractual arrangement with each customer
- 5. Visualization of data and the associated KPIs through a dashboard and reporting tool





Figure 2: Tracking & Matching Platform Process Detailed Stages

DATA GOVERNANCE MODEL

The defined **governance** of the platform (see Figure 3 below) provides a set of roles and responsibilities that allow the ecosystem to work as a whole. The roles are defined according to each user group's specific needs. The permitted functions depend on sub-processes that need to be performed in each of the process flow stages.



PLATFORM'S ARCHITECTURE AND T-EACS' ALLOCATION ALGORITHM

The following figure shows the modular architecture of EGP's Renewable Electricity Tracking & Matching Platform.



Figure 4: EGP's Renewable EACs Tracking & Matching Platform Architecture To perform the matching between generation and energy consumption, the Tracking & Matching Platform uses an **in-house developed customizable ranking allocation algorithm. This algorithm** takes into account **inputs** such as tracked electricity production, customers' electricity consumption data and preferred time granularity, as well as **constraints** derived from the customer's preferences and contractual arrangements. Constraints might include preferred/avoided generation sources, renewable power plant age and customer's preferred optimization target.

Once the algorithm provides an allocation proposal for the matching of customers consumption with the desired granularity, this must be validated by the supplier. After this validation process is complete, the T-EACs can be issued.

PLATFORM'S BLOCKCHAIN MODULE

The platform can optionally use **blockchain** to ensure transparency and data validity. It can also help to avoid double counting of electricity volumes allocated into the matching for specific customers' consumption.

Blockchain infrastructure allows the tracking of each transfer between users into the platform ecosystem. One token is associated with one MWh produced in a certain time interval by a specific power plant, which means information about time and location are coded inside the token. Each time the MWh is sent to another user and resent again to another, the code will grow, recording each transfer and addition. To know the energy's origin, the user must decrypt the token code.

In the Tracking & Matching Platform, the decryption is simplified, and users can explore energy details and history through the application interface, including the name of the power plant, where it is located, and the time of generation.

Each EAC in the Tracking & Matching Platform corresponds to 1 MWh of energy. Every batch of EACs contains the following information:

- Batch ID
- Owner & ID
- ID of the plant
- Technology
- Renewable Source
- Type of certificate
- EAC number of the batch
- Production period
- Date of issuing



Solution Testing with Real Customers

PILOT TESTING PLANNING

The Tracking and Matching Platform pilot testing engaged 5 companies in Chile who currently certify their electricity consumption with EGP's Renewable Electricity Voluntary Certificate scheme audited by an independent third-party verification entity (Sello Verde), with an overall electricity consumption of 61 GWh for the year 2021.

Customers that took part in this pilot were selected from Enel's client portfolio based on the following criteria:

- Shared views about sustainability with a clear commitment towards decarbonization to ensure full engagement
- Industry sector diversification to diversify hourly consumption
 load profiles
- Diversified customer size and internal complexity, to understand different needs and concerns related to a product such as 24/7 CFE

The pilot was carried out over an initial 9-month development and testing phase. The primary objective was to certify that 100% of 2021 electricity consumption at those customer's point of delivery was matched by tracked renewable electricity produced by a selection of Enel Green Power renewable power plants in the country, every hour of the year.

An additional feature we also tested was blockchain registration and traceability reporting tools for each MWh consumed.

WHY CHILE?

Chile was not selected by chance. A robust metering scheme, strong renewables penetration and a diversified EGP's portfolio, both on renewable generation and the customer side were important. In addition, the success of EGP's Renewable Electricity Voluntary Certificate product **(Sello Verde)** in the previous years provided an optimal framework for testing our solution:

A robust metering scheme. The national electric system operates a robust metering network, meeting the technical requirements in terms of data availability and granularity, included by the regulator, and enforced by the system operator.

A leader in renewables. Chile's main market (Sistema Eléctrico Nacional, SEN) is a hydro-thermal system with an overall installed capacity of 30.5 GW and a growing percentage of carbon-free energy sources. Geothermal, wind, solar photovoltaic, concentrated solar, and hydro are currently 56% of overall installed capacity. In terms of electricity generation, carbon-free sources accounted for 43% of the overall 2021 volume.





Figure 5: Installed Capacity SEN⁸ and 2021 Electricty Production (both SEN and Enel's)

 SEN: Sistema Electrico Nacional, Chilean National Electrical System. Figures updated 4 august 2022 – Ministry of Energy http://energiaabierta.cl/visualizaciones/capacidad-instalada/ **Enel Green Power's well-diversified portfolio and better-than-average duration curve.** EGP's diversified generation portfolio, driven by the company's commitment to wind and solar development and a solid hydro asset base, means we hold approximately 35-40% of total annual renewable electricity production in the SEN. That number becomes roughly 40-45% when comparing Enel's hourly equivalent baseload generation form carbon-free sources with the same indicator for the entire SEN system.

Equivalent baseload generation from the hourly generation duration curve is a good indicator for assessing the maximum capability of a generation portfolio to serve 100% of a stable electricity demand profile. Hourly Duration curve of a carbon-free portfolio can be used as a proxy measurement of that portfolio's maximum capability to serve 24/7 carbon-free power demand.



	Enel		SEN		
Time Granularity	Equivalent Baseload MW	Total annual Volume TWh	Equivalent Baseload MW	Total annual Volume TWh	% Enel vs
Annual	1,474	12.9	3,878	34.0	38%
Monthly	889	7.8	2,473	21.7	36%
Hourly	414	3.6	914	8.0	45%

An hourly *energy map* is an effective way to visualize how decarbonized the operation of an energy system is, with a focus on the percentage of electricity that is being generated with renewable sources in each hour of the year.

Figure 6: Duration curve concept

Figure 7: Equivalent baseload generation form carbon free sources 2020 (Enel Chile vs SEN) The following figure compares Chilean SEN energy map for 2021 and Enel's Chilean portfolio for the same period. Operation of Enel's asset base resulted in a much greener footprint than the total SEN system operation, with 57% of overall renewable energy vs 42% observed for the SEN during 2020. An interesting insight is that Enel's portfolio shows a more balanced structure, as it is not so dependent on renewable energy generated in solar hours.



Diversity of Energy Attribute Certificates. In addition to the regulatory framework that creates a local attribute, in Chile we can find International Renewable Energy Certificates (I-RECs) and a variety of proprietary voluntary certification schemes, such as EGP's 'Sello Verde' voluntary certification. These are audited by independent third-party entities through a manual verification process. Therefore, Chile was a perfect market for testing the blockchain module developed in our platform to provide an additional layer of transparency and matching data quality and reliability to our existing voluntary certificate scheme.

PILOT TESTING RESULTS

The selection of renewable power plants used for this exercise included small hydro, geothermal, solar photovoltaics and wind. The following table shows the full year volumes allocated from each renewable source into each customer's consumption. This allocation is based on the cumulative volumes, derived from one of the optimal local solutions after hourly allocation algorithm convergence.

Matching Full year 2021 (MWh)	Hydro	Solar	Wind	Geo	TOTAL
Food & Beverage	291	10.980	10.542	-	21.813
Automotive	1.876	-	-	-	1.876
Hospitality	4.321	120	89	0	4.531
Health	216	16.970	14.306	64	31.556
Retail	4	1.413	558	-	1.975
TOTAL	6.709	29.483	25.494	65	61.751

As an example of an hourly allocation outcome, Figure 11 shows the energy map of the Food and Beverage customers FY 2021 consumption. The horizontal axis shows the 365 days of the year, and the vertical axis provides hourly information of the predominant energy supply source each hour every day. We can see that most of the energy comes from wind and solar, but small hydro provided a solid backup for any hourly shortfall in wind and solar production.



Figure 10: Full Year 2021 Matching per Technology

4.

Figure 11:

allocation)

Energy Map

EGP's platform allows each customer easy access to the information through a **dashboard** that provides visual data, relevant KPIs, and the ability to download data showing matching and traceability to the origin of the electricity supplied.



Figure 11: Information Dashboard – Matched Consumption and Certificates Data – Food and Beverage Customer FY 2021 For those customers with a power purchase agreement (PPA) with Enel Green Power, these certificate tracking dashboard capabilities can be coupled with PPA performance information.



Figure 12:

Information Dashboard – Enel Green Power PPA Partner Portal https://www.enelgreenpower. com/our-offer/additional-services/egp-partner-portal 4.



Main Takeaways and Next Steps

LESSON LEARNED AND MAIN TAKEAWAYS

Improving hourly matching between purchased and/or self-generated renewable electricity and consumption from baseline (today's) levels up to higher percentages will be a long journey. It will require new market instruments, innovative technology, and time to adapt processes and purchase strategies to future standards.

At Enel Green Power we have embraced the challenge of this transition. By developing this tool, we are aiming to start paving the way towards new 24/7 carbon-free energy. This includes creating an additional stream of new renewable capacity additions on top of the existing support schemes from governments. It also entails growing the size and volume of corporate renewable purchases with monthly or annual matching for EACs, following current carbon accounting rules for Scope 2.

However, based on Enel's experience of many energy markets with very different designs and conditions, a full transition towards a real zero emissions objective every hour every day needs to be addressed collectively. This will allow developers, buyers, suppliers, operators, issuing bodies, market design and support schemes to progress at the same pace. Currently, balancing capabilities and the flexibility needed to complete a 100% hourly matching in many markets remains limited.

EVEN THE MERE MEASUREMENT OF ACTUAL HOURLY MA-TCHING LEVEL BRINGS VALUE

Understanding hourly matching between purchased and/or self-generated renewable electricity and consumption can provide valuable information to decision makers. This can help to properly assess the impacts of their operations on climate and potential additional actions to improve (reduce) their Scope 2 carbon footprint.

THE INTEGRATION OF EXISTING EACS' SCHEMES TOGETHER WITH NEW 24/7 CAPABILITIES IN A SINGLE TOOL IS MUCH AP-PRECIATED BY CORPORATE CUSTOMERS

For corporate customers communication is of the essence. Communication allows all stakeholders to understand and evaluate the impact of corporate renewable purchase initiatives in achieving climate change commitments. Having a consolidated repository with all the information related to EACs and how they match electricity consumption with different time granularities provides a powerful tool to improve carbon accounting assessment and save time and resources. Tools such as **EGP's Tracking & Matching Platform** are a valuable resource for customers of all sectors.

WHAT'S NEXT IN THE TOOL'S ROADMAP

EGP's Renewable Energy Attribute Certificate Tracking & Matching Platform further developments will follow a structured continuous improvement plan that includes:

- New integration and compatibility features with other dashboard tools (Enel X Connect Suite, Enel green Power's PPA Portal)
- Combination with a carbon accounting layer (compatibility with internal and 3rd party technology)
- New processes for reconciliation of official EAC volumes with T-EAC volumes (ledger of unmatched volumes)
- Improvement of dashboard graphical capabilities and report generation